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Renal Complications in Patients After Open-Heart Surgery

Mohanad H. Naqqash[1], Husam K. Ayoob[1], Zain Al-Abdeen H. AL-Rammahi[1], Kifah H. Alani[2]*

[1] *College of Medicine, University of Baghdad, Baghdad, Iraq.*
[2]*Department of Pathology, College of Medicine, University of Baghdad, Baghdad, Iraq.*

**Corresponding Author: kifahalani@comed.uobaghdad.edu.iq*

Abstract:

Background: Acute kidney injury (AKI) is a frequent complication of open-heart surgery, with a reported global incidence of 20-40%. Local Iraqi data on postoperative AKI incidence and predictors remain limited despite its designation as a 2025 Iraqi Ministry of Health perioperative research priority.
Objectives: To determine the incidence, severity, independent predictors, and short-term outcomes of AKI among adult patients undergoing open-heart surgery at a tertiary cardiac center in Iraq.
Methods: This single-centre observational case-series analyzed 99 adults undergoing elective open-heart surgery at the Iraq Center for Heart Diseases, Baghdad, between January 2024 and December 2025. Patients with end-stage renal disease on dialysis or chronic kidney disease stage 4 were excluded. Preoperative renal dysfunction was defined as serum creatinine >1.1 mg/dL or estimated glomerular filtration rate <60 mL/min/1.73 m2. AKI was diagnosed and staged using KDIGO serum-creatinine criteria. Statistical analysis included Mann-Whitney U, chi-square/Fisher exact tests, and multivariable logistic regression.
Results: AKI occurred in 23/99 patients (23.2%): 19 (82.6%) were KDIGO stage 1, two (8.7%) stage 2, and two (8.7%) stage 3. One AKI patient (4.3%) required new postoperative renal-replacement therapy. In the adjusted model, male sex (adjusted OR 8.43, 95% CI 1.50-47.46, p=0.016) and impaired baseline renal function (adjusted OR 7.11, 95% CI 1.58-32.05, p=0.011) were independent predictors. CPB duration >120 minutes showed a numerically higher AKI incidence but was not statistically significant.
Conclusion: Postoperative AKI occurred in nearly one quarter of patients. Male sex and impaired baseline renal function were the only independent predictors, supporting targeted preoperative renal-risk stratification and postoperative renal surveillance in Iraqi cardiac centers.

Keywords: Acute Kidney Injury; Cardiac Surgical Procedures; Cardiopulmonary Bypass; Postoperative Complications; Risk Assessment.

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Introduction

Acute kidney injury (AKI) is one of the most clinically significant complications of open-heart surgery, with a reported global incidence of 20–40 % and a strong association with prolonged intensive-care utilization, longer hospitalization, higher in-hospital mortality, and progression to chronic kidney disease (1–3, 6–8). Cardiac surgery–associated AKI (CSA-AKI) arises from the interplay of ischemia–reperfusion injury, systemic inflammation, oxidative stress, and CPB-related microvascular dysfunction (4, 5, 20). Even mild episodes of AKI can initiate maladaptive renal repair and accelerate progression to chronic kidney disease (6, 7).

Several preoperative variables have been associated with postoperative AKI, including older age, male sex, pre-existing renal dysfunction, diabetes mellitus and hypertension. Intraoperative factors include prolonged cardiopulmonary bypass (CPB) and procedure complexity (9–13). Reports indicate a higher AKI risk in male patients (12, 13), and meta-analyses have linked CPB duration above 120 minutes to increased renal injury (15, 17). Long-term renal outcomes are influenced by both surgical technique and pre-existing renal reserve (10, 16).

Regional Middle-Eastern data on AKI after cardiac surgery broadly mirror the global incidence (18). However, no Iraqi single-center study has reported KDIGO-defined AKI incidence with multivariable predictor analysis after elective open-heart surgery. Despite the 2025 Iraqi Ministry of Health designation of perioperative AKI after cardiac surgery as a national research priority, local risk profiles remain unverified, leaving an evidence gap that the present study addresses.

