



COMPARISON OF POSTOPERATIVE OUTCOMES AFTER CORONARY ARTERY BYPASS GRAFTING (CABG) USING ON- PUMP CARDIOPULMONARY BYPASS VERSUS OFF-PUMP CABG AT A TERTIARY CARE CARDIAC CENTER

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Abstract

Introduction: Coronary artery bypass grafting (CABG), is the most common surgical procedure for coronary artery disease. There are two basic techniques: On-pump CABG (cardiopulmonary bypass) and Off-pump CABG (performed on a beating heart). The two methods have different perioperative physiological effects and postoperative results, with the best technique still being a subject of debate.

Objective: To compare postoperative outcomes between on-pump and off-pump CABG.

Methodology: This comparative cross-sectional study was carried out at Fauji Foundation Hospital, Peshawar from 1st April 2025 to 30th September 2025 through consecutive non-probability sampling 340 patients who were scheduled to undergo isolated CABG were included and randomized into on-pump (n=170) and off-pump (n=170) groups. A structured proforma was used to gather the data on demographic variables, intra-operative findings and postoperative outcomes. Ventilation time, length of stay for the ICU, hospital, presence of postoperative complications, and in-hospital mortality were all outcomes. SPSS version 26 was used for data analysis, which included an independent-samples t-test and a chi-square test with a p-value ≤ 0.05 set for statistical significance.

Results: Baseline characteristics were comparable between groups. The ventilation time, stay in the ICU, and in the hospital were significantly less after OPCAB ($p < 0.001$). Patients receiving blood transfusions, re-examination for bleeding, atrial fibrillation, and acute renal injury were significantly more common in the on-pump group ($p < 0.05$).

Conclusion: Off-pump CABG has a major advantage over on-pump CABG in terms of better early postoperative outcomes and less morbidity; in-hospital mortality was comparable between the two methods.

Keywords: Coronary artery bypass grafting, off-pump CABG, postoperative outcomes

Introduction

Coronary artery disease (CAD) remains a major public health issue and one of the world's leading causes of death and morbidity.[1] According to the World Health Organization, cardiovascular illnesses account for around 17.9 million fatalities worldwide each year, or nearly one-third of all deaths, with ischemic heart disease being the primary cause.[2] The rising prevalence of risk factors, including hypertension, diabetes mellitus, dyslipidaemia, overweight, smoking, and lack of physical activity, is increasing the burden of CAD in both developed and developing countries.[3] For patients with challenging multivessel coronary artery disease, left main coronary artery disease (LMCAD), and diabetic patients with widespread coronary involvement, coronary artery bypass grafting (CABG) remains the recommended revascularization approach.[4] CABG has been greatly refined since its introduction in the 1960s, but today's patients who have severe coronary artery disease can enjoy a better survival rate and better quality of life.[5] Cardiac surgery for CABG is one of the most frequently performed cardiac surgical procedures performed worldwide, with an estimated 800,000 procedures conducted each year.[6] The traditional approach is called on-pump CABG, in which a pump (CPB) and cardioplegic arrest create a bloodless and motionless operating field for the surgeon to perform the coronary anastomosis.[7] Although there are benefits to using CPB, there are some negative physiological side effects.[8] The potential of contact of blood with bypass circuit surfaces can cause a generalized inflammatory response, causing endothelial dysfunction, coagulation disorders and organ damage.[9] Because of this, on pump CABG surgery patients risk neurological abnormalities, renal problems, respiratory issues, atrial fibrillation, excessive bleeding and longer intensive care unit (ICU) hospitalizations.[10] Off-pump coronary artery bypass (OPCAB) surgery, which is carried out on a beating heart without the assistance of cardiopulmonary bypass, was developed as a result of these concerns. [11]

The introduction of the off-pump CABG procedure was intended to reduce the inflammatory and haemodynamic effects caused by ECB.[12] The goal of off-pump CABG was to reduce the inflammatory and haemodynamic effects caused by ECB. OPCAB has been suggested to minimize the perioperative morbidity, blood transfusion, hospital stays and accelerate the postoperative recovery without the use of cardiopulmonary bypass.[11] There have been several studies that have found decreased rates of stroke, acute kidney injury, and postoperative atrial fibrillation in OPC cases.[13]

As the debate around the comparative effectiveness and safety of on-pump and off-pump CABG continues, it is important to monitor the outcomes after CABG in modern clinical practice. Knowledge of any variations in mortality, postoperative complications, recovery time in intensive care and hospital stays, and overall recovery can offer valuable evidence for surgical decision-making and the best management of the patient. This is especially crucial when the healthcare environment is limited and minimizing postoperative morbidity and healthcare utilization are priorities. This study took place to compare postoperative results of coronary artery bypass grafting using on-pump cardiopulmonary bypass with those of off-pump coronary artery bypass surgery.

