Mehta tool as favorable scoring to predict the need for renal replacement therapy in post-CABG patients

Gian Christian Kasim[1], Andi Adil[1], Muhammad Rum[1], Syafri Kamsul Arif[1], Alamsyah Ambo Ala Husain[1], Andi Alamsyah Irwan[1]

Abstract

***Objective*: The study aimed to determine the comparison of the Cleveland Clinic Score, simplified renal index, and Mehta tool in predicting the need for renal replacement therapy in post-coronary artery bypass graft (CABG) patients in Makassar.**

***Design*: This study employed an analytical observational methodology, utilizing a retrospective approach.**

***Setting*: Medical record data for the period of January 2019-December 2023 at the Integrated Heart Center of Dr. Wahidin Sudirohusodo Central General Hospital, Makassar.**

***Patient and participants*: Patients undergoing CABG surgical procedures.**

***Interventions*: None.**

***Measurement and results*: The data collected included demographic data (age, gender, body mass index [BMI], American Society of Anesthesiologists Physical Status [ASA PS]), the prevalence of renal replacement therapy and diagnostic testing, Cleveland Clinic Score, simplified renal index, and the Mehta tool with area under the curve (AUC). Cleveland Clinic score, simplified renal index, and Mehta tool have good discrimination in predicting post-CABG kidney replacement therapy in predicting post-CABG kidney replacement therapy, where the best discrimination is the Cleveland Clinic Score. Mehta tool obtained the best accuracy, reaching 85.95%.**

***Conclusions*: The Cleveland Clinic Score, simplified renal index, and Mehta tool could be used to predict the need for post-CABG kidney replacement therapy. The Cleveland Clinic Score had the best discrimination, while the Mehta tool had the best diagnostic accuracy.**

Key words: Coronary artery bypass graft, Cleveland Clinic Score, Mehta tool, simplified renal index, renal replacement therapy.

[1] Department of Anesthesiology, Intensive Therapy, and Pain Management, Faculty of Medicine, Hasanuddin University/Dr. Wahidin Sudirohusodo Central General Hospital, Makassar, South Sulawesi, Indonesia

Address for correspondence:
Andi Adil
Dr. Wahidin Sudirohusodo Central General Hospital
Jln. Perintis Kemerdekaan Km.11, Tamalanrea Jaya, Tamalanrea, Makassar, South Sulawesi 90245, Indonesia
Tel: +62853-9979-1104
Email: adil_zanetti@yahoo.co.id

Introduction

Acute kidney injury is one of the most common complications after coronary artery bypass graft (CABG), with an incidence rate of between 20-42%. (1) Severe post-CABG acute kidney injury can increase mortality by 3-8 times higher, increase treatment costs, and increase the length of stay both in the intensive care unit (ICU) and in the hospital in general, which is longer compared to patients without acute kidney injury. (2)

In patients with acute kidney injury after cardiac surgery, renal replacement therapy should be performed as early as possible to promote recovery of renal function. (3) Early patient identification before surgery regarding the risk of acute kidney in-

jury after CABG can offer strategies for preventing acute kidney injury and more optimal treatment to improve kidney function. (1) Various tools have been developed to predict acute kidney injury requiring renal replacement therapy. (3) However, there are no guidelines recommending the use of specific prediction models.

Cleveland Clinic score (CCS), Mehta tool (MT), and simplified renal index (SRI) have been used to predict the need for dialysis initiation. (4) The validity of the three in predicting post-CABG renal replacement therapy varies in different populations. In a Spanish population, the CCS had the best discrimination compared with the MT and was similar to the SRI. (5) In the Rochester, New York population, the CCS and the MT demonstrated significantly better discrimination than the SRI score. (6) A comparison of the CCS, MT, and SRI in predicting post-CABG kidney replacement therapy in the population in Indonesia, in general, and Makassar, in particular, has never been done before. This study aimed to compare the CCS, SRI, and MT to predict the use of renal replacement therapy in post-CABG surgery patients in Makassar, Indonesia.

Methods

The retrospective observational study was conducted on patients who underwent CABG surgical procedures based on medical record data in the period of January 2019-December 2023 at the Integrated Heart Center of Dr. Wahidin Sudirohusodo Hospital, Makassar. Inclusion criteria were patients who underwent CABG surgery based on medical record data in the period of January 2019-December 2023, age >18 years, and patients with complete medical record data according to the data required by the research. Patients with renal failure and other renal diseases before CABG surgery, preoperative renal replacement therapy, preoperative mechanical ventilation, acute aortic dissection, and sepsis were excluded. Patient data regarding age, gender, body mass index (BMI), and American Society of Anesthesiologists Physical Status (ASA PS) were collected. In this study, diagnostic tests were carried out on the CCS, SRI, and MT. Data were analyzed using the area under the curve (AUC) with the help of the IBM SPSS 26 program.

