ORIGINAL ARTICLE

Acute Kidney Injury after adult Cardiac Surgery with Cardiopulmonary Bypass: Incidence and Predictors

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ABSTRACT

Aim: To study the incidence and predictorsfor postoperative acute kidney injury in adults undergoing cardiac surgery using cardiopulmonary bypass in Pakistani population

Methods: This prospective observational study was performed at the Department of Cardiac Surgery, Punjab Institute of Cardiology, Lahore, Pakistan over a period of 6 months from 1st March 2013 to 1st September 2013. All those adult patients undergoing cardiac surgery with a cardiopulmonary bypass were included in the study. Preoperative, per operative and cardiopulmonary bypass related variables were studied prospectively. Acute kidney injury was diagnosed as postoperative creatinine >1.6 mg/dl, in the postoperative period in ICU within the first 24 hours after surgery. The Data was analyzed using SPSS version 16.0. P-value ≤0.05 were considered significant.

Results: Out of 250 patients, (39.13%) patients were females and (60.87%) patients were male.Acute kidney injury was observed in 16 (6.5%) patients. Predictors of postoperative kidney injury identified by Logistic Regression were Diabetes Mellitus (OR: 1.50, CI 95%:0.47-4.83; P value = 0.004), Hypertension (OR:3.819, CI:95%, 0.79-18.35),Pre-op urea (OR: 1.88, CI: 95%, 0.43-1.78, P=0.001), Pre-op creatinine (OR:1.93, CI:95%, 0.74-1.84, P=0.001), CPB time (OR: 1.01, CI: 95%, 0.98-1.039, P= 0.001), Cross clamp time (OR: 1.01, CI 95%: 0.93-0.99; P value = 0.001)and Lowest hematocrit on pump (OR: 1.89, CI: 95%, 0.90-3.98, P=0.001).

Conclusion: Acute kidney injury (AKI) is a significant complication after cardiac surgery. Predictors of acute kidney injury are Diabetes Mellitus, Hypertension, Pre-op urea, pre-op creatinine, cardiopulmonary bypass time, cross clamp time, lowest hematocrit on pump.

Keywords: Acute kidney injury, cardiopulmonary bypass, cardiac surgery

INTRODUCTION

Acute renal insult is a serious postoperative complication of cardiac surgery with cardiopulmonary bypass[1]. It leads to increased intensive care unit (ICU) stay and more cost burden on the hospital resources. Despite the advances in the perioperative care of the cardiac surgery patients, acute renal injury still remains a notable problem in the postoperative patients[2].

The incidence varies depending upon the definition or the criteria used to diagnose AKI. The incidence of acute renal failure requiring renal replacement therapy is 1.3-2.9%[3]. But mild to moderate impairment is lower with most studies stating the incidence as 5-30 % after cardiac surgery with cardiopulmonary bypass[4]. Cardiopulmonary bypass affects the body's physiology including the renal function in a negative way.

The pathological mechanism seems to be acute tubular necrosis. This is confirmed by the presence of granular casts in the urine of patients who develop ARF[5]. Acute kidney injury increases the duration of hospital stay and carries an increased risk of mortality after cardiac surgery.

Although no definitive preventive protocol has been described in literature, various studies have described the risk factors for AKI after cardiac surgery.[6]various predictor models have been described as well. Various perioperative factors associated with an increased risk of AKI postoperatively are female gender, reduced left ventricular ejection fraction, diabetes, hypertension, perioperative use of an intra-aortic balloon pump, increasing age, CPB related factors like increased cross clamp time and bypass time. Increased preoperative serum urea and creatinine have been consistently found as predictors of postoperative acute kidney injury.

This important issue has not been studied extensively in Pakistani population. Only scant local literature is available locally addressing AKI after cardiac surgery. Our study aims at finding the predictors of AKI in our population undergoing cardiac surgery. With a good understanding of the predictors, important preventive steps can be taken.

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MATERIALS ANDMETHODS

This prospective observational study was conducted at the Punjab Institute of Cardiology Lahore, Pakistan over a period of 6 months from 1st March 2013 to 1st September 2013. A total of 250 consecutive patients undergoing cardiac surgery with the use of cardiopulmonary bypass were included in the study. Patients undergoing surgery both for valve related pathology and coronary artery bypass grafting were included in the study. Information was obtained on a proforma including preoperative and intraoperative variables. Acute kidney injury was identified in the intensive care unit in the first 24 hours postoperatively. Acute kidney injury was defined as a rise in creatinine above 1.6 mg/dl. Data was analyzed using the SPSS version 17. A logistic regression analysis was used to develop a predictor model from the various variables considered in the study. P value of less than 0.05 is considered significant.

