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Utility of Preoperative Risk Scoring to Predict Acute Kidney Injury (AKI) Following Cardiac Surgery

(Research Article)

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ABSTRACT

Acute kidney injury (AKI) is known to affect up to 30% of patients who undergo cardiacsurgeries (CS). This study was done to estimate the incidence of AKI and AKI-D (AKI requiring dialysis) after CS and analyze the effectiveness of pre-operative scoring. All consecutive patients (1146, Males: 952; Females:194), aged 18-82 years (Mean 55.90; SD:11.15) who underwent CS at AIMS, Kochi, Kerala, from May 2008 to April 2010 were included in the study. Postoperative AKI was defined as >25% change in serum creatinine corresponding to a 20% reduction in Cockroft-Gault GFR from baseline within one week after surgery. The overall incidence of AKI, AKI-D and mortality rate were 25.7, 2.1 and 2.18% respectively. The AKI risk categorization was done by using Cleveland Clinic Foundation score for CS. The frequency of AKI and AKI-D ranged between 13.05 to 92% and 0.24 to 28 %; in low to high risk categories of patients. The need for prolonged hospital stays (> 10 days) and mortality rates ranged between 38.18 to 64% and 0.49 to

20%, respectively, from low to high risk score categories. In multivariate analysis, gender, presence of COPD did not have significant effect and age >40 had a significant effect on AKI. In conclusion, AKI risk score correlated incidence rates of AKI, AKI-D, prolonged hospital stays and mortality. This study validates the ARF risk scoring system by Cleveland Clinic Foundation for the Indian population. We propose a modified risk scoring system for AKI, by including relevant parameters with statistical significance.

Key words: *AKI, AKI-D, cardiac surgery, risk scoring.*

INTRODUCTION

Acute kidney injury (AKI) occurs in up to 30% of patients who undergo cardiac surgery, with dialysis being required in approximately1% of all patients. [1-8] The development of AKI is associated with substantial morbidity and mortality independent of all other factors. [1-8] There is very limited data regarding the post cardiac surgery AKI from Indian studies. [4-8] Five predictive models of AKI after cardiac surgery have been developed so far, with an aim is to risk stratify the patients according to scoring. [9-13] This study to analyze the effectiveness of pre-operative scoring in predicting incidence of AKI following cardiac surgery among Indian population by using risk scoring as proposed by Cleveland Clinic Foundation. [9]

AIMS AND OBJECTIVES

1. To study the incidence of AKI following all cardiac surgeries.
2. This study was done to assess the effectiveness of preoperative risk factor scoring in predicting the occurrence of AKI and to formulate a modified risk scoring system that suits the Indian population.
3. To study the effect risk score on duration of hospital stay and mortality.

METERIALS AND METHODS

All patients undergoing all cardiac surgeries from May 2008 to April 2010 were included in the study. The patients undergoing re-operations (within 30 days) and those with chronic kidney disease stage 5 on renal replacement therapy (hemodialysis or continuous ambulatory peritoneal dialysis) were excluded. Postoperative AKI was defined as >25% change in serum creatinine corresponding to a 20% reduction in Cockroft-Gault GFR from baseline within one week after surgery. [14] AKI risk scoring system (Table 1) by Cleveland Clinic Foundation was used in the study to stratify the patients in to risk groups. [9] Data analysis was done using SPSS 17.0 for Windows (SPSS Inc., Chicago, IL, USA). Two tailed, p value < 0.05 was considered as significant.

The following factors and their association with AKI as analyzed;

- Age, gender, presence of insulin requiring diabetes mellitus, left ventricular ejection fraction <35%, congestive heart failure (CHF), chronic obstructive pulmonary disease (COPD), use of intra-aortic balloon pump (IABP), nature of surgery, preoperative renal disease & serum creatinine levels.

Cardio pulmonary bypass system;

Terumo Sarns 8000, Soma Technology, Inc., USA - A modular heart lung machine was used in all patients who underwent on-pump surgery, with pulsatile flow. Blood cardioplegia delivery system by Medtronic (BCD - Myotherm) was used in on-pump surgeries.

RESULTS

A total of 1146 (Males: 952; Females:194) patients, aged 18-82 years (Mean 55.90; SD:11.15) were included in the study. The nature of surgeries and patient number were; CABG (on pump: 841, off pump: 73), CABG with valve surgery (32), valve surgery (158) and ASD repair (42) respectively.

Incidence of AKI and its relation to type of surgery

The overall incidence rate of AKI was 25.7 % (295 out of 1146 patients) using the definition as >25% change in serum creatinine from baseline within1-week post-surgery (Table-2). The incidence rate of AKI varied according to the type of surgery (Table-2). The incidence rates of AKI were; 4.8, 17.1, 27.24 and 53.1 % after atrial septal defect (ASD) repair, valve surgery, coronary artery bypass grafting (CABG) and combined CABG with valve surgery, respectively (Table-2).