Results

This study collected 121 patients who underwent CABG surgical procedures with an average age of 56.65±7.69 years and an average BMI of 25.05±3.31 kg/m^2. Most of the research subjects were male with ASA PS 3 (**Table 1**).

A total of 12 (9.9%) patients underwent renal replacement therapy after CABG surgery, and 38 (31.4%) patients experienced acute kidney injury (**Table 2**).

Figure 1a shows the AUC of CCS and renal replacement therapy obtained an AUC value of 0.840 (95% confidence interval [CI] 0.733-0.947, p<0.001). **Figure 1b** shows the AUC of the SRI and renal replacement therapy obtained an AUC value of 0.753 (95% CI 0.593-0.914, p=0.004). Meanwhile, the AUC of the MT and renal replacement therapy obtained an AUC value of 0.820 (95% CI 0.663-0.976, p<0.001) (**Figure 1c**). These three prediction tools had good discrimination.

The results of the AUC between each scoring system and renal replacement therapy in post-CABG surgery patients obtained AUC values, cut-off and sensitivity, specificity, positive likelihood ratio (PLR), negative likelihood ratio (NLR), positive predictive value (PPV), negative predictive value (NPV), and accuracy are summarized in **Table 3**.

Table 3 shows the cut-off value for predicting kidney replacement therapy is 2.50 for the CCS, 1.50 for the SRI, and 18.50 for the MT. The three diagnostic tools obtained the highest sensitivity with the CCS but the highest specificity with the MT. The highest PPV and PLR values were found on the MT. The highest NPV and lowest NLR values were found in the CCS. The highest diagnostic accuracy was found in the MT, reaching 85.95%.

Discussion

Prevalence of acute kidney injury in post-CABG patients who underwent renal replacement therapy

This study shows the prevalence of acute kidney injury in post-CABG patients was 31.4%. In Barkhordari et al.'s study, the incidence of acute kidney injury after CABG surgery was 27.7%. (7) In a multiethnic Southeast Asian study by Chun et al., of 1260 patients who underwent CABG surgery, 36.2% of patients experienced acute kidney injury after CABG surgery. (8) The difference in the prevalence of acute kidney injury after CABG was due to the presence of various factors for acute kidney injury, such as high body mass index, older patients, more blood transfusions in the intensive care unit (ICU), preoperative creatinine levels, high cardiopulmonary bypass time, and lack of intraoperative blood transfusion in post-CABG patients. (7)

In this study, 9.9% of patients underwent renal replacement therapy. In research by Chang et al., as many as 20.1% of post-CABG surgery patients experienced acute kidney injury, with 1% requiring renal replacement therapy. (9) In a multiethnic Southeast Asian study by Chun et al., of 1260 patients who underwent CABG, 36.2% experienced acute

kidney injury, and 5.5% of them underwent renal replacement therapy. (8) Early renal replacement therapy can improve outcomes and reduce mortality. (10)

Comparison of diagnostic test results

These results indicated that the CCS, SRI, and MT had good discrimination in predicting the need for renal replacement therapy in post-CABG patients. The best discrimination was found in the CCS, followed by the MT, and the lowest was the SRI. These results were in line with the research by O'Neal et al., who reported that CCS offered the best discrimination. (11) The research of Englberger et al. also reported that the CCS and the MT consistently showed much better discrimination compared with the SRI score. (6)

Accuracy comparison

In this study, the highest diagnostic accuracy was found in MT, reaching 85.95%. These results were in line with the research by Cataluna et al. which showed that MT score was the best tool in predicting kidney replacement therapy with an R2 of 0.58, followed by CCS with an R2 of 0.42 and SRI with an R2 of 0.29. (12)

Mehta's model identified characteristics associated with the need for postoperative dialysis, such as age, type of surgery, race, diabetes, preoperative serum creatinine, New York Heart Association class, shock, lung disease, previous cardiovascular surgery, and recent myocardial infarction. The risk score on the MT accurately differentiates a patient's dialysis needs. MT shows good results in patients undergoing off-pump CABG, isolated CABG, aortic valve surgery with CABG, isolated aortic valve surgery, and isolated mitral valve surgery. (13) The Mehta score was created based on large epidemiological studies, and the results showed that acute kidney damage was influenced by the type of surgery and also depended on postoperative dialysis. (14)

Research limitations

This research was only conducted on a small sample of CABG patients in Makassar and did not measure predictive biomarkers of acute kidney injury.