This study aimed to estimate the incidence, severity, independent predictors and short-term outcomes of postoperative AKI among adult patients undergoing open-heart surgery at a tertiary Iraqi cardiac center. We hypothesized that impaired baseline renal function and prolonged CPB duration would independently predict postoperative AKI.

Cases and Methods

This was a single-center case-series observational study conducted at the Iraq Center for Heart Diseases, Baghdad. The study included adult patients (≥ 18 years) who underwent elective open-heart surgery between January 2024 and December 2025.

Inclusion criteria were age ≥ 18 years, elective open-heart surgery (coronary artery bypass grafting [CABG], valve replacement or repair, or other cardiac procedures on cardiopulmonary bypass), with the availability of complete preoperative and postoperative serum-creatinine values. Patients with end-stage renal disease (ESRD) on dialysis or with chronic kidney disease (CKD) stage 4 (estimated glomerular filtration rate 15–29 mL/min/1.73 m²) at baseline were excluded to ensure homogeneity of the analytic cohort. After application of these criteria the final analytic cohort comprised 99 patients.

Demographic information (age and gender), pre-existing comorbidities (diabetes mellitus and hypertension), baseline serum creatinine (sCr) and estimated glomerular filtration rate (eGFR) were extracted from the electronic medical records. Preoperative renal dysfunction was defined as sCr > 1.1 mg/dL or eGFR < 60 mL/min/1.73 m² (9, 16). Intraoperative data included surgical modality (valve surgery, CABG, or other) and cardiopulmonary bypass (CPB) duration. CPB duration was categorized as ≤ 60 minutes, 61–120 minutes, and > 120 minutes, on the basis of cut-points used in international studies (15, 17). Accordingly, the variables analyzed in the present study were sex, age, baseline renal function, surgery type, and CPB duration — the variables consistently documented in our institutional records; the descriptive associations of diabetes mellitus and hypertension with AKI were also examined.

Acute kidney injury was diagnosed and staged according to the KDIGO serum-creatinine criteria. The urine-output criterion was not applied because of inconsistent retrospective documentation of urine volumes. All laboratory values were measured by the standardized hospital-laboratory equipment.

The study was approved by the Research Ethics Committee, Department of Pathology and Forensic Medicine, College of Medicine, University of Baghdad (approval no. 186, dated 4 December 2025). The requirement for informed consent was waived because the study consisted of de-identified retrospective record review without patient contact.

Statistical Analysis:

Continuous variables were assessed for normality using the Shapiro–Wilk test. Age was non-normally distributed and is reported as median with interquartile range (IQR); group comparisons used the Mann–Whitney U test. Categorical variables were analyzed using the chi-square test or Fisher's exact test, as appropriate. Independent predictors of postoperative AKI were identified using two complementary multivariable logistic regression models. Model A entered four pre-specified clinically relevant variables — age, sex, baseline renal function, and CPB duration > 120 min — to allow direct comparison with previously reported cardiac-AKI cohorts (11, 12). Model B was a sensitivity analysis restricted to variables with $p < 0.10$ in univariable analysis (sex and impaired baseline renal function). Multicollinearity was assessed using the variance inflation factor (VIF), and model calibration was evaluated using the Hosmer–Lemeshow goodness-of-fit test. Given the limited number of

AKI events (n = 23) and the resulting events-per-variable ratio of 5.75 in Model A, results are interpreted as exploratory and confirmed against Model B (events-per-variable 11.5). All analyses were performed using SPSS version 26; $p < 0.05$ was considered statistically significant.

Results

After applying the eligibility criteria, the final analytic cohort comprised 99 adult patients; 72 (72.7%) were males, and the median age was 57 years (IQR 52–64; range 20–77).

Baseline demographic, comorbidity and operative characteristics are presented in Table 1. Diabetes mellitus was present in 43 patients (43.4%) and hypertension in 40 (40.4%); neither comorbidity was significantly associated with postoperative AKI in the present cohort (DM chi-square p = 1.000; HTN chi-square p = 0.920).

