RESEARCH PAPER

A comparative study of operative & postoperative parameters in coronary artery bypass grafting patients: Insights from a tertiary care experience

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Abstract

Background: Coronary artery bypass grafting (CABG) remains the standard surgical treatment for multivessel coronary artery disease. Off-pump and on-pump techniques differ in intraoperative management and postoperative outcomes. This study aimed to compare operative and postoperative parameters between off-pump and on-pump CABG patients.

Methods: This comparative cross-sectional study was conducted in a cardiac surgery department. A total of 60 patients undergoing CABG were divided into two groups: off-pump CABG (n=30) and on-pump CABG (n=30). Baseline characteristics, operative variables, postoperative clinical outcomes and myocardial injury markers including CK-MB and cardiac troponin I (cTnI) were analyzed. Statistical comparisons were performed using appropriate tests, with $p \leq 0.05$ considered significant.

Results: Baseline demographic characteristics, risk factors and preoperative cardiac function were comparable between groups. Operative time was significantly shorter in the off-pump group compared to the on-pump group (254.00 ± 28.75 vs. 334.50 ± 23.72 minutes; $p<0.001$). Postoperative inotropic support requirement was significantly higher in the on-pump group (76.7% vs. 10.0%; $p<0.00001$). CK-MB and cTnI levels were significantly elevated in the on-pump group at 6, 12 and 24 hours postoperatively, indicating greater myocardial injury. However, mechanical ventilation time, blood loss, transfusion requirement and postoperative complications showed no significant differences between groups.

Conclusion: Both on-pump and off-pump CABG are safe and effective techniques with comparable early clinical outcomes. Off-pump CABG is associated with shorter operative time and reduced perioperative myocardial injury, while on-pump CABG requires greater postoperative inotropic support.

Keywords: Coronary artery bypass grafting, off-pump CABG, on-pump CABG, myocardial injury, operative outcomes, postoperative outcomes.

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Introduction

Coronary artery disease (CAD) remains one of the leading causes of morbidity and mortality worldwide, representing a major burden on healthcare systems [1]. Among the various therapeutic strategies, coronary artery bypass grafting (CABG) is widely established as an effective surgical intervention for patients with multivessel coronary artery disease, particularly when medical therapy or percutaneous interventions are insufficient to restore adequate myocardial perfusion [2]. CABG aims to improve blood flow to ischemic myocardium, relieve angina symptoms, enhance functional capacity and improve long-term survival [3].

CABG can be performed using two main techniques: on-pump CABG, which utilizes cardiopulmonary bypass (CPB) and off-pump CABG (OPCAB), which is performed on a beating heart without CPB [4]. Each

technique has distinct physiological implications. On-pump CABG provides a bloodless and stable surgical field, facilitating precise anastomosis, but exposure to cardiopulmonary bypass may trigger systemic inflammatory responses, coagulation disturbances and myocardial injury due to ischemia-reperfusion effects [5]. In contrast, off-pump CABG avoids the use of CPB and is thought to reduce inflammatory activation and organ dysfunction; however, it may present technical challenges and concerns regarding completeness of revascularization in certain cases [6]. Operative and postoperative parameters play a crucial role in evaluating and comparing these two surgical approaches [7]. Operative variables such as duration of surgery, number of grafts, cardiopulmonary bypass time and aortic cross-clamp time reflect the technical complexity and intraoperative efficiency of the procedure [8]. Postoperative outcomes, including mechanical ventilation time, blood loss, transfusion requirements, arrhythmias, myocardial injury markers, intensive care unit stay and early morbidity, provide important indicators of patient recovery and surgical success [9].

Biochemical markers such as cardiac troponins and creatine kinase-MB (CK-MB) are increasingly used to assess perioperative myocardial injury, while hemodynamic stability and postoperative complications help determine overall procedural safety [10]. A comparative evaluation of these parameters between on-pump and off-pump CABG is essential to understand their relative benefits and risks and to guide optimal surgical decision-making [11].

