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Acute kidney injury in post cardiac surgery - An evaluation with eGFR (Estimated glomerular filtration rate) and akin Criteria

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Abstract

Acute Kidney Injury (AKI) is one of the major complications of cardiac surgery affecting 17% to 45% of the cardiac surgical patients. It is associated with high morbidity and mortality. Prevention and management of AKI in post cardiac surgery is still a matter of concern due to the lack of early markers. This study was designed as a single centered retrospective cohort study aimed to find out the proportion of the kidney injury in patients who underwent cardiac surgery and to evaluate the efficiency of eGFR and AKIN criteria for the early prediction of AKI. The retrospective data of consecutive patients (January 2008 to November 2013), were collected and analyzed. Diagnosis of kidney injury was confirmed by a serum creatinine level > 1.4mg/dL. Out of 301 patients (aged between 18 to 75 years) studied 26.5% were diagnosed with AKI. AKIN criteria identified 31.3% with AKI and based on eGFR it was 29.2%. Our findings suggest that, both AKIN and eGFR estimations may be useful for earlier detection of AKI than serum creatinine. The high incidence of AKI associated with cardiac surgery should prompt the inclusion of these parameters in the prediction of kidney damage to identify patients at increased risk for the timely management and patient care.

Introduction

Acute kidney injury (AKI) leads to rapid loss of kidney function [1]. AKI occurs in as many as 45% of patients after cardiac surgery and requires dialysis in 1% of cases. It is associated with an increased hazard of morbidity and mortality, leads to long hospitalization, requires additional treatments, and increases the hospital costs [2]. It runs a progressive worsening course due to the interplay of different pathophysiologic mechanisms, with patient-associated factors and cardiopulmonary bypass as major reasons. It may lead to a number of complications, including metabolic acidosis, high potassium levels, uremia, changes in body fluid balance, and adversely effects other organ systems [3,4].

AKI is diagnosed on the basis of characteristic laboratory findings, such as raised serum creatinine and blood urea nitrogen and/or inefficiency of the kidneys to produce sufficient amounts of urine. Several novel biomarkers have emerged during the last few years, demonstrating reasonable sensitivity and specificity for AKI prediction and protection [5]. The development and execution of potentially protective therapies for AKI remains essential, especially for the relevant impact of AKI on early and late survival [2].

Reports from various groups have described the incidence and prognostic importance of cardiac surgery-associated AKI for clinical outcomes in different patient settings, placed both in the context of the specific operation performed and the type of practice. It is at present realized that the overall incidence of AKI after adult cardiac surgery is about 5% to 10% and is highly dependent on pre-existing renal function and the complexity of the proposed surgery[6].

Acute kidney injury network (AKIN) introduced a specific criteria for the diagnosis of AKI[7]. This criteria depends on the reduction of kidney function which is dependent on rise in serum creatinine, ie, absolute increase in serum creatinine of ≥ 0.3 mg/dl or ≥ 26.4 µmol/L and reduction in urine output, defined as < 0.5 ml/kg/hr for more than 6 hours.

A recent report from the Laboratory Working Group of the National Kidney Disease Education Program, recommends that serum creatinine alone should not be applied to assess the GFR or to observe the presence of kidney disease because serum creatinine is affected by the GFR and by factors independent of the GFR, including age, sex, race, body size, diet, certain drugs, and laboratory analytical methods[8]. Rather, the Working Group suggests implementing the estimated GFR calculated using different formulas.

In the absence of suitable baseline data, the Acute dialysis quality initiative (ADQI) recommends an estimation of serum creatinine levels based on calculations using the modification of diet in renal disease (MDRD) formula assuming a normal GFR of

approximately 75- 100 ml/min/1.73 m^2[9]. A commonly used surrogate marker for estimate of creatinine clearance is the Cockcroft-Gault formula, which in turn estimates GFR in ml/min. One of the main features of the Cockcroft and Gault equation is that it shows the effect of age on the estimation of CCr[10]. These factors entail the need to evaluate the diagnostic efficiency of eGFR and AKIN criteria for predicting AKI and compare their fulfillment in detecting kidney injury associated with cardiac surgery[11].

The purpose of this study was to find out the proportion of kidney injury in post cardiac surgery patients attending a tertiary care hospital in south India (Kasturba Hospital, Manipal) and to evaluate and compare the eGFR and AKIN criteria for the diagnosis of AKI in patients who underwent cardiac surgery.