On univariable analysis, male sex and impaired baseline renal function were significantly associated with AKI (sex chi-square p = 0.044; baseline renal function Fisher's exact p = 0.006). Age, CPB duration, surgery type, diabetes mellitus and hypertension were not significantly associated with AKI on univariable testing.

The incidence of AKI by CPB-duration category was 0/5 (0%) for ≤ 60 minutes, 8/41 (19.5%) for 61–120 minutes, and 15/53 (28.3%) for > 120 minutes (chi-square p = 0.273). CPB > 120 min versus ≤ 120 min corresponded to AKI incidences of 28.3% versus 17.4%; in the multivariable model the adjusted odds ratio was 2.14 (95 % CI 0.71–6.44, p = 0.178), indicating a numerical but not statistically significant association.

Table 1: Baseline demographics, comorbidity and operative characteristics of the study cohort

Variable	Total (n = 99)	No AKI (n = 76)	AKI (n = 23)	p-value
Age (years), median (IQR)	57 (52–64)	56 (51–63)	59 (54–68)	0.124†
Male sex, n (%)	72 (72.7)	51 (67.1)	21 (91.3)	0.044
Female sex, n (%)	27 (27.3)	25 (32.9)	2 (8.7)	
Diabetes mellitus, n (%)	43 (43.4)	33 (43.4)	10 (43.5)	1.000
Hypertension, n (%)	40 (40.4)	30 (39.5)	10 (43.5)	0.920
Pre-operative renal function				0.006‡
Normal	87 (87.9)	71 (93.4)	16 (69.6)	
Impaired (sCr > 1.1 mg/dL or eGFR < 60)	12 (12.1)	5 (6.6)	7 (30.4)	
CPB duration				0.273
≤ 60 minutes	5 (5.1)	5 (6.6)	0 (0.0)	
61–120 minutes	41 (41.4)	33 (43.4)	8 (34.8)	
> 120 minutes	53 (53.5)	38 (50.0)	15 (65.2)	
Surgery type				0.480
CABG	77 (77.8)	57 (75.0)	20 (87.0)	
Valve replacement/repair	14 (14.1)	12 (15.8)	2 (8.7)	
Other	8 (8.1)	7 (9.2)	1 (4.3)	

† Mann–Whitney U test; ‡ Fisher's exact test; remainder Pearson chi-square.
Patients with end-stage renal disease on dialysis or chronic kidney disease stage 4 at baseline were excluded from the analytic cohort.

Postoperative AKI severity, dialysis requirement and short-term outcomes are presented in Table 2. Among the 23 patients who developed AKI, 19 (82.6%) were classified as KDIGO stage 1, 2 (8.7%) as stage 2, and 2 (8.7%) as stage 3, indicating that the great majority of cases were mild. One AKI patient (4.3%) required new postoperative renal-replacement therapy. At hospital discharge, full renal recovery was observed in 7 patients (30.4%), partial recovery in 3 (13.0%), persistent renal dysfunction in 11 (47.8%), and in-hospital mortality in 2 (8.7%). For comparison, among the 76 patients without AKI, persistent renal dysfunction and in-hospital mortality were 1.3% and 5.3% respectively, indicating that AKI was associated with a substantially higher short-term burden of unresolved renal impairment.

Table 2: Severity, dialysis requirement and outcomes at hospital discharge among patients who developed acute kidney injury (n = 23)

Variable	**n (%)**
KDIGO stage 1 (Mild)	19 (82.6)
KDIGO stage 2 (Moderate)	2 (8.7)
KDIGO stage 3 (Severe)	2 (8.7)
Required new postoperative renal-replacement therapy	1 (4.3)
Outcome at discharge — full renal recovery	7 (30.4)
Outcome at discharge — partial renal recovery	3 (13.0)
Outcome at discharge — persistent renal dysfunction	11 (47.8)
Outcome at discharge — in-hospital mortality	2 (8.7)

