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Incidence, Risk factors and Outcomes of Postoperative Acute Kidney Injury Requiring Dialysis After Cardiac Surgery: A Retrospective Study from the National Heart Institute of Malaysia

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Declarations

Ethics approval and consent to participate

Approved by IJN Research Ethics Committee (IJNREC)

Consent for publication

Approved.

Availability of data and material

Available on request.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

CYC performed literature review, involved in initial data synthesis, screening and extraction. CYC was involved in the conceptualization and design of the study. CYC and HIS were involved in data screening and collection. HIS conducted the statistical analysis. CYC was involved in the manuscript writing.

MNN, PSKM, JD, MAY, MEMT and AY were involved in the supervision, editing and final review of the manuscript. The author(s) read and approved the final manuscript.

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Abstract

Background: Acute kidney injury (AKI) requiring dialysis is a rare but devastating complication following cardiac surgery, associated with significant morbidity and mortality. While chronic kidney disease (CKD) is a known risk factor, the impact of other perioperative variables and the differential outcomes between CKD and non-CKD patients remain inadequately defined.

Objective: To determine the incidence, risk factors, and outcomes of AKI requiring dialysis after cardiac surgery, with stratification by baseline renal function.

Methods: This retrospective cohort study included adult patients undergoing coronary artery bypass grafting, valve surgery, or combined procedures at the National Heart Institute of Malaysia between January 2022 and July 2024. AKI was defined using KDIGO criteria, and patients with end-stage renal disease on chronic dialysis were excluded. Multivariable logistic regression identified predictors of dialysis-requiring AKI. Propensity score matching was used to compare outcomes between patients with and without CKD.

Results: Among 6,779 patients, the incidence of AKI requiring dialysis was 4.5%. The incidence was significantly higher in patients with CKD (13.9%) compared to matched non-CKD patients (5.5%). Independent predictors included advanced age (AOR 1.038, 95% CI 1.003-1.073), urgent surgery (AOR 2.393, 95% CI 1.211-4.726), diabetes mellitus (AOR 1.798, 95% CI 1.001-3.231), reoperation (AOR 7.202, 95% CI 4.127-12.568), and prolonged ICU stay (AOR 1.148, 95% CI 1.081-1.220). Coronary angiography timing was not associated with increased risk. Mortality was 45.1% among CKD patients and 53.3% among non-CKD patients who developed dialysis-requiring AKI. Compared to those without AKI, mortality risk increased 16-fold in CKD and 30-fold in non-CKD patients. ICU stay was prolonged by approximately two weeks in affected patients.

Conclusion: AKI requiring dialysis after cardiac surgery is associated with dramatically increased mortality and healthcare resource utilization, particularly in patients without preexisting CKD. Several modifiable perioperative factors contribute to risk. These findings support the need for early risk stratification, perioperative kidney-protective strategies, and multidisciplinary planning to prevent this serious complication.

Keywords

Acute Kidney Injury (AKI), Dialysis, Cardiac Surgery, Chronic Kidney Disease (CKD), Mortality, Risk Factors, Renal Protection Strategies

MANUSCRIPT

Introduction

Acute kidney injury (AKI) is one of the most common and devastating complications following cardiac surgery, affecting between 12% and 40% of patients, and conferring a substantial increase in short- and long-term morbidity and mortality.[1,2] While most cases are transient, a subset progresses to dialysis-requiring AKI, which is associated with dramatic increases in perioperative mortality, prolonged intensive care utilization, and long-term renal sequelae.

The pathophysiology of cardiac surgery-associated AKI (CSA-AKI) is complex and multifactorial, involving ischemia-reperfusion injury, systemic inflammation, oxidative stress, hemolysis, micro embolism, and nephrotoxicity from medications and contrast agents.[3,4] Risk factors such as advanced age, diabetes, chronic kidney disease, prolonged cardiopulmonary bypass (CPB), and perioperative hemodynamic instability have been consistently associated with increased AKI risk.[5]Additionally, the timing of coronary angiography prior to surgery and the use of high-dose statins for contrast protection remain areas of evolving evidence.[6,7]

In Asian populations, the burden of postoperative AKI is amplified by a high prevalence of diabetes, hypertension, and earlier onset of cardiovascular disease. Regional cohorts from Singapore, Taiwan, and China have demonstrated that even mild postoperative AKI confers a several-fold increase in long-term mortality and progression to chronic kidney disease and end-stage renal disease.[8-11] These data reframe AKI not as a transient perioperative complication, but as a disease-modifying biological event with enduring systemic consequences.

Several prediction models for AKI after cardiac surgery have been developed, primarily in Western populations.[12] These models often focus on preoperative renal function, comorbidity burden, and procedural complexity. However, their applicability to Southeast Asian health systems remains uncertain. Moreover, most prior studies have evaluated AKI as a single entity without stratifying outcomes by baseline chronic kidney disease (CKD) status, despite the fundamentally different renal reserve and recovery trajectories between these populations.

