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Research

Comparison of Long-term Outcomes of On-pump and Off-pump Techniques in Isolated Coronary Artery Bypass Surgery: A Cohort Study

İzole Koroner Arter Bypass Cerrahisinde Pompalı ve Pompasız Tekniklerin Uzun Dönem Sonuçlarının Karşılaştırılması: Bir Kohort Çalışması

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ABSTRACT

Objective: This study aims to analyze and compare the short- and long-term clinical outcomes of on-pump versus off-pump coronary artery bypass grafting (CABG) techniques in patients undergoing isolated CABG.

Methods: This study was designed as a retrospective, single-institution observational analysis, including 285 patients who underwent isolated CABG between 2010 and 2023. The participants were classified into two cohorts: on-pump (n=191) and off-pump (n=94). A comprehensive evaluation of perioperative and postoperative parameters was conducted, encompassing inflammatory markers, mechanical ventilation duration, hospital and intensive care unit (ICU) stay, and long-term outcomes such as mortality, myocardial infarction (MI), and revascularization rates.

Results: The on-pump group exhibited a significantly higher postoperative inflammatory response, with elevated white blood cell count (7.7±2.5 vs. 6.1±1.3 x10³/μL, p<0.001) and C-reactive protein levels (11.6±13.2 vs. 7.1±1.5 mg/L, p<0.001). The postoperative drainage volume was significantly higher in the on-pump group (565.2±146.6 vs. 263.8±46.2 mL, p<0.001), as were, mechanical ventilation duration (5.2±1.0 vs. 3.5±0.7 hours, p<0.001), ICU stay (2.6±1.3 vs. 2.1±0.3 days, p<0.001), and hospital length of stay (6.7±1.8 vs. 5.3±0.7 days, p<0.001). The incidence of postoperative atrial fibrillation was significantly higher in the on-pump group (8.4% vs. 2.1%, p=0.041), whereas the prevalence of peripheral artery disease (37.7% vs. 52.1%, p=0.020) and hypercholesterolemia (34.0% vs. 48.9%, p=0.015) was higher in the off-pump group. No significant differences were found in long-term mortality, MI, or revascularization rates between the groups (p>0.05).

Conclusion: While off-pump CABG was associated with lower postoperative inflammation, shorter ICU and hospital stays, and fewer early complications, both techniques demonstrated comparable long-term clinical outcomes.

Keywords: Coronary artery bypass grafting, on-pump CABG, off-pump CABG, long-term outcomes, postoperative complications

ÖZ

Amaç: Bu çalışmanın amacı, izole koroner arter baypas greftleme (KABG) uygulanan hastalarda pompalı ve pompasız KABG tekniklerinin kısa ve uzun dönem klinik sonuçlarını analiz etmek ve karşılaştırmaktır.

Gereç ve Yöntem: 2010-2023 yılları arasında izole KABG uygulanan 285 hastanın dahil edildiği, retrospektif ve tek merkezli gözlemsel bir çalışma yürütülmüştür. Hastalar pompa destekli (n=191) ve pompasız (n=94) olmak üzere iki gruba ayrılmıştır. Preoperatif, intraoperatif ve postoperatif parametreler analiz edilmiştir. Bu parametreler arasında enflamatuvar belirteçler, mekanik ventilasyon süresi, hastane ve yoğun bakım ünitesinde (YBÜ) kalış süresi ile uzun dönem sonuçlar (mortalite, miyokard enfarktüsü ve revaskülarizasyon oranları) yer almaktadır.

Bulgular: Pompa destekli grupta postoperatif enflamatuvar yanıt anlamlı derecede yüksek olup, beyaz kan hücresi sayısı (7,7±2,5 vs. 6,1±1,3 x10³/μL, p<0,001) ve C-reaktif protein seviyeleri (11,6±13,2 vs. 7,1±1,5 mg/L, p<0,001) daha yüksek bulunmuştur. Postoperatif drenaj hacmi pompa destekli grupta belirgin şekilde yüksek olup (565,2±146,6 vs. 263,8±46,2 mL, p<0,001), mekanik ventilasyon süresi (5,2±1,0 vs. 3,5±0,7 saat, p<0,001), YBÜ'de kalış süresi (2,6±1,3 vs. 2,1±0,3 gün, p<0,001) ve hastanede yatış süresi de (6,7±1,8 vs. 5,3±0,7 gün, p<0,001) daha uzun olarak saptanmıştır. Pompa destekli grupta postoperatif atriyal fibrilasyon insidansı daha yüksek bulunmuştur (%8,4 vs. %2,1, p=0,041). Öte yandan, pompasız grupta periferik arter hastalığı (%37,7 vs. %52,1, p=0,020) ve hiperkolesterolemi (%34,0 vs. %48,9, p=0,015) oranları daha yüksektir. Uzun dönem mortalite, miyokard enfarktüsü ve revaskülarizasyon oranları açısından iki grup arasında anlamlı fark saptanmamıştır (p>0,05).