Methodology

This is a cross sectional study with comparative approach which was conducted at the Department of Cardiac Family Unit, Fauji Foundation Hospital, Peshawar. The study was conducted for 6 months from 1st April 2025 till 30th September 2025.

Sample size was determined using the OpenEpi version 3.01 for comparison of two proportions. This calculation was calculated with reference to a previous study showing 11.7% of morbidity in on-pump CABG group and 6.5% of morbidity in off-pump CABG group.[14] The following were assumed: a 95% level of confidence, 80% power and equal allocation ratio between the two groups. The minimum calculated sample size was 340 patients with 170 patients included in the on-pump CABG group and 170 patients in the off-pump CABG group.

Non-probability consecutive sampling technique was used for sampling. The study included adult patients (18 years and older) with documented coronary artery disease who had isolated coronary artery bypass grafting (CABG). The procedure performed was CPB CABG or OPCAB and eligibility included both male and female patients. Informed consent was obtained and complete peri- and postoperative records were available for analysis. Patients who had concurrent cardiac surgery (valve replacement/valve repair, congenital cardiac surgery, aortic surgery) were not included in the study. Patients who underwent emergency CABG after acute mechanical complications of myocardial infarction, a history of previous cardiac surgery (redo CABG) or a history of incomplete clinical records were excluded. In addition, patients who died in operation room or were lost to follow-up after the operation before the measurement of outcomes in the studies were excluded from analysis.

All participants gave written, informed consent before entering the study. Data on basic demographic and clinical parameters such as age, gender, body mass index, history of smoking, hypertension, diabetes mellitus, dyslipidaemia, and history of myocardial infarction, LV EF and the extent of coronary artery disease were collected on a structured proforma. Information obtained intraoperatively, such as type of CABG procedure (on-pump or off-pump), number of grafts performed, length of surgery, and cardiopulmonary bypass time (if applicable) was recorded.

Postoperative results were evaluated as mechanical ventilation time, intensive care unit (ICU) time, hospital time, re-exploration for bleeding, atrial fibrillation, stroke, myocardial infarction, renal dysfunction, wound infection, blood transfusion requirements and in-hospital mortality. The principal investigator gathered all data with the supervision of the research team from the patient's interview, clinical examination, operative notes, nursing chart and hospital medical records. The anonymity of the patients was ensured during the study.

The Statistical Package for Social Sciences (SPSS) version 26 was used to enter and analyze the collected data. The mean $\pm$ standard deviation (SD) was used to report the quantitative data (age, body mass index, length of surgery, ICU stay, ventilation time, hospital stay). Frequencies and percentages were used to display qualitative factors such as gender, diabetes mellitus, hypertension, surgical complications, and death. Prior to analysis, the normality of each continuous variable was verified. The means of the on-pump and off-pump CABG groups were compared using an independent-samples t-test. Fisher's exact test and the chi-square test were used to compare categorical variables between the two groups. A statistically significant p-value was defined as ≤ 0.05 .

Results

The baseline characteristics of the study population showed that both the on-pump and off-pump CABG groups were comparable in terms of age distribution and gender composition. There was a higher proportion of males than females in both cohorts, with no significant intergroup difference. The anthropometric profile of the two groups was also similar, as reflected in body mass index (BMI). The proportion of cardiovascular risk factors was similar in both groups. The two groups had almost equal incidence of hypertension, diabetes mellitus, dyslipidaemia and history of previous myocardial infarction. Likewise, the percentage of patients with triple vessel disease was similar and the value of LVEF did not differ significantly, confirming that baseline cardiac function was similar between the groups. (Table 1)

Compared to the off-pump CABG group, on-pump CABG patients had more grafts and a longer operating duration, according to intraoperative data. The on-pump group also required a lot more blood transfusions, although there was no discernible difference in the incidence of intraoperative arrhythmias between the two methods. (Table 2)

The early postoperative results showed significant benefit for off-pump CABG over on-pump surgery in terms of ventilation time, length of stay in the intensive care unit and hospital stay. Moreover, the on-pump group had significantly higher re-exploration rates for bleeding and blood transfusion for postoperative use, suggesting a higher perioperative morbidity. (Table 3)

