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Original Article

A Clinical Score to Predict Acute Renal Failure after Cardiac Surgery in Egypt

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Abstract

Background: Acute Kidney Injury (AKI) after cardiac surgery is a serious complication. AKI could occur in 30% of patients, and 1-5% develop severe kidney injury. The present study aimed to evaluate the use of the Cleveland Clinic Score (CCS) to identify patients at higher risk of AKI after cardiac surgery.

Methods: This study included 100 patients, 83 were males, and the mean age was 52.47±11.3 years. All patients had elective operations; 30% had isolated valve surgery, 64% had isolated coronary artery bypass grafting (CABG), and 6% had combined CABG and valve operation.

Results: Creatinine serum level ranged between 0.5-2 mg/dL with a mean of 0.98±0.32 mg/dL. Seventy-four patients had good renal function postoperatively, and their CCS was 1.45±0.36, while 26 patients had renal impairment, and their CCS was 12.5±0.44 (P= 0.001). Patients who had AKI were older (62.87±8.7 vs. 49.9±13.9; P<0.001) and had higher preoperative creatinine (1.1±0.32 vs. 0.94±0.31; P= 0.03). AKI was more common in diabetics (23 (88.5%) vs. 28 (37.85, P<0.001) and patients with COPD (6 (23.1%) vs. 3 (4.1%); P= 0.004). CCS score was significantly higher among the different degrees of severity of AKI.

Conclusion: Cleveland Clinic Score could be good for predicting acute kidney injury after cardiac surgery.

KEYWORDS

Acute Renal Failure; Cardiac Surgery; Cleveland Renal Score

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Introduction

Acute Kidney Injury (AKI) after cardiac surgery is a serious complication. Depending on the definition used, up to 30% of cardiac surgery patients develop some form of AKI post-surgery, and 1-5% develop severe kidney injury necessitating dialysis (AKI-D) [1]. The mortality following AKI-D ranged between 50 and 80%. Even milder forms of AKI can impact short-term and long-term morbidity and mortality [2]. AKI associated with cardiac surgery increases infectious risk, extends the length of stay in the intensive care unit, thereby increasing health care resources and independently predicting death [3].

Recent advancements in cardiac surgery reduced mortality; however, the incidence of renal dysfunction has more or less remained the same. The goal is to predict AKI accurately, apply preventive measures, and early recognize and treat AKI [4]. There are few externally valid tools for risk stratification for AKI-D, such as the Cleveland Clinic Scoring tool and Mehta score [5,6]. The Cleveland Clinic Scoring tool tested a large cohort of patients (n = 15,838) to identify

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patients at risk of developing AKI after open-heart surgery [7,8]. The present study aimed to evaluate the use of the Cleveland Clinic Score (CCS) to identify patients at higher risk of AKI after cardiac surgery.

Patients and methods:

Design and patients:

This research is a prospective cohort study that included 100 patients (≥18 yrs) who underwent open cardiac surgery. The study was conducted in the hospitals of Benha Faculty Medicine, 6th October Hospital for Health Insurance, National Heart Institute, and Nasser institute. The study was performed from May 2018 until July 2020. The patients were then divided (according to CCS) into four risk categories of increasing severity (scores 0-2, 3-5, 6-8, and 9-≥13).

Inclusion criteria were all adult patients who had elective cardiac surgery. Patients who required preoperative dialysis, patients with score (≥13), heart failure requiring extracorporeal membrane oxygenation (ECMO), preoperative tracheostomy, preoperative mechanical ventilation (MV), complicated procedures, and missing data and emergency cases, were excluded from the study.

Eighty-three of our patients were males (83%). The age of patients ranged between 18 and 70 years with a mean age of 52.47±11.3 years.

Surgical techniques:

Valve replacement

Median sternotomy was performed, followed by the aorta and bicaval cannulation. Then cardiopulmonary bypass was started, the aorta was cross-clamped, cardioplegia was given (antegrade blood enriched intermittent cold crystalloid) or (warm blood enriched antegrade). Left atriotomy was done (or aortotomy), followed by removal of the diseased mitral (or aortic) valve (with or without preservation of posterior leaflet). We performed mitral valve replacement with interrupted 2/0 Ethibond sutures on Teflon pledgets. Aortic valve replacement was performed with interrupted 2/0 Ethibond sutures (on or without Teflon pledgets). This was followed by the closure of the left atriotomy (or aortotomy). Tricuspid valve repair was performed using DeVaga sutures through right atriotomy.

Coronary artery bypass grafting (CABG)

Median sternotomy was done, then we harvested the left internal mammary artery and left or right great saphenous vein. Cardiopulmonary bypass was started using aorta and single-stage venous cannula. The left internal mammary artery was anastomosed to the left anterior descending artery and venous grafts to the other targets.

