Comparison of Postoperative Serum Creatinine Levels Between On-Pump and Off-Pump Coronary Artery Bypass Graft in Coronary Artery Disease Patients With Normal Preoperative Creatinine Levels at H. Adam Malik General Hospital, Medan

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DOI: 10.29322/IJSRP.15.10.2025.p16604
https://dx.doi.org/10.29322/IJSRP.15.10.2025.p16604

Paper Received Date: 18th August 2025
Paper Acceptance Date: 28th September 2025
Paper Publication Date: 6th October 2025

***Abstract*-** Coronary artery disease (CAD) remains a major cause of morbidity and mortality worldwide, with coronary artery bypass grafting (CABG) serving as the standard revascularization therapy. Two main surgical approaches are used: conventional CABG with cardiopulmonary bypass (On Pump) and off-pump CABG (Off Pump). While the On Pump technique facilitates surgical exposure and precision, it may increase the risk of acute kidney injury (AKI) through mechanisms such as hemodilution, non-pulsatile flow, and systemic inflammatory responses. In contrast, the Off Pump technique is considered less invasive to renal physiology and may reduce the risk of renal complications. However, comparative evidence on postoperative renal outcomes between these approaches remains scarce in Indonesia. This study aimed to compare postoperative renal outcomes, specifically serum creatinine levels, incidence of AKI, and the need for hemodialysis, between On Pump and Off Pump CABG in patients with preserved preoperative renal function at the Integrated Heart Center, H. Adam Malik General Hospital, Medan. A retrospective cohort design was applied to 60 patients with CAD undergoing CABG in 2024, including 32 On Pump and 28 Off Pump cases. Eligible patients underwent elective CABG with preoperative serum creatinine ≤1.2 mg/dL, while those with pre-existing renal disease, combined cardiac procedures, or incomplete records were excluded. Postoperative serum creatinine was assessed on day 1 and day 2, and AKI was classified using AKIN criteria. Results showed no significant differences in postoperative creatinine, AKI incidence, or dialysis requirement between groups, suggesting that both surgical techniques demonstrate comparable renal safety profiles in low-risk populations.

***Index Terms*-:** acute kidney injury, coronary artery bypass grafting, serum creatinine, hemodialysis, off pump, on pump

I. Introduction

Coronary heart disease (CHD) occurs due to the narrowing of coronary arteries, which restricts blood flow to the myocardium and can manifest either acutely or chronically. Patients with CHD often experience chest pain that limits physical activity and reduces quality of life.[1] The prevalence of CHD in Indonesia continues to rise, reaching 1.45% of the productive-age population (15–55 years) in 2018, or approximately two million people. Indonesia even ranks second among countries with the highest loss of disability-adjusted life years (DALYs) due to CHD, with 130 DALYs per 1,000 population.[2]

Coronary artery bypass grafting (CABG) remains the recommended revascularization therapy for patients with CHD who continue to experience symptoms despite optimal pharmacological treatment.[3] Numerous clinical studies have demonstrated the benefits of CABG in reducing symptoms and improving survival. There are two CABG techniques based on the use of cardiopulmonary bypass (CPB): conventional CABG (On-Pump) and off-pump CABG (Off-Pump). The conventional technique employs a CPB machine, which may have adverse effects on other organ functions, particularly the kidneys.[4] Due to hypotension, renal hypoperfusion, hypothermia, and non-pulsatile blood flow, complications such as acute kidney injury (AKI) may occur, characterized by increased postoperative creatinine levels. AKI develops in up to 30% of patients undergoing On-Pump CABG, with approximately 2–7% requiring acute hemodialysis.[5,6] Animal models and observational human studies have shown that AKI can progress to chronic kidney disease (CKD) and increase the risk of mortality.[6,7]

A study by Rydén et al. (2014) found that after long-term follow-up of more than four years, the occurrence of postoperative AKI

increased the risk of developing CKD by up to 2.92 times compared to patients without postoperative AKI following CABG.[8] One of the advantages of choosing the Off-Pump technique is the reduced incidence of postoperative AKI, as it eliminates the effects of systemic inflammatory response syndrome (SIRS).[4] However, the Off-Pump technique removes the benefits of a bloodless and motionless surgical field. With the Off-Pump approach, the surgeon must exercise greater caution and maintain closer communication with the anesthesiologist to monitor intraoperative hemodynamic stability, which is why this technique has not yet become the primary choice for many operators.[9]