Contemporary Asian studies have begun to highlight this heterogeneity. Regional risk models identified phenotypes characterized by advanced age, anemia, reduced estimated glomerular filtration rate, and procedural stressors such as prolonged cardiopulmonary bypass and transfusion exposure.[9] Large population-based cohorts further demonstrated that dialysis-requiring AKI exerts differential prognostic impact depending on surgical context and baseline renal reserve, underscoring that the biological meaning of AKI is highly context-dependent.[8,10] Yet, data from Southeast Asia remain sparse, and no large Malaysian cohort has examined dialysis-requiring AKI with stratification by baseline CKD.

The present study addresses this knowledge gap by examining the incidence, predictors, and outcomes of dialysis-requiring AKI in a large contemporary Malaysian cardiac surgical cohort from National Heart Institute of Malaysia, with explicit stratification by baseline CKD status. This study examines how institutional renal practices and patient baseline vulnerability influence the risk and outcomes of severe AKI. Notably, we address why non-CKD patients with dialysis-requiring AKI face especially high mortality, suggesting a more severe disease form.

Materials and Methods

Study Design and Population

This was a retrospective cohort study of adult patients (aged ≥18 years) who underwent cardiac surgery at the National Heart Institute of Malaysia between January 2022 and July 2024. The study included patients undergoing coronary artery bypass grafting (CABG), valve surgery, or a combination of both. Patients with end-stage renal disease requiring chronic dialysis before surgery were excluded from the analysis.

Data Collection

Data were collected from electronic medical records and included patient demographics, comorbidities, preoperative laboratory values, intraoperative details (e.g., CPB time, cross-clamp time), postoperative laboratory values, and clinical outcomes. The time between coronary angiography and cardiac surgery was also recorded to assess its potential impact on renal outcomes.

The primary outcome variable was the incidence of dialysis-requiring AKI stratified by CKD. Secondary outcomes were mortality, ICU length of stay, hospital stay, and postoperative complications following AKI required dialysis.

Renal Definitions and Indications for Dialysis

Chronic kidney disease (CKD) was defined using KDIGO-based estimated glomerular filtration rate (eGFR) staging. Baseline renal function was determined from the most recent preoperative serum creatinine, typically obtained within one week prior to surgery, and eGFR was calculated using a standardized formula. Patients with an eGFR below 60 mL/min/1.73 m^2 were classified as having CKD. Albuminuria data were not routinely available in this cohort and were therefore not incorporated into CKD classification.

Acute kidney injury (AKI) was diagnosed according to the RIFLE criteria, incorporating both changes in serum creatinine and urine output. Oliguria was defined as urine output less than 0.5 mL/kg/hour. Postoperative serum creatinine was measured routinely in the intensive care unit, and peak creatinine within the early postoperative period was used for AKI staging.

The initiation of renal replacement therapy was individualized and guided by clinical context rather than creatinine thresholds alone. In patients with non-oliguric AKI and satisfactory cardiac output, a period of observation was often permitted to allow for renal recovery. Dialysis was initiated promptly in the presence of refractory metabolic acidosis, fluid overload, uremic complications, or persistent hyperkalemia, in accordance with KDIGO principles and through multidisciplinary consensus between intensivists and nephrologists.

Interval between coronary angiography and operation

In patients undergoing coronary angiography prior to surgery, the interval between angiography and operation was classified as ≤5 days or >5 days. This cut-off reflects institutional practice, in which dual antiplatelet therapy is routinely withheld for a minimum of five days before elective cardiac surgery to mitigate perioperative bleeding risk. Patients proceeding to surgery within five days of angiography therefore represent either urgent or emergent cases in whom antiplatelet interruption is not feasible. This categorization was chosen to distinguish patients exposed to recent contrast load and heightened procedural acuity from those undergoing elective, optimized surgery, and to better capture the clinical context in which angiography may influence postoperative renal outcomes.

