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ORIGINAL ARTICLE

Frequency of re-exploration for bleeding in ON PUMP versus OFF PUMP coronary artery bypass grafting at Peshawar Institute of Cardiology

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ABSTRACT

Background: Postoperative bleeding is a significant complication of on-pump coronary artery bypass grafting (CABG), due to an increased risk of coagulopathy compared to off-pump techniques. Due to limited local data, this study aimed to compare re-exploration rates for bleeding between on-pump and off-pump CABG.

Methods: This cross-sectional study was conducted in the Department of Cardiac Surgery at the Peshawar Institute of Cardiology, enrolling 160 patients (80 per group) via consecutive sampling. Adults aged 30–80 years undergoing elective CABG were included. Patients with bleeding disorders, recent anticoagulant use, valvular disease, emergency, or re-do surgeries were excluded. Postoperative bleeding within 24 hours was assessed via clinical evaluation and drain output; re-exploration was defined as return to the OR within 24 hours. Data were analyzed using t-tests and chi-square tests, with significance set at $p < 0.05$.

Results: The mean patient age was 57.16 ± 8.95 years, and 80.00% were male. Both groups were statistically similar in baseline characteristics ($p > 0.05$). Prior MI was noted in 12.5% (CABG) and 11.25% (OPCAB) of patients. Mean ejection fraction was 52.35 ± 7.23 (CABG) vs. 53.19 ± 6.73 (OPCAB). Triple-vessel disease was most common. CABG patients received more grafts (median: 3.0) compared to OPCAB (median: 2.0; $p < 0.001$). Re-exploration for bleeding occurred in 3 patients, all in the CABG group. One death was reported postoperatively.

Conclusion: Both CABG and OPCAB are effective in managing complex coronary disease with low short-term mortality. However, CABG is associated with a higher number of grafts and re-exploration rates, while off-pump coronary artery bypass (OPCAB) offers a less invasive alternative with fewer complications. OPCAB may be preferred in high-risk patients without compromising outcomes.

Keywords: Bleeding, Coronary Artery Bypass Grafting, Coronary Artery Surgery, Myocardial Revascularization

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Introduction

Cardiovascular disease is the leading global cause of death, responsible for approximately 17.8 million deaths annually, with coronary artery disease (CAD) contributing 47.8% of these fatalities (1-3). Coronary artery bypass grafting (CABG) is a key intervention, performed via off-pump (OPCABG) or on-pump (ONCABG) techniques. OPCABG reduces cardiopulmonary bypass (CPB)-

related complications, such as systemic inflammation, neurocognitive decline, renal and pulmonary dysfunction, and multi-organ failure (4). It is beneficial for patients with previous CABG, diabetes, moderate left ventricular dysfunction (EF 30–50%), and for women and older adults (66–75 years) (5).

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Re-exploration due to bleeding is more frequent in ONCABG (8.00%) compared to OPCABG (2.2%) (6, 7). This serious complication can result in hemodynamic instability, increased infection risk, and transfusion-related complications (8, 9). Risk factors include advanced age, low BMI, prolonged CPB time, multiple anastomoses, and use of internal mammary arteries (10). In OPCABG, mortality after re-exploration ranges from 9% to 26% (11). CPB contributes to coagulopathy due to blood exposure to artificial surfaces and mechanical trauma, impairing hemostasis and increasing complications. OPCABG avoids CPB, reducing bleeding risks (12, 13).

Limited local studies have compared ONCABG and OPCABG in terms of re-exploration. This study evaluates the frequency of re-exploration for bleeding in patients undergoing these procedures at the Peshawar Institute of Cardiology.

Methods

This six-month cross-sectional study was conducted in the Department of Cardiac Surgery at the Peshawar Institute of Cardiology, enrolling 160 patients (80 in each group) through consecutive sampling based on the type of CABG. Patients aged 30–80 years undergoing elective CABG were included, while those with bleeding disorders, recent use of clopidogrel or warfarin, valvular disease, combined or emergency CABG, or re-do surgeries were excluded.

Ethical approval was obtained from institutional review board committee via letter number IRC/24187 dated 6th august 2024, and informed consent was secured. Baseline data, including age, gender, BMI, smoking status, comorbidities, and surgical history, were recorded. BMI was calculated using WHO criteria. The procedure type was decided by senior cardiac surgeons: Group A underwent on-pump CABG, and Group B underwent off-pump CABG. All patients received postoperative ICU care per institutional protocol and were monitored for 24-hour bleeding.

Postoperative bleeding was assessed using predefined clinical signs and drainage thresholds. Re-exploration was defined as return to the OR within 24 hours for significant bleeding, and causes were documented intraoperatively. Both groups were compared for re-exploration rates using a structured proforma.