Despite advancements in surgical techniques and perioperative care, there remains ongoing debate regarding the superiority of one approach over the other [12]. Variability in patient characteristics, surgical expertise and institutional protocols further contributes to differing outcomes reported in the literature. Therefore, systematic comparison of operative and postoperative parameters between these two techniques is important for generating evidence-based insights [13].

In this context, the present study aimed to compare operative and postoperative parameters between patients undergoing on-pump and off-pump CABG, with a focus on intraoperative characteristics, early biochemical responses and short-term clinical outcomes in a tertiary care setting.

Methodology & Materials

This comparative cross-sectional study was conducted in the Department of Cardiac Surgery, Bangladesh Medical University, over a 12-month period from 1 February 2024 to 31 January 2025. The study population comprised patients who underwent coronary artery bypass grafting (CABG) for multivessel coronary artery disease with or without cardiopulmonary bypass and fulfilled the predefined inclusion and exclusion criteria. A total of 60 patients were enrolled using a convenience sampling technique and divided into two groups based on the use of cardiopulmonary bypass: Group A consisted of 30 patients who underwent off-pump CABG (OPCAB) and Group B consisted of 30 patients who underwent on-pump CABG.

All patients irrespective of age who underwent on-pump or off-pump CABG for multivessel coronary artery disease were eligible for inclusion. Patients with left main coronary artery stenosis ≥50%, ejection fraction <35%, preoperative myocardial infarction within the last 2 weeks or ongoing myocardial infarction, on-pump beating CABG, redo CABG, combined cardiac procedures, emergency cardiac surgery, hepatic failure, renal failure, respiratory failure, or cerebrovascular disease were excluded.

Data were collected through face-to-face interviews using a semi-structured questionnaire, review of medical records and a comprehensive checklist. Baseline demographic and clinical data including age, gender, smoking status, diabetes mellitus, dyslipidemia and hypertension were recorded. Preoperative serum levels of cardiac troponin I (cTnI), creatine kinase-MB (CK-MB) and NT-proBNP were measured on the day before surgery. Operative variables including number of grafts, operation time, cardiopulmonary bypass time and aortic cross-clamp time were documented. Postoperatively, cTnI, CK-MB and NT-proBNP levels were reassessed at 6, 12, 24, 48 and 72 hours after aortic unclamping in the on-pump group and after the final distal anastomosis in the OPCAB group. All patients were followed for 7 days after surgery.

Statistical analyses were performed using SPSS version 27. Continuous variables were expressed as mean ± SD and categorical variables as frequency and percentage. Comparisons between groups were performed using the independent sample t-test, Chi-square test, or Fisher's exact test as appropriate. A p-value ≤0.05 was considered statistically significant. Informed written consent was obtained from all participants.

Results

Table 1: Comparison of age and gender between Group A (OPCAB) and Group B (On-pump CABG)

Parameter	Group A (OPCAB) (n=30)	Group B (On-pump) (n=30)	p-value

Age distribution			0.537^{ns}
40–55 years	13 (43.3%)	8 (26.7%)	
56–70 years	17 (56.7%)	22 (73.3%)	
Mean age (years)	56.83 ± 5.54	57.87 ± 4.95	0.441^{ns}
Gender			0.739^{ns}
Male	24 (80.0%)	25 (83.3%)	
Female	6 (20.0%)	5 (16.7%)	
Male: Female ratio	4:01	5:01	

Data expressed as frequency (f), percentage (%), or mean ± SD.
Chi-square (χ^2) test was used for categorical variables; independent sample t-test was used for continuous variables.
p-value ≤ 0.05 was considered statistically significant.
ns = Not significant

Table 1 compares the baseline demographic characteristics of age and gender between Group A (OPCAB, n=30) and Group B (on-pump CABG, n=30). Regarding age distribution, most patients in both groups belonged to the 56–70 years age group (56.7% in Group A vs. 73.3% in Group B). The mean age was 56.83 ± 5.54 years in Group A and 57.87 ± 4.95 years in Group B. The difference in mean age (p = 0.441) and the distribution of patients according to age categories (p = 0.537) were not statistically significant between the two groups. Regarding gender distribution, male patients were predominant in both groups, with a male-to-female ratio of 4:1 in Group A and 5:1 in Group B. There was no significant difference in gender distribution between the two groups (p = 0.739).