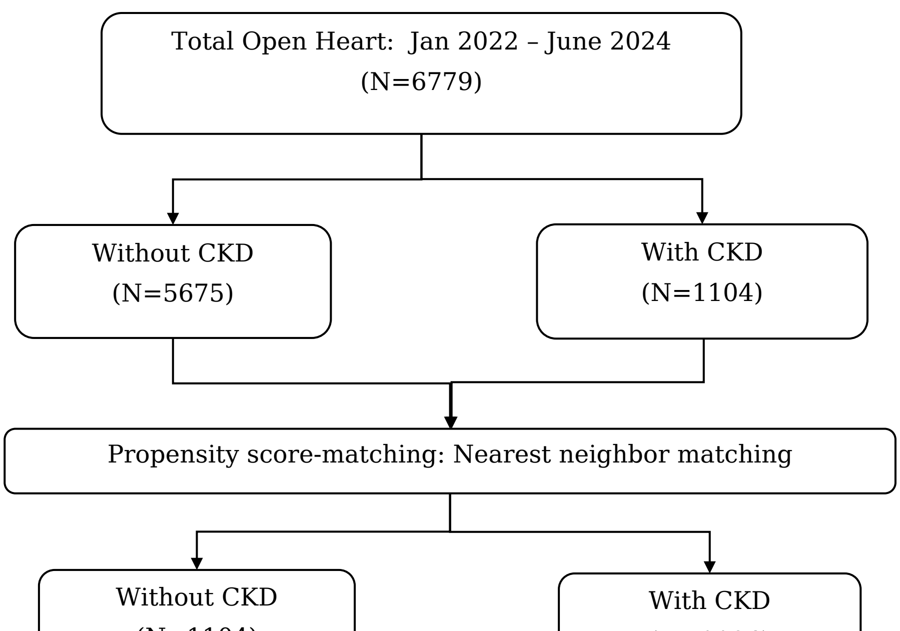
Sample Size and Statistical Analysis

A total of 6779 patients with cardiac surgery were identified from January 2022 to June 2024 by convenience sampling, of whom 1104 having chronic kidney disease (CKD) and 5675 were those without CKD. Following propensity score matching, 1104 matched pairs (2208 patients) were included in the final comparative analysis, with stratification of AKI with and without dialysis for both cohorts (Figure 1). Propensity score matching was used to compare outcomes between patients with and without CKD who developed AKI requiring dialysis. The matching was performed using a nearest neighbor approach, and standardized mean differences (SMD) were calculated to assess the balance between groups after matching.

Baseline characteristics were summarized using means and standard deviations for continuous variables or medians and interquartile ranges for non-normally distributed data. Categorical variables were reported as frequencies and percentages and compared using chi-square or Fisher's exact test as appropriate.

Univariable and multivariable logistic regression analyses were performed to identify risk factors for postoperative AKI requiring dialysis. Variables with a p-value <0.1 in the univariable analysis were included in the multivariable model. Results were reported as odds ratios (OR) with 95% confidence intervals (CI). A p-value <0.05 was considered statistically significant. Data were analyzed using IBM SPSS Statistics for Windows, version 30.0 (IBM Corp., Armonk, NY, USA).

Figure 1: Propensity Score Matching Flowchart for AKI Requiring Dialysis in CKD and Non-CKD Patients



Results

A total of 6,779 patients were included in the analysis. Prior to propensity matching, patients with chronic kidney disease (CKD) were significantly older (median age 65 vs. 61 years, $p < 0.001$), more likely to be male (81% vs. 76%, $p < 0.001$), and had a higher prevalence of hypertension (91% vs. 71%, $p < 0.001$) and diabetes mellitus (59% vs. 40%, $p < 0.001$) compared to those without CKD.

After propensity matching, the baseline characteristics between CKD and non-CKD patients were largely balanced, although CKD patients still had significantly higher median baseline serum creatinine levels (131 vs. 109 μmol/L, $p < 0.001$). (Table 1)

Table 1: Baseline Characteristics After Propensity Matching

Covariate factors	**After propensity**			
	Without CKD N= 1,104	With CKD N= 1,104	SMD	P value
Age; median (IQR)	65 (59, 69)	65 (58, 70)	0.9	0.005*
Gender = Male (%)	923 (84)	898 (81)	0.060	0.200

Angina = CSS,No sign (%)	440 (40.0)	447 (40.0)	0.068	0.800
Dyspnea = NYHA I (%)	487 (44.0)	468 (42.0)	0.048	0.900
Smoking = Yes (%)	400 (36.0)	397 (36.0)	0.700	0.039*
Hypertension = Yes (%)	995 (90.0)	999 (91.0)	0.024	0.900
Diabetes = Yes (%)	533 (48.0)	582 (59.0)	0.092	0.100
Creatinine; median (IQR)	109 (97, 125)	131 (113, 157)	0.518	< 0.001*
Urgency = Elective (%)	912 (83.0)	887 (80.0)	0.079	0.300
Ejection fraction; median (IQR)	48 (38, 56)	46 (37, 55)	0.028	0.073

Note: *Significant at $p<0.05$

The overall incidence of acute kidney injury (AKI) requiring dialysis was 4.5%, with 308 patients affected. Among those with preexisting CKD, 13.9% (153/1104) developed dialysis-requiring AKI, compared to 5.5% (61/1104) of matched non-CKD patients. (Table 2)

Table 2: Incidence of Acute Kidney Injury Requiring Dialysis

	CKD	Non- CKD	p value
AKI + normal	951 (86.1)	1043 (94.5)	< 0.001*
AKI with dialysis	153 (13.9)	61 (5.5)	
Total	**1104**	**1104**	

Note: *Significant at p<0.05

Multivariable logistic regression analysis identified several independent predictors of AKI requiring dialysis. Increasing age was associated with a modest but statistically significant risk, with an adjusted odds ratio (AOR) of 1.038 per year (95% CI: 1.003–1.073, $p = 0.033$), indicating that each additional year of age increased the likelihood of dialysis-requiring AKI by 3.8%. Urgent inpatient surgery, including in-house referrals and inter hospital transfers, was associated with a nearly 2.4-fold increased risk (AOR: 2.393, 95% CI: 1.211–4.726, $p = 0.012$). Diabetes mellitus was also a significant predictor (AOR: 1.798, 95% CI: 1.001–3.231, $p = 0.050$).

Reoperation emerged as the most potent risk factor, with a more than sevenfold increased risk of dialysis-requiring AKI (AOR: 7.202, 95% CI: 4.127–12.568, $p < 0.001$). This likely reflects the cumulative physiological stress and complexity associated with repeat surgery. Additionally, longer ICU stay was independently associated with higher odds of developing AKI requiring dialysis (AOR: 1.148, 95% CI: 1.081–1.220, $p < 0.001$), with each extra ICU day increasing the risk by nearly 15%.