Sonuç: Pompasız KABG, daha düşük postoperatif enflamasyon, daha kısa YBÜ ve hastane yatış süresi ile daha az erken komplikasyon ile ilişkilendirilmiştir. Ancak, uzun dönem klinik sonuçlar açısından her iki teknik benzer etkinlik göstermektedir.

Anahtar Kelimeler: Koroner arter baypas greftleme, pompa destekli CABG, pompasız CABG, uzun dönem sonuçlar, postoperatif komplikasyonlar

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INTRODUCTION

Globally, coronary artery disease (CAD) represents a common cardiovascular condition, substantially influencing both mortality and morbidity rates (1). Despite the pharmacological and interventional treatment options offered by modern medicine, coronary artery bypass grafting (CABG) continues to be the leading approach for enhancing myocardial blood flow and extending long-term survival, particularly in individuals with advanced CAD (2). CABG involves revascularization using alternative vascular grafts to bypass diseased coronary arteries, and represents one of the most frequently conducted surgical interventions across the globe (3).

Traditional CABG surgeries are performed using cardiopulmonary bypass (CPB) while the heart is arrested (4). This technique provides a more stable environment for the surgeon to perform anastomoses. However, CPB use has several disadvantages, including the induction of a systemic inflammatory response, an increased risk of neurological complications, and potential adverse effects on postoperative recovery (5). To minimize these issues, off-pump CABG (OPCABG) was developed. OPCABG is performed without the use of a CPB machine and is associated with lower complication rates, particularly in high-risk patients (6).

The advantages and disadvantages of on-pump and off-pump techniques have been debated for many years. It has been suggested that on-pump CABG (ONCABG) offers better long-term revascularization success due to its technical feasibility and higher graft patency rates (7). In contrast, OPCABG is reported to reduce complications associated with CPB, making it a safer option, particularly for elderly patients and those with comorbid systemic diseases (8). However, there is no clear consensus in the literature regarding the long-term outcomes of these two techniques.

This research sought to evaluate and contrast the postoperative and extended outcomes of on-pump versus off-pump approaches in individuals undergoing standalone CABG. By evaluating the 1-month, 1-year, and 3-year follow-up data of individuals who received CABG, with or without CPB, we analyzed the impact of both techniques on mortality, stroke (cerebrovascular accident), reintervention rates, and complications such as bleeding. The results of this investigation will offer essential insights to inform clinical decision-making and assess which method yields superior benefits concerning long-term survival and potential complications.

METHODS

Study Design and Patient Selection

This research was designed as a retrospective observational study conducted at a single center. It was conducted at the department of cardiovascular surgery at a tertiary center, including patients who received isolated CABG within the period of 2010 to 2023. The study exclusively included individuals who had undergone isolated CABG, while those who had additional cardiac interventions, including valve replacement surgery, aortic surgery, or repair of atrial septal defects were not considered within the study. This study was approved by the Non-Interventional Scientific Research Ethics Committee of the University of Health Sciences Türkiye, Bakırköy Dr. Sadi Konuk Training and Research Hospital (approval no: 2024-13-03, date: 27.11.2024). The study was conducted in accordance with the principles of the Declaration of Helsinki.

Patient Grouping and Follow-up

Participants were classified into two distinct groups according to the surgical technique applied. The first group included individuals who underwent ONCABG, in which CPB was utilized to temporarily suspend cardiac function during the procedure. The second group consisted of patients who underwent OPCABG, where the surgery was performed while the heart was still beating, eliminating the need for CPB. This approach is believed to reduce the systemic inflammatory response and may lead to improved postoperative recovery. The study population consisted of 285 patients who met the predefined inclusion criteria. To assess long-term clinical outcomes, postoperative follow-up evaluations were conducted at 1 month, 1 year, and 3 years. These follow-up periods allowed for the monitoring of potential complications, survival rates, and overall patient recovery trajectories.

Inclusion and Exclusion Criteria

For participation in the study, patients were required to fulfill specific eligibility criteria. The inclusion criteria specified that participants should be aged between 40 and 85 years, have undergone only isolated CABG surgery, and have been treated using an open surgical technique via sternotomy. Additionally, patients had to have available follow-up data for at least three years. Exclusion criteria included patients requiring emergency CABG, patients who underwent single-vessel revascularization, and patients with a history of previous cardiac surgery or requiring redo surgery. Moreover, individuals who needed additional cardiac surgical procedures or had a diagnosis of peripheral artery disease or advanced cerebrovascular

disease were excluded. These criteria were established to ensure the study was conducted on a homogeneous patient population and to allow for a direct comparison between the two surgical techniques.