Methods

This study was designed as a retrospective cohort study. The study group comprised of patients who underwent cardiac surgery in Kasturba Medical college, Manipal. Ethical clearance was obtained from institutional ethic committee (IEC 429/2012). Anticipating a 40% of post cardiac surgery cases (based on previous records) to develop AKI for a 15% relative precision and for comparison of the predictive value of the eGFR with that of AKIN, at an alpha value of 0.05, a sample size of 260 post cardiac surgery cases were studied at 95% confidence level (80% power to detect a difference in AUC-ROC values of 0.1 performance units). Expecting an exclusion of around 60 patients, a total of 320 patients were included in the study. Finally 301 patients were enrolled in the study after excluding 19 patients as per the eligibility criteria.

Evaluation of the proportion of kidney injury in post cardiac surgery patients

From the medical records the retrospective data of patients who underwent cardiac surgery from January 2008 to November 2012 were collected. The data on age, sex, height, weight, the presence or absence of arterial hypertension, duration of hospital stay, type of surgery, other co-morbidities, and the data on all biochemical parameters of all the enrolled patients were collected and analyzed. Diagnosis of kidney injury was confirmed by a serum creatinine level > 1.4mg/dL.

Evaluation of eGFR and AKIN criteria for the diagnosis of AKI

GFR was estimated using the Cockcroft Gault formula[12], ie,

eGFR = (140-age) x Weight in Kg x (0.85 if female) / 72 x SCr.(mg/dl).

The patients were grouped as AKI when the difference in eGFR from the baseline (before Surgery) was > 25% and those with < 25% difference were grouped under non-AKI. The selected patients were grouped using AKIN criteria[13] also. Accordingly patients with an increase in serum creatinine of ≥0.3 mg/dl from baseline were grouped under AKI and those with < 0.3mg/dl grouped under non-AKI group.

Statistical Analysis

Continuous variables were summarized as mean and standard deviation. Categorical variables were summarized as percentages. Association of eGFR and AKIN criteria for the diagnosis of AKI was studied by Mc Nemar test. The diagnostic efficiency of these parameters was assessed by ROC analysis. The analysis was done using SPSS, version 16.

Results

The present study included 301 patients who underwent cardiac surgery at KMC Hospital, Manipal. Acute kidney injury was confirmed by a serum creatinine level of > 1.4 mg/dl. According to Serum Creatinine levels, out of the total 301 subjects 80(26.5%) were diagnosed with acute kidney injury (Fig 1). 94 (31.3%) were grouped into acute kidney Injury based on AKIN criteria. When diagnosis of AKI was carried out based on eGFR, the number of AKI cases were less than those obtained by AKIN criteia, ie, 88 (29.2%).

Evaluation of eGFR and AKIN Criteria

When the diagnostic performance of AKIN criteria for AKI was studied by ROC analysis, an AUC of 0.796 (95% CI: 0.740 - 0.852), with sensitivity of 78% and Specificity of 69% (Cut off value: 13.8% (percentage difference from baseline) were obtained(Fig 3). When the efficiency of eGFR for the diagnosis of AKI was studied an AUC of 0.797 (95% CI: 0.741 - 0.853), with sensitivity of 77% and specificity of 70% (Cut off value: 24.5% (percentage difference) were obtained(Fig 2).

When the diagnostic characteristics of eGFR and AKIN criteria were compared, the Mc Nemar test revealed a significant association (P < 0.001). According to AKIN Classification, 92% of the AKI group patients were categorized as AKIN Stage-I and 8% patient as AKIN Stage-II.

Comparison of biochemical parameters before and after cardiac surgery

Few biochemical parameters including Hemoglobin (Hb), Urea, Potassium and Creatinine showed a significant difference before and after cardiac surgery when compared using student t test (Table 2).

Discussion

Cardiopulmonary bypass (CPB) surgery is the most frequent major surgical procedure performed in hospitals worldwide, with well over a million operations undertaken each year in adults alone. AKI is common in cardiac surgery patients and is associated with significant morbidity and death rate [14]. We observed that the proportion of AKI in post cardiac surgery based on AKIN criteria was slightly more than that based on eGFR. ROC analysis has shown a similar diagnostic performance when compared the sensitivity and specificity of the AKIN and eGFR in assessing the presence of AKI. Previous studies have assessed the RIFLE criteria in an effort to validate its role in different clinical contexts such as intensive care units (ICU), non-ICU settings, and cardiac patients and found useful[15]. The revised AKIN criteria provide a better option in assessing hospital mortality due to AKI [16]. Our results are in agreement with the studies which compared RIFLE and AKIN criteria for predicting AKI[17]. Both sets of criteria demonstrated similar performance in predicting in-hospital mortality, with sCr being the strongest predictor and urinary output the weakest predictor of in-hospital mortality. The advantage of AKIN criteria is that it does not require a baseline creatinine value, as two sCr values within 48 hours would suffice to detect the development of AKI. For clinical decision making, it is important to consider the clinical context when interpreting changes in eGFR. For routine clinical decision making, we suggest that it would be reasonable for clinicians to interpret a change in eGFR as a reflection of a change in measured GFR and act accordingly. However, if clinical circumstances suggest a change in non-GFR determinants of serum creatinine, the change in eGFR could reflect the change in non-GFR determinants of serum creatinine, rather than a change in measured GFR[18].