The time interval between coronary angiography and cardiac surgery was not a significant predictor of dialysis-requiring AKI (crude OR: 0.986, 95% CI: 0.945–1.029, p = 0.525), suggesting that contrast timing may be less relevant in severe AKI cases. (Table 3)

Table 3: Multivariable Logistic Regression Analysis for AKI Requiring Dialysis

Variables	**Univariate analysis**		**Multivariate analysis**	
	Crude OR (95%CI)	P value	Adjusted OR (95%CI)	P value
Pre-operative				
Age	1.037 (1.019, 1.055)	< 0.001*	1.038 (1.003, 1.073)	0.033*
Urgency; Elective as reference				
Urgent	2.186 (1.578,3.030)	< 0.001*	2.393 (1.211, 4.726)	0.012*
DM	1.561 (1.145,2.128)	0.005*	1.798 (1.001, 3.231)	0.050*
Timing between	0.986 (0.945,1.029)	0.525	Not significant -remove from fitted model using Stepwise	

coronary angiography				
Intra operative				
CPB time (mins)	1.004 (1.002,1.007)	< 0.001*		
Cross clamp time (mins)	1.002 (1.000,1.005)	0.048*	Not significant -remove from fitted model using Stepwise	
Hemofiltration	0.999 (0.999,1.000)	< 0.001*		
Post-operative				
Reoperation	8.574 (6.281,11.704)	< 0.001*	7.202 (4.127, 12.568)	< 0.001*
ICU Stay	1.206 (1.173,1.240)	< 0.001*	1.148 (1.081, 1.220)	< 0.001*
Hospital Stay	1.079 (1.066,1.092)	< 0.001*	0.963 (0.929, 0.997)	0.035*

Note: *Significant at $p<0.05$

Outcomes were significantly worse among patients who developed AKI requiring dialysis. Although the absolute number of deaths was higher among patients with CKD (69 vs. 32), the relative mortality risk was greater in non-CKD patients (53.3% vs. 45.1%). This reflects a higher baseline mortality among CKD patients, whereas the development of severe AKI represents a proportionally larger deviation from baseline risk in patients without underlying CKD. Consequently, dialysis-requiring AKI conferred a 30-fold increase in mortality among non-CKD patients compared with a 16-fold increase among CKD patients. Thus, CKD contributes to a greater absolute mortality burden, while non-CKD patients appear more vulnerable in relative terms (Table 4).

Table 4: Mortality Risk by AKI and CKD Status

	CKD		**Crude OR (95%CI)**	**p value**	**Non- CKD**		**Crude OR (95%CI)**	**p value**
	AKI + normal (n=951)	**AKI with dialysis (n=153)**			**AKI + normal (n=1043)**	**AKI with dialysis (n=61)**		
Mortality	44 (4.6%)	69 (45.1%)	16.933 (10.913, 26.272)	< 0.001*	48 (4.6%)	32 (53.3%)	30.666 (16.708, 52.283)	< 0.001*

Note: *Significant at p<0.05

ICU stays were significantly prolonged in patients who developed dialysis-requiring AKI, regardless of baseline CKD status. Patients with CKD had a mean ICU stay of 15.7 days compared with 3.2 days in those without AKI, while non-CKD patients had a mean ICU stay of 13.9 days versus 2.9 days, respectively ($p < 0.001$). (Table 5). This represents an approximate two-week increase in ICU utilization associated with dialysis-requiring AKI. The median time from cardiac surgery to initiation of renal replacement therapy was 3 days, with an interquartile range of 2 to 5 days.

Table 5: ICU Length of Stay Among Patients with AKI Requiring Dialysis

	CKD		**p**	**Non- CKD**		**p**
	AKI + normal	**AKI with dialysis**	**value**	**AKI + normal**	**AKI with dialysis**	**value**
ICU Stay (days)						
Mean ± SD	3.2 ± 4.8	15.7 ± 17.2	< 0.001*	2.9 ± 3.3	13.9 ± 16.1	< 0.001*
Median (Q1, Q3)	2.0 (1.0, 4.0)	9.0 (6.0, 21.0)		1.0 (1.0, 4.0)	8.0 (4.5, 16.5)	

Note: *Significant at p<0.05

Discussion

This study presents the largest contemporary Malaysian cohort examining dialysis-requiring AKI following cardiac surgery and provides three principal insights. First, dialysis-requiring AKI remains an infrequent but catastrophic complication, associated with markedly increased perioperative mortality and prolonged critical care utilization. Second, baseline CKD significantly modifies both the incidence and outcome of postoperative AKI. Third, and most notably, non-CKD patients who progress to dialysis-requiring AKI exhibit disproportionately high relative mortality, despite a lower absolute event burden; a finding that underscores the biological heterogeneity of postoperative renal injury.

Independent predictors of dialysis-requiring AKI in our study including advanced age, urgent surgery, diabetes, reoperation, and prolonged ICU stay are consistent with previous literature.[7, 9] The strong association between urgent or emergent surgery and AKI supports the view that inadequate time for preoperative renal optimization may predispose to renal injury. Of note, the interval between coronary angiography and surgery was not identified as an independent predictor of dialysis-requiring AKI in our cohort. This observation should be considered within the context of institutional workflow. We categorized angiography timing based on a five-day threshold, mirroring standard practice whereby dual antiplatelet therapy is typically withheld for at least five days before elective surgery. Patients undergoing surgery within this timeframe generally represent urgent or emergent cases, in which preoperative optimization is not achievable. In such scenarios, the physiological effects of recent contrast exposure may be eclipsed by factors such as the severity of underlying illness, hemodynamic instability, or procedural complexity. Consequently, angiography timing alone may not sufficiently discriminate renal risk when these predominant variables are present.