Evaluated Parameters

Data covering preoperative, intraoperative, and postoperative periods were retrospectively obtained from medical records, surgical reports, and the hospital database. The demographic and clinical factors analyzed included age, sex, smoking history, and the presence of comorbid conditions such as hypertension, diabetes mellitus, and chronic obstructive pulmonary disease (COPD). Additionally, peripheral vascular disease, chronic kidney disease, and hypercholesterolemia were among the other medical conditions assessed. To evaluate preoperative functional capacity, the New York Heart Association (NYHA) classification was applied (9). Furthermore, the European System for Cardiac Operative Risk Evaluation II (EuroSCORE II) was utilized to calculate surgical risk scores for all patients, aiding in the assessment of potential postoperative outcomes (10).

The laboratory evaluations encompassed assessments of white blood cell (WBC) count, hemoglobin (Hb), hematocrit (HCT), C-reactive protein (CRP), and ejection fraction (EF) during both the preoperative and postoperative phases. Intraoperative parameters included the use of the internal mammary artery (right, left, or bilateral), cross-clamp time, CPB duration, and the number of bypass grafts performed.

Postoperative Outcomes

Early postoperative results were evaluated by examining complications that arose within the initial 30 days following surgery. Throughout this period, parameters such as the duration of mechanical ventilation, length of stay in the intensive care unit (ICU), total hospitalization period, mortality rates, and the occurrence of postoperative atrial fibrillation were documented. Furthermore, early postoperative complications, including chest drainage volume and incidences of bleeding, were analyzed. For long-term follow-up, outcomes were assessed at 1-month, 1-year, and 3-years post-surgery. Key factors such as myocardial infarction (MI), cerebrovascular events, mortality, developed dialysis dependency, and the necessity for repeat revascularization were closely monitored. The long-term survival rates and surgical success of both groups were statistically analyzed to identify any significant differences.

Surgical Techniques

In ONCABG procedures, standard ascending aortic cannulation and two-stage venous cannulation of the right atrium were performed to establish CPB. Aortic cross-clamping was applied to induce cardioplegic arrest with antegrade intermittent cold blood cardioplegia. After completing the anastomoses, protamine was administered to reverse heparinization. In OPCABG procedures, surgery was performed without the use of a CPB device. Stabilization was achieved using the Medtronic Octopus device, along with pericardial anchoring sutures to maintain hemodynamic stability. After completing the distal anastomoses, side clamping of the aorta was performed for proximal anastomoses if necessary. Both techniques were carried out by the same surgical team, and anesthesia and pharmacological management followed standardized protocols.

Statistical Analysis

The statistical evaluations were performed using IBM SPSS Statistics for Windows, Version 27.0 (IBM Corp., Armonk, NY, USA). The assumption of normality for continuous variables was assessed utilizing the Kolmogorov-Smirnov test. Continuous variables were expressed as mean±standard deviation, while categorical variables were presented as frequencies and percentages. For comparisons between two groups, the independent samples t-test was applied to analyze parametric data, whereas the Mann-Whitney U test was used for non-parametric distributions. Categorical variables were compared using the chi-square (χ^2) test, and Fisher's exact test was implemented when the expected frequency was below a predefined threshold. A p-value of less than 0.05 was considered statistically significant, and statistically significant p-values were highlighted in bold within the tables to facilitate interpretation.

RESULTS

There was no statistically significant variation between the groups concerning age, body mass index, gender distribution, smoking status, or hypertension ($p>0.05$). However, one of the parameters that exhibited a significant difference in this study was the EF. The preoperative EF was measured as 44.5±6.0% in the on-pump group and 42.3±6.7% in the off-pump group, with this difference reaching statistical significance ($p=0.007$) (Table 1).

The postoperative WBC count was recorded as 7.7±2.5 (10^3/μL) in the on-pump group, whereas it was 6.1±1.3 (10^3/μL) in the off-pump group. This difference was statistically significant ($p<0.001$). The postoperative Hb concentration was 8.3±0.4 g/dL in the on-pump group and 9.9±0.9 g/dL in the off-pump group, with significantly higher levels observed in the latter group ($p<0.001$). Similarly, the postoperative HCT level was 25.1±1.3% in the on-pump

group and 29.9±2.4% in the off-pump group, demonstrating a statistically significant elevation in the off-pump group (p<0.001). Additionally, postoperative CRP levels were 11.6±13.2 mg/L in the on-pump group and 7.1±1.5 mg/L in the off-pump group; values were significantly elevated in the on-pump group (p<0.001). No statistically significant difference was identified between the groups regarding preoperative Hb, HCT, and CRP levels (p>0.05) (Table 2).