Data analysis was done using SPSS v27. Quantitative variables (age, BMI, grafts, time to re-exploration) were presented as mean ± SD or median (IQR), based on distribution (Shapiro-Wilk test). Categorical variables (gender, diabetes, hypertension, CKD, MI, re-exploration outcomes) were reported as frequencies/percentages. Chi-square tests were used to assess associations between categorical variables, and independent t-tests or Mann-Whitney U tests were used for group comparisons. A p-value ≤ 0.05 was considered statistically significant.

Results

The mean age of study participants was 57.16 ± 8.95 years, with a nearly equal distribution between those aged 30–57 years

(46.88%) and those older than 57 years (53.13%). The majority of patients were male (79.38%), and the overall mean BMI was 29.40 ± 5.70. Among the 58 patients with available smoking data, 91.38% were non-smokers.

Regarding comorbidities, 21.56% of patients had a history of myocardial infarction (MI), 11.88% had experienced a cerebrovascular accident (CVA), and 2.50% had a relevant past surgical history. Among 58 patients with available data on percutaneous coronary intervention (PCI), 31.03% had previously undergone PCI. Diabetes mellitus (DM) was present in 36.48% of the patients, while hypertension was the most prevalent comorbidity, affecting 76.10% of the study population.

When comparing the two groups, the mean age was similar (CABG: 58.20 ± 8.98 vs. OPCAB: 56.11 ± 8.86), and age group distribution showed no significant variation. Gender distribution was also comparable, with males predominating in both groups. While the mean BMI was slightly higher in the CABG group, the difference was not statistically significant.

No significant differences were observed between the CABG and OPCAB groups regarding smoking status, history of CVA, past surgical history, diabetes mellitus (DM), and chronic kidney disease (CKD). However, hypertension was significantly more common in the CABG group compared to the OPCAB group (p = 0.008). Conversely, a history of PCI was significantly more frequent in OPCAB patients than in those undergoing CABG (p = 0.001).There was no statistically significant difference in the history of MI between the groups (p = 0.807), although it was slightly more prevalent in the CABG group, suggesting that patients with prior MI were more often managed with conventional CABG, as shown in Table 1.

Table 1: Baseline demographics and comorbidities by surgical Procedure (CABG vs OPCAB)

Variables		Total N=160	Procedure		p-value
			CABG N=80	OPCAB N=80	
Age (Mean ± SD)		57.16 ±8.95	58.20±8.98	56.11±8.86	0.129
Age groups, n (%)	30-57	75(46.88)	33(41.25)	42(52.50)	0.154
	>57	85 (53.13)	47(58.75)	38(47.50)	
Gender, n (%)	Female	33(20.63)	16(20.00)	17(21.25)	0.845
	Male	127(79.38)	64(80.00)	63(78.75)	
BMI (Mean ± SD)		29.40±5.70	29.60±5.33	29.18±6.09	0.568
Smoking status, n (%)	No	53(91.38)	30(85.71)	23(100)	0.058
	Yes	5(8.62)	5(14.29)	0(0)	
History of myocardial infraction, n (%)	No	141(88.13)	70(87.50)	71(88.75)	0.807
	Yes	19(11.88)	10(12.50)	9(11.25)	
Histroy of Cerebrovascular accident, n (%)	No	156(97.50)	77(96.25)	79(98.75)	0.311
	Yes	4(2.50)	3(3.75)	1(1.25)	
Past surgical history, n (%)	No	105(65.63)	49(61.25)	56(70.00)	0.224
	Yes	55(34.38)	31(38.75)	24(30.00)	
Percutaneous coronary intervention n (%)	No	40(68.97)	30(88.24)	10(41.67)	<0.001
	Yes	18(31.03)	4(11.76)	14(58.33)	
Diabetes mellitus, n (%)	No	101(63.52)	51(63.75)	50(63.29)	0.952
	Yes	58(36.48)	29(36.25)	29(36.71)	
Hypertension, n (%)	No	38(23.90)	12(15.00)	26(32.91)	0.008
	Yes	121(76.10)	68(85.00)	53(67.09)	

Chronic kidney disease, n (%)	No	159(99.38)	79(98.75)	80(100)	0.316
	Yes	1(0.63)	1(1.25)	0(0)	

Among all patients included in the study, the mean ejection fraction (EF) was 52.77 ± 6.98. The most common diagnosis was triple-vessel coronary artery disease (TVCAD), present in 77.50% of cases. Re-exploration was required in 1.89% of patients, whereas the majority (98.11%) did not require reopening. In terms of grafts placed, most patients received either three (36.48%) or two (33.96%) grafts, with a smaller proportion receiving either one or four grafts. The median number of grafts was 3.00 (IQR 1.00). The median time to re-opening was 340.00 minutes (SD 124.90).