Based on these considerations, further information is needed regarding the comparison of postoperative serum creatinine elevation between On-Pump and Off-Pump procedures performed at the Integrated Heart Center of H. Adam Malik General Hospital, Medan. The results of this study may serve as an additional reference to assist surgeons in selecting the appropriate CABG technique in the future.

II. Methodology

This study employed a retrospective cohort design using medical records of patients with coronary artery disease (CAD) who underwent coronary artery bypass grafting (CABG) at the Integrated Heart Center, H. Adam Malik General Hospital, Medan. Data collection was conducted from January to February 2025 and included patients who had undergone CABG procedures between January and December 2024.

The target population consisted of all CAD patients who underwent CABG, while the accessible population included those who underwent either conventional on-pump CABG (On Pump) or off-pump CABG (Off Pump) within the study period. Patients were eligible if they underwent elective CABG with preoperative serum creatinine ≤1.2 mg/dL. Exclusion criteria were patients who underwent combined procedures (valve, aortic, thoracic, or vascular surgery), those with a history of chronic kidney disease or preoperative hemodialysis, and incomplete medical records.

A total sampling technique was applied, yielding 60 eligible patients, consisting of 32 who underwent On Pump and 28 who underwent Off Pump CABG. Baseline demographic and clinical characteristics such as age, sex, body mass index, comorbidities (diabetes mellitus, hypertension, dyslipidemia, smoking, heart failure, stroke), medication history (statins, ACE-inhibitors, beta blockers, aspirin), and left ventricular ejection fraction were obtained through preoperative assessment and echocardiography.

Serum creatinine was measured preoperatively (within one month before surgery) and postoperatively on day one and day two. The diagnosis and staging of acute kidney injury (AKI) were determined according to the Acute Kidney Injury Network (AKIN) criteria, based on changes in serum creatinine. The need for postoperative hemodialysis was established by the attending anesthesiologist in cases of stage 3 AKI.

All patients were admitted to the intensive care unit (ICU) following surgery, and perioperative management was performed according to standard institutional protocols.

Statistical analysis was performed using SPSS version 22.0 (SPSS Inc., Chicago, Illinois). Normality of numerical data such as age, body mass index, ejection fraction, and serum creatinine levels was assessed using the Kolmogorov-Smirnov test. Normally distributed variables were presented as mean ± standard deviation (SD), whereas non-normally distributed variables were presented as median (minimum–maximum). Categorical variables were expressed as frequencies and percentages.

To compare postoperative serum creatinine levels between the On Pump and Off Pump groups, the independent t-test was used for normally distributed data, and the Mann-Whitney test was used for non-normally distributed data. Associations between categorical variables were analyzed using the chi-square test. A p-value of <0.05 was considered statistically significant.

Ethical approval was obtained from the Institutional Ethics Committee of the Integrated Heart Center, H. Adam Malik General Hospital, Medan (Approval No. DP.04.03/KEP106/EC059/2025). As this was a retrospective study, no additional intervention or risk was posed to the patients, and all data were collected anonymously from medical records.

III. Result

A total of 60 patients with coronary artery disease (CAD) who underwent coronary artery bypass grafting (CABG) at the Integrated Heart Center, H. Adam Malik General Hospital, Medan, during the study period were included in the analysis. Of these, 32 patients (53.3%) underwent conventional on-pump CABG (On Pump), and 28 patients (46.7%) underwent off-pump CABG (Off Pump). All patients had normal preoperative renal function, defined as serum creatinine ≤1.2 mg/dL, and none had a prior history of chronic kidney disease or hemodialysis.

The demographic and clinical characteristics of the patients are summarized in Table 1. The mean age of patients in the On Pump group was 56.9 ± 6.8 years, while in the Off Pump group it was slightly higher, 58.8 ± 7.1 years, but this difference was not statistically significant ($p = 0.321$). The majority of patients in both groups were male, accounting for 81.3% in the On Pump group and 71.4% in the Off Pump group ($p = 0.234$).