The preoperative EF was measured at 44.5±6.0% in the on-pump group and 42.3±6.7% in the off-pump group, showing significantly higher values in the on-pump cohort (p=0.007). However, no statistically significant differences were identified between the groups in terms of postoperative EF values (p=0.381). Regarding postoperative fluid balance, the drainage volume was found to be 565.2±146.6 mL in the on-pump group and 263.8±46.2 mL in the off-pump group, with a significantly greater volume observed in the on-pump group (p<0.001). The mean duration of mechanical ventilation was 5.2±1.0 hours for the on-pump group and 3.5±0.7 hours for the off-Pump group, indicating a statistically significant prolongation in the on-pump group (p<0.001). Similarly, the ICU stay was 2.6±1.3 days for on-pump patients and 2.1±0.3 days for off-pump patients, demonstrating an extended ICU stay for the on-pump cohort (p<0.001). The reported total hospitalization duration was 6.7±1.8 days for the on-pump group and 5.3±0.7 days for the off-pump group, with significantly longer hospital stays observed in the on-pump cohort (p<0.001). These findings suggest that while ONCABG may be associated with prolonged postoperative recovery, further investigation is needed to determine its long-term clinical implications (Table 3).

Based on the EuroSCORE II evaluation, the proportion of patients classified as low-risk was 12.6% in the on-pump group and 3.2% in the off-pump group, demonstrating a statistically significant distinction (p=0.010). The incidence of postoperative atrial fibrillation was documented as 8.4% in the on-pump cohort and 2.1% in the off-pump group, with a considerably higher occurrence in the on-pump cohort (p=0.041). Similarly, the prevalence of peripheral artery disease was noted at 37.7% in the on-pump group and 52.1% in the off-pump group, with significantly higher rates observed in the off-pump cohort (p=0.020). The incidence of hypercholesterolemia was 34.0% among on-pump patients and 48.9% in the off-pump group, indicating a statistically significant increase in the off-pump cohort (p=0.015). Despite these differences, no statistically significant variation was found between the two groups concerning NYHA functional capacity classification, preoperative atrial fibrillation, diabetes mellitus, COPD, or chronic kidney disease (p>0.05).

Table 1. Comparison of demographic characteristics and risk factors between on-pump and off-pump groups

		On-pump (n=191)	Off-pump (n=94)	p-value
Age (years)		60.5±6.8	61.5±7.9	0.245[a]
BMI (kg/m²)		27.8±3.2	28.3±4.0	0.566[b]
Gender	Female Male	81 (42.4) 110 (57.6)	38 (40.4) 56 (59.6)	0.750
Smoking		115 (60.2)	61 (64.9)	0.444
Hypertension		63 (33.0)	36 (38.3)	0.376

[a]: Independent samples t-test, [b]: Mann-Whitney U test, BMI: Body mass index

Table 2. Comparison of hematological and inflammatory parameters between on-pump and off-pump groups

	On-pump (n=191)	Off-pump (n=94)	p-value
	Mean±SD	**Mean±SD**	
WBC (10³/µL)	6.4±1.8	4.7±0.9	**<0.001[b]**
Postop WBC (10³/µL)	7.7±2.5	6.1±1.3	**<0.001[b]**
Hemoglobin (g/dL)	12.5±0.9	12.7±0.9	0.286[a]
Postop hemoglobin (g/dL)	8.3±0.4	9.9±0.9	**<0.001[b]**
Hematocrit (%)	37.7±2.8	38.1±22.5	0.510[b]
Postop hematocrit (%)	25.1±1.3	29.9±2.4	**<0.001[b]**
CRP (mg/L)	4.5±2.3	3.7±1.1	**0.001[b]**
Postop CRP (mg/L)	11.6±13.2	7.1±1.5	**<0.001[b]**

[a]: Independent samples t-test, [b]: Mann-Whitney U test, WBC: White blood cell, CRP: C-reactive protein, SD: Standard deviation

These findings emphasize the potential impact of different surgical approaches on postoperative cardiovascular risk factors and suggest the need for further investigation into their long-term clinical implications (Table 4).

The early postoperative complication rate was 15.2% in the on-pump group and 4.3% in the off-pump group, with a significantly higher incidence in the on-pump group (p=0.003). The need for reoperation due to bleeding was 1.6% in the on-pump group and 0.0% in the off-pump group (p=0.007). The requirement for hemofiltration due to dialysis was 1.1% in the on-pump group and 0.0% in the off-pump group, with a significantly higher incidence in the on-pump group (p=0.043). No statistically significant differences were found between the groups in terms of other early postoperative complications, including MI, pulmonary complications, neurological complications, sternal wound complications, gastrointestinal complications, and reintubation/tracheostomy (p>0.05). No significant difference was observed between the groups in terms of hospital mortality (p=0.482) (Table 5).