Overall, the on-pump group had more severe complications after surgery. Patients undergoing on-pump CABG had significantly higher incidences of atrial fibrillation, as well as acute kidney injury; the other differences did not achieve statistical significance: stroke, wound infection, myocardial infarction, pneumonia and renal replacement therapy. (Table 4)

The in-hospital complications were lower and the uneventful recovery was better in the off-pump group. The difference in mortality was not quite statistically significant, but higher in the on-pump group. On-pump CABG, however, had a significantly greater composite adverse outcome rate while off-pump surgery had a significantly greater proportion of uncomplicated recoveries. (Table 5)

On-pump CABG was found to be an independent risk factor for major complications after multivariate logistic regression analysis. The other significant predictors were advanced age, diabetes mellitus, and lower LVEF, while hypertension and gender were not statistically associated with poor outcome. (Table 6)

Table 1: Baseline Demographic and Clinical Characteristics of Study Participants (n = 340)

Variable	CABG		p-value
	On-Pump (n=170) Mean $\pm$ SD/n(%)	Off-Pump (n=170) Mean $\pm$ SD/n(%)	
Age (years)	59.8 $\pm$ 9.4	58.6 $\pm$ 10.1	0.261
Gender			0.612
Male	128 (75.3)	124 (72.9)	
Female	42 (24.7)	46 (27.1)	
BMI (kg/m ²)	27.3 $\pm$ 3.8	27.0 $\pm$ 4.1	0.489
Current Smokers	82 (48.2)	76 (44.7)	0.516
Hypertension	118 (69.4)	112 (65.9)	0.489
Diabetes Mellitus	84 (49.4)	78 (45.9)	0.518
Dyslipidemia	96 (56.5)	91 (53.5)	0.577
Previous Myocardial Infarction	57 (33.5)	51 (30.0)	0.486
Triple Vessel Disease	121 (71.2)	117 (68.8)	0.621
Left Ventricular Ejection Fraction (%)			

Table 2: Intraoperative Characteristics of Patients Undergoing CABG (n = 340)

Variable	CABG		p-value
	On-Pump (n=170) Mean $\pm$ SD/n(%)	Off-Pump (n=170) Mean $\pm$ SD/n(%)	
Number of Grafts	3.2 $\pm$ 0.8	2.9 $\pm$ 0.7	<0.001
Duration of Surgery (minutes)	246.7 $\pm$ 42.5	218.3 $\pm$ 37.8	<0.001
Blood Transfusion Required	68 (40.0)	39 (22.9)	0.001
Intraoperative Arrhythmias	11 (6.5)	15 (8.8)	0.420

Table 3: Comparison of Early Postoperative Outcomes between On-Pump and Off-Pump CABG (n = 340)

Outcome	CABG		p-value
	On-Pump (n=170) Mean $\pm$ SD/n(%)	Off-Pump (n=170) Mean $\pm$ SD/n(%)	
Ventilation Time (hours)	12.7 $\pm$ 4.8	9.1 $\pm$ 3.7	<0.001
ICU Stay (days)	3.8 $\pm$ 1.6	2.7 $\pm$ 1.2	<0.001
Hospital Stay (days)	9.4 $\pm$ 3.2	7.1 $\pm$ 2.5	<0.001
Re-exploration for Bleeding	12 (7.1)	4 (2.4)	0.039

Blood Transfusion Postoperatively	74 (43.5)	45 (26.5)	0.001
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Table 4: Comparison of Major Postoperative Complications (n = 340)

Complication	CABG		p-value
	On-Pump (n=170) n(%)	Off-Pump (n=170) n(%)	
Atrial Fibrillation	31 (18.2)	16 (9.4)	0.019
Stroke	8 (4.7)	2 (1.2)	0.052
Acute Kidney Injury	19 (11.2)	8 (4.7)	0.027
Wound Infection	13 (7.6)	9 (5.3)	0.389
Myocardial Infarction	5 (2.9)	4 (2.4)	0.733
Pneumonia	14 (8.2)	6 (3.5)	0.067
Renal Replacement Therapy	4 (2.4)	1 (0.6)	0.174

Table 5: In-Hospital Mortality and Composite Adverse Outcomes (n = 340)

Outcome	On-Pump (n=170) n(%)	CABG	Off-Pump (n=170) n(%)	CABG	p-value
In-Hospital Mortality	7 (4.1)		3 (1.8)		0.201
Any Major Postoperative Complication	58 (34.1)		34 (20.0)		0.003
Uneventful Recovery	105 (61.8)		131 (77.1)		0.002