The mean body mass index (BMI) was comparable between groups (24.5 ± 3.2 kg/m² vs. 24.8 ± 3.4 kg/m², $p = 0.678$). Regarding comorbidities, 40.6% of On Pump patients and 42.9% of Off Pump patients had diabetes mellitus ($p = 0.851$). A high proportion of patients in both groups were smokers, 87.5% in On Pump and 85.7% in Off Pump ($p = 0.827$). Similarly, hypertension and heart failure were common in both groups, with no significant differences ($p > 0.05$).

Preoperative renal function was preserved in all patients. The mean preoperative serum creatinine level was 0.92 ± 0.34 mg/dL in the On Pump group and 0.98 ± 0.45 mg/dL in the Off Pump group ($p = 0.487$). The mean left ventricular ejection fraction was also comparable (46.3 ± 9.4% vs. 47.2 ± 12.1%, $p = 0.721$). Medication use, including ACE-inhibitors, aspirin, and beta blockers, was similar across both groups ($p > 0.05$).

These results suggest that the baseline clinical characteristics of patients were well balanced between the On Pump and Off Pump groups, reducing the likelihood of confounding due to demographic or comorbidity differences.

Table 1. Baseline demographic and clinical characteristics of patients

Variable	On Pump (n=32)	Off Pump (n=28)	p-value
Age (years, mean ± SD)	56.9 ± 6.8	58.8 ± 7.1	0.321
Male sex, n (%)	26 (81.3%)	20 (71.4%)	0.234
Body mass index (kg/m², mean ± SD)	24.5 ± 3.2	24.8 ± 3.4	0.678
Diabetes mellitus, n (%)	13 (40.6%)	12 (42.9%)	0.851
Smoking, n (%)	28 (87.5%)	24 (85.7%)	0.827
Hypertension, n (%)	22 (68.8%)	20 (71.4%)	0.819
Heart failure, n (%)	23 (71.9%)	22 (78.6%)	0.535
Preoperative serum creatinine (mg/dL, mean ± SD)	0.92 ± 0.34	0.98 ± 0.45	0.487
ACE-inhibitor use, n (%)	26 (81.3%)	23 (82.1%)	0.928
Aspirin use, n (%)	28 (87.5%)	24 (85.7%)	0.827
Beta blocker use, n (%)	25 (78.1%)	22 (78.6%)	0.962
Left ventricular ejection fraction (% ± SD)	46.3 ± 9.4	47.2 ± 12.1	0.721

The postoperative serum creatinine levels are shown in Table 2. The mean postoperative serum creatinine level in the On Pump group was 1.19 ± 0.41 mg/dL, compared with 1.05 ± 0.54 mg/dL in the Off Pump group. Although the Off Pump group exhibited a trend toward lower postoperative creatinine, the difference did not reach statistical significance (p = 0.268).

This finding suggests that both surgical techniques were associated with only a modest increase in serum creatinine, and no clinically meaningful difference was observed between the groups.

Table 2. Postoperative serum creatinine

Variable	On Pump (n=32)	Off Pump (n=28)	p-value
Postoperative serum creatinine (mg/dL, mean ± SD)	1.19 ± 0.41	1.05 ± 0.54	0.268

Importantly, no patient in either the On Pump or Off Pump group developed acute kidney injury (AKI) as defined by the Acute Kidney Injury Network (AKIN) criteria. Similarly, no patient required postoperative hemodialysis during the study period.

The absence of AKI and hemodialysis requirements in this cohort may be attributed to strict inclusion criteria that excluded patients with preoperative renal impairment and ensured that all subjects had baseline serum creatinine ≤1.2 mg/dL. Additionally, careful perioperative management, including optimal hydration and hemodynamic monitoring in the intensive care unit, may have contributed to the preservation of renal function in both groups.