Multivariable logistic regression results are presented in Table 3. In Model A (entering age, sex, baseline renal function, and CPB > 120 min), male sex (adjusted OR 8.43, 95% CI 1.50–47.46, p = 0.016) and impaired baseline renal function (adjusted OR 7.11, 95% CI 1.58–32.05, p = 0.011) were the only independent predictors of postoperative AKI. Age (adjusted OR 1.05 per year, 95% CI 0.99–1.12, p = 0.083) and CPB duration > 120 min were not statistically significant. The sensitivity Model B (Sex and baseline renal function only) yielded similar estimates (male sex adjusted OR 7.51, 95% CI 1.38–40.97, p = 0.020; impaired baseline renal function adjusted OR 9.15, 95% CI 2.10–39.78, p = 0.003). The Hosmer–Lemeshow goodness-of-fit test for Model A was non-significant (chi-square = 10.34, p = 0.242), indicating acceptable calibration; variance inflation factors were below conventional concern thresholds (≤ 3.96). The wide confidence intervals reflect the limited sample size and the small number of AKI events.

Table 3: Univariable and multivariable logistic regression for predictors of postoperative acute kidney injury (n = 99; 23 events)

Predictor	OR / aOR	95% CI	p-value
Univariable logistic regression			
Age (per year)	1.05	1.00–1.10	0.071
Male sex	5.15	1.12–23.71	0.036
Impaired baseline renal function	6.21	1.75–22.11	0.005
CPB > 120 min	1.87	0.71–4.94	0.203
Diabetes mellitus	1.00	0.39–2.57	0.996
Hypertension	1.18	0.46–3.03	0.732
Multivariable Model A - adjusted for age, sex, baseline renal function, CPB > 120 min			
Age (per year)	1.05	0.99–1.12	0.083
Male sex	8.43	1.50–47.46	0.016
Impaired baseline renal function	7.11	1.58–32.05	0.011
CPB > 120 min	2.14	0.71–6.44	0.178
Multivariable Model B - sensitivity analysis (univariable p < 0.10 only)			
Male sex	7.51	1.38–40.97	0.020
Impaired baseline renal function	9.15	2.10–39.78	0.003

Hosmer–Lemeshow goodness-of-fit (Model A) chi-square = 10.34, p = 0.242. Variance inflation factors ≤ 3.96 (no problematic collinearity). Events-per-variable: Model A = 5.75; Model B = 11.50. The wide confidence intervals reflect the limited sample size and small number of AKI events.

Discussion

In this Iraqi single-center cohort the incidence of postoperative AKI after open-heart surgery fell within the global range of 20–40% reported by Wang et al. (1) and consistent with regional Middle-Eastern data summarized by Ibrahim et al. (18). Most AKI episodes were KDIGO stage 1, in keeping with prior reports indicating that mild AKI accounts for the majority of CSA-AKI cases (6–8).

Male sex emerged as an independent predictor of AKI. Although the direction of effect is consistent with the literature describing increased CSA-AKI risk in men (12, 13), three features of our data require caution before extrapolating this finding: The cohort was 72.7% male, the absolute number of female AKI events was small (n = 2), and the resulting confidence interval is wide. The sex–AKI association in our data should therefore be regarded as hypothesis-generating and confirmed in larger sex-balanced cohorts.

Impaired baseline renal function was the second independent predictor. This is consistent with reduced nephron reserve limiting the kidney's ability to compensate for perioperative ischemic, inflammatory and hemodynamic stressors (9, 16). The clinical implication is direct: Patients identified preoperatively with sCr > 1.1 mg/dL or eGFR < 60 mL/min/1.73 m² constitute a recognizable high-risk group for whom intensified perioperative renal-protective measures are warranted.

CPB duration > 120 minutes was associated with a numerically higher AKI incidence, but did not reach statistical significance. Larger studies by Barbu et al. (15) and Chen et al. (17) have reported a significant CPB–AKI relationship; the absence of significance in our study probably reflects limited statistical power and the categorical recording of CPB time, which prevented analysis of CPB as a continuous variable.