When comparing groups, mean ejection fraction (EF) was not significantly different between the CABG group (52.35 ± 7.23) and the OPCAB group (52.35 ± 7.23) (p = 0.524). TVCAD was the most frequent diagnosis in both groups; however, overall diagnostic distribution showed a statistically significant difference (p < 0.001). Re-opening rates were significantly higher in the CABG group (3.75%) compared to the OPCAB group (0.00%) (p < 0.001). Regarding graft numbers, CABG patients predominantly received 3 to 4 grafts, while OPCAB patients most commonly received 1 to 2 grafts, indicating a statistically significant difference in graft usage between groups (p < 0.001). The median time to re-opening (340 minutes) was reported only in the CABG group, as no re-opening occurred in the OPCAB group; therefore, statistical comparison was not applicable.

Table 2: Surgical variables, diagnoses, and re-exploration comparison between CABG and OPCAB

Variables		Total n=160	Procedure		p-value
			CABG n=80	OPCAB n=80	
EF (Mean±SD)		52.77±6.98	52.35±7.23	53.19±6.73	0.524
Diagnosis, n (%)	DVCAD	19(11.88)	7(8.75)	12(15.00)	<0.001
	SVCAD	17(10.63)	1(1.25)	16(20.00)	
	TVCAD	124(77.50)	72(90.00)	52(65.00)	
Re-open, n (%)	No	156(98.11)	77(96.25)	79(100.00)	0.082
	Yes	3(1.89)	3(3.75)	0(0.00)	
Grafts, Median(IQR)		3.00(1.00)	3.00(4.00)	2.00(2.00)	<0.001
Grafts, n (%)	One	22(13.84)	0(0.00)	22(27.85)	<0.001
	Two	54(33.96)	13(16.25)	41(51.90)	
	Three	58(36.48)	43(53.75)	15(18.99)	
	Four	25(15.48)	24(30.00)	1(1.27)	
Time to re-open [median(range)]		340.00(240)	340(240)	-	NC

NC: Not Computable

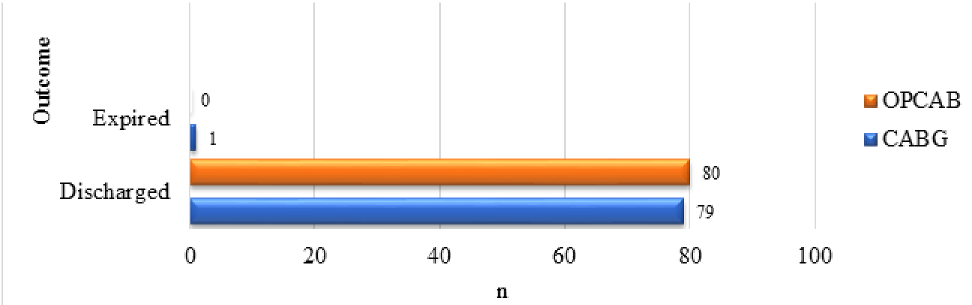

Figure 1: Outcome by Surgical Procedure (CABG vs OPCAB)

Figure 1 illustrates that the discharge rates among the 160 patients were similarly high in both groups, with 79 patients discharged in the CABG group and 80 in the OPCAB group. Only one mortality was reported, which occurred in the CABG group.

Table 3: Outcome by Re-exploration status

Outcome	Re-open		p-value
	No	Yes	
	N (%)	N (%)	
Discharged	155(98.36%)	3(100%)	0.316
Expired	1(0.64%)	0(0.00)	

All patients who underwent re-exploration survived, resulting in a 100% discharge rate. In contrast, a mortality rate of 0.63% was observed among patients who were not re-explored. Although this may suggest a potential protective effect of timely re-intervention, the association was not statistically significant (p = 0.316).

Re-exploration was observed in 3 patients, all of whom belonged to the CABG group, while no re-exploration cases occurred in the OPCABG group. Consequently, post-stratification analysis and the chi-square test were not conducted because the necessary assumptions were not fulfilled, specifically, each cell must have an expected frequency of at least 5, and no more than 20% of cells may have expected frequencies below 5.

Discussion

Postoperative bleeding is notable complications of coronary artery bypass grafting (CABG), often requiring re-exploration, which can increases patient morbidity, extend hospital stays, and elevate healthcare costs. The use of Cardiopulmonary bypass (CPB) in on-pump CABG contributes to bleeding risk due to its associated with coagulopathy and systemic inflammatory responses. In contrast, off-pump coronary artery bypass (OPCAB) eliminates the need for CPB and may reduce these complications.