Data:

All patients had a preoperative assessment, including history taking, complete clinical examination, full laboratory investigation, preoperative chest X-ray, electrocardiography (ECG), echocardiography (ECHO), and coronary angiography.

Intraoperative data collected were cardiopulmonary bypass and aortic cross-clamp times, cardioplegia "type, number of doses," and inotropic support. Postoperative data included intensive care unit (ICU) stay, duration of mechanical ventilation, the need for inotropic use, echocardiographic findings, the need for renal replacement therapy, and the total hospital stay. Postoperative complications were reported, including re-exploration for bleeding, arrhythmia and myocardial infarction (MI), neurological complications such as transient ischemic attacks and/or cerebrovascular accident (CVA), pulmonary complications including pulmonary infection, atelectasis, re-intubation, and wound infection.

Endpoints and definitions:

The primary outcome was AKI as defined by the KDIGO (Kidney Diseases Improving Global Outcomes) criteria; stage 1, stage 2, or stage 3. Stage 1 was defined as an increase in serum creatinine 1.5–1.9 times the baseline within five days, stage 2 was an increase in creatinine 2.0–2.9 times the baseline within five days, and stage 3 was a documented increase of more than 3.0 times the baseline or requirement or initiation of renal replacement therapy (RRT) during the hospital stay. Measurement of urine output was avoided as it is frequently influenced by volume resuscitation and the administration of medications like diuretics, making it hard to assess dependably.

To evaluate the use of the Cleveland Clinic Scoring tool, a score for each patient was calculated based on the general method described by Thakar and colleagues [5]. The Thakar model has been shown to offer the best discriminative value. It can be used in the preoperative setting and is appropriate for all patients undergoing cardiac surgery.

The following point system was utilized: female gender: 1, congestive heart failure: 1, left ventricular ejection fraction <35%: 1, preoperative use of IABP: 2, COPD: 1, insulin-requiring diabetes: 1, previous cardiac surgery: 1, emergency surgery: 2, surgery type: CABG: 0, Valve only: 1, CABG + Valve: 2, Other cardiac surgeries: 2, preoperative creatinine: 1.2 to <2.1 mg/dl: 2, ≥2.1 mg/dl: 5.

Risk scores are converted to estimated risk of dialysis with 0-2, 3-5, 6-8, 9-13 points had risk of dialysis of 0.4%, 1.8%, 7.8-9.5%, 21.5% respectively. Emergency surgeries were not included in the scoring tool. Thereby, the minimum score in our data set was 0, and the maximum score was 15. Patients were risk-stratified as per the score into low-risk (score 0–2), intermediate-risk (3–5), and high risk (≥6) groups as described in the original study.

Statistical analysis

Descriptive statistics were provided as frequency (%) for categorical variables, whereas continuous variables were presented as means (standard deviation). Categorical variables were compared between AKI patients and non-AKI patients with Chi-square or Fischer exact test if appropriate. Continuous variables have been compared using the t-test or Mann-Whitney test. The score was compared between more than two groups using one-way ANOVA. All statistical tests were double-sided with a threshold of alpha of 0.05 for statistical relevance. STATA version 11.0 SE was used for statistical analyses (StataCorp LP, College Station, TX, USA).

Results:

Patients' height ranged between 155-185 cm with a mean height of 172.16± 6.83 cm. The patients' weight ranged between 50-125 kg with a mean weight of 87.12 ± 17.31 kg. On echocardiographic examination, seventy-three of our patients had good ejection fractions, 26 had a fair ejection fraction, and one had a poor ejection fraction. Creatinine serum level ranged between 0.5-2 mg/dL with a mean of 0.98±0.32 mg/dL. Heart failure was present in three patients (3%). Chronic lung diseases were present in 9% of patients. Thirty patients had diabetes mellitus; 12 were on oral antidiabetic drugs, and 18 were on insulin therapy. (Table 1)

Table 1: Preoperative data. Categorical data were presented as numbers and percentages.

Variable	n= 100
Ejection fraction	
Good	73 (73%)
Fair	26 (26%)
Poor	1 (1%)
Renal impairment	4 (4%)
Previous heart failure	3 (3%)
Chronic lung disease	9 (9%)
Diabetes Mellitus	30 (30%)
Oral	12 (12%)
Insulin	18 (18%)

All of our patients had elective surgery, and ninety-four of them had primary surgery. Most of our patients (91%) did not need intra-aortic balloon pump (IABP) insertion. Fourteen patients came off bypass with a minimal dose of inotropic support. Six patients needed a high dose of inotropic support. Postoperatively, all patients needed mechanical ventilation; three had prolonged mechanical ventilation. The period of mechanical ventilation ranged between 4-72 hours with a mean period of 10.88 ± 8.04 hours (Table 2)

During the early postoperative period, ninety-two patients had a smooth course and did not need reoperation. Reoperation was needed in eight patients due to severe bleeding, cardiac tamponading, and mediastinitis. Most patients had good cardiac output postoperatively, while it was impaired in ten patients with a statistically significant difference. Low cardiac output was due to arrhythmia, pericardial tamponade, and MI. (Table 2).