In the postoperative 1-month evaluation, the incidence of new dialysis requirement was 1.0% in the on-pump group and 2.1% in the off-pump group; however, this difference was not statistically significant (p>0.05). In the postoperative 1-year and 3-year evaluations, no significant differences were observed between the groups in terms of mortality, MI, revascularization, or cardiovascular disease (p>0.05) (Table 6).

DISCUSSION

This study compared the long-term outcomes of on-pump and off-pump techniques in patients undergoing isolated CABG. The results suggest that the postoperative inflammatory response was more pronounced in the on-pump group, as evidenced by elevated WBC and CRP levels. Additionally, the on-pump group exhibited significantly

Table 3. Comparison of cardiac function, drainage volume, and clinical outcomes between on-pump and off-pump groups

	On-pump (n=191)	Off-pump (n=94)	p-value
	Mean±SD	Mean±SD	
Preop ejection fraction (%)	44.5±6.0	42.3±6.7	**0.007**[a]
Postop ejection fraction (%)	43.6±6.0	43.1±6.6	0.381[b]
Average chest drainage amount (mL)	565.2±146.6	263.8±46.2	**<0.001**[b]
Ventilation time (hours)	5.2±1.0	3.5±0.7	**<0.001**[b]
Total ICU stay (days)	2.6±1.3	2.1±0.3	**<0.001**[b]
Hospital length of stay (days)	6.7±1.8	5.3±0.7	**<0.001**[a]

[a]: Independent samples t-test, [b]: Mann-Whitney U test, SD: Standard deviation, ICU: Intensive care unit

Table 4. Comparison of functional capacity, risk scores, and comorbidities between on-pump and off-pump groups

		On-pump (n=191)	Off-pump (n=94)	p-value
		Count (%)	Count (%)	
Functional capacity	NYHA class 2	79 (41.4)	39 (41.5)	0.781
	NYHA class 3	111 (58.1)	55 (58.5)	
	NYHA class 4	1 (0.5)	0 (0.0)	
EuroSCORE II	Low score	24 (12.6)	3 (3.2)	**0.010**
	Moderate score	165 (86.4)	87 (92.6)	
	High score	2 (1.0)	4 (4.3)	
Diabetes mellitus		112 (58.6)	56 (59.6)	0.880
Preop atrial fibrillation		4 (2.1)	2 (2.1)	0.985
Postop atrial fibrillation		16 (8.4)	2 (2.1)	**0.041**
COPD		84 (44.0)	40 (42.6)	0.819
Peripheral artery disease		72 (37.7)	49 (52.1)	**0.020**
Chronic kidney disease		2 (1.0)	0 (0.0)	0.319
Hypercholesterolemia		65 (34.0)	46 (48.9)	**0.015**

NYHA: New York Heart Association, EuroSCORE II: European System for Cardiac Operative Risk Evaluation II, COPD: Chronic obstructive pulmonary disease

greater postoperative drainage volume, prolonged mechanical ventilation duration, and extended stays in both the ICU and hospital. Furthermore, the incidence of postoperative atrial fibrillation was notably higher among patients in the on-pump cohort. In contrast, peripheral artery disease and hypercholesterolemia were more prevalent in the off-pump group. Regarding long-term outcomes, no statistically significant differences were identified between the groups in terms of mortality, MI, or the necessity for revascularization. These findings indicate that while the on-pump technique may be associated with increased systemic inflammation and postoperative complications, both surgical approaches exhibit comparable effectiveness in long-term clinical outcomes. Further research with larger sample sizes and extended follow-up periods is warranted to better delineate the advantages and drawbacks of each technique.

Managing morbidity and mortality after coronary revascularization in high-risk patients continues to be a significant challenge (11,12). Various observational studies suggest that the OPCABG approach may provide a viable alternative in addressing this concern (13-15). Unlike the conventional on-pump method, OPCABG eliminates the necessity for CPB and cardioplegic arrest, thereby reducing systemic inflammatory responses and minimizing the effects of global hypoxia. This physiological benefit is believed to lower the incidence of organ-specific postoperative

Table 5. Comparison of artery usage, mortality, and early postoperative complications between on-pump and off-pump groups