Urine output was not used in classifying renal function of patients because accurate documentation of preoperative and postoperative urine output was not available. As we did not want to compromise the accuracy of our analysis, we have only used changes in sCr to stage patients using the AKIN criteria.

In conclusion, the AKIN criteria and the eGFR were studied in an attempt to improve clinical decision of patients who experienced an acute decrease in renal function after cardiac surgery. Based on our analysis, both AKIN and eGFR estimations may be useful in early prediction of AKI. The high incidence of AKI associated with cardiac surgery should prompt the use of either AKIN criteria or eGFR estimation in the early postoperative period to identify patients at increased risk and to institute measures that target AKI as a quality improvement initiative.

Though biomarker estimations can give more accurate results [18], our study highlights the utility of eGFR and AKIN classification together with other routine laboratory investigations in providing vital information for the management of kidney injury in patients undergoing cardiac surgery without any added cost.

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Illustrations

Illustration 1

Fig 1 - Proportion of Acute kidney injury in post cardiac surgery

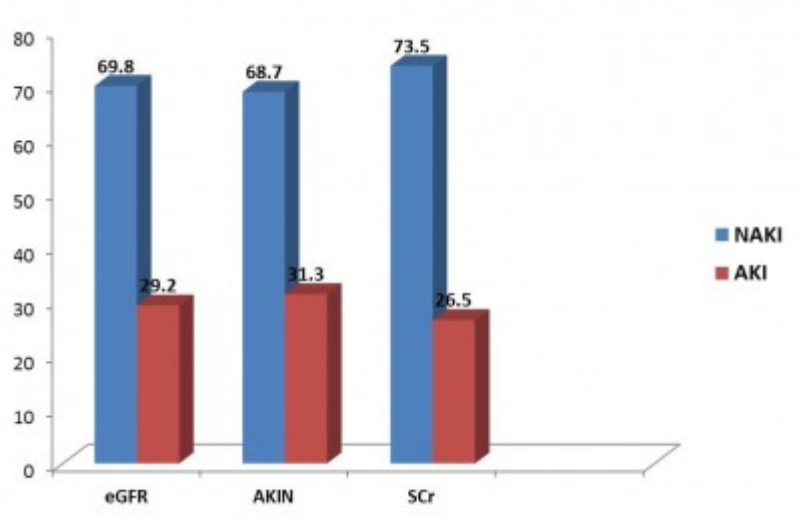

Illustration 2

Figure.2 - ROC Analysis of eGFR

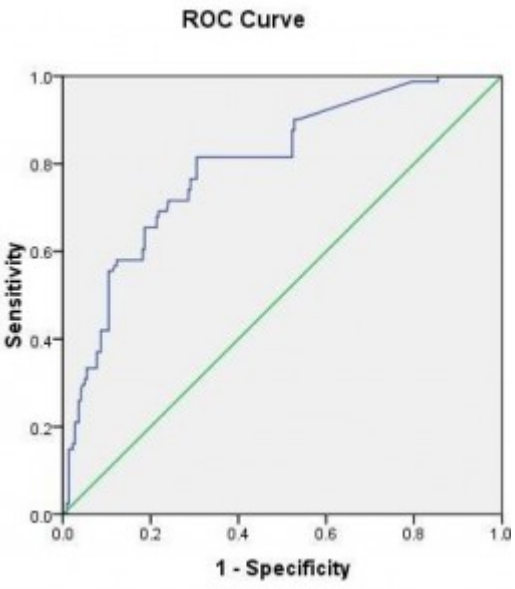

Illustration 3

Figure 3: ROC Analysis of AKIN Criteria

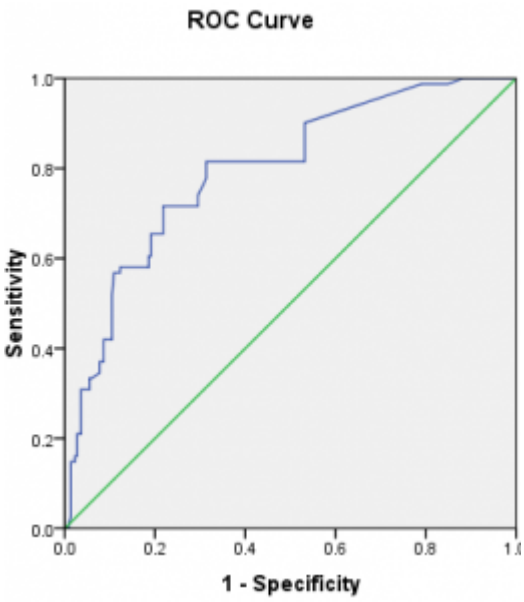

Illustration 4

Table 1: Patient characteristics

Characteristics/ parameters		All (n=301)	AKI (n=81)	NAKI (n=220)
Gender(n)	**Male**	238	74	164
	Female	63	7	56
Blood Group (n)	**A Pos**	95	25	70
	A Neg	3	0	3
	B Pos	79	19	60
	B Neg	0	0	0
	AB Pos	22	6	16
	AB Neg	0	0	0
	O Pos	80	24	56
	O Neg	6	1	5

