Journal of the Saudi Heart Association

Manuscript 1322

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ORIGINAL ARTICLE

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Abstract

Background and objectives: **Following cardiac surgery, acute kidney injury (AKI) is a well-known complication that increases morbidity and mortality. This study was carried out to determine the factors associated with acute kidney injury and to assess the predictive value of three predictive scores for the development of AKI post-cardiac surgery in the Saudi community.**

Methods: **In this retrospective study, the medical records of patients aged 18 years and above who underwent cardiac surgery on cardiopulmonary bypass (CPB) at Saud Albabtin Cardiac Center between January 2018 and March 2021 were reviewed. The first stage of both Kidney Disease Improving Global Outcomes (KDIGO) criteria and the risk, injury, failure, loss, end-stage (RIFLE) criteria were used to define AKI. The predicting value for acute kidney injury following cardiac surgery (AKICS score) and Renal replacement therapy for acute kidney injury (RRT-AKI) (Cleveland score, and SRI) were evaluated by area under receiver operating characteristic curve (AUROC) for the discrimination and Hosmer−Lemeshow test for the calibration.**

Results: **Among the 329 patients evaluated, the total postoperative incidence of acute kidney injury was 26.4%. Moreover, the incidence of RRT-AKI was 2.1%. Using multivariate logistic analysis, the factors independently associated with AKI were CABG on pump-beating heart, presence of chronic kidney disease, pre-operative anemia, prolonged bypass time, and post-operative exposure to inotropes or vasopressors. For the prediction of CSA-AKI, the discrimination of AKICS (AUROC = 0.689) was poor, while the calibration (x2 = 9.380, P = 0.311) was fair. For RRT-AKI prediction, the discrimination of Cleveland score (AUROC = 0.717) was fair while the discrimination of SRI (AUROC = 0. 681) was poor. On the other hand, the calibration for both of them was fair (Cleveland score x2 = 3.339, P = 0.342; SRI x2 = 7.326, P = 0.120).**

Conclusion: **In this single-center study, SRI score demonstrated a reasonably good prediction of RRT-AKI incidence. However, further researches are required to investigate the perioperative factors in order to create a unique risk score model that may be used in a population with widespread comorbidities.**

Keywords: Acute kidney injury, Cardiac surgery, Cardiopulmonary bypass, Validation scores

1. Introduction

The risk of increased morbidity and mortality after cardiac surgery can be attributed to many causes and one of them is the development of acute kidney injury (AKI) post-operatively [1,2]. AKI after cardiac surgery carries a wide range of post-operative complications from increased intensive care unit (ICU) stay and hospital stay, to renal failure and dialysis [1,2]. The prevalence of AKI after cardiac surgery was reported to be up to 30%−50%. However, the prevalence of AKI-requiring dialysis post-

Received 15 September 2022; revised 4 December 2022; accepted 5 December 2022.
Available online 27 December 2022

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https://doi.org/10.37616/2212-5043.1322

cardiac surgery is about 4%. This wide range of AKI prevalence is attributed to type of definition used [3,4,5,6]. The reported incidence of AKI associated with coronary artery bypass grafting (CABG) is 8–15% [7,8]. The risk of AKI post-operatively increases by 4.8 folds for each 1 mg/dl increase in serum creatinine (SCr) level [9,10]. The severity of AKI is a main determinant of short- and long-term mortality being 10.7% and 30%, respectively, with increasing rates with more severe AKI [11].

For decades, more than thirty different definitions were used to diagnose AKI as there was no standard definition or staging system. RIFLE classification has been introduced by Bellomo et al. in which a reduction in estimated glomerular filtration rate (GFR) of >25% was the definition of the first stage of AKI. After that, the Acute Kidney Injury Network (AKIN) group suggested another definition of AKI involving an abrupt increase in SCr of 0.3 mg/dL or 50% or greater increase in SCr over baseline within 48 h. Lastly, Kidney Disease Improving Global Outcomes (KDIGO) workshop proposes a more concise definition of AKI which was established in 2012 including a 1.5 increase in SCr over 7 days or an increase in SCr of 0.3 mg/dL that persist over 48 h above the baseline [9].

Cardiac surgery-associated acute kidney injury (CS-AKI) pathophysiology is not well understood. It is usually due to multifactorial causes occurring during the preoperative, intraoperative and postoperative periods [12].