		On-pump (n=191)	Off-pump (n=94)	p-value
		Count (%)	Count (%)	
Internal mammary artery usage	Right	4 (2.1)	0 (0.0)	0.078
	Left	181 (94.8)	94 (100.0)	
	Bilateral	6 (3.1)	0 (0.0)	
Hospital mortality		1 (0.5)	0 (0.0)	0.482
Early postop complications		29 (15.2)	4 (4.3)	**0.003**
Reoperation for bleeding		3 (1.6)	0 (0.0)	**0.007**
MI/reintervention		1 (0.5)	0 (0.0)	0.222
Pulmonary complications		1 (0.5)	0 (0.0)	0.482
Neurological complications		16 (8.4)	3 (3.2)	0.462
Sternal wound complications		8 (4.2)	0 (0.0)	0.097
Hemofiltration for dialysis		2 (1.1)	0 (0.0)	**0.043**
GIS complications		7 (3.7)	0 (0.0)	0.060
Reintubation/tracheostomy		1 (0.5)	0 (0.0)	0.482

GIS: Gastrointestinal, MI: Myocardial infarction

Table 6. Comparison of postoperative outcomes at 1-month, 1-year, and 3-years between on-pump and off-pump groups

		On-pump (n=191)	Off-pump (n=94)	p-value
		Count (%)	Count (%)	
Postop 1-month evaluation	No	181 (94.8)	87 (92.6)	0.926
	Mortality	1 (0.5)	1 (1.1)	
	MI+revascularisation	2 (1.0)	1 (1.1)	
	CVD	5 (2.6)	3 (3.2)	
	New dialysis	2 (1.0)	2 (2.1)	
Postop 1-year evaluation	No	189 (99.5)	93 (98.9)	0.610
	CVD	1 (0.5)	1 (1.1)	
Postop 3-year evaluation	No	185 (97.4)	93 (98.9)	0.522
	Mortality	1 (0.5)	0 (0.0)	
	MI+revascularisation	1 (0.5)	1 (1.1)	
	CVD	3 (1.6)	0 (0.0)	

MI: Myocardial infarction, CVD: Cardiovascular disease

complications, which are more frequently observed in high-risk populations (16,17). Additionally, OPCABG has been associated with a reduction in postoperative morbidities, including shorter ventilation times, a decreased likelihood of atrial fibrillation, reduced transfusion requirements, and a lower risk of stroke, renal impairment, and prolonged ICU stays (18). Despite these advantages, large-scale randomized trials such as the ROOBY trial (19) and the CORONARY trial (20) have not demonstrated a significant superiority of OPCABG over conventional ONCABG in the general patient population. Furthermore, the BEST bypass surgery trial (21), which focused on high-risk individuals with a EuroSCORE II of 5, found no significant difference in morbidity or mortality between OPCABG and ONCABG at the 30-day follow-up. A study by Dhurandhar et al. (22) reported that the off-pump technique was associated with lower postoperative morbidity, reduced atrial fibrillation rates, and decreased transfusion needs. However, it did not improve long-term mortality outcomes compared to those of the on-pump approach (22). Similarly, findings from our study revealed a higher incidence of postoperative atrial fibrillation and a more intense inflammatory response in the on-pump group. In contrast to Dhurandhar et al.'s (22) findings, our study identified prolonged ICU and hospital stays among on-pump patients. Regarding long-term survival, neither study detected a significant difference suggesting that despite the early postoperative benefits of off-pump surgery its long-term clinical efficacy remains comparable to that of the on-pump technique. Further research with extended follow-up periods and larger sample sizes is warranted to establish a more definitive comparison between these two surgical approaches.

Previous meta-analyses and large-scale propensity-matched observational studies have reported a significant increase in long-term mortality associated with OPCABG (23-27). This observation aligns with the higher mid-term coronary reintervention rates linked to off-pump procedures. Consequently, the rise in long-term mortality incidence appears to be a plausible outcome. However, data from the 10-year follow-up suggest a more nuanced perspective. Findings from the ROOBY trial did not reveal a statistically significant elevation in long-term mortality for patients undergoing OPCABG compared to those receiving ONCABG (28). These results contrast with the 5-year follow-up data, which demonstrated a substantial increase in long-term mortality among the OPCABG cohort (29). A study conducted by He et al. (30) suggested that OPCABG may lower the short-term risk of stroke. However, it was also associated with an increased need for revascularization and a potential rise in long-term mortality rates (30). In our study, the off-pump group exhibited a reduced postoperative inflammatory response, shorter hospital stays, and fewer early postoperative complications. Additionally, no statistically significant difference was identified between the groups regarding the necessity for revascularization necessitated by MI or repeat intervention. These results indicate that contrary to the findings of He et al. (30), off-pump surgery did not contribute to an increased requirement for long-term revascularization. Further investigations incorporating a larger sample size and extended follow-up periods are necessary to refine these conclusions and determine the optimal surgical strategy for long-term patient outcomes.