IV. Discussion

This study aimed to compare postoperative increases in serum creatinine, the incidence of acute kidney injury (AKI), and the need for hemodialysis between patients undergoing conventional coronary artery bypass grafting (On Pump) and off-pump coronary artery bypass grafting (Off Pump) at the Integrated Heart Center, H. Adam Malik General Hospital, Medan. Based on the data analysis, no significant difference was found in the postoperative increase in serum creatinine between the On Pump group (1.19 ± 0.41 mg/dL) and the Off Pump group (1.05 ± 0.54 mg/dL) (p = 0.268). Furthermore, there were no cases of AKI or need for hemodialysis in either group, indicating that the study hypothesis, which proposed that Off Pump would have lower increases in serum creatinine, lower incidence of AKI, and lower requirement for hemodialysis compared to On Pump, could not be confirmed by these findings.

The mean postoperative serum creatinine was higher in the On Pump group compared to the Off Pump group, although the difference was not statistically significant. This finding contrasts with the study by Garg et al. (2014), which reported that Off Pump patients had significantly lower increases in serum creatinine compared to On Pump.[1] The discrepancy may be due to differences in study populations. In the present study, patients had relatively good preoperative renal function (preoperative serum creatinine: On Pump 0.92 ± 0.34 mg/dL; Off Pump 0.98 ± 0.45 mg/dL), which may have reduced the risk of a significant postoperative increase. The study by Seabra et al. (2010) demonstrated that good preoperative renal function, defined as serum creatinine <1.2 mg/dL, significantly reduced the risk of AKI after cardiac surgery.[2]

The use of cardiopulmonary bypass (CPB) in On Pump is known to cause renal hypoperfusion, hypothermia, and non-pulsatile flow, which may increase oxidative stress and tubular injury (Rosner and Okusa, 2006).[3] However, in this study, the minimal postoperative increase in serum creatinine in both groups suggests that perioperative management, such as adequate hydration and hemodynamic monitoring, may have minimized the impact of CPB. Kumar et al. (2019) emphasized that kidney-protective strategies, such as optimal intravenous fluid administration and avoidance of nephrotoxic agents, can reduce the risk of postoperative serum creatinine increases in CABG patients.[4]

In addition, the relatively small sample size (n = 60) in this study may have limited the statistical power to detect significant differences. According to Lamy et al. (2012), in the CORONARY trial comparing On Pump and Off Pump, small differences in postoperative serum creatinine often go undetected in studies with small sample sizes, particularly in low-risk populations. Therefore, studies with larger sample sizes are required to confirm whether Off Pump truly offers an advantage in reducing postoperative increases in serum creatinine.[5]

The absence of AKI or hemodialysis requirement in this study is an unusual finding, given that literature reports an incidence of AKI of up to 30% in On Pump patients, with 2–7% requiring acute hemodialysis (Mangano et al., 1998).[6] The strict exclusion criteria, such as excluding patients with preoperative serum creatinine >1.2 mg/dL or a history of renal failure, likely contributed to these results. Chertow et al. (1997) showed that preoperative serum creatinine >1.2 mg/dL increased the risk of AKI threefold in cardiac surgery patients. Thus, selecting patients with good baseline renal function in this study may have minimized the incidence of AKI.[7]

Moreover, optimal perioperative management at H. Adam Malik General Hospital, such as strict hemodynamic monitoring and avoidance of intraoperative hypotension, may have reduced the risk of AKI. According to Ranucci et al. (2008), intraoperative blood pressure control and prevention of renal hypoperfusion are key factors in

reducing AKI after CABG. However, these findings differ from those of Rocha et al. (2019), who reported that Off Pump significantly reduced the incidence of dialysis-requiring AKI compared to On Pump.[8] This discrepancy may be due to the short duration of postoperative creatinine measurement in this study, which only extended to the second postoperative day. Thakar et al. (2005) demonstrated that the peak incidence of AKI often occurs between the third and fifth postoperative days, suggesting that short-term monitoring may not be sensitive enough to detect all cases of AKI.[9]

The absence of hemodialysis in this study is also consistent with the low incidence of AKI. According to Oh et al. (2021), severe AKI requiring dialysis increases short-term mortality risk up to 18-fold, but such events are more common in patients with significant comorbidities or high preoperative serum creatinine. Thus, this low-risk study population may not reflect the general CABG population.[10]