Conclusion

CCS, SRI, and MT were good discriminators in predicting the need for renal replacement therapy after CABG. The CCS provided the best discrimination. The MT produced the best diagnostic accuracy in predicting renal replacement therapy after CABG surgery. These results had implications for using the CCS, SRI, and MT as tools to predict the need for renal replacement therapy after CABG. Further research should be carried out using larger samples and measurements of biomarkers such as interleukin (IL)-18.

Table 1. Characteristics of research subjects

Characteristics		Mean±SD or n (%)
Age (years)		56.65±7.69
Gender	Male	105 (86.8)
	Female	16 (13.2)
BMI (kg/m^2)		25.05±3.31
ASA PS	2	2 (1.7)
	3	61 (50.4)
	4	58 (47.9)

Legend: BMI=body mass index; ASA PS=American Society of Anesthesiologists Physical Status; SD=standard deviation.

Table 2. Prevalence of renal replacement therapy and acute kidney injury after CABG

Parameter	n	%
Renal replacement therapy - Yes - No	 12 109	 9.9 90.1
Acute kidney injury - Yes - No	 38 83	 31.4 68.6

Legend: CABG=coronary artery bypass graft.

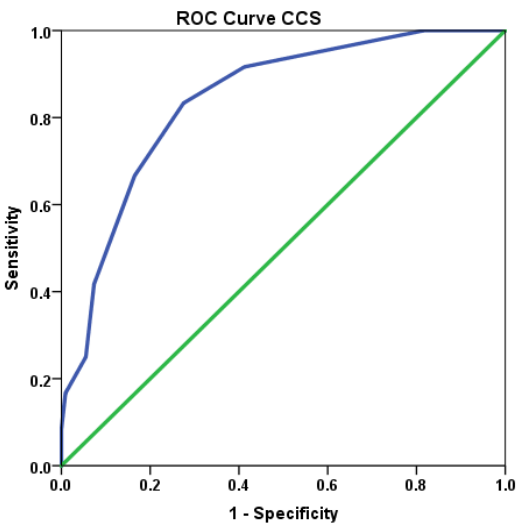
Table 3. Summary of comparison of diagnostic test results

Parameter	Cleveland Clinic Score	Simplified renal index	Mehta tool
AUC (ROC)	0.840	0.753	0.820
Cut-off	2.500	1.500	18.500
Sensitivity	0.833	0.667	0.750
Specificity	0.725	0.741	0.872
PPV	0.250	0.235	0.391
NPV	0.975	0.954	0.969
PLR	3.029	2.575	5.859
NLR	0.230	0.449	0.287
Accuracy	73.55%	75.21%	85.95%

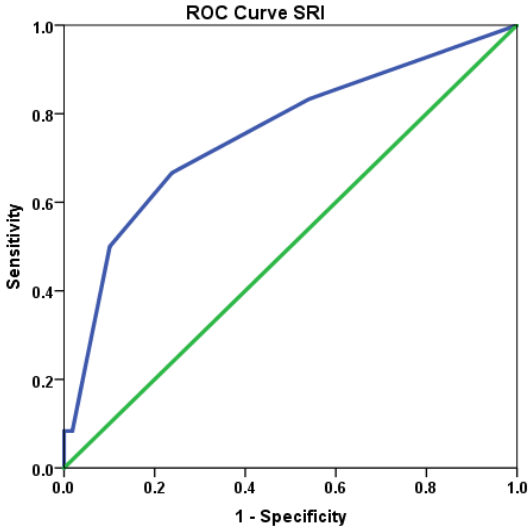
Legend: AUC=area under the curve; ROC=receiver operating characteristic; PPV=positive predictive value; NPV=negative predictive value; PLR=positive likelihood ratio; NLR=negative likelihood ratio.