Table 6: Multivariate Logistic Regression Analysis for Predictors of Major Postoperative Complications

Variable	Adjusted OR	95% CI	p-value
On-Pump CABG	2.11	1.28 – 3.49	0.003
Age >65 years	1.87	1.09 – 3.20	0.021
Diabetes Mellitus	1.69	1.01 – 2.84	0.046
LVEF <40%	2.48	1.39 – 4.41	0.002
Hypertension	1.19	0.71 – 2.01	0.501
Male Gender	0.92	0.51 – 1.66	0.784

Discussion

In the present study, OPCAB was found to be significantly associated with better early postoperative outcomes compared to conventional on-pump coronary artery bypass (on-pump CABG), including shorter ventilation time, fewer major complications, such as atrial fibrillation and acute kidney injury, lower transfusion requirements, and shorter ICU or hospital stay. The in-hospital mortality, however, was not statistically different between the two techniques. They are consistent with several recent studies completed from 2021 to 2026, though there is some variation in the long-term results. The present study shows no significant difference in mortality, and in a large meta-analysis by He et al. (2024) that included more than 16,000 patients, OPCAB was shown to significantly reduce the incidence of stroke in the short-term, yet there was no significant difference between the two techniques in terms of overall mortality.[15] Similarly, a systematic review by Comanici et al. (2025) indicated that these outcomes were observed in patients who had OPCAB, which was also reported as having better recovery profile compared with ECPR.[16] In the postoperative atrial fibrillation and renal dysfunction groups, we found that the incidence was significantly lower in the off-pump group. This is in line with the results obtained in a 2022 meta-analysis published by Frontiers in Cardiovascular Medicine, showing that OPCAB patients had lower rates of perioperative complications such as atrial fibrillation and renal complications than on-

pump CABG patients, which may be attributed to the reduction of complete cardiopulmonary bypass (CPB) induced systemic inflammatory response (SIR).[17] However, not all studies have demonstrated the clear superiority of OPCAB. According to a 2024 updated meta-analysis study in the International Journal of Surgery, OPCAB appeared to lower the risk of early stroke, but also increased the risk of long-term deaths and conduction of more coronary re-interventions.[18] These are in contrast to the long-term patency and durability of off-pump procedures, which are unclear, and to the short-term patency achieved in the present study. Likewise, a large systematic review in those with chronic kidney disease (2025) indicated that OPCAB provided a survival benefit, but this benefit was not seen in all subgroups, particularly high-risk patients. These results are somewhat similar to those of our regression analysis in that reduced LVEF, diabetes, and on-pump technique were independent predictors of postoperative complications. In a systematic review by Lin et al. (2023), the reduction in transfusion requirement and ICU stay was seen following OPCAB, while the mortality outcome was not consistently better.[19] Recent analysis data also indicates that although surgical benefits are more pronounced in specific patient subsets, on-pump CABG might be superior in achieving completeness of grafts and long-term survival for complex multivessel disease, given the more controlled conditions of the anastomoses.[20] This might be due to better exposure and technical precision, which might be why our study showed more grafts in the on-pump group. Our results clearly demonstrated the short-term advantages of the OPCAB technique for reduced morbidity and quicker recovery; however, the literature is inconclusive about long-term outcomes. There have been several recent meta-analyses reporting potential concerns about graft completeness and long-term survival with OPCAB, while others show similar results when performed in experienced centers. The differences are mainly due to surgeon skill, patient selection, and differences in surgical technique. The present study is in agreement with the majority of the recent evidence that shows that off-pump CABG (OPCAB) has associated lower morbidity and better recovery in the early period, with comparable outcomes for mortality compared to an on-pump CABG (ONCAB). However, the general long-term advantage of either procedure is not definitive and consistent with contemporary literature; instead, it should be decided on a case-by-case basis, taking into account the institution's experience and the patient's risk profile.

Limitations:

There were some limitations of the present study. It was carried out in a single tertiary care hospital and may not be representative of other populations and health care facilities. The length of follow-up was limited to the in-hospital period and therefore late complications and survival rates of grafts could not be evaluated. Selection bias may have been present in the use of non-probability consecutive sampling and residual confounding factor could not be completely ruled out after statistical analysis. Furthermore, differences in surgeon experience and surgical judgment during the procedure could have affected the results of this study.