	Mean(SD)	**Mean(SD)**	**Mean(SD)**
Weight	62.2(11.59)	63.7(10.32)	61.6(12.0)
Height	160.6(11.17)	163.4(9.04)	159.6(11.69)
BMI	23.67(3.63)	23.68(3.84)	23.66(3.56)
HB Pre	12.77(1.89)	12.32(2.179)	12.93(1.76)
HB Post	10.23(1.6)	9.74(1.4)	10.38(1.6)
Urea Pre	33.36(16.25)	40.69(20.88)	31.02(13.74)
Urea Post	44.89(37.36)	65.30(33.8)	37.96(36)
Creatinine Pre	1.09(0.26)	1.32(0.22)	1.01(0.22)
Creatinine Post	1.26(0.39)	1.77(0.32)	1.07(0.2)
Sodium Pre	135.77(4.09)	136.05(4.46)	135.68(3.98)
Sodium Post	135.4(4.73)	136.3(6.28)	135.1(4.07)
Potassium Pre	4.18(0.6)	4.32(0.6)	4.13(0.59)
Potassium Post	3.99(0.58)	4.05(0.65)	3.97(0.55)

Illustration 5

Table 2: Comparison of Biochemical parameters before and after cardiac surgery in AKI

Parameter	Mean	SD	P Value
Hb Pre	12.47	2.0	**<0.001**
Hb Post	9.84	1.2	
Platelet Pre	240825	92931	0.004
Platelet Post	191444	98617	
Urea Pre	28	15.5	**<0.001**
Urea Post	48.5	45.08	
Sodium Pre	137	9.8	0.2
Sodium Post	135	4.2	
Potassium pre	4.5	2.6	**<0.001**
Potassium Post	3.8	0.5	
Creatinine Pre	1.04	0.3	**<0.001**
Creatinine Post	1.4	0.6	

Illustration 6

Table 1: Patient characteristics

Characteristics/ parameters		**All (n=301)**	**AKI (n=81)**	**NAKI (n=220)**
Gender(n)	**Male**	238	74	164
	Female	63	7	56
Blood Group (n)	**A Pos**	95	25	70
	A Neg	3	0	3
	B Pos	79	19	60
	B Neg	0	0	0
	AB Pos	22	6	16
	AB Neg	0	0	0
	O Pos	80	24	56
	O Neg	6	1	5
		Mean(SD)	**Mean(SD)**	**Mean(SD)**
Weight		62.2(11.59)	63.7(10.32)	61.6(12.0)
Height		160.6(11.17)	163.4(9.04)	159.6(11.69)
BMI		23.67(3.63)	23.68(3.84)	23.66(3.56)
HB Pre		12.77(1.89)	12.47(2)	12.93(1.76)
HB Post		10.23(1.6)	9.84(1.2)	10.38(1.6)

Urea Pre	33.36(16.25)	28(15.5)	31.02(13.74)
Urea Post	44.89(37.36)	48.5(25.08)	37.96(36)
Creatinine Pre	1.09(0.26)	1.07(0.19)	1.01(0.22)
Creatinine Post	1.26(0.39)	1.75(0.47)	1.07(0.2)
Sodium Pre	135.77(4.09)	137(9.8)	135.68(3.98)
Sodium Post	135.4(4.73)	135(4.2)	135.1(4.07)
Potassium Pre	4.18(0.6)	4.5(2.6)	4.13(0.59)
Potassium Post	3.99(0.58)	3.8(0.5)	3.97(0.55)

Illustration 7

Table 2: Comparison of Biochemical parameters before and after cardiac surgery in AKI

Parameter	Mean	SD	P Value
Hb Pre	12.47	2.0	
Hb Post	9.84	1.2	
Platelet Pre	240825	92931	0.004
Platelet Post	191444	98617	
Urea Pre	28	15.5	
Urea Post	48.5	25.08	
Sodium Pre	137	9.8	0.2
Sodium Post	135	4.2	
Potassium pre	4.5	2.6	
Potassium Post	3.8	0.5	
Creatinine Pre	1.07	0.19	
Creatinine Post	1.75	0.47	