Table 2: Comparison of associated comorbidities between two groups

Risk factors	**Group A**	**Group B**	**p-value**
	f (%)	**f (%)**	
Diabetes mellitus	12 (40.0%)	14 (46.7%)	0.602^{ns}
Hypertension	17 (56.7%)	19 (63.3%)	0.598^{ns}
Dyslipidemia	15 (50.0%)	16 (53.3%)	0.796^{ns}
Smoking	14 (46.7%)	19 (53.3%)	0.194^{ns}

Data were expressed as frequency (f) and percentage (%).
Figures in the parentheses denote corresponding percentage (%).
Statistical analysis was done by Chi-square ($\chi 2$) test to compare between two groups.
p-value ≤0.05 was considered significant.
Ns = Not significant

Risk factors including diabetes mellitus, hypertension, dyslipidemia and smoking were compared between Group A and Group B. While there were differences in the prevalence of these risk factors between the two groups, none of these differences were statistically significant as indicated by the p-values, which were all greater than 0.05 (Table 2).

Table 3: Comparison of preoperative clinical and biochemical findings

Parameter	**Group A (OPCAB) (n=30) Mean ± SD**	**Group B (On-pump) (n=30) Mean ± SD**	**p-value**
CK-MB (U/L)	16.63 ± 6.47	15.17 ± 5.99	0.938^{ns}
cTnI (ng/mL)	0.0069 ± 0.0050	0.0080 ± 0.0055	0.175^{ns}
NT-proBNP (pg/mL)	189.37 ± 47.77	193.77 ± 39.49	0.230^{ns}
LVEF (%)	50.30 ± 7.38	51.17 ± 6.75	0.924^{ns}

Data were expressed as mean ± SD.
Statistical analysis was done by independent sample t-test to compare the mean between the two groups.
p-value ≤0.05 was considered significant.
LVEF = Left ventricular ejection fraction
Ns = Not significant

There was no significant difference between the two groups in regard to mean left ventricular ejection fraction (50.30 ± 7.38% in group A vs. 51.17 ± 6.75% in group B; p = 0.924), CK-MB (16.63 ± 6.47 in group A vs. 15.17± 5.99 in group B; p = 0.938), Troponin I (0.0069± 0.0050 in group A vs 0.0080 ± 0.0055 in group B; p = 0.175) and NT-proBNP levels (189.37± 47.77 in group A vs 193.77 ± 39.49 in group B; p = 0.230) (Table 3).

Table 4: Comparison of per-operative attributes between Group A (OPCAB) and Group B (On-pump CABG)

Per-operative Attribute	Group A (OPCAB) (n=30)	Group B (On-pump) (n=30)	p-value
Total number of grafts			0.485^{ns}
Two grafts	7 (23.3%)	7 (23.3%)	
Three grafts	20 (66.7%)	16 (53.3%)	
Four grafts	2 (6.7%)	6 (20.0%)	
Five grafts	1 (3.3%)	1 (3.3%)	
Per-operative arrhythmia	2 (6.7%)	2 (6.7%)	1.00^{ns}
Duration of operation (minutes)	254.00 ± 28.75	334.50 ± 23.72	<0.001*
Cross-clamp time (minutes)	Not applicable	68.9 ± 9.43	-
CPB time (minutes)	Not applicable	113.0 ± 11.49	-

Data were expressed as frequency (f) and percentage (%) and Mean ± SD.
Figures in the parentheses denote corresponding percentages (%).
Statistical analysis was done by Chi-square ($\chi 2$) test to compare between two groups and independent sample t-test to compare the mean between the two groups.
p-value ≤0.05 was considered significant.
Ns = Not significant