Conclusion:

The present study showed that off-pump CABG had significantly better early postoperative results than on-pump CABG, such as shorter ventilation time, shorter hospital stay, and lower incidence of some postoperative complications. The in-hospital mortality rate, however, was similar for the two techniques. In conclusion, off-pump CABG had a relatively good short-term clinical outcome, and both techniques were safe and effective, with the choice to be determined by the patient's condition and the surgical skill.

References

1. Mir, M.A., M.A. Dar, and A. Qadir, *Exploring the landscape of coronary artery disease: a comprehensive review*. Am. J. Biomed. Pharm, 2024. **1**: p. 9-22.

2. Ibrahim, H.K., *Global trends in cardiovascular mortality and risk factors: insights from WHO and Global Burden of Disease data*. Libyan Open University Journal of Medical Sciences and Sustainability, 2025: p. 28-36.
3. Pająk, A., P. Jankowski, and T. Zdrojewski, *The burden of cardiovascular disease risk factors: A current problem*. Polish Heart Journal (Kardiologia Polska), 2022. **80**(1): p. 5-15.
4. Khawaja, M., et al., *Left main coronary artery disease: a contemporary review of diagnosis and management*. Reviews in Cardiovascular Medicine, 2024. **25**(2): p. 66.
5. Nguyen, D., et al., *Coronary Artery Bypass Grafting: History, Landmark Trials, and the Evolution of Surgical Practice*. International Journal of Angiology, 2026.
6. Raja, S.G., *Global trends and practices in coronary artery bypass surgery*. Academia Medicine, 2025. **2**(3).
7. Leivaditis, V., et al., *Between air and artery: a history of cardiopulmonary bypass and the rise of modern cardiac surgery*. Journal of cardiovascular development and disease, 2025. **12**(9): p. 365.
8. Roberts, A., et al., *Complications of cardiopulmonary bypass from an anesthesia perspective: a clinical review*. HCA healthcare journal of medicine, 2023. **4**(1): p. 13.
9. Kant, S., et al., *Microvascular dysfunction following cardiopulmonary bypass plays a central role in postoperative organ dysfunction*. Frontiers in medicine, 2023. **10**: p. 1110532.
10. Naeem, M.W., et al., *Exploring Complications After Coronary Artery Bypass graft in Cardiothoracic Intensive Care Unit at Assuit University*. Assiut Scientific Nursing Journal, 2022. **10**(29): p. 39-47.
11. Yoo, K.-J., *The past, present, and future of off-pump coronary artery bypass grafting*. Journal of Chest Surgery, 2025. **58**(4): p. 121.
12. Cserép, Z., *IDENTIFYING PSYCHOSOCIAL FACTORS INFLUENCING SHORT-AND LONG-TERM MORTALITY AND MORBIDITY AFTER ADULT CARDIAC SURGERY*. 2025.
13. Siontis, K.C., et al., *Associations of atrial fibrillation after noncardiac surgery with stroke, subsequent arrhythmia, and death: a cohort study*. Annals of internal medicine, 2022. **175**(8): p. 1065-1072.
14. Davoodi, S., et al., *Early outcome of off-pump versus on-pump coronary revascularization*. The Pan African medical journal, 2014. **17**: p. 309.
15. He, L., et al., *Clinical outcomes of on-pump versus off-pump coronary-artery bypass surgery: a meta-analysis*. International Journal of Surgery, 2024. **110**(8): p. 5063-5070.
16. Comanici, M., N. Bithi, and S.G. Raja, *Comparison of outcomes between total arterial off-pump versus on-pump coronary artery bypass surgery: a meta-analysis and meta-regression*. The American Journal of Cardiology, 2025. **249**: p. 43-50.
17. Zhang, S., et al., *A meta-analysis of early, mid-term and long-term mortality of on-pump vs. off-pump in redo coronary artery bypass surgery*. Frontiers in Cardiovascular Medicine, 2022. **9**: p. 869987.
18. Comanici, M., H.I. Bulut, and S.G. Raja, *10-Year mortality of off-pump versus on-pump coronary artery bypass grafting: an updated systematic review, meta-analysis, and meta-regression*. The American Journal of Cardiology, 2024. **219**: p. 77-84.
19. Lin, Y., et al., *Anesthesia management of patients undergoing off-pump coronary artery bypass grafting: A retrospective study of single center*. Frontiers in Surgery, 2023. **9**: p. 1067750.
20. Ruengsakulrach, P., P. Jetwanna, and N. Arayawudhikul, *Minimally Invasive Cardiac Surgery: A Practical Overview for Clinicians*. The Bangkok Medical Journal, 2026. **22**(1).