This "mortality paradox" is biologically plausible. Patients without pre-existing CKD who develop severe AKI likely represent an extreme physiological phenotype—those exposed to profound perioperative insult, hemodynamic instability, inflammatory burden, or catastrophic procedural complexity. In such patients, dialysis-requiring AKI may function less as an isolated renal event and more as a surrogate marker of multisystem failure. Population-based Asian data demonstrate that the prognostic impact of dialysis-requiring AKI varies by surgical context and baseline vulnerability, with certain phenotypes exhibiting particularly poor recovery trajectories.[11] Our findings extend this concept by showing that preserved baseline renal function does not confer protection once severe AKI occurs; instead, it may reflect a biologically more aggressive insult.

Importantly as part of institutional perioperative care, our institution employs standardized perioperative nephroprotective strategies, including structured medication reconciliation, protocolized hemodynamic targets during cardiopulmonary bypass, avoidance of prolonged hypotension, judicious fluid management, minimization of hemodilution, and early correction of metabolic derangements. These measures constitute a relatively constant background practice across cases. Consequently, intraoperative renal protection is not a discriminating variable within this cohort, and the observed risk gradients predominantly reflect patient vulnerability and procedural phenotype rather than variability in intraoperative care.

Within this framework, AKI should be viewed not as a binary postoperative complication but as an inflection point along a continuum of renal vulnerability. Asian longitudinal cohorts demonstrate that even mild postoperative AKI confers a several-fold increase in long-term progression to chronic kidney disease, end-stage renal disease, and mortality.[10] Dialysis-requiring AKI therefore represents a disease-modifying event that alters organ trajectory rather than a transient ICU complication. Our data identify phenotypes in whom this inflection point occurs, even within a system practicing standardized nephroprotection.

These findings support a shift from reactive to anticipatory renal care. Rather than viewing AKI prevention as a uniform peri-operative goal, high-risk phenotypes patients with CKD, anemia, urgent surgery, redo procedures, or complex hemodynamic profiles should trigger intensified, multidisciplinary kidney-protective pathways. Preoperative optimization, intraoperative nephroprotective constancy, and post-operative surveillance with early nephrology engagement may be most impactful when deployed in a risk-stratified manner.

From a regional perspective, this study complements emerging Asian literature by providing Southeast Asian outcome data from a middle-income health system. Whereas prior studies have focused on AKI prediction or long-term renal progression, our cohort uniquely integrates CKD stratification with contemporary procedural outcomes. In settings where resource allocation and ICU capacity remain constrained, identifying phenotypes in whom dialysis-requiring AKI marks a catastrophic biological transition carries direct operational and ethical significance.

Limitations

Several limitations merit acknowledgment. This is a retrospective single-center study, subject to residual confounding and unmeasured bias. Granular perioperative variables, including nephrotoxic medication exposure, detailed fluid balance, vasopressor dosing, and intraoperative hemodynamic indices, were not available and therefore could not be analyzed. Although standardized nephroprotective strategies are routinely applied, their individual components could not be quantified. Finally, long-term renal outcomes beyond hospital discharge were not captured. These constraints limit causal inference and underscore the need for prospective, pathwaybased evaluation to better define long-term renal trajectories and patient-centered outcomes following AKI.

Conclusion

In summary, these findings support a shift from reactive to anticipatory renal care. High-risk phenotypes should trigger intensified, multidisciplinary kidney-protective pathways spanning preoperative optimization, intraoperative constancy, and postoperative surveillance with early nephrology engagement. In Southeast Asian health systems where renal disease burden and resource constraints intersect, identifying and intervening at this inflection point carries direct clinical and operational importance.

List of Abbreviations

AKI: Acute kidney injury

AOR: Adjusted odds ratio

CABG: Coronary artery bypass grafting

CI: Confidence interval

CKD: Chronic kidney disease

CPB: Cardiopulmonary bypass

ESRD: End-stage renal disease

ICU: Intensive care unit

KDIGO: Kidney Disease: Improving Global Outcomes

OR: Odds ratio

RRT: Renal replacement therapy

SMD: Standardized mean difference

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Supplementary Materials

Descriptive statistics

Variables	**(-) CKD (N=1104)**	**(+) CKD (N=1104)**	**P value**
Pre-operative			
Age			
Mean ± SD	63.2 ± 9.0	63.3 ± 8.9	0.787
Median (Q1, Q3)	64.0 (59.0, 69.0)	64.5 (58.0, 70.0)	
Gender			
Male	920 (83.3)	898 (81.3)	0.121
Female	184 (16.7)	206 (18.7)	
Race			
Malay	785 (71.1)	773 (70.0)	0.827
Chinese	147 (13.3)	162 (14.7)	
Indian	135 (12.2)	131 (11.9)	
Others	37 (3.4)	38 (3.4)	
BMI Group			
Underweight	46 (4.3)	33 (3.1)	0.166
Normal	317 (29.4)	353 (33.1)	
Overweight	467 (43.2)	437 (40.9)	
Obese	191 (17.7)	198 (18.5)	
Morbidity obese	59 (5.5)	47 (4.4)	