Table 2: Operative and postoperative data

Variable	(n= 100)
Primary operation	94 (94%)
Redo	6 (6%)
Need for High inotropic support	6 (6%)
Prolonged postoperative mechanical ventilation:	3 (3%)
Period of mechanical ventilation (hours) [Mean±SD]	10.88±8.04
Postoperative ICU (hours) [Mean±SD]	49.26±36.7
Postoperative renal impairment	26 (26%)
Low cardiac output	10 (10%)
Arrhythmia	5 (50%)
Tamponade	3 (30%)
Severe MI	2 (2%)
Reoperation	8 (8%)
Severe bleeding	2 (25%)
Cardiac tamponade	5 (62.5%)
Mediastinitis	1 (12.5%)

ICU: intensive care unit, MI: myocardial infarction

By comparing pre and perioperative risk variables in patients with and without AKI, all of these parameters (except gender) were significantly higher in patients who developed AKI (Table 3). CCS score was significantly higher among the different degrees of severity of AKI (Table 4).

During the postoperative period, seventy-three patients had a smooth postoperative course without complications, while twenty-seven had postoperative complications related to the wound site; the most frequent were superficial wound infections. The most common causes of death among six patients were cardiac failure and AKI. (Table 5)

Discussion

Multiple studies have found that the Cleveland Clinic Score (CCS) has the highest discriminative power in the Western population [9]. However, as the authors have stated, the model needed to be tested prospectively in multiple centers and heterogeneous populations to substantiate its broad applicability [10,11].

A key limitation of this risk score is the inability to predict milder forms of AKI, which may have significant and long-term effects. The purported reasons for AKI following cardiac surgery include renal ischemia-reperfusion injury, inflammation, athero-embolism, neurohormonal activation, and oxidative stress [12].

Though this is not equivocal, most of this data has been from the Western literature in a predominantly white and Caucasian population with no available data in the Egyptian population who may exhibit different clinical outcomes. The Egyptian population is probably the best suited to test the applicability of the scoring tool as Egypt has one of the highest rates of diabetes and cardiovascular disease in the developing world [9,13].

In our study, 3% had heart failure, 2% had chronic lung diseases, and 30% of our patients were diabetics on oral or insulin therapy. In their study, Rao and coworkers found diabetes mellitus and chronic obstructive pulmonary diseases (COPD) as risk factors for AKI postoperatively, which aligns with our study [14].

Kristovic and colleagues found that 28.8% had diabetes mellitus, 9% had COPD, and 14.5% had congestive heart failure [15]. Machado and coworkers found that about 23% of the patients were diabetics, which aligns with our study [16].

All of our patients had elective surgery, and 94% of them had primary surgery. Weaning from cardiopulmonary bypass was smooth with or without minimal support with inotropes. These findings agree with other studies [15, 16].

Mechanical ventilation was used in 97% of patients postoperatively, and the mean period was about 11 hours mainly. Additionally, 90% of our patients had postoperative good cardiac output. The reoperation was required in 8% of the patients primarily due to postoperative bleeding, cardiac failure and/or mediastinitis. After discharge from ICU, the readmission to ICU was

Table 3: Pre and perioperative risk variables in patients with and without postoperative acute kidney injury

	AKI (n=26)	No AKI (n= 74)	P-value
Age (years)	62.87±8.7	49.9±13.9	<0.0001
Male	24(92.3%)	59(79.7%)	0.14
Preoperative IABP	5(19.2%)	4(5.4%)	0.03
COPD	6(23.1%)	3(4.1%)	0.004
DM	23(88.5%)	28(37.8%)	<0.0001
Previous cardiac surgery	5(19.2%)	1(1.4%)	0.005
Surgery type			
CABG	51(68.9%)	13(50%)	
Valve only	20(27%)	10(38.5%)	0.16
CABG + valve	3(4.1%)	3(11.5%)	
Preoperative creatinine (mg/dl)	1.1±0.32	0.94±0.31	0.03

AKI: acute kidney injury, IABP: Intra-aortic balloon pump, COPD: chronic obstructive pulmonary disease, DM: diabetes mellitus, CABG: coronary artery bypass graft. Continuous data were presented as mean and standard deviation, and categorical data as numbers and percentages.