Study Limitations

This study has certain limitations. Patients were monitored at 1-month, 1-year, and 3-years postoperatively. Extending the follow-up duration could have facilitated a more comprehensive assessment, particularly concerning the necessity for revascularization and long-term mortality outcomes. Although revascularization rates were documented, angiographic follow-up was not conducted, potentially leading to gaps in data regarding graft patency and long-term myocardial perfusion. Furthermore, while all surgical procedures were performed by the same team, variations in individual surgeon and anesthesia practices may have influenced the findings. Consequently, the impact of off-pump surgery performed by highly experienced surgical teams could not be fully evaluated. This study primarily concentrated on clinical outcomes, including mortality, MI, revascularization, and renal failure. However, patient-centered factors such as quality of life, neurocognitive function, and functional recovery were not considered, which may limit the generalizability of the results. Future research incorporating these additional parameters could provide a more holistic understanding of postoperative outcomes.

CONCLUSION

In this study, the early and long-term outcomes of isolated CABG operations performed using on-pump and off-pump techniques were compared. The on-pump technique was associated with a higher postoperative inflammatory response, increased drainage volume, prolonged mechanical ventilation, and longer ICU and hospital stays. In contrast, the off-pump technique provided advantages such as lower postoperative complication rates and shorter hospital stays. Long-term follow-up revealed no significant differences between the two techniques regarding mortality, MI, and revascularization. These findings suggest, that while

the off-pump technique may offer advantages in the early postoperative period, it demonstrates similar efficacy to the on-pump technique in long-term clinical outcomes. Further validation of these findings requires larger sample sizes, multicenter studies, and prospective research.

ETHICS

Ethics Committee Approval: This study was approved by the Non-Interventional Scientific Research Ethics Committee of the University of Health Sciences Türkiye, Bakırköy Dr. Sadi Konuk Training and Research Hospital (approval no: 2024-13-03, date: 27.11.2024).

Informed Consent: Retrospective study.

FOOTNOTES

Authorship Contributions

Concept: H.T., G.T., Design: Y.K., A.A.K., Data Collection or Processing: H.T., S.T., Analysis or Interpretation: G.T., Literature Search: Y.K., S.T., Writing: H.T., A.A.K.

Conflict of Interest: No conflict of interest was declared by the authors.