Table 4 compares per-operative attributes between Group A (OPCAB, n=30) and Group B (on-pump CABG, n=30). Regarding the total number of grafts, the majority of patients in both groups received three grafts (66.7% in Group A vs. 53.3% in Group B), followed by two grafts (23.3% in both groups), with no statistically significant difference between the groups (p = 0.485). Per-operative arrhythmia occurred in 2 patients (6.7%) in each group (p = 1.00). The mean duration of operation was significantly shorter in the OPCAB group compared to the on-pump group (254.00 ± 28.75 minutes vs. 334.50 ± 23.72 minutes; p < 0.001). In Group B, the mean aortic cross-clamp time was 68.9 ± 9.43 minutes and the mean cardiopulmonary bypass time was 113.0 ± 11.49 minutes.

Table 5: Comparison of postoperative clinical outcomes between Group A (OPCAB) and Group B (On-pump CABG)

Postoperative Attribute	Group A (OPCAB) (n=30)	Group B (On-pump) (n=30)	p-value
Mechanical ventilation time (hours)	7.05 ± 1.61	8.13 ± 1.91	0.382^{ns}
Blood loss (mL)	454.67 ± 134.95	556.33 ± 163.70	0.092^{ns}
Blood transfusion requirement (units)	4.23 ± 0.50	5.07 ± 0.69	0.380^{ns}
Postoperative LVEF (%)	48.80 ± 5.89	49.17 ± 4.38	0.126^{ns}
Categorical variables [f (%)]			
Reoperation	2 (6.7%)	1 (3.3%)	0.554^{ns}
Post-operative MI	0 (0.0%)	0 (0.0%)	-
New postoperative AF	3 (10.0%)	3 (10.0%)	1.00^{ns}
Stroke	0 (0.0%)	0 (0.0%)	-
Pulmonary complication	0 (0.0%)	0 (0.0%)	-
Renal impairment	0 (0.0%)	0 (0.0%)	-
Inotrope support > 24 hours	3 (10.0%)	23 (76.7%)	<0.00001*
ICU stay > 3 days	1 (3.3%)	3 (10.0%)	0.300^{ns}
In-hospital mortality	0 (0.0%)	0 (0.0%)	-

Continuous data expressed as mean ± SD; categorical data expressed as frequency (f) and percentage (%).
Independent sample t-test was used for continuous variables; Chi-square (χ^2) test was used for categorical variables.
p-value ≤ 0.05 was considered statistically significant.
ns = Not significant; * = Significant
AF = Atrial fibrillation; LVEF = Left ventricular ejection fraction; MI = Myocardial infarction

Table 5 compares postoperative clinical outcomes between Group A (OPCAB, n=30) and Group B (on-pump CABG, n=30). Regarding continuous variables, there were no statistically significant differences between the two groups in mechanical ventilation time (7.05 ± 1.61 vs. 8.13 ± 1.91 hours; p = 0.382), postoperative blood loss (454.67 ± 134.95 vs. 556.33 ± 163.70 mL; p = 0.092), blood transfusion requirement (4.23 ± 0.50 vs. 5.07 ± 0.69 units; p = 0.380), or postoperative LVEF (48.80 ± 5.89% vs. 49.17 ± 4.38%; p = 0.126). Regarding categorical variables, there was no significant difference in reoperation rates (6.7% in Group A vs. 3.3% in Group B; p = 0.554), new postoperative atrial fibrillation (10.0% in both groups; p = 1.00), or ICU stay exceeding 3 days (3.3% in Group A vs. 10.0% in Group B; p = 0.300). However, the need for inotrope support for more than 24 hours was significantly higher in Group B (76.7%) compared to Group A (10.0%) (p < 0.00001). There were no cases of postoperative myocardial infarction, stroke, pulmonary complication, renal impairment, or in-hospital mortality in either group.