Coronary artery disease (CAD) is a major cause of death worldwide [13,14] and CABG predominates the procedures in cardiac surgery [13,14]. Cardiopulmonary bypass (CPB) carries a great risk for the development of AKI, though different interventional approaches have an impact on the onset of AKI [15]. Coronary surgery has not been directly linked to renal injury, unlike valve surgery which is an independent risk factor for postoperative AKI [16].

To manage CS-AKI appropriately, an accurate prediction model to identify high-risk patients is required to facilitate and optimize treatment strategies postoperatively and therefore improve the prognosis [17].

Several predictive models have been established to predict CS-AKI. These models include the Cleveland Clinic score, the acute kidney injury following cardiac surgery (AKICS) score, simplified renal index (SRI) score, and Mehta score [17] (Table 1). Each model has different predictors, and the definitions of AKI are inconsistent between these models. Furthermore, only a few models have included intraoperative variables as one of their predictors which is one of the major influences of the prediction of AKI post-operatively [18,19]. Therefore, it is important to recognize the factors and to validate a predictive model that can predict AKI development post-cardiac surgery, and by these, appropriate measures can be taken to reduce its incidence.

Abbreviation list

AKI	Acute kidney injury
CS-AKI	Cardiac surgery-associated acute kidney injury
CPB	Cardiopulmonary bypass
CABG	Coronary artery bypass grafting
KDIGO	Kidney Disease Improving Global Outcomes
SCr	Serum creatinine
AKICS score	Acute kidney injury following cardiac surgery score
RRT-AKI	Renal replacement therapy for acute kidney injury
SRI	Simplified renal index
AUROC	Area under receiver operating characteristic curve
OPBHC	On-pump beating-heart CABG

1.1. Objective of the study

This study aims to:

1. Validate the predictive value of three predictive scores (Cleveland score, acute kidney injury following cardiac surgery (AKICS score), and simplified renal index (SRI) score) for the development of AKI post-cardiac surgery in which the comorbidities are widely prevalent in Saudi Arabia.
2. Identify the factors associated with AKI after cardiac surgery.

2. Materials and methods

Patients aged 18 years and above who underwent cardiac surgery on cardiopulmonary bypass (CPB) between January 2018 and March 2021 were enrolled. Excluded from the study: patients who are less than 18 years, who had assisted device insertion, who required preoperative dialysis and renal transplant patients. Moreover, patients who did not meet the inclusion criteria for a specific predictive score were excluded from the analysis of that score (Table 1). If more than one cardiac surgical procedures were performed during the same hospitalization, only the data of the first procedure was considered. The study design was approved by the research ethics committee of the Research Exemption Board (REB) at Saud Al-Babtain Cardiac Center and it complied with the declaration of Helsinki updated on 2008.

Table 1. Predictive models of cardiac surgery-associated AKI.

Predictive models	Cleveland Score		SRI Score		AKICS Score	
Inclusion and exclusion criteria	Inclusion: First cardiac surgery only Exclusion: preoperative dialysis, previous renal transplant, heart transplant recipients, required preoperative extracorporeal membrane oxygenation, pre operative mechanical ventilation and/or left ventricular assist devices.		Inclusion: Adults (≥18 years) who underwent cardiac surgery under cardiopulmonary bypass. Exclusion: Patients who required pre-operative dialysis, had a SCr ≥3.4 mg/dL, and/or required procedures such as heart transplant and ventricular assist device		Inclusion: Elective CABG and/or valve replacement surgery with CPB. Exclusion: preoperative dialysis and serum creatinine >3 mg/dl, renal transplant patients, congenital heart disease repair and aortic aneurysm,	
Variable	RRT-AKI		RRT-AKI		AKI	
	Description	Score	Description	Score	Description	Score
Age					>65 years old	2.3
Gender	Female	1				
Diabetes	Insulin-requiring diabetes	1	Diabetes requiring medication	1	Preoperative capillary glucose >140 mg/dL	1.7
Preoperative kidney function	SCr 1.2 to< 2.1 mg/dL	2	GFR 31–60 mL/min	1	Preoperative SCr >1.2 mg/dL	3.1
	SCr ≥2.1 mg/dL	5	GFR ≤30 mL/min	2		
COPD	Yes	1				
CHF	Yes	1				
NYHA Class					3 or 4	3.2
Left ventricular EF	<35%	1	≤40%	1		
Previous cardiac surgery	Yes	1	Yes	1		
Preoperative IABP	Yes	2	Yes	1		
Urgency of surgery	Emergence	2	Non-elective	1		
CPB time					>120 min	1.8
Postoperative CVP					>14 cmH2O	1.7
Low cardiac output					Yes	2.5
Type of surgery	Valve only	1	Other than CABG	1	Combined surgery	3.7
	CABG + valve	2				
	Other cardiac surgeries	2				
Score range	0–17		0–8		0–20	