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REFERENCES

1. Stone PH, Libby P, Boden WE. Fundamental pathobiology of coronary atherosclerosis and clinical implications for chronic ischemic heart disease management-the plaque hypothesis: a narrative review. JAMA Cardiol. 2023;8:192-201.
2. Olsen DB, Pedersen PU, Noergaard MW. Prehabilitation before elective coronary artery bypass grafting surgery: a scoping review. JBI Evid Synth. 2023;21:1190-242.
3. Sef D, Raja SG. Bilateral internal thoracic artery use in coronary artery bypass grafting in the post-ART era - perspective. Int J Surg. 2021;86:1-4.
4. Alvarez JM. Off-pump coronary bypass surgery: time for the myths to face reality. Heart Lung Circ. 2023;32:284-6.
5. Shirasaka T, Arayawudhikul N, Tantraworasin A, Chartrungsan A, Sakboon B, Cheewinmethasiri J, et al. Successful introduction of off-pump coronary artery bypass grafting in Southeastern Asian countries: a single center's experience in Thailand. Surg Open Sci. 2022;8:27-32.
6. Kilic Y, Jalalzai I, Sonmez E, Erkut B. On pump beating heart coronary artery surgery in patients requiring urgent revascularization. Heart Surg Forum. 2023;26:E808-e16.
7. Shaefi S, Mittel A, Loberman D, Ramakrishna H. Off-pump versus on-pump coronary artery bypass grafting-a systematic review and analysis of clinical outcomes. J Cardiothorac Vasc Anesth. 2019;33:232-44.
8. Ren Q, Li G, Chu T, Liu Q, Huang Y, Liu K, et al. Off-pump versus on-pump coronary artery bypass grafting in diabetic patients: a meta-analysis of observational studies with a propensity-score analysis. Cardiovasc Drugs Ther. 2024.
9. Caraballo C, Desai NR, Mulder H, Alhanti B, Wilson FP, Fiuzat M, et al. Clinical implications of the new york heart association classification. J Am Heart Assoc. 2019;8:e014240.
10. Atashi A, Amini S, Tashnizi MA, Moeinipour AA, Aazami MH, Tohidnezhad F, et al. External validation of European System for Cardiac Operative Risk Evaluation II (EuroSCORE II) for risk prioritization in an Iranian population. Braz J Cardiovasc Surg. 2018;33:40-6.
11. Montague NT 3rd, Kouchoukos NT, Wilson TA, Bennett AL 3rd, Knott HW, Lochridge SK, et al. Morbidity and mortality of coronary bypass grafting in patients 70 years of age and older. Ann Thorac Surg. 1985;39:552-7.
12. Mullany CJ, Darling GE, Pluth JR, Orszulak TA, Schaff HV, Ilstrup DM, et al. Early and late results after isolated coronary artery bypass surgery in 159 patients aged 80 years and older. Circulation. 1990;82(5 Suppl):Iv229-36.
13. Cleveland JC Jr, Shroyer AL, Chen AY, Peterson E, Grover FL. Off-pump coronary artery bypass grafting decreases risk-adjusted mortality and morbidity. Ann Thorac Surg. 2001;72:1282-8; discussion 1288-9.
14. Plomondon ME, Cleveland JC Jr, Ludwig ST, Grunwald GK, Kiefe CI, Grover FL, et al. Off-pump coronary artery bypass is associated with improved risk-adjusted outcomes. Ann Thorac Surg. 2001;72:114-9.
15. Calafiore AM, Di Mauro M, Canosa C, Di Giammarco G, Iaco AL, Contini M. Early and late outcome of myocardial revascularization with and without cardiopulmonary bypass in high risk patients (EuroSCORE > or = 6). Eur J Cardiothorac Surg. 2003;23:360-7.
16. Horneffer PJ, Gardner TJ, Manolio TA, Hoff SJ, Rykiel MF, Pearson TA, et al. The effects of age on outcome after coronary bypass surgery. Circulation. 1987;76:V6-12.
17. Cernaianu AC, Vassilidze TV, Flum DR, Maurer M, Cilley JH Jr, Grosso MA, et al. Predictors of stroke after cardiac surgery. J Card Surg. 1995;10:334-9.
18. Rich MW, Sandza JG, Kleiger RE, Connors JP. Cardiac operations in patients over 80 years of age. J Thorac Cardiovasc Surg. 1985;90:56-60.
19. Shroyer AL, Grover FL, Hattler B, Collins JF, McDonald GO, Kozora E, et al. On-pump versus off-pump coronary-artery bypass surgery. N Engl J Med. 2009;361:1827-37.
20. Lamy A, Devereaux PJ, Prabhakaran D, Taggart DP, Hu S, Paolasso E, et al. Off-pump or on-pump coronary-artery bypass grafting at 30 days. N Engl J Med. 2012;366:1489-97.
21. Møller CH, Perko MJ, Lund JT, Andersen LW, Kelbaek H, Madsen JK, et al. No major differences in 30-day outcomes in high-risk patients randomized to off-pump versus on-pump coronary bypass surgery: the best bypass surgery trial. Circulation. 2010;121:498-504.
22. Dhurandhar V, Saxena A, Parikh R, Vallely MP, Wilson MK, Butcher JK, et al. Outcomes of on-pump versus off-pump coronary artery bypass graft surgery in the high Risk (AusSCORE > 5). Heart Lung Circ. 2015;24:1216-24.
23. Filardo G, Hamman BL, da Graca B, Sass DM, Machala NJ, Ismail S, et al. Efficacy and effectiveness of on- versus off-pump coronary artery bypass grafting: a meta-analysis of mortality and survival. J Thorac Cardiovasc Surg. 2018;155:172-9.e5.
24. Smart NA, Dieberg G, King N. Long-term outcomes of on- versus off-pump coronary artery bypass grafting. J Am Coll Cardiol. 2018;71:983-91.
25. Park SJ, Jo AJ, Kim HJ, Cho S, Ko MJ, Yun SC, et al. Real-world outcomes of on- vs off-pump coronary bypass surgery: result from korean nationwide cohort. Ann Thorac Surg. 2022;113:1989-98.
26. Squiers JJ, Schaffer JM, Banwait JK, Ryan WH, Mack MJ, DiMaio JM. Long-term survival after on-pump and off-pump coronary artery bypass grafting. Ann Thorac Surg. 2022;113:1943-52.

27. Chikwe J, Lee T, Itagaki S, Adams DH, Egorova NN. Long-term outcomes after off-pump versus on-pump coronary artery bypass grafting by experienced surgeons. J Am Coll Cardiol. 2018;72:1478-86.
28. Quin JA, Wagner TH, Hattler B, Carr BM, Collins J, Almassi GH, et al. Ten-year outcomes of off-pump vs on-pump coronary artery bypass grafting in the department of veterans affairs: a randomized clinical trial. JAMA Surg. 2022;157:303-10.
29. Shroyer AL, Hattler B, Wagner TH, Collins JF, Baltz JH, Quin JA, et al. Five-year outcomes after on-pump and off-pump coronary-artery bypass. N Engl J Med. 2017;377:623-32.
30. He L, Tiemuerniyazi X, Chen L, Yang Z, Huang S, Nan Y, et al. Clinical outcomes of on-pump versus off-pump coronary-artery bypass surgery: a meta-analysis. Int J Surg. 2024;110:5063-70.