Age was not significantly associated with AKI, most likely because of the limited number of AKI events (n = 23) and the clustering of patients around the median age (IQR 52–64 years), which restricted statistical power to detect age-related effects despite the wide overall age range of 20–77 years. Surgery type was likewise non-significant - consistent with reports that patient-related rather than procedure-related factors are the principal drivers of postoperative AKI as reported by Chen et al. (10) and Ibrahim et al.(18). Diabetes mellitus and hypertension were not associated with AKI in this cohort, which

contrasts reports from larger cardiac-surgery series by Yi et al. (9) and Haredasht et al.(11) and is most plausibly explained by the limited sample size, the binary recording of comorbidity status, and the high background prevalence of these conditions in the cohort.

While the Iraqi Ministry of Health has identified perioperative AKI after cardiac surgery as a 2025 research priority, no published Iraqi national-incidence data are available. Our single-center estimate of 23.2 % is therefore presented as a baseline against which future Iraqi multicenter studies can be compared.

At discharge, persistent renal dysfunction was observed in 47.8% of AKI patients and in-hospital mortality in 8.7%, compared with 1.3% and 5.3% respectively in patients without AKI. These outcome data emphasize that AKI after cardiac surgery in this population is not a transient laboratory abnormality but is associated with substantial short-term renal and survival burden, mirroring international data reported by Kellum et al. (6) and Coca et al. (7).

Our findings argue specifically for: (i) routine preoperative renal-risk stratification using sCr and eGFR for every adult cardiac-surgery candidate; (ii) intensified postoperative renal surveillance — particularly serial serum creatinine for the first 72 hours — in male patients and those with impaired baseline renal function; and (iii) prospective Iraqi multicenter data collection that captures the perioperative variables our retrospective dataset could not.

Limitations

Several limitations of this study should be acknowledged. First, the case-series single-center design precludes causal inference and limits external generalizability; the associations reported here should therefore be interpreted as descriptive rather than causal. Second, AKI was diagnosed using the KDIGO serum-creatinine criterion only; urine-output data were not consistently available and may have led to under-detection of AKI. Third, the limited number of AKI events yielded an events-per-variable ratio of 5.75 in the four-predictor multivariable model, below the conventional threshold of 10; this is reflected in the wide confidence intervals around the adjusted odds ratios and creates a risk of model overfitting, which we partially mitigated through the sensitivity Model B (events-per-variable 11.5). Fourth, several established AKI predictors - anemia and hemoglobin levels, blood-transfusion volume, perioperative hypotension, vasopressor use, exposure to nephrotoxic agents, and heart-failure status were not consistently captured in the retrospective records and could not be analyzed. Fifth, intensive-care-unit and total hospital length-of-stay were not available for inclusion in the outcomes analysis. Sixth, exact CPB duration in minutes was not recorded; only the three categorical bands could be analyzed. Seventh, novel renal-injury biomarkers (e.g., neutrophil gelatinase-associated lipocalin, kidney injury molecule-1) were not measured, and subclinical AKI may therefore have been under-detected.

Conclusions

The current study concluded that male sex and impaired baseline renal function were the only independent predictors of AKI. These findings support targeted preoperative renal-risk stratification in Iraqi cardiac centers while underscoring the need for larger, multicenter Iraqi studies that capture intraoperative hemodynamic, transfusion and biomarker data.

Authors' declaration

We confirm that all the Figures and Tables in the manuscript belong to the current study. Besides, the figures and images, which do not belong to the current study, have been given permission for re-publication attached to the manuscript. Authors sign on ethical considerations. Approval-Ethical Clearance: The project was approved by the local ethical committee (Department of Pathology, College of Medicine, University of Baghdad.) according to the code number (186) on (4/12/ 2025).

Informed Consent: Patient consent was waived because the study involved retrospective review of de-identified medical records, with no direct patient contact.

Conflict of Interest: The authors declare that there is no conflict of interest regarding the publication of this paper.

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Data availability: Data supporting the findings of this study are available from the corresponding author upon reasonable request.

Authors' contributions:

Study conception & design: (Kifah H. Alani, Husam K. Ayoob & Mohanad H. Naqqash & Zain Al-Abdeen H. AL-Rammahi).