Analysis of subject characteristics showed no significant differences between the On Pump and Off Pump groups with respect to variables such as age, sex, body mass index, diabetes mellitus, smoking, hypertension, heart failure, ACE-inhibitor use, aspirin, beta-blocker use, or ejection fraction. This indicates that the comparison between the two groups was not biased by confounding factors. However, preoperative risk factors such as diabetes mellitus and low ejection fraction, which are known to increase the risk of AKI (Thakar et al., 2005; Barkhordari et al., 2018), did not have a significant impact in this study, likely due to the overall low incidence of AKI.[11]

The study by Barkhordari et al. (2018) found that older age and higher body mass index significantly increased the risk of AKI after CABG. In this study, the mean age (On Pump: 56.9 years; Off Pump: 58.8 years) was within the productive age range, which may explain the low incidence of AKI. Moreover, the mean ejection fraction (On Pump: 46.3%; Off Pump: 47.2%) indicated relatively preserved left ventricular function, which reduced the risk of systemic hypoperfusion during surgery. This finding is supported by Wijeysundera et al. (2007), who linked an ejection fraction <35% with an increased risk of AKI.[12]

Although no significant differences were found between On Pump and Off Pump, these findings suggest that both techniques have comparable safety profiles in patients with good preoperative renal function. This is consistent with the meta-analysis by Moller et al. (2010), which concluded that Off Pump did not provide significant benefit in reducing AKI in low-risk patients.[13] However, in high-risk patients, such as those with diabetes mellitus or early-stage chronic kidney disease, Off Pump may offer greater advantages by avoiding the systemic inflammatory effects of CPB, as shown by Rocha et al. (2019).[8]

The clinical implication of this study is that the choice of CABG technique can be based on other factors, such as operator expertise or patient preference, in low-risk populations. However, for patients at high risk of AKI, further research is needed to confirm the benefits of Off Pump. The study by Shroyer et al. (2009) in the ROOBY trial reported that Off Pump was associated with lower rates of complete revascularization compared to On Pump, which may influence clinical decision-making even if the risk of AKI is lower.[14]

Study Limitations

This study has several limitations. First, the small sample size (n = 60) limited the statistical power to detect significant differences, as also reported in similar study designs (Lamy et al., 2012).[5] Second, the absence of AKI and hemodialysis limited the ability to analyze associations between surgical technique and renal outcomes. Third, serum creatinine measurement was only carried out until the second postoperative day, which may not capture AKI occurring later, as reported by Thakar et al. (2005). Fourth, the retrospective design relied on the completeness of medical records, which may have affected data accuracy, particularly for variables such as body mass index. Fifth, this study only included low-risk patients, so the results may not be generalizable to populations with more complex comorbidities.[9]

Recommendations for Future Research

To overcome these limitations, future studies should consider larger sample sizes to increase statistical power, as recommended by Garg et al. (2014).[1] In addition, serum creatinine should be measured for at least seven days postoperatively to improve the sensitivity of AKI detection, in line with the findings of Thakar et al. (2005).[9] Prospective or randomized trial designs are also needed to minimize bias from retrospective data, as demonstrated in the CORONARY trial (Lamy et al., 2012). Finally, including high-risk patients, such as those with preoperative serum creatinine close to the threshold or with significant comorbidities, could provide further insight into the potential benefits of Off Pump in preventing renal complications.[5]

V. Conclusion

This study found no significant differences in postoperative serum creatinine, acute kidney injury (AKI), or hemodialysis requirements between On Pump and Off Pump CABG in patients with preserved preoperative renal function. Although the On Pump group showed a slightly higher mean creatinine level, the difference was not statistically significant. The absence of AKI and dialysis may be explained by good baseline renal function, strict patient selection, and optimal perioperative management.

These findings suggest that both techniques are equally safe for renal outcomes in low-risk patients, and surgical choice may instead be guided by operator expertise or patient preference. Further studies with larger sample sizes, longer follow-up, and high-risk populations are needed to clarify whether Off Pump provides greater renal protection

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