Table 6: Comparison of postoperative serum CK-MB between two groups

Postoperative S. CK-MB (U/L)	Group A Mean ± SD	Group B Mean ± SD	p-value
6 hours after surgery	56.33 ± 5.18	83.70± 9.69	0.023^{s}
12 hours after surgery	69.63 ±5.18	108.63 ± 16.74	<0.001^{s}
24 hours after surgery	80.90 ± 5.80	120.37 ± 20.30	< 0.001^{s}
48 hours after surgery	62.57 ± 6.13	75.50 ± 6.70	0.306^{ns}
72 hours after surgery	42.33 ± 5.50	52.60 ± 5.95	0.503^{ns}

Data were expressed as mean ± SD.
Statistical analysis was done by independent sample t-test to compare mean between two groups.
p-value ≤0.05 was considered significant.
S = Significant
Ns = Not significant

CK-MB was significantly higher in group B patients compared to group A at 6 hours (56.33 ± 5.18 vs. 83.70± 9.69 U/L; p= 0.023), 12 hours (69.63 ±5.18 vs. 108.63 ± 16.74; p <0.001), 24 hours (80.90 ± 5.80 vs. 120.37 ± 20.30; p < 0.001). Thereafter, there was decline in CK-MB levels at 48hours (62.57 ± 6.13 vs. 75.50 ± 6.70; p= 0.306), 72hours (42.33 ± 5.50 vs 52.60 ± 5.95; p= 0.503) after surgery (Table 6).

Table 7: Comparison of postoperative cTnI between two groups

Postoperative cTnI (ng/ml)	Group A Mean ± SD	Group B Mean ± SD	p-value
6 hours after surgery	0.331 ± 0.044	0.663 ± 0.068	0.045^{s}
12 hours after surgery	0.640 ± 0.0721	1.185 ± 0.162	0.002^{s}
24 hours after surgery	1.231 ± 0.104	2.355 ± 0.191	0.007^{s}
48 hours after surgery	0.513 ± 0.601	0.835 ± 0.701	0.224^{ns}
72 hours after surgery	0.303 ± 0.059	0.547 ± 0.064	0.903^{ns}

Data were expressed as mean ± SD.
Statistical analysis was done by independent sample t-test to compare mean between two groups.
p-value ≤0.05 was considered significant.
S = Significant
Ns = Not significant

cTnI was significantly higher in group B patients compared to group A at 6 hours (0.331 ± 0.044 vs 0.663 ± 0.068; p= 0.045), 12 hours (0.640 ± 0.0721 vs 1.185 ± 0.162; p= 0.002), 24 hours (1.231 ± 0.104 vs 2.355 ± 0.191; p= 0.007). Thereafter, there was a decline in the cTnI levels at 48hours (0.513 ± 0.601 vs

0.835 ± 0.701; p= 0.224), 72hours (0.303 ± 0.059 vs 0.547 ± 0.064; p= 0.903) after surgery (Table 7).

Discussion

The present study compared operative and postoperative parameters between patients undergoing off-pump coronary artery bypass grafting (OPCAB) and on-pump CABG, focusing on intraoperative efficiency, biochemical myocardial injury markers and early clinical outcomes. Overall, the findings demonstrated significant differences in operative duration, perioperative myocardial injury biomarkers and inotropic support requirement, while most baseline characteristics and several postoperative clinical outcomes remained comparable between the two groups.

In the present study, baseline demographic variables including age and gender distribution were comparable between groups, with no statistically significant differences. Similar findings were reported by Phothikun et al., who compared different CABG techniques and observed that patient demographics were evenly distributed across surgical approaches, ensuring comparability of outcomes across groups [14]. Likewise, Krasivskyi et al. also emphasized that balanced baseline characteristics are essential for minimizing confounding in comparative CABG outcome analyses [15].

In terms of comorbidities such as diabetes mellitus, hypertension, dyslipidemia and smoking status, no significant differences were observed between the two groups in our study. These findings are consistent with the observations of Mazzeffi et al., who reported that baseline cardiovascular risk factors did not significantly differ between CABG cohorts when evaluating postoperative outcomes such as infection and recovery [16]. This similarity strengthens the validity of our comparative analysis by reducing baseline bias.

