J Surg Med. 2023;7(9):628-631.
DOI: 10.28982/josam.7970

Research article

Journal of Surgery and Medicine
e-ISSN: 2602-2079
https://jsurgmed.com/

Renal implications of off-pump coronary artery bypass grafting: A retrospective cohort study analyzing postoperative creatinine levels

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Ethics Committee Approval
The study was approved by Koç University Ethical Committee (2019. 353.IRB2.113).
All procedures in this study involving human participants were performed in accordance with the 1964 Helsinki Declaration and its later amendments.

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

Financial Disclosure
The authors declared that this study has received no financial support.

Published
2023 September 29

Abstract

Background/Aim: Coronary artery disease is a significant health concern worldwide. While coronary artery bypass grafting is a gold standard of treatment, acute kidney injury (AKI) is a possible postoperative complication of concern. Off-pump coronary artery bypass grafting (OPCABG) aims to curtail perioperative complications; however, its impact on postoperative AKI is debated. This retrospective study aims to inform patient care by identifying potential effects of OPCABG on AKI utilizing postoperative creatinine alterations.

Methods: This retrospective study was conducted at Koç University Hospital in Istanbul, Turkey. We reviewed the records of patients who underwent OPCABG between June 2018 and June 2019. Patients with incomplete records or individuals who had undergone renal replacement therapy prior to surgery were excluded. The primary metric was serum creatinine levels, which were assessed preoperatively and up to 7 days postoperatively. Preoperative creatinine levels were compared with postoperative levels using the Wilcoxon signed-rank test. Acute kidney injury was defined using Kidney Disease: Improving Global Outcomes (KDIGO) criteria.

Results: Seventy-two patients satisfied the inclusionary criteria. A significant increase in creatinine was observed on postoperative Day 1 ($P<0.001$); creatinine levels fell below baseline by postoperative Day 4 and 5. We note that the incidence of AKI was low; there were no instances of Stage 2 or higher AKI during the observation period.

Conclusion: Our data suggest that OPCABG may result in a transient increase in creatinine post-surgery. Creatinine levels normalize over time, implicating the renal safety of OPCABG. Despite these promising findings, additional comprehensive studies are essential to validate these observations and assess long-term renal outcomes after OPCABG.

Keywords: coronary artery bypass, off-pump, coronary artery disease, kidney, creatinine

How to cite: Darcin K, Karakaya MA. Renal implications of off-pump coronary artery bypass grafting: A retrospective cohort study analyzing postoperative creatinine levels. J Surg Med. 2023;7(9):628-631.

Introduction

Coronary artery disease (CAD) remains a leading cause of morbidity and mortality worldwide [1]. Coronary artery bypass grafting (CABG) has been established as a gold standard for the treatment of multivessel CAD, and it has significantly improved outcomes in a significant number of patients. Coronary artery bypass grafting is traditionally performed using cardiopulmonary bypass (CPB). However, off-pump coronary artery bypass grafting (OPCABG), which avoids the use of CPB, has gained popularity in recent decades due to its ability to reduce perioperative complications [2,3].

Acute kidney injury (AKI) is a well-recognized and often devastating complication after cardiac surgery [4-6]. The pathogenesis of postoperative AKI is multifactorial, with factors such as systemic inflammation, oxidative stress, and hemodynamic instability playing pivotal roles [7,8]. Off-pump coronary artery bypass grafting, by potentially mitigating some of these factors, particularly the systemic inflammatory response associated with CPB, has been hypothesized to reduce the incidence or severity of AKI postoperatively [9,10].

However, the actual impact of OPCABG on postoperative AKI remains a topic of ongoing debate: while some studies have suggested a reduced risk of AKI with off-pump techniques, others have found no significant differences [9-13]. A better understanding of this relationship is crucial given that AKI is associated with prolonged hospitalization stays, increased healthcare costs, and elevated long-term morbidity and mortality rates [14-17].

This retrospective study aims to contribute to this discourse by analyzing creatinine levels before and after OPCABG surgery to determine the potential effects of this technique on postoperative AKI. By assessing the incidence and severity of AKI following OPCABG, we aim to provide clinicians with further insights into patient management and the potential renal implications of choosing an off-pump technique.