The database and medical records of all included patients were reviewed, and the data was collected on the basis of the demographic information and history (age at the time of surgery, gender, body mass index (BMI)),smoking, hypertension, peripheral vascular disease, diabetes mellitus, dyslipidaemia, chronic obstructive pulmonary disease (COPD), Liver disease, Chronic kidney disease(defined as chronic elevation of SCr ≥1.5 mg/dL preoperatively), stroke,anemia (<120 g/L for females and <130 g/L for males)], type of surgery, chronic heart failure (CHF), New York Heart Association (NYHA) classification, left ventricular ejection fraction(EF), urgency of surgery, SCr levels on preoperative laboratory testing, estimated glomerular filtration rate, pre-op glucose level in mg/dl, preoperative use of IABP, previous cardiac surgery).

Intraoperative variables were CPB duration, need to return to CPB, hematocrit level during CPB, aortic cross-clamp time and Inotropes use, ECMO or IABP insertion and transfusion of blood or blood products.

Postoperative variables include inotropes and vasopressors use, anemia, low cardiac output state, CVP value, transfusion of blood or blood products.

The primary outcome was the development of AKI after cardiac surgical procedures.

AKI was defined according to the first stage of Kidney Disease Improving Global Outcomes (KDIGO) criteria (defined earlier) which involve a 1.5 increase in SCr over 7 days or an increase in SCr of 0.3 mg/dL that persist over 48 h above the baseline [20] or a decrease in estimated glomerular filtration rate (GFR) of >25% as per the risk, injury, failure, loss, end-stage (RIFLE) criteria [9]. The GFR was calculated by an equation developed by the Chronic Kidney Disease Epidemiology Collaboration (CKD-EPI Equation):

$$GFR = 141 \times \min\left(Scr/\kappa, 1\right)^{\alpha} \times \max\left(\left(Scr/\kappa, 1\right)\right)^{-1.209} \times 0.993^{Age} \times 1.018\,[\text{if female}] \times 1.159\,[\text{if black}]$$

The baseline SCr value and GFR was determined by the most recent level before surgery.

The three prediction scores analysed in this study are Cleveland score, the acute kidney injury following cardiac surgery (AKICS) score, and simplified renal index (SRI) score.

AKI requiring dialysis was the outcome for validation of Cleveland score and SRI during the post-operative period until discharge. Development of uremia, hyperkalemia, acidosis or severe fluid overload were initiatives for the nephrologists to start the dialysis. KDIGO guideline was the outcome for validation of AKICS score.

2.1. Data analysis

Data entry and analysis was done using the statistical software program SPSS.

Logistic regression was used to identify the association between the development of AKI and different factors (variables). Continuous variables were demonstrated as means ± 1 standard deviation (SD). Non-parametric variables were demonstrated as median and 25–75 percentiles. Categorical variables were demonstrated as absolute (n) and relative (%) frequency. Odds ratios (OR) were demonstrated with 95% confidence interval (CI) and P-values. Variables that showed significant association (P-value <0.05) with the development of AKI were included in a multivariate logistic model.

To evaluate the calibration and discrimination of each predictive risk score, area under receiver operating characteristic curves (AUROC) and Hosmer–Lemeshow goodness of-fit test were used.

Discrimination defined as the ability to distinguish between people with disease from people without disease. Statistically, the AUROC >0.85 indicate good discrimination, AUROC between 0.70 and 0.85 indicates fair discrimination and AUROC <0.70 indicates poor discrimination. Moreover, calibration compare between observed and predicted risk (Hosmer–Lemeshow P value > 0.05 indicate fair calibration).