Table 4: Cleveland Clinic Score in patients with different degrees of acute kidney injury

	Non-AKI (n= 74)	Moderate AKI (n= 23)	Severe AKI (n= 3)	P value
CCS score	1.3±0.4	4.2±0.35	10.55±0.33	0.01

CCS: Cleveland clinical score, AKI: acute kidney injury

needed in 3% of cases with a mean duration of two days.

A similar study by Machado and colleagues found that only 12% of patients needed prolonged MV more than 24 hours, which runs in line with our study. Moreover, 80% of their patients had good postoperative cardiac functions, and the length of ICU stay ranged between 2-5 days with a mean of about two days which is consistent with our study [16].

Table 5: Postoperative outcome in patients of the study

Variable	(n= 100)
Postoperative complications	
Superficial skin infection	21 (21%)
Rocking sternum	2 (2%)
Deep infection	4 (4%)
Postoperative mortality	6 (6%)
Cardiac failure	2 (33.3%)
Severe PO bleeding	1 (16.7%)
Mediastinitis	1 (16.7%)
Acute kidney injury	2 (33.3%)

Most of our patients had good renal function (74%), while 26% developed AKI. Patients who developed AKI showed significant CCS with significant perioperative variables. Ranucci and coworkers had an 8.2% incidence of AKI in patients who underwent cardiac surgery [17]. While Rao and colleagues found that the incidence of postoperatively AKI was 6.88% [14].

On the other hand, Pickering and colleagues had an 18.2% rate of AKI [18]. Several other studies found a different incidence of AKI. Kristovic and colleagues found an incidence of AKI of 3.6% [15]. The reported rate of AKI postcardiac surgery ranged from 5 to 50% [19-25].

Rao and coworkers found that the mean CCST scores were 1.6 in those without AKI, 1.5 in stage 1, 3.0 in stage 2, and 3.4 in stage 3 AKI. Higher risk scores predicted a greater risk of AKI. Still, they found that mean age, gender, BMI, preoperative serum creatinine, diabetes mellitus, COPD, cardiopulmonary bypass time was similar in patients who developed AKI vs. those who did not have AKI postoperatively [14].

While Nuh and colleagues found that age, hypertension, diabetes mellitus, previous myocardial infarction, left ventricular ejection fraction <30%, preoperative anemia, preoperative creatinine, eGFR ≤60 ml/min, type of surgery, and intraoperative use of IABP were risk factors for AKI. Additionally, AKI frequency increased with increase clinical score, which matches our finding [26].

Similarly, Liu and coworkers found that patients who developed post-cardiac surgery AKI had significant preoperative elevated serum creatinine. They confirmed that preoperative occult renal insufficiency was associated with elevated postoperative risk of AKI [27]. Postoperative complications occurred in 27% of our cases and mortality in 6% primarily due to cardiac failure, severe postoperative bleeding, and mediastinitis. Ranucci and coworkers found that the mortality rate was 1.3% in non-AKI patients and about 12.2% in patients with AKI, which agrees with our results [17]. Rao and colleagues found that the mortality rate was about 4% postoperatively [14]. Similarly, Jiang and coworkers reported a mortality rate of about 6.1% postoperatively, coping with our study [24]. Pickering and colleagues found a pooled mortality rate of 2.2%, Machado and coworkers found a mortality rate of 2.2% in non-AKI patients and increase with the stage of AKI and a general mortality rate in all patients of about 7.1%, which agrees with what we found in our study [16,18]. Another study by Robert and colleagues found a mortality rate of 36.8% in advanced AKI and 14.2% in moderate AKI, while the mortality with mild AKI was 4.1%, which matches our finding [25]. In addition, De Santo and coworkers found a mortality rate of 5% in their study, which supports our results [28].

Strengths and limitations:

The strength of this study was the multicenter design. The cohort of patients was well represented in age, sex, and type of surgery, including CABG and valve surgery. Our model incorporated both preoperative and intraoperative components, offering more exact risk stratification for AKI advancement. This gave a management tool for doctors to distinguish high-risk patients so that early management strategies can be established.

A limitation of this study was the utilization of serum creatinine to characterize AKI. The current tests and criteria utilized for the determination of AKI might preclude early discovery of AKI. Diagnosis of AKI relied upon the increase in serum creatinine, which takes 12–48 h to accumulate. Serum levels increment solely after 50% or more of renal function was lost, and numerous elements could influence it.

Conclusion

Our study concludes that Cleveland Clinic Score could be a good score for predicting acute kidney injury after cardiac surgery.

Conflict of interest: Authors declare no conflict of interest.

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