Materials and methods

Study design and patient selection

This retrospective study was conducted at Koç University Hospital in Istanbul, Turkey. After obtaining approval from the Koç University Committee on Human Research (Approval No: 2019. 353.IRB2.113 and approval date: 26.11.2019), we reviewed the medical records of patients who underwent OPCABG surgery between June 2018 and June 2019. Patients with incomplete records or who had undergone renal replacement therapy prior to the surgery were excluded. Demographic information, relevant comorbidities, medications, and perioperative variables were extracted from the patients' electronic health records. The primary data of interest included serum creatinine levels recorded preoperatively and on postoperative days up to Day 7.

Definition of AKI

Acute kidney injury was defined using the Kidney Disease: Improving Global Outcomes (KDIGO) criteria [16]. According to the KDIGO guidelines, AKI is present when there is:

- An increase in serum creatinine of at least 0.3 mg/dL (26.5 μmol/L) within 48 hours or an increase in serum creatinine of 1.5–1.9-fold above baseline within the last 7 days (Stage 1)
- An increase in serum creatinine of 2.0–2.9-fold above baseline (Stage 2)
- An increase in serum creatinine at least 3.0-fold above baseline OR a value exceeding 4.0 mg/dL (353.6 μmol/L) (Stage 3)

Statistical analysis

Changes in serum creatinine levels between the preoperative and postoperative periods were analyzed using the Wilcoxon signed-rank test, which is a non-parametric test suitable for paired, non-normally distributed data. The normality of the data was assessed using the Kolmogorov-Smirnov test. A *P*-value less than 0.05 was considered to indicate statistical significance. All of the statistical analyses were performed using the Statistical Package for Social Sciences for Windows version 24.0 program (SPSS, Chicago, IL).

Results

Of the 98 patients who underwent OPCABG and had recorded preoperative creatinine levels, 26 exhibited creatinine levels above 1.1 mg/dL. That level surpassed our laboratory's threshold for normal creatinine. Those patients were subsequently excluded from further analysis, and the final study cohort therefore consisted of 72 patients.

Postoperative creatinine monitoring

As time progressed postoperatively, the number of patients with recorded creatinine levels decreased. On postoperative Day 1, creatinine levels were available for 64 patients. This number successively decreased to 58, 57, 48, 27, 12, and 10 patients for postoperative Days 2, 3, 4, 5, 6, and 7, respectively. This trend was due to patients either being discharged from the hospital or, unfortunately, mortality. Figure 1 shows the postoperative creatinine levels of the patients.

Incidence of acute kidney injury

Throughout the postoperative monitoring period, none of the patients developed AKI at Stage 2 or above. However, the incidence of Stage 1 AKI varied over the 7-day postoperative period. Specifically, the number of patients who developed Stage 1 AKI on postoperative Days 1–7 were 11, 8, 4, 5, 1, 1, and 1, respectively. Figure 2 shows the number of patients with and without AKI over the course of the study.

Figure 1: Postoperative creatinine levels

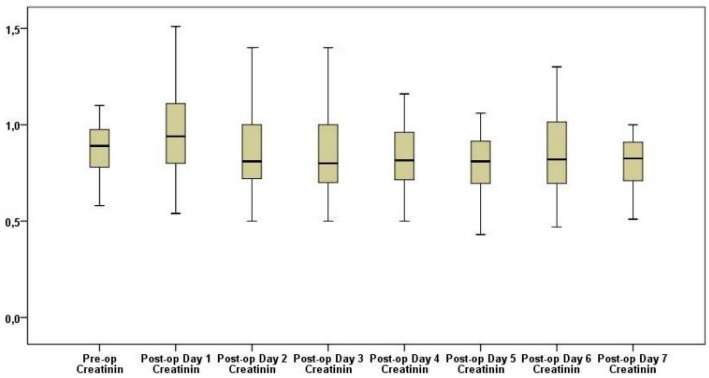
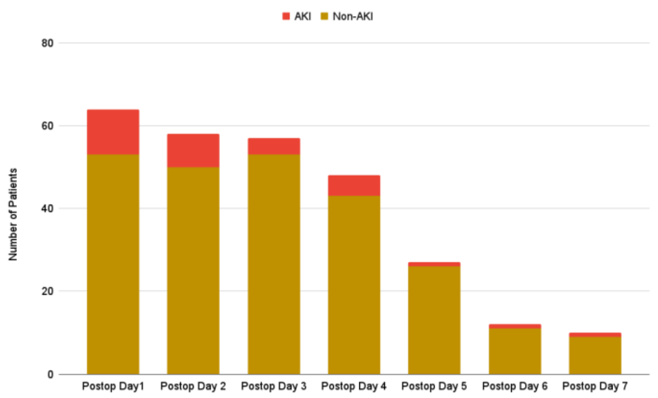


Figure 2: AKI trends of patients



Comparison of creatinine levels

The Wilcoxon signed-rank test was used to assess changes in postoperative creatinine levels from Day 1 to Day 7.