Literature search: (Mohanad H. Naqqash & Husam K. Ayoob).

Data acquisition: (Husam K. Ayoob & Zain Al-Abdeen H. AL-Rammahi).

Data analysis & interpretation: (Mohanad H. Naqqash & Husam K. Ayoob).

Manuscript preparation: (Mohanad H. Naqqash).

Manuscript editing & review: (Kifah H. Alani, Mohanad H. Naqqash).

AI Declaration: No artificial intelligence tools were used in the design, analysis, or writing of this manuscript.

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المضاعفات الكلوية لدى المرضى بعد جراحة القلب المفتوح

مهند حيدر النقاش[1]
حسام خلدون ايوب[1]
زين العابدين حيدر الرماحي[1]
كفاح حمدان العاني[2]

[1] كلية الطب، جامعة بغداد، بغداد، العراق.
[2] فرع الامراض، كلية الطب، جامعة بغداد، بغداد، العراق

الخلاصة:

الخلفية: تُعد إصابة الكلى الحادة من المضاعفات الشائعة بعد جراحة القلب المفتوح، إذ تتراوح نسبة حدوثها عالميًا بين 20-40%. ولا تزال البيانات العراقية المحلية حول معدل حدوث إصابة الكلى الحادة بعد الجراحة والعوامل المتنبئة بها محدودة، رغم إدراجها ضمن أولويات البحث المحيط بالجراحة لوزارة الصحة العراقية لعام 2025.

الأهداف: تحديد معدل حدوث إصابة الكلى الحادة وشدتها والعوامل المستقلة المتنبئة بها والنتائج قصيرة الأمد لدى المرضى البالغين الخاضعين لجراحة القلب المفتوح في مركز قلبي متخصص في العراق.

المنهجية: شملت هذه الدراسة الرصدية ذات السلسلة الحالاتية 99 مريضًا بالغًا خضعوا لجراحة قلب مفتوح اختيارية في مركز العراق لأمراض القلب في بغداد بين كانون الثاني 2024 وكانون الأول 2025. استُبعد مرضى الفشل الكلوي النهائي المعتمدون على الديال أو المصابون بمرض كلوي مزمن من المرحلة الرابعة. عُرّف ضعف الوظيفة الكلوية قبل الجراحة بوجود كرياتينين مصل >1.1 ملغم/دل أو معدل ترشيح كبيبي مقدر <60 مل/دقيقة/1.73 م2. شُخّصت إصابة الكلى الحادة وصُنفت وفق معايير KDIGO المعتمدة على كرياتينين المصل.

النتائج: حدثت إصابة الكلى الحادة لدى 23 من أصل 99 مريضًا (23.2%)؛ وكان 19 مريضًا (82.6%) في المرحلة 1، ومريضان (8.7%) في المرحلة 2، ومريضان (8.7%) في المرحلة 3 وفق KDIGO. احتاج مريض واحد (4.3%) إلى علاج تعويضي كلوي جديد بعد العملية. في النموذج المعدل، كان الجنس الذكري (OR معدل 8.43، 95% CI 1.50-47.4695، p=0.016) وضعف الوظيفة الكلوية الأساسية (OR معدل 7.11، 95% CI 1.58-32.0595، p=0.011) منبئين مستقلين. أما مدة المجازة القلبية الرئوية >120 دقيقة فأظهرت ارتفاعًا عدديًا في معدل الإصابة دون دلالة إحصائية.

الاستنتاج: حدثت إصابة الكلى الحادة بعد الجراحة لدى نحو ربع المرضى. وكان الجنس الذكري وضعف الوظيفة الكلوية الأساسية العاملين المستقلين الوحيدين المتنبئين بها، مما يدعم اعتماد تقييم خطورة كلوي قبل الجراحة ومراقبة كلوية مبكرة بعد الجراحة في مراكز القلب العراقية.

الكلمات المفتاحية: إصابة الكلية الحادة؛ إجراءات جراحة القلب؛ المجازة القلبية الرئوية؛ المضاعفات بعد الجراحة؛ تقييم الخطورة.