Despite these differences, there is limited local data directly comparing re-exploration rates for bleeding between on-pump CABG and OPCAB. This study aimed to fill that gap by evaluating and comparing the frequency of re-exploration due to postoperative bleeding between these two surgical techniques. In the present study, all re-exploration cases occurred in the on-pump CABG group (3.75%), while none were reported in the OPCAB group. Although this difference did not reach statistical significance (p = 0.082), the trend suggests that OPCAB may be associated with a lower risk of postoperative bleeding requiring re-exploration. This finding is consistent with previous studies indicating reduced bleeding complications in OPCAB. For instance, Choong et al. reported a re-exploration rate of 5.9% in on-pump CABG patients, which aligns with our findings (14). In contrast, Patel et al. documented a 2.2% re-exploration rate in OPCAB patients, slightly higher than our OPCAB cohort (0%). The avoidance of CPB-induced coagulopathy and systemic inflammation may explain this reduced risk in OPCAB patients (7).

Islam et al. reported a notably higher re-exploration rate of 9.3% following on-pump cardiac surgeries, with no associated mortality. While their re-exploration rate was higher than ours, the mortality trend is in agreement (15). Similarly, Mathur et al. observed a lower re-exploration rate in OPCAB (1.18%) but a higher in-hospital mortality rate (9.09%), potentially due to delayed re-exploration (mean time 10.6 hours) and patient comorbidities (16). In contrast, our study had a median time to re-exploration of less than 12 hours, which may have contributed to improved outcomes. Prompt re-exploration has been shown to reduce adverse events, as delayed intervention is linked with higher mortality and complications, as highlighted by Choong et al(14).

In terms of clinical profiles, the CABG group had a slightly lower mean ejection fraction (52.35 ± 7.23 vs. 53.19 ± 6.73, $p = 0.524$) and a higher prevalence of previous myocardial infarction (12.50% vs. 11.25%, $p = 0.807$). Although these differences were not statistically significant, they may have contributed to increased bleeding risk. Alström et al. (17) found that factors such as emergency surgery and low ejection fraction were independent predictors of re-exploration, while Niazi and Khan identified hypertension as a significant risk factor, an association also observed in our CABG group (18).

Importantly, none of the patients who underwent re-exploration in our study died, while 0.64% of patients who did not require re-exploration expired. This trend, although based on a small sample size (n = 3 re-explored cases), suggests that early re-exploration may be associated with better outcomes. These findings highlight the need for timely identification and intervention in cases of postoperative bleeding.

Previous literature supports the observation that bleeding and tamponade are the leading causes of re-exploration. Patel et al. (7) reported bleeding/tamponade in 90.48% of re-exploration cases ($p < 0.001$), with graft or anastomotic sites being the most frequent source (53.8%). This underscores the importance of meticulous surgical technique, especially in patients undergoing on-pump CABG.

Some studies, like Choong et al. (14), reported higher mortality in re-explored patients, despite the fact that our study found significant difference in mortality between CABG and OPCAB of 1 (0.68%). This disparity could result from variations in surgical techniques, postoperative care, or patient demographics. For instance, since delayed re-exploration has been associated with higher rates of morbidity and mortality (7, 14), our institution's policy of early re-exploration (median time <12 hours) may have improved results.

Regarding overall re-exploration rates, our OPCAB group (0%) showed a lower rate than the 4% reported by Nasir et al., despite both studies being conducted in the same institution (19). This discrepancy may be due to variations in surgical experience, patient selection, or intraoperative bleeding control protocols. Notably, the number of grafts was lower in the OPCAB group (1–2 grafts in 27.85%–51.90% of cases) compared to the

CABG group (3–4 grafts in 53.75%–30.00%), possibly contributing to a reduced risk of bleeding by minimizing anastomotic sites.

Limitations of the study

This study's design limits causal inference and control for confounding. Only three patients required re-exploration, reducing statistical power and limiting subgroup analysis. Findings may not generalize to centers with different surgical practices or patient populations.

Coagulation profiles and bleeding sources (e.g., graft vs. sternal) were not documented, restricting insight into bleeding mechanisms. The on-pump group had more prior MIs, suggesting a higher baseline risk, which may have influenced outcomes. None of the re-explored patients died, possibly due to better postoperative care or timely intervention. The lower re-exploration rate in OPCAB may reflect meticulous intraoperative hemostasis or differences in antiplatelet use. The absence of worse outcomes suggests a slower, less severe bleeding course, allowing delayed intervention without harm.

Conclusion

The findings support that OPCAB is associated with lower re-exploration rates, likely due to the avoidance of CPB-related coagulopathy. However, the higher re-exploration rate in CABG patients with hypertension, prior MI, or lower ejection fraction underscores the need for careful patient selection and close postoperative monitoring.

Recommendations

Future studies with larger sample sizes and detailed bleeding data are needed to validate these results and refine surgical techniques.

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Data acquisition, analysis and interpretation	UUR, MAH, MN
Manuscript writing and approval	MN AI, AN, MAG

All the authors agree to take responsibility for every facet of the work, making sure that any concerns about its integrity or veracity are thoroughly examined and addressed.