3. Results

A total of 355 medical records were reviewed. 26 patients were excluded (preoperative dialysis (n = 7), missing data (n = 17) and intra-operative and early post-operative death (<24 h) (n = 2)), 329 patients were enrolled in the study. Moreover, exclusion criteria for each score were applied e.g., patients who underwent elective surgeries only (n = 163) were qualified in the validation of AKICS score.

In our study, the total incidence of AKI was 26.4% (87/329). On the other hand, the incidence of RRT-AKI was 2.1% (7/329). Among the different variables, AKI was found to be associated with the presence of chronic kidney disease, anemia, prolonged cardiopulmonary bypass and/or aortic cross-clamp time, intra-operative insertion of ECMO or IABP and low cardiac output syndrome. Moreover, AKI was more common among elderly patients, patients who have hypertension, peripheral vascular disease, low hematocrit level during CPB, who was exposed to intraoperative or postoperative inotropes or vasopressors, who had intra or post-operative blood transfusion and elevated CVP measurement postoperatively (Table 2). The mean bypass duration in patients who developed AKI was 141 min compared to 115 min in patients who did not develop AKI post cardiac surgery.

Smoking history, the presence of diabetes mellites, dyslipidemia, chronic obstructive pulmonary disease, liver disease, prior stroke, pre operative CHF, advanced NYHA classification, left ventricular dysfunction, urgent/emergent surgery, elevated pre-op glucose level, preoperative use of IABP and previous cardiac surgery were not associated with the development of AKI.

Using multivariate logistic analysis, CABG on pump-beating heart (OR = 5.08, 95% CI: 1.3–19.2), presence of chronic kidney disease (OR = 0.068, 95% CI: 0.01–0.34), pre-operative anemia (OR = 0.48, 95% CI: 0.25–0.91), prolonged bypass time (OR = 1.01, 95% CI: 1.0–1.02) and post-operative exposure to inotropes or vasopressors (OR = 0.36, 95% CI: 0.16–0.77) were independently associated with the development of AKI (Table 3).

The discrimination (area under the curve (AUC), 95% CI, P-value) for the prediction of CS-AKI of AKICS (0.689, 95% CI 0.599 to 0.779, P-value 0.001) (Table 4, Fig. 1) and the prediction of RRT-AKI of SRI (0. 681, 95% CI 0. 516 to 0.846, P-value 0.102) were poor. However, the discrimination of Cleveland score (0.717, 95% CI 0.464 to 0. 969, P-value 0.050) was fair (Table 5, Fig. 2). On the other hand, the findings showed a fair calibration for Cleveland score ($x2 = 3.339$, $P = 0.342$), SRI score ($x2 = 7.326$, $P = 0.120$) and AKICS score ($x2 = 9.380$, $P = 0.311$).

Compared to the predicted incidence of AKI post cardiac surgery, it has been found that AKICS score underestimate the incidence of AKI (predicted 14% vs observed 21.5%). Moreover, the Cleveland score was also found to underestimate the incidence of RRT-AKI slightly (predicted 1.7% vs observed 2.1%). The SRI score was the only score who showed reasonably good prediction of the incidence of RRT-AKI (predicted 1.3–2.2%% vs observed 2.1%) (Table 6).

Table 2. Patients 'characteristics and intraoperative variables associated with acute kidney injury after cardiac surgery.