A substantial increase in creatinine levels on postoperative Day 1 was observed relative to baseline (Z value: -4.151; *P*<0.001). On the other hand, creatinine levels on postoperative Days 4 and 5 were statistically lower than baseline levels (*P*=0.042 and 0.029, respectively; Table 1). And while changes in creatinine levels on Days 2, 3, 6, and 7 were observed, those changes were not statistically significant.

Table 1: Test statistics.

	Z	*P*-value
Pre-op vs Post-op Day 1	-4.151	<0.001
Pre-op vs Post-op Day 2	-0.254	0.799
Pre-op vs Post-op Day 3	-1.271	0.204
Pre-op vs Post-op Day 4	-2.038	0.042
Pre-op vs Post-op Day 5	-2.187	0.029
Pre-op vs Post-op Day 6	-0.314	0.754
Pre-op vs Post-op Day 7	-0.663	0.507

P<0.05: statistically significant

Discussion

Coronary artery bypass grafting is as a critical intervention for managing CAD [1-3]. Off-pump coronary artery bypass grafting, which eschews CPB, holds promise for minimizing perioperative complications [9,10]. One of the most notable complications that arises post-cardiac surgery is AKI, which has profound implications on patient outcomes and healthcare costs [14-17]. Given the multi-faceted nature of the pathogenesis of AKI, OPCABG might be a potential mitigating solution given that it can possibly counteract certain instigating factors such as systemic inflammation [9,10]. However, the literature is replete with divergent findings on the impact of OPCABG on AKI [12,13].

This retrospective study investigated this complex relationship and explored creatinine levels as a surrogate for kidney function in the context of OPCABG. We specifically gauged whether OPCABG might exert a protective effect against AKI, potentially reflecting decreased renal insult compared with traditional CABG.

An integral finding was a discernible spike in creatinine levels on the first postoperative day. This observation hinted at either initial kidney stress or reduced glomerular filtration. This elevation, which was statistically significant, is consistent with previous research that found immediate postoperative renal alterations [14,15]. The etiology of this increase might encompass factors such as intraoperative hemodynamic changes, inflammation, or other transient insults. Interestingly, by postoperative Day 4 or 5, creatinine levels dipped below baseline. This finding possibly signifies renal recovery or adaptation, which is in accordance with a number of studies that claim AKI may be temporary and suggests that the initial damage may be transient and repairable [18,19].

While our study did record fluctuations in creatinine levels on postoperative Days 2, 3, 6, and 7, these changes did not attain statistical significance. This finding underscores the importance of not just noting clinical changes but also evaluating their statistical and therefore potential clinical significance.

Furthermore, our study observed that the incidence of AKI, as classified by KDIGO criteria, was relatively low; no cases exceeded Stage 1 during the observed postoperative period. This finding is encouraging and hints at the potential renal safety of OPCAB, at least during the immediate postoperative period.

Limitations

There are several limitations to this study. Retrospective studies are beneficial for cost-efficiently investigating uncommon diseases, but they suffer from drawbacks. For instance, these types of studies depend on information that was gathered for clinical uses and not for research purposes. Because the data were not collected using a predesigned proforma in accordance with the unique criteria of the study, some data are almost always going to be missing. Additionally, it is impossible to document all of the parameters that might possibly influence the results. Second, while serum creatinine is a widely accepted marker for renal function, it is not without limitations: factors such as muscle mass, hydration status, and medications can influence creatinine levels, and it might not be the most sensitive indicator of early renal injury [20].

Conclusion

In conclusion, our study reveals the renal implications of OPCABG and highlights transient postoperative increases in creatinine levels. (Those levels appear to normalize from postoperative Day 2 onwards.) While our findings are promising in terms of the potential renal safety of OPCABG, more extensive prospective studies are warranted to corroborate our observations and to better understand long-term renal outcomes post-OPCABG. Our hope is that such insights can guide clinical decision-making, ensuring optimal patient outcomes for individuals battling CAD.

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