Dialysis requiring AKI (AKI-D) was seen 2.1 % (24 out of 1146) of all patients (Table-2). The incidence rate of AKI – D also varied according to type of surgery (Table-2); it was 1.3, 2.2 and 6.25 % after valve surgery, CABG and in combined CABG with valve surgeries, respectively. None of the patients developed AKI-D after ASD repair. The indications for dialysis were presence of one or combinations features like; anuria/oliguria, pulmonary edema, fluid overload and biochemical abnormalities (hyperkalemia).

Risk factors and its relation to post-operative AKI

The risk factors used in Cleveland clinic scoring and the scoring for each are summarized in table 1. The patients with CHF pre-operatively had higher (44.8 %) incidence of AKI than those without CHF (24.7 %) with an odds ratio (OR) 2.41 for AKI (Table 3). Patients with left ventricular ejection fraction (LVEF) < 35 % and insulin requiring diabetes mellitus (DM) had higher incidence of AKI, 50 % (OR 3.04) and 34.1 % (OR 2.18) respectively, than those with LVEF > 35 % and with insulin requiring DM (Table 3).

The presence of pre-operative renal disease and serum creatinine more than 1.2 mg /dl also increased the incidence of AKI to 72 % (OR 8.85) and 62 % respectively (Table 3). The incidence rate of AKI was 17.6 % in patients with preoperative serum creatinine was < 1.2 mg/dl. Pre-operative renal disease was found in 6.5 % of patients and the most common was diabetic nephropathy (90 %), followed by primary glomerular disease (5 %), urolithiasis (2.5 %), and renal artery stenosis (2.5 %).

Emergency surgery was done in 9 patients (CABG:8, MVR redo:1) and incidence rate of AKI were 44.44 % (4 out of 9) and all 4 required hemodialysis (Table 3). Five patients (CABG:4, MVR:1) who had previous cardiac surgery underwent redo CABG (4) and redo MVR (1) with incidence rate of AKI of 60 % (3 out of 5) and all 3 required hemodialysis (Table 3). One patient required pre-operative IABP and was managed without hemodialysis for AKI in post-operative period (Table 3).

The incidence of AKI was higher in males (26.57%) than females (21.64%); but the difference was not statistically significant. The incidence rate of AKI in patients with and with COPD was 16.67% (6 out of 36) and 26.03% (289 out of 1110) respectively, but the difference was not statistically significant (Table 3). The incidence of AKI was higher (27.2 %) in patients aged > 40 years (1049 subjects, mean:58.28 years) than those aged < 40 (97 subjects, mean:30.16 years) (10.3 %). So, female gender and presence of COPD were not significant predisposing factors in our study population. Whereas, age >40 years was significantly associated with higher incidence of AKI, and age was not included as factor in Cleveland clinic scoring.

Relation of risk scoring with incidence of AKI and AKI-D

Acute kidney injury risk scoring system by Cleveland Clinic Foundation was used in the study to stratify the patients in to risk groups. The subjects were categorized into 4 groups based on the risk score; 1-2, 3-5,6-8and > 8 and were named as low-risk, moderate-risk, high-risk and very high risk groups, respectively (Table 4). There were no patients with very high risk score group in the study population. The incidence rates of AKI and AKI-D in the low risk group were 13.05 and 0.24%, respectively (Table 4).The

incidence rates of AKI & AKI-D in moderate and high risk groups were 30.63 & 2.24 % and 92 & 28 %, respectively (Table 4).

Relation of risk scoring with duration of hospital stay and mortality

The need for prolonged hospital stays (> 10 days) was in was seen 38.18, 44.62 and 64 % of patients in low, moderate and high risk score categories, respectively (Table 4). The mean duration of hospital stays in patients without AKI, with AKI (not requiring RRT) and AKI-D were 11.27, 13.27 and 27.04 days, respectively. Need for prolonged hospital stay (>10 days) was seen in 79.16 % (19 out of 24), 57.19 % (155 out of 271) and 37.13 % (316 out of 851) in patients with AKI-D, AKI (not requiring RRT) and no AKI, respectively. The difference in duration hospital stay and its relation AKI was statistically significant. The mortality rates were 0.49, 2.52, and 20 % in patients belonging to low, moderate and high risk score categories, respectively (Table 4). The mortality rates were, 0.47 (4 out of 851), 3.32 (9 out of 271) and 50 % (12 out of 24) in those without AKI, AKI (not requiring RRT) and AKI-D, respectively. Majority (76.14%, 206 out of 271) of the patients with AKI (not requiring RRT) had recovered from AKI at the time of discharge. Among the patients having AKI-D, 3 (12.5%) were discharged to continue hemodialysis, 3 (12.5%) had mild renal insufficiency and 6 (25%) had normal renal parameters.