Variables	(-) CKD (N=1104)	(+) CKD (N=1104)	P value
HB			
Mean ± SD	12.0 ± 2.0	12.1 ± 2.1	0.093
Median (Q1, Q3)	11.9 (10.5, 13.4)	12.1 (10.6, 13.6)	
Creatinine			
Mean ± SD	114.6 ± 33.4	148.6 ± 66.1	< 0.001*
Median (Q1, Q3)	109.0 (97.0, 125.0)	132.0 (115.0, 158.0)	
Angina			
CSS (No sign)	436 (39.5)	447 (40.5)	0.720
CSS1	449 (40.7)	436 (39.5)	
CSS 2	185 (16.8)	180 (16.3)	
CSS 3	22 (2.0)	22 (2.0)	
CSS 4	11 (1.0)	18 (1.6)	
Dyspnea			
NYHA I	476 (43.2)	468 (42.5)	0.833
NYHA II	584 (53.0)	585 (53.1)	
NYHA III	39 (3.5)	44 (4.0)	
NYHA IV	3 (0.3)	5 (0.5)	
Smoking status			
Never	537 (57.2)	544 (57.8)	0.769

Variables	**(-) CKD (N=1104)**	**(+) CKD (N=1104)**	**P value**
Current smoker	93 (9.9)	84 (8.9)	
Ex-smoker	309 (32.9)	313 (33.3)	
Ejection fraction			
Mean ± SD	47.0 ± 11.4	45.9 ± 11.2	0.027*
Median (Q1, Q3)	48.0 (39.0, 56.0)	46.0 (37.0, 55.0)	
Ejection fraction group			
EF: <= 20%	15 (1.4)	15 (1.4)	0.332
EF: 21-30%	95 (8.9)	117 (10.7)	
EF: 31-50%	534 (49.8)	557 (51.1)	
EF: > 50%	428 (39.9)	402 (36.8)	
Urgency			
Elective	893 (80.9)	887 (80.3)	0.846
Urgent	175 (15.9)	186 (16.8)	
Emergency	33 (3.0)	29 (2.6)	
Myocardial infarction (MI)	577 (54.5)	584 (55.1)	0.406
Percutaneous Coronary Intervention (PCI)	142 (13.5)	137 (13.0)	0.405
Previous Cardiac	127 (11.7)	122 (11.2)	0.394
Pulmonary	79 (7.2)	71 (6.5)	0.281
DM	531 (53.4)	582 (58.8)	0.008*

Variables	(-) CKD (N=1104)	(+) CKD (N=1104)	P value
Neurological	66 (6.0)	88 (8.0)	0.040*
Poor mobility	26 (2.4)	38 (3.4)	0.081
Gastroenterology	47 (4.7)	82 (8.0)	0.002*
Hypertension	998 (90.6)	999 (90.7)	0.474
Hypercholesterolemia	931 (85.0)	966 (87.9)	0.028*
Sinus rhythm	972 (88.0)	982 (88.9)	0.274
Atrial fibrillation	67 (6.1)	80 (7.2)	0.153
Angiography	213 (19.3)	188 (17.0)	0.093
Timing between coronary angiography			
Mean ± SD	6.2 ± 6.3	5.3 ± 7.2	0.145
Median (Q1, Q3)	6.0 (2.0, 9.0)	5.0 (1.0, 8.0)	
Timing between coronary angiography			
<= 5 days	94 (44.1)	91 (48.4)	0.225
> 5 days	119 (55.9)	97 (51.6)	
Intra operative			
CBP time (mins)			
Mean ± SD	112.8 ± 55.0	110.5 ± 48.6	0.309
Median (Q1, Q3)	98.0 (76.0, 135.3)	99.0 (76.0, 134.0)	
Cross clamp time (mins)			

Variables	**(-) CKD (N=1104)**	**(+) CKD (N=1104)**	**P value**
Mean ± SD	89.2 ± 60.0	86.1 ± 41.1	0.167
Median (Q1, Q3)	75.0 (58.0, 106.0)	77.0 (59.0, 105.0)	
Hemofiltration			
Mean ± SD	-203.8 ± 629.4	-337.2 ± 775.1	< 0.001*
Median (Q1, Q3)	0.0 (0, 0)	0 (-700.0, 0)	
Post operative			
Reoperation	149 (13.8)	188 (17.5)	0.011*
Stroke	14 (1.3)	23 (2.2)	0.085
Pulmonary complication	73 (6.7)	115 (10.6)	< 0.001*
GI Complication	9 (0.8)	37 (3.4)	< 0.001*
Heart failure	18 (1.6)	28 (2.6)	0.085*
Period MI	14 (1.3)	12 (1.1)	0.430
Surgical site infection	18 (1.7)	31 (2.9)	0.040*
Arrythmias	439 (40.1)	462 (42.4)	0.144
Pericardial effusion	110 (10.1)	121 (11.2)	0.234
Pleural effusion	99 (9.2)	134 (12.4)	0.010*
Fever	73 (6.7)	90 (8.3)	0.092
Transfused	914 (82.8)	965 (87.4)	0.001*