Figure 1. AUC of (a) Cleveland Clinic Score, (b) Simplified renal index, and (c) Mehta tool in predicting renal replacement therapy

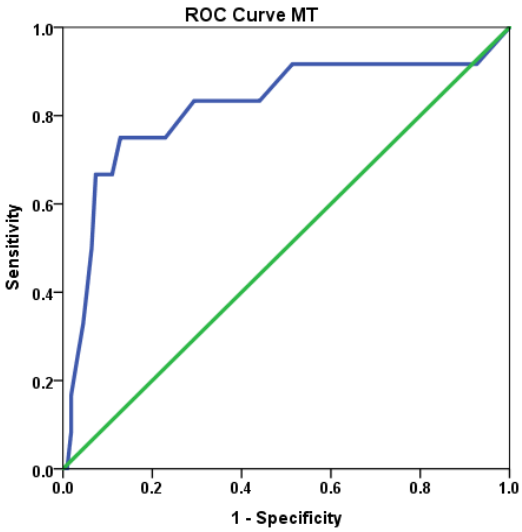
(a)



(b)



(c)



Legend: AUC=area under the curve; ROC=receiver operating characteristic; CCS=Cleveland Clinic Score; SRI=simplified renal index; MT=Mehta tool.

References

1. Montrief T, Koyfman A, Long B. Coronary artery bypass graft surgery complications: A review for emergency clinicians. Am J Emerg Med 2018;36:2289-97.
2. Wang Y, Bellomo R. Cardiac surgery-associated acute kidney injury: Risk factors, pathophysiology and treatment. Nat Rev Nephrol 2017;13:697-711.
3. Grieshaber P, Möller S, Arneth B, Roth P, Niemann B, Renz H, et al. Predicting Cardiac Surgery-Associated Acute Kidney Injury Using a Combination of Clinical Risk Scores and Urinary Biomarkers. Thorac Cardiovasc Surg 2020;68:389-400.
4. Vives M, Hernandez A, Parramon F, Estanyol N, Pardina B, Muñoz A, et al. Acute kidney injury after cardiac surgery: Prevalence, impact and management challenges. Int J Nephrol Renovasc Dis 2019;12:153-66.
5. Vives M, Monedero P, Perez-Valdivieso JR, Garcia-Fernandez N, Lavilla J, Herreros J, et al. External validation and comparison of three scores to predict renal replacement therapy after cardiac surgery: A multicenter cohort. Int J Artif Organs 2011;34:329-38.
6. Englberger L, Suri RM, Li Z, Dearani JA, Park SJ, Sundt 3rd TM, et al. Validation of clinical scores predicting severe acute kidney injury after cardiac surgery. Am J Kidney Dis 2010;56:623-31.
7. Barkhordari K, Fakhre Yasseri AM, Yousefshahi F, Shafiee A. Risk factors for acute kidney injury in coronary artery bypass graft surgery patients based on the acute kidney injury network criteria. J Tehran Heart Cent 2018;13:52-7.
8. Hiew KC, Sachithanandan A, Arif M, Badmanaban B, Muiz A, Faisal I, et al. Acute kidney injury following coronary artery bypass graft surgery in a tertiary public hospital in Malaysia: An analysis of 1228 consecutive cases. Med J Malaysia 2016;71:126-30.
9. Chang TI, Leong TK, Boothroyd DB, Hlatky MA, Go AS. Acute kidney injury after CABG versus PCI: An observational study using 2 cohorts. J Am Coll Cardiol 2014;64:985-94.
10. Steinthorsdottir KJ, Kandler K, Windelov NA, Steinbrüchel DA. Renal replacement therapy after cardiac surgery; Renal function recovers. Scand Cardiovasc J 2013;47:303-6.
11. O'Neal JB, Shaw AD, Billings 4th FT. Acute kidney injury following cardiac surgery: Current understanding and future directions. Crit Care 2016;20:1-9.
12. Cataluña JG, Panjaitan F, Panlilio CA, Bayaca J. Comparison of Cleveland Clinic Score, Simplified Renal Index (SRI), and Mehta Tool in Predicting Renal Replacement Therapy after Cardiac Surgery [Internet]. 2017 [cited 2024 Mar 17]. Available from: https://www.stlukes.com.ph/health-library/research-and-biotechnology/comparison-of-cleveland-clinic-score-simplified-renal-index-sri-and-mehta-tool-in-predicting-renal-replacement-therapy-after-cardiac-surgery
13. Mehta RH, Grab JD, O'Brien SM, Bridges CR, Gammie JS, Haan CK, et al. Bedside tool for predicting the risk of postoperative dialysis in patients undergoing cardiac surgery. Circulation 2006;114:2208-16.
14. Cheruku SR, Raphael J, Neyra JA, Fox AA. Acute Kidney Injury after Cardiac Surgery: Prediction, Prevention, and Management. Anesthesiology 2023;139:880-98.