Table 1: ARF risk scoring system by Cleveland Clinic Foundation for cardiac surgery [a]

Risk Factor	Points
Female gender	1
Congestive heart failure	1
Left ventricular ejection fraction < 35%	1
Preoperative use of IABP	2
Chronic obstructive pulmonary disease	1
Insulin-requiring diabetes	1
Previous cardiac surgery	1
Emergency surgery	2
Valve surgery only	1
CABG [b] +valve surgery	2
Other cardiac surgeries	2
Preoperative creatinine 1.2 to 2.1 mg/dl	2
Preoperative creatinine >2.1	5

[a] Adapted from Thakar CV et al: A clinical score to predict acute renal failure after cardiac surgery. J Am SocNephrol 2005; 16: 162–168.Minimum score, 0; maximum score, 17,

[b] CABG, coronary artery bypass graft.

Table 2: Type surgery of surgery and incidence of AKI and AKI-D

Parameter		Surgery					Total
		CABG on pump n (%)	CABG off pump n (%)	CABG + Valve n (%)	Valve only n (%)	ASD repair n (%)	
Gender	Males	753	70	21	91	17	952
	Females	88	3	11	67	25	194
Age in years (Mean)		58.55	59.19	60.98	45.42	34.07	55.90
AKI	No	615	50	15	131	40	851
	Yes	226 (26.9)	23 (31.5)	17 (53.1)	27 (17.1)	2 (4.8)	295 (25.7)
Patient with AKI needing RRT		19 (2.25)	01 (1.36)	02 (6.25)	02 (1.26)	00	24 (2.1)
Total		841	73	32	161	42	1146

Table 3: Pre-operative risk factors and relation to post-operative AKI

Parameter		Patients without ARF (*n* - 851)	Patients with ARF (*n* - 295)	P value (2- sided)	OR	95 % CI
Females		152	42	0.176 *	0.763	0.527 to 1.106
Congestive heart failure		16	13	0.029 *	2.406	1.143 to 5.064
LVEF < 35 %		23	23	< 0.0001 *	3.044	1.681 to 5.513
Preoperative IABP		00	01	-	-	-
COPD		30	06	0.248 *	0.568	0.234 to 1.379
Insulin requiring DM		335	173	< 0.0001 *	2.184	1.668 to 2.860
Previous cardiac surgery		02	02	-	-	-
Emergency Surgery		05	04	-	-	-
Surgery type	Valve surgery only	131	27	< 0.0001 **	-	-
	Valve + CABG	15	17			
	Other cardiac surgeries	705	251			
Preoperative creatinine (mg/dl)	< 1.2	772	165	< 0.0001 **	-	-
	1.2 to 2.1	79	127			
	> 2.1	00	03			

* Fisher's Exact test
** Pearson Chi-Square test

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Table 4: Relation of AKI risk score to incidence of AKI, AKI-D, prolonged hospital stays and mortality

	ARF risk score category			Total *n* – 1146 (%)
	Low *n* –406 (%)	Moderate *n* – 715 (%)	High *n* – 25 (%)	
ARF	53 (13.05)	219 (30.63)	23(92)	295 (25.7)
AKI-D	1 (0.24)	16 (2.24)	07(28)	24(2.1)
Prolonged hospital stay (> 10 days)	155 (38.18)	319(44.62)	16(64)	490(42.7)
Mortality	02(0.49)	18(2.52)	05 (20)	25 (2.18)

low risk score 1 - 2, Moderate risk score 3-5, High – risk score 6-8, very high risk >8
There were no patients with very high risk score in study population
p value < 0.0001(2 - sided),

Table 5: Modifiedof ARF risk scoring system for cardiac surgery	
Risk Factor	Points
Age > 40 years	2
Congestive heart failure	1
Left ventricular ejection fraction < 35%	1
Preoperative use of IABP	2
Insulin-requiring diabetes	1
Previous cardiac surgery	1
Emergency surgery	2
Valve surgery only	1
Coronary artery bypass graft +valve surgery	2
Other cardiac surgeries	2
Preoperative creatinine 1.2 to 2.1 mg/dl	2
Preoperative creatinine >2.1	5
Minimum score, 0; maximum score, 17,	

DISCUSSION

The overall incidence rates of AKI and AKI-D were 25.7 and 2.1% respectively, using the definition as >25% change in serum creatinine from baseline within1-week post-surgery. The incidence rates of AKI and AKI-D were highest (53.1 and 6.25 %) in combined CABG with valve surgery and lowest (4.8 and 0 %) following ASD repair. The incidence of AKI varied from 1 to 30 % based on the criteria for AKI. [1-8] The incidence rate of AKI was 17.2 % following CABG in which a defining criteria, was similar to the present study. [14] The incidence of AKI – D has been reported in 0.7 to 3.3 % in different studies, consistent with our study. [1,3,15,16] The highest risk group included combined CABG and valvular surgery with an incidence of AKI of 4.6% and AKI-D of 3.3%, similar to the present study. [15,16]