Variable	Acute kidney injury		No acute kidney injury		Crude OR (95% CI)	*P*-value
	No. %	No. mean(SD)	No. %	No. mean(SD)		
DEMOGRAPHIC:						
Age	87	58.4(9.1)	242	53.9(10.9)	1.08 (1.0-1.1)	0.001
Sex						
Male	72	82.8%	202	83.5%		
Female	15	17.2%	40	16.5%	1.05 (0.55-2.0)	0.88
BMI	87	28.9(5.7)	242	28.6(6.4)	1.0 (0.97-1.0)	0.75
PREOPERTAIVE:						
Type of surgery:						
CABG only	53	60.9%	134	55.4%		0.31
Valve only	6	6.9%	38	15.7%	0.39 (0.16-1)	0.050
Combined (CABG and VALVE)	6	6.9%	10	4.1%	1.5 (0.52-4.4)	0.44
CABG on pumb-beating heart	17	19.6%	47	19.4%	0.91 (0.48-1.7)	0.78
Other cardiac surgeries	5	5.7%	13	5.4%	0.97 (0.33-2.8)	0.96
Diabetes mellites						
Yes						
With insulin	35	40.3%	110	45.5%		0.60
Without insulin	19	21.8%	54	22.3%	1.1 (0.56-2.1)	0.76
No	33	37.9%	78	32.2%	1.3 (0.76-2.3)	0.32
Hypertension						
Yes	72	82.8%	173	71.5%		
No	15	17.2%	69	28.5%	0.52 (0.29-0.98)	0.041
Peripheral vascular disease						
Yes	31	35.6%	46	19%		
No	56	64.4%	196	81%	0.42 (0.24-0.73)	0.002
Chronic kidney disease						
Yes	7	8%	3	1.2%		
No	80	92%	239	98.8%	0.14 (0.04-0.5)	0.006
Anemia						
Yes	44	50.6%	78	32.2%		
No	43	49.4%	164	67.8%	0.47 (0.28-0.7)	0.003
Intraoperative:						
CPB duration	87	141(98,183)	242	115(88,143)	1 (1-1.01)	0.000
Hematocrit level during CPB	87	25.9(2.7)	242	26.8(3.2)	0.89 (0.82-0.98)	0.016
Aortic cross-clamp duration	87	86(66.4)	242	71(49.2)	1 (1.0-1.0)	0.031
Inotrope and vasopressors exposure						
Yes	80	92%	194	80.2%		
No	7	8%	48	19.8%	0.35 (0.15-0.8)	0.015
ECMO or IABP insertion						
Yes	14	16.1%	10	4.1%		
No	73	83.9%	232	95.9%	0.23 (0.09-0.53)	0.001
Transfusion of blood or blood products						
Yes	76	87.4%	180	74.4%		
No	11	12.6%	62	25.6%	0.42 (0.2-0.84)	0.014
Postoperative:						
Inotropes and vasopressors use						
Yes	67	77%	111	45.9%		
No	20	23%	131	54.1%	0.25 (0.14-0.44)	0.000
Anemia (Postop Hb)	87	7.8(0.9)	242	8.2(.9)	0.55 (0.39-0.76)	0.000
Low cardiac output syndrome						
Yes	23	26.4%	14	5.8%		
No	64	73.6%	228	94.2%	0.18 (0.08-0.35)	0.000
CVP	87	15.6(3.6)	242	14.2(3.4)	1.12 (1.04-1.19)	0.003
Transfusion of blood or blood products						
Yes	77	88.5%	169	69.8%		
No	10	11.5%	73	30.2%	0.3 (0.15-0.6)	0.001

4. Discussion

Acute kidney injury following cardiac surgery confers a major medical drawback and it plays a significant role in increasing short-term morbidity and long-term mortality [21]. The incidence of AKI after cardiac surgery varies in the literature and it has been attributed to different criteria used to

Table 3. Multivariate analysis of risk factors associated with the development of Cardiac surgery-associated acute kidney injury.

Variable	Adjusted OR (95% CI)	P-value
DEMOGRAPHIC:		
Age	1.03 (1.0−1.07)	0.46
PREOPERTAIVE:		
Type of surgery:		
CABG only		0.11
Valve only	1.2 (0.19−7.9)	0.83
Combined (CABG and VALVE)	4.8 (0.8−29)	0.09
CABG on pumb-beating heart	5.08 (1.3−19.2)	0.017
Other cardiac surgeries	2.4 (0.42−13.8)	0.32
Chronic kidney disease		
Yes		
No	0.068 (0.01−0.34)	0.001
Anemia		
Yes		
No	0.48 (0.25−0.91)	0.026
Intraoperative:		
CPB duration	1.01 (1.0−1.02)	0.029
Inotrope and vasopressors exposure		
Yes		
No	0.99 (0.36−2.7)	0.98
Transfusion of blood or blood products		
Yes		
No	0.94 (0.41−2.1)	0.88
Postoperative:		
Inotropes and vasopressors use		
Yes		
No	0.36 (0.16−0.77)	0.008
Anemia (Postop Hb)	0.69 (0.456−1.04)	0.08