Variables	(-) CKD (N=1104)	(+) CKD (N=1104)	P value
Platelet	389 (35.2)	429 (38.9)	0.043*
Fresh frozen plasma	425 (38.5)	451 (40.9)	0.138
Cryoprecipitate	382 (34.6)	415 (37.6)	0.078
HB Day 1			
Mean ± SD	10.6 ± 1.3	10.7 ± 1.3	0.926
Median (Q1, Q3)	10.6 (9.8, 11.5)	10.6 (9.8, 11.4)	
HB Day 2			
Mean ± SD	10.1 ± 1.0	10.1 ± 1.1	0.983
Median (Q1, Q3)	10.1 (9.4, 10.8)	10.0 (9.4, 10.7)	
Creatinine			
Mean ± SD	127.2 ± 38.6	164.9 ± 68.0	< 0.001*
Median (Q1, Q3)	123.0 (103.0, 144.0)	149.0 (125.0, 185.0)	
Creatinine before discharge			
Mean ± SD	111.1 ± 45.4	154.5 ± 85.9	< 0.001*
Median (Q1, Q3)	102.0 (87.0, 123.0)	132.0 (109.0, 169.0)	
Mortality			

Variables	(-) CKD (N=1104)	(+) CKD (N=1104)	P value
Alive	1039 (94.1)	991 (89.8)	< 0.001*
Dead	65 (5.9)	113 (10.2)	
ICU Stay			
Mean ± SD	1.1 ± 0.2	1.1 ± 0.3	< 0.001*
Median (Q1, Q3)	1.0 (1.0, 1.0)	1.0 (1.0, 1.0)	
Hospital Stay			
Mean ± SD	14.1 ± 8.7	16.0 ± 12.7	< 0.001*
Median (Q1, Q3)	11.0 (9.0, 16.0)	12.0 (9.0, 17.0)	

Risk factors/predictors of post-operative AKI required dialysis post cardiac surgery

Logistics regression

Variables	Univariate analysis		Multivariate analysis	
	COR (95%CI)	P value	AOR (95%CI)	P value
Pre-operative				
Age	1.037 (1.019, 1.055)	< 0.001*	1.038 (1.003, 1.073)	0.033*
Gender; Male as reference	1.397 (0.993, 1.966)	0.055		
Race; Malay as reference				
Chinese	1.223 (0.824, 1.817)	0.318		
Indian	1.211 (0.794, 1.847)	0.375		
Others	1.182 (0.556, 2.509)	0.664		
BMI Group; Normal as reference				
Underweight	1.472 (0.805, 2.693)	0.209	Not significant -remove from fitted model using Stepwise	
Overweight	0.455 (0.323,0.639)	< 0.001*		

Variables	Univariate analysis		Multivariate analysis	
	COR (95%CI)	P value	AOR (95%CI)	P value
Obese	0.582 (0.383,0.886)	0.011		
Morbidity obese	0.246 (0.089,0.685)	0.007		
HB	0.797 (0.739,0.859)	< 0.001*	Not significant -remove from fitted model using Stepwise	
Creatinine	1.014 (1.011,1.016)	< 0.001*		
Angina; CSS (No sign) as reference				
CSS1	0.891 (0.641, 1.239)	0.493		
CSS 2	1.102 (0.732,1.659)	0.642		
CSS 3	2.512 (1.167,5.409)	0.019*		
CSS 4	5.970 (2.726,13.071)	< 0.001*		
Dyspnea; NYHA I as reference				

Variables	Univariate analysis		Multivariate analysis	
	COR (95%CI)	**P value**	**AOR (95%CI)**	**P value**
NYHA II	1.276 (0.942,1.730)	0.116	Not significant -remove from fitted model using Stepwise	
NYHA III	3.209 (1.809,5.690)	< 0.001*		
NYHA IV	6.952 (1.630,29.657)	0.009*		
Smoking status; Never as reference				
Current smoker	0.597 (0.314,1.134)	0.115		
Ex-smoker	0.980 (0.704,1.364)	0.903		
Ejection fraction; EF: > 50%				
EF: <= 20%	3.208 (1.263,8.151)	0.014	Not significant -remove from fitted model using Stepwise	
EF: 21-30%	2.281 (1.442,3.609)	< 0.001*		
EF: 31-50%	1.483 (1.069,2.056)	0.018		

Variables	Univariate analysis		Multivariate analysis	
	COR (95%CI)	P value	AOR (95%CI)	P value
Urgency; Elective as reference				
Urgent	2.186 (1.578,3.030)	< 0.001*	2.393 (1.211, 4.726)	0.012*
Emergency	1.658 (0.774,3.551)	0.193	0.048 (0.002, 1.301)	0.071
Salvage	2.798 (0.311,25.197)	0.359	1.000 (11432, 0)	1.000
Myocardial infarction (MI)	0.880 (0.661,1.172)	0.382		
Percutaneous Coronary Intervention (PCI)	0.684 (0.423,1.104)	0.120		
Previous Cardiac	1.053 (0.678,1.636)	0.817		
Pulmonary	1.388 (0.839, 2.295)	0.202		
DM	1.561 (1.145,2.128)	0.005*	1.798 (1.001, 3.231)	0.050