Five predictive models of AKI after cardiac surgery in adult patients have been developed so far, with an aim to select patients who are at high risk and then to adoptstrategies that would offer renal protection.[9-13] The Cleveland Clinic Foundation scoring included patients undergoing all cardiac surgeries similar our study and only recipients of a renal transplant and patients who were on preoperative dialysis were excluded.A score (Table 1) is given on the basis of 13 preoperative factors and ranges from 0 to 17. [9]This scoring system was adapted for our study as it was simple and the patients included those undergoing all types of cardiac surgeries.

The patents were divided into groups as per risk score (low, moderate, high risk and very high risk). There were no patients with very high risk score in the study group. The incidence rate of AKI across categories ranged from 13.5 to 92%; low to high risk groups, with definition for AKI as >25% change in serum creatinine from baseline within1-week post-surgery. The frequency of AKI-D across categories ranged from 0.24 to 28 %; low to high risk groups. The patients in the Cleveland Clinic Foundation study were divided into 4 risk categories of increasing severity (scores 0 to 2, 3 to 5, 6 to 8, and 9 to 13) were formed arbitrarily, with a primary aim of predicting AKI requiring dialysis (AKI-D). The frequency of AKI-D across these categories ranged between 0.5 and 22.1 % from low to highest risk group. [9] The predictability of AKI-D, across risk groups, in our study is similar to earlier study. [9] The predictability for AKI, was also stronger across risk groups in our study.

The patients needing prolonged hospital stays (> 10 days) showed a consistent increase from low to high risk scores; 38.18, 44.62 and 64 % of patients in low, moderate and high risk score categories, respectively. The mortality rates also increased with higher risk scoring; 0.49, 2.52, and 20 % in patients belonging to low, moderate and high risk score categories, respectively. The need for prolonged hospital stays and mortality rates and their correlation to risk categories were not analyzed earlier study. [9] Two studies, using Cleveland Clinic Foundation scoring also proven its utility in predicting AKI-D. [8, 17] Other scoring systems, have shown that there is consistent increase in hospital stay and risk of AKI-D, in patients with high risk score, similar to our finding. [11, 12]

These clinical scoring systems require validation across several medical centers before their routine use can be adopted. Furthermore, given that these scoring systems attempt to identify a small number of high-risk patients, they will have good negative predictive power but necessarily low positive predictive power. However, they provide a very useful framework to identify patients who are at risk for AKI and AKI-D. The results of the present study are consistent with that of Thakar *et al.* in predicting AKI-D. The present study also showed that the scoring system is useful in predicting prolonged hospital stay and mortality. This study validates the AKI risk scoring system by Cleveland Clinic Foundation for the Indian population.

Among the risk factors used in the in Cleveland clinic scoring effect of gender and presence of COPD was not significant on multivariate analysis. Whereas, age >40 years was a significant factor in affecting AKI, in addition to other factors in the scoring. Hence, we propose a modified risk scoring system for all cardiac surgeries by including age >40 years and deleting gender & presence of COPD as risk factors to Indian population (Table 5).

CONCLUSIONS

Cardiac surgery is associated with a high risk for AKI with an overall incidence rate of was AKI and AKI-D of 25.7 and 2.1 %, respectively. The incidence rates of AKI and AKI-D were highest (53.1 and 6.25 %) in combined CABG with valve surgery and lowest (4.8 and 0 %) following ASD repair. Pre-operative renal disease was found in 6.5 % of patients and the most common was diabetic nephropathy.

Patients were stratified according to AKI risk scoring system by Cleveland Clinic Foundation to assess its utility in predicting incidence of AKI and AKI-D. The frequency of AKI and AKI-D ranged between 13.05 to 92 % and 0.24 to 28 %; in low to high risk categories of patients.

The AKI risk score also correlated with the need for prolonged hospital stay and mortality. The mortality rates ranged between 0.49 to 20 %; low to high risk score categories. Majority of the patients with AKI had recovered at the time of discharge. Among the patients having AKI-D, 12.5% were discharged to continue hemodialysis, 12.5% had mild renal insufficiency and 25% had normal renal parameters and 50 % were expired.

This study validates the ARF risk scoring system by Cleveland Clinic Foundation for the Indian population. This scoring system can be used to identify the high risk category patients who may develop ARF and require renal replacement therapy so that they can be managed at centers with appropriate facilities. Scoring systems may also be used to explain the patient and family regarding need prognosis, need for prolonged hospital stay and possibility of AKI and requirement of dialysis. We propose a modified risk scoring system by including age >40 years and deleting gender and COPD to Cleveland clinic scoring system (Table 5).

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