Preoperative cardiac function and biomarker levels, including LVEF, CK-MB, cTnI and NT-proBNP, were also comparable between groups in our study. This aligns with the findings of Hsu et al., who demonstrated that preoperative biomarker profiles are generally similar in patients undergoing on-pump and off-pump CABG, allowing postoperative variations to be more reliably attributed to surgical technique rather than baseline differences [17].

Regarding operative parameters, our study demonstrated significantly shorter operative time in the OPCAB group compared to the on-pump group (254.00 ± 28.75 vs. 334.50 ± 23.72 minutes). This finding is consistent with Phothikun et al., who reported reduced procedural duration in off-pump CABG due to avoidance of cardiopulmonary bypass setup and cross-clamping procedures [14]. Similarly, Solanki et al. observed that minimally invasive and off-pump techniques were associated with reduced operative time and faster surgical workflow compared to conventional on-pump CABG [18].

Intraoperative myocardial injury, reflected by postoperative CK-MB and cTnI levels, was significantly higher in the on-pump group in our study at 6, 12 and 24 hours after surgery. These findings are supported by Hsu et al., who reported increased inflammatory and myocardial injury biomarkers following cardiopulmonary bypass due to ischemia-reperfusion injury and systemic inflammatory activation [17]. The higher biomarker release in on-pump CABG may reflect the physiological stress associated with extracorporeal circulation.

Postoperative outcomes in our study showed no significant differences in ventilation time, blood loss, transfusion requirement, or LVEF between the two groups. Similar results were reported by Krasivskyi et al., who found comparable early clinical recovery profiles between on-pump and off-pump CABG when performed in appropriately selected patients [15]. However, we observed a significantly higher requirement for prolonged inotropic support in the on-pump group (76.7% vs. 10.0%), suggesting greater perioperative hemodynamic instability. This finding is consistent with the study by Zea-Vera et al., who reported that cardiopulmonary bypass-related myocardial stress may contribute to increased postoperative circulatory support needs [19].

Postoperative atrial fibrillation occurred at similar rates in both groups in our study. This is in agreement with Yavuz et al. and Topal et al., who demonstrated that postoperative atrial fibrillation is influenced by multiple factors including systemic inflammation and metabolic status rather than surgical technique alone [20,21]. Guzelburc et al. further highlighted the role of inflammatory and platelet-related indices in predicting postoperative atrial fibrillation, supporting the multifactorial nature of this complication [22].

Importantly, no mortality or major complications such as stroke, renal failure, or myocardial infarction were observed in either group in our study, indicating the overall safety of both surgical approaches in selected patients. Similar low early complication rates have been reported by Urbanowicz et al. and Zukowska et al., who emphasized that modern CABG techniques, when performed with appropriate perioperative care, are associated with improved short-term safety profiles [23,24].

Limitations of the study

This study has certain limitations. The sample size was relatively small, which may limit the generalizability of the findings to a broader population. The study design was cross-sectional, which restricts the ability

to establish long-term outcomes and causal relationships between surgical technique and postoperative results. Additionally, the use of convenience sampling may introduce selection bias despite comparable baseline characteristics between groups. Another limitation is the relatively short follow-up period, which focused mainly on early postoperative outcomes. Long-term graft patency, survival outcomes and late complications were not assessed. Therefore, further large-scale prospective studies with longer follow-up are recommended to validate these findings.

Conclusion

In conclusion, both on-pump and off-pump CABG techniques demonstrate comparable baseline characteristics and overall early postoperative clinical outcomes. However, off-pump CABG is associated with shorter operative time and lower perioperative myocardial injury markers, while on-pump CABG shows a higher requirement for postoperative inotropic support. These findings suggest that both techniques are safe and effective and the choice of surgical approach should be individualized based on patient condition, anatomical complexity and surgical expertise to optimize outcomes.

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Conflicts of interest

There are no conflicts of interest.

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