Variables	Univariate analysis		Multivariate analysis	
	COR (95%CI)	**P value**	**AOR (95%CI)**	**P value**
CKD	2.751 (2.019, 3.749)	< 0.001*	Not significant -remove from fitted model using Stepwise	
Neurological	0.850 (0.473,1.528)	0.587		
Poor mobility	1.547 (0.754,3.176)	0.235		
Gastroenterology	2.091 (1.299,3.367)	0.002*	Not significant -remove from fitted model using Stepwise	
Hypertension	1.065 (0.650,1.746)	0.803		
Hypercholesterolemia	1.489 (0.932,2.377)	0.096		
Renal disease	3.003 (2.117, 4.260)	< 0.001*	Not significant -remove from fitted model using Stepwise	
Sinus rhythm	0.657 (0.443,0.972)	0.036*		

Variables	Univariate analysis		Multivariate analysis	
	COR (95%CI)	P value	AOR (95%CI)	P value
Atrial fibrillation	1.420 (0.858,2.351)	0.172		
Angiography	1.427 (1.019,1.999)	0.039*	Not significant -remove from fitted model using Stepwise	
Timing between coronary angiography	0.986 (0.945,1.029)	0.525		
Intra operative				
CBP time (mins)	1.004 (1.002,1.007)	< 0.001*	Not significant -remove from fitted model using Stepwise	
Cross clamp time (mins)	1.002 (1.000,1.005)	0.048*		
Hemofiltration	0.999 (0.999,1.000)	< 0.001*		
Post-operative				
Reoperation	8.574 (6.281,11.704)	< 0.001*	7.202 (4.127, 12.568)	< 0.001*
Stroke	5.791 (2.899,11.567)	< 0.001*	Not significant -remove from fitted model using Stepwise	

Variables	Univariate analysis		Multivariate analysis	
	COR (95%CI)	P value	AOR (95%CI)	P value
Pulmonary complication	16.447 (11.675,23.171)	< 0.001*	4.347 (2.149, 8.794)	< 0.001*
GI Complication	20.936 (11.193,39.158)	< 0.001*	5.259 (1.355, 20.412)	0.016*
Heart failure	17.146 (9.300,31.613)	< 0.001*	4.209 (1.027, 17.247)	< 0.001*
Period MI	4.456 (1.913,10.381)	< 0.001*	Not significant -remove from fitted model using Stepwise	
Surgical site infection	6.011 (3.300,10.952)	< 0.001*		
Arrythmias	4.610 (3.344,6.356)	< 0.001*		
Pericardial effusion	3.351 (2.362,4.754)	< 0.001*		
Pleural effusion	3.646 (2.582,5.150)	< 0.001*		
Fever	6.521 (4.534,9.380)	< 0.001*		
Transfused	6.701 (2.950,15.219)	< 0.001*		

Variables	Univariate analysis		Multivariate analysis	
	COR (95%CI)	**P value**	**AOR (95%CI)**	**P value**
Platelet	5.141 (3.761,7.027)	< 0.001*		
Fresh frozen plasma	3.995 (2.944,5.421)	< 0.001*		
Cryoprecipitate	4.325 (3.199,5.848)	< 0.001*		
HB Day 1	0.787 (0.702,0.883)	< 0.001*		
HB Day 2	1.127 (0.986,1.289)	0.081		
Creatinine after operation	1.017 (1.014,1.019)	< 0.001*	1.011 (1.005, 1.016)	< 0.001*
Creatinine before discharge	1.012 (1.010,1.014)	< 0.001*	1.006 (1.002, 1.010)	0.003*
ICU Stay	1.206 (1.173,1.240)	< 0.001*	1.148 (1.081, 1.220)	< 0.001*
Hospital Stay	1.079 (1.066,1.092)	< 0.001*	0.963 (0.929, 0.997)	0.035*

Propensity score matching analysis

Covariate factors	Before propensity			
	Without CKD	With CKD	SMD	P value
	N= 5,675	N= 1,104		
Age; median (IQR)	61 (53, 67)	65 (58,70)	0.462	< 0.001*
Gender = Male (%)	4,329 (76.0)	898 (81)	0.124	< 0.001*
Angina = CSS,No sign (%)	2,822 (50.0)	447 (40.0)	0.208	< 0.001*
Dyspnea = NYHA I (%)	3,184 (56.0)	468 (42.0)	0.295	< 0.001*
Smoking = Yes (%)	1,808 (37.0)	397 (42.0)	0.117	0.001
Hypertension = Yes (%)	4,000 (71.0)	999 (91.0)	0.523	< 0.001*
Diabetes = Yes (%)	2,068 (40.0)	582 (59.0)	0.371	< 0.001*
Creatinine; median (IQR)	86 (71, 100)	131 (113, 157)	1.072	< 0.001*
Urgency = Elective (%)	4,855 (86.0)	887 (80.0)	0.159	< 0.001*
Ejection fraction; median (IQR)	51 (43, 58)	46 (37, 55)	0.196	< 0.001*

Commented [n1]: May discard the After propensity result, just retain the Before propensity table in Supplementary (to avoid redundancy). Already presented at Table 1 in Results section.