define AKI [22]. It is worth noting that earlier studies utilized arbitrary criteria to define AKI such as an increase of 50% in SCr, a raise of 1.0 mg/dL or greater above baseline, or AKI requiring dialysis [23,24]. Alkhunaizi et al. analyzed data from 293 patients who had cardiac surgery at Dhahran Health Centre in eastern Saudi Arabia and found an overall incidence of AKI of 29.0% [25] In this study, a more concise definition of AKI per the recommendations of the Kidney Disease Improving Global Outcomes (KDIGO) criteria and RIFLE criteria were used. Based on recent evidence, it is suggested that the use of the Kidney Disease Improving Global Outcomes (KDIGO) criteria has a higher sensitivity in diagnosing AKI following open-heart surgery and to estimate in-hospital death [18,26]. This may explain the lower incidence of AKI in our study (26.4%).

The pathogenesis of AKI following cardiac surgery is complex and has been linked to numerous factors occurring in the perioperative period, resulting in either reduction in renal perfusion or decline in renal reserve [27]. These factors include advancing age, diabetes mellitus, hypertension, COPD, pre-existing kidney disease, peripheral vascular disease, preoperative anemia, ECMO or IABP insertion, prolonged cardiopulmonary bypass, and/or aortic cross-clamp time, haemodilution resulting in low hematocrit level during CPB [5,25,27]. In this retrospective study, many but not all these factors were found to be linked with the development of AKI following cardiac surgery. The variation between our results and those described in earlier studies may be attributed to the difference in the population size and patients' characteristics.

Table 4. The discrimination for the prediction of CS-AKI of AKICS.

Area Under the Curve				
Test Result Variable(s):AKICS				
Area	Std. Error[a]	Asymptotic Sig.[b]	Asymptotic 95% Confidence Interval	
			Lower Bound	Upper Bound
0.689	0.046	0.001	0.599	0.779

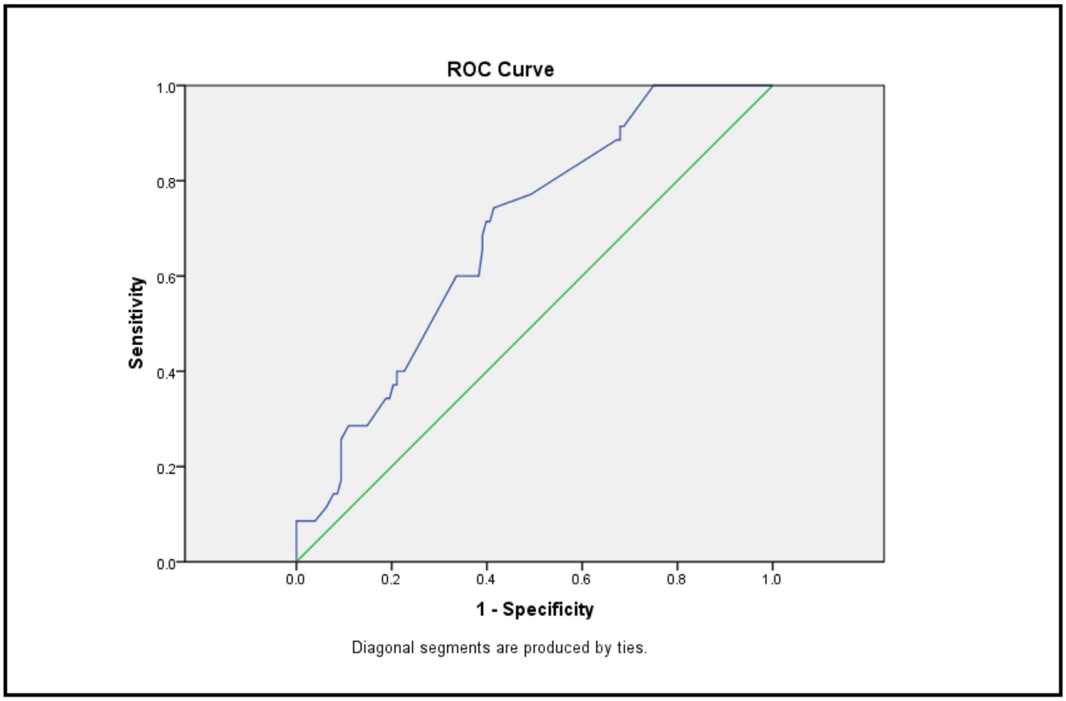

Fig. 1. ROC curve for the prediction of CSA-AKI of AKICS score.

Moreover, multivariate analysis demonstrated that the presence of chronic kidney disease, preoperative anemia, prolonged bypass time, and post-operative exposure to inotropes or vasopressors were independently associated with the development of AKI. These findings are consistent with those of Pontes et al. [28] and Ramos et al. [29] who found a relationship between the use of postoperative inotropic drugs and the development of AKI. A popular explanation of this is that the hemodynamic instability and poor cardiac performance in such cases are likely associated with the mechanisms of renal ischemia and reperfusion injury [30].

Although several studies demonstrated that patients who have valvular surgery, with or without coronary artery bypass graft (CABG) are at a higher risk of developing AKI than those who have CABG alone [17,29,31], this finding contrasted with our result. This study showed that patients who underwent CABG on pump-beating heart surgery are more likely to develop AKI than in other types of cardiac surgery. It is difficult to explain such results but the fact that on-pump beating-heart CABG (OPBHC) is usually used in high-risk patients in which off-pump CABG cannot be utilized due to hemodynamic deterioration and adequate end-organ perfusion can't be achieved which may explain such result [32]. Furthermore, OPBHC is an alternative to on-pump CABG in which complications from cardioplegic arrest or manipulation of the heart are anticipated [32].

In the last two decades, several predictive scores have been established to estimate the risk of AKI or RRT-AKI following cardiac surgery so that preventive measures can be taken in high-risk patients [33]. Since the Cleveland clinic score, AKICS score, and the simplified renal index score have been validated in the Caucasian cohorts with adequate predictive power, utilizing these risk models in a population other than Caucasians is needed [3,5,34]. Palomba

Table 5. The discrimination for the prediction of RRT-AKI of Cleveland score and SRI score.

Area Under the Curve					
Test Result Variable(s)	Area	Std. Error[a]	Asymptotic Sig.[b]	Asymptotic 95% Confidence Interval	
				Lower Bound	Upper Bound
Cleveland	0.717	0.129	0.050	0.464	0.969
SRI	0.681	0.084	0.102	0.516	0.846

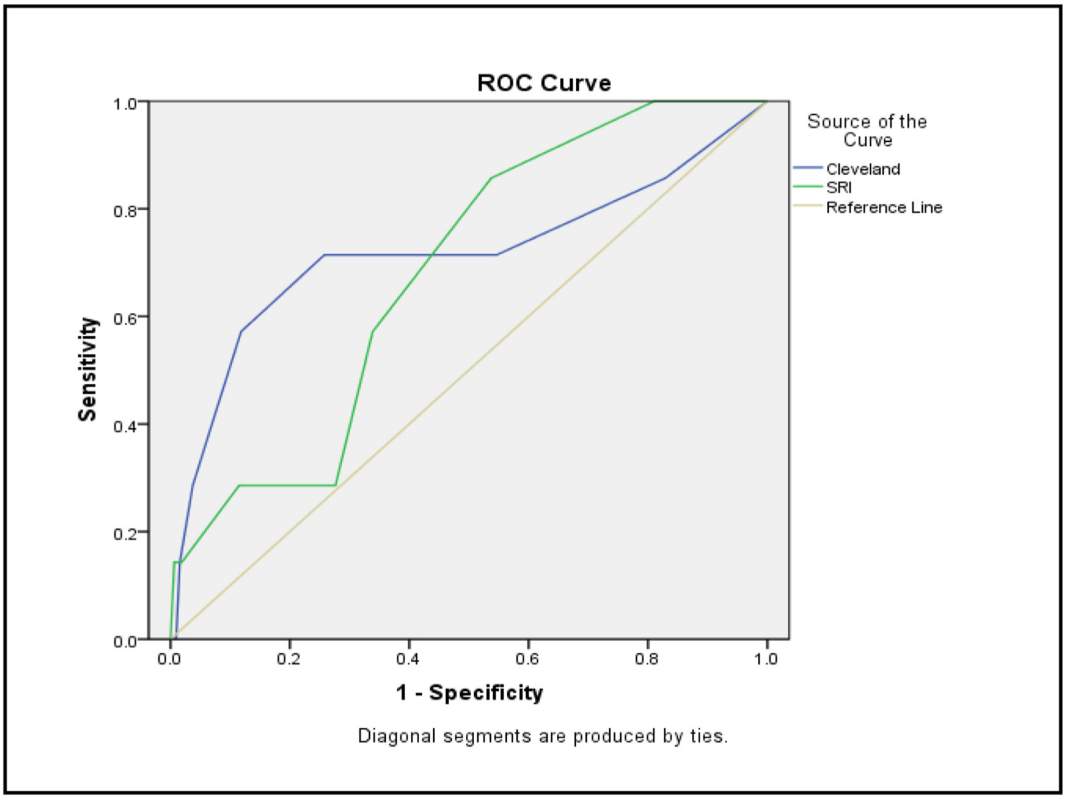

Fig. 2. ROC curve for the prediction of RRT-AKI of Cleveland score and SRI score.

et al. have developed a score to predict CSA-AKI by analyzing a cohort of 603 patients who underwent elective valve replacement and/or CABG surgery. In that cohort, the definition of AKI was a raise of SCr above 2.0 mg/dl within 7 days following cardiac surgery for patients with a baseline SCr less than 1.5 mg/dl. For patients with a baseline SCr between 1.5 and 3.0 mg/dl, AKI was defined as a 50% increase over the baseline value. In addition, the intraoperative and early postoperative risk factors have been identified as a contributor to CSA-AKI. As a result, the predictive power of this score was good with AUROC 0.84(34). In our study, however, the validation of this score is not as good as that which can be contributed to the discrepancy between the CSA-AKI definition in the primary cohort and the present study. Moreover, racial differences may also affect the validation result.

The other two risk models analyzed in this study were derived from large sample cohorts predicting RRT-AKI. SRI score was established by Wijeysundera et al. in multicentre studies and has been validated among the Caucasian population [3]. Although the present study revealed poor discrimination of this score, the SRI score was the only score that showed a reasonably good prediction of the incidence of renal replacement therapy (RRT) following cardiac surgery. The Cleveland Clinic score was created by Thakar et al. from a cohort of 31,677 patients who had open-heart surgery. The predictive power of this cohort was good with AUROC 0.82 [5]. The current study showed a fair discrimination of this score (AUROC 0.717) but with an underestimated RRT-AKI incidence. These results may be due to the fact that the primary outcome for both scores is AKI requiring dialysis. Although it has been disputed whether or not early initiation of dialysis is beneficial up to this point [35], certain studies have suggested that it can lower short-term mortality [36]. So based on the above, the incidence may be greatly impacted by the variation in local practices regarding when to start dialysis. Moreover, despite the use of tight inclusion and

Table 6. Comparison between predicted and observed outcomes for each score.

	AKI	AKI Requiring Dialysis	
	AKICS n = 165	Cleveland n = 329	SRI n = 329
Predicted[a]	14%	1.7%	1.3−2.2%
Observed	21.5%	2.1%	2.1%

[a] The predicted incidences of each outcome were derived from the origin papers.

exclusion criteria, there was still a significant discrepancy between our cohort and the derivation cohorts especially in the patients' characteristics and the comorbidities which are widely present in our community.

The present study has some limitations including the single-centre data, the relatively small population size and the retrospective observational study design.

5. Conclusion

Preventive and therapeutic strategies are greatly needed since AKI following cardiac surgery is significantly associated with high morbidity and mortality. This study was design to validate three risk scores that could predict either CSA-AKI or RRT-AKI. The only score with a reasonably good prediction of RRT-AKI incidence was SRI score. Further researches are needed to analyze the risk factors in the perioperative period in order to generate a specific risk score models that can be utilize in population with widely prevalent comorbidities.

Source of funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Author contribution

Conception and design of Study: MSK; Literature review: AAA, AMA; Acquisition of data: AAA, AMA, ASA, FNA, MSK; Analysis and interpretation of data: FNA; Research investigation and analysis: AAA, AMA, FNA; Data collection: AAA, AMA, ASA, FNA; Drafting of manuscript: AAA, AMA, FNA, HSA: Revising and editing the manuscript critically for important intellectual contents: ASA, HSA, MSK: Data preparation and presentation: AAA, ASA, FNA, HSA; Supervision of the research: ASA, MSK; Research coordination and management: AAA, ASA, MSK.

Acknowledgment

None.

Conflict of interest

None declared.

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