RESULTS

Out of 250 patients included in the study, 152(61%) were males while 97(39%) were females. Acute kidney injury, as defined by the set definition, was observed in 16(6.5%) patients. The mean age of the patients was 37.69±14.49. The demographic and clinical characteristics of the patients are described in table 1. The effect of the type of procedure on development of postoperative AKI is shown in table 2 while table 3 shows Binary logistic regression analysis for the predictors of AKI. Acute kidney injury was associated more with valvular procedures than coronary artery bypass grafting. Binary logistic regression results indicated thatDiabetes Mellitus (OR: 1.50, CI 95%:0.47-4.83; P value=0.004), Hypertension (OR:3.819, CI:95%, 0.79-18.35), Pre-op urea (OR: 1.88, CI: 95%, 0.43-1.78, P=0.001), Pre-op creatinine (OR:1.93, CI:95%, 0.74-1.84, P=0.001), CPB time (OR: 1.01, CI: 95%, 0.98-1.039, P= 0.001), Cross clamp time (OR: 1.01, CI 95%: 0.93-0.99; P value=0.001) and Lowest hematocrit on pump (OR: 1.89, CI: 95%, 0.90-3.98, P=0.001) were significantly associated with acute kidney injury postoperatively. Nagelkerke R^2 value in this study analysis was (0.309) which signify that factor in this study contributing only (30.9%) to acute kidney injury. Other contributing factors were not included in the study. The classification table shows that the overall predictive accuracy is 90.4%.

Table-1: Descriptive and inferential statistics.

Variables		**Non-AKI**	**AKI**	**P-value**
Gender	Male	140(91.00)	13(9.00%)	0.204
	Female	94(97.07%)	3(3.09%)	
Age		37.88±16.06	39.50±14.37	0.517
Weight		58.47±9.6	64.85±15.08	0.077
Body surface area		1.70±0.139	1.58±0.236	0.056
Flow rate		4.09±.343	3.8±.607	0.060
Hypertension		15(10.3%)	3(17.6%)	0.040
Diabetes		35(23.5%)	6(41.2%)	0.004
Smoking		27(17.8%)	2(11.8%)	0.744
Pre-op hematocrit		40.05±6.3	40.06±5.66	0.999
Pre-op serum urea		30.4±9.4	41.23±20.1	0.001
Pre-op serum creatinine		0.758±.196	1.06±.28	0.001
Aortic Cross Clamp time in minutes		71.76±46.89	90.8±34.22	0.001
CBP time in minutes		113.55±44.67	140.34±42.17	0.001
Lowest Level of Hemodilution in %		26.90±0.62	23.42±1.01	0.001

Table 2: Association of the procedure type with AKI in adults undergoing cardiac surgery using cardiopulmonary bypass.

Operation type	**Renal Insufficiency**	**Renal sufficiency**	**P-value**
MS	0	16(7.5%)	0.383
MR	2(5.88%)	45(20.18%)	0.207
AS	0	13(6.10%)	0.601
AR	2(5.88%)	7(3.2%)	0.999
MS+AS	3(11.76%)	3(0.93%)	0.028
MS+AR	0	2(0.94%)	1.00
MR+AS	8(17.64%)	9(3.7%)	0.038
MR+AR	6(17.64%)	20(8.4%)	0.0377
ASD	0	43(19.25%)	0.47
VSD	0	5(1.4%)	1.00
CABG	6(6.5%)	60(27.69%)	0.47
Total	27(100%)	223(100%)	

Table-3: Regression analysis of the AKI with predictors.

	B	Wald	Sig.	Exp(B)	95.0% C.I.for EXP(B)	
					Lower	Upper
Age	0.001	0.002	0.961	1.001	0.954	1.05
Sex(male)	0.753	1.141	0.286	2.124	0.533	8.462
weight	-0.024	0.567	0.451	0.976	0.917	1.039
Hypertension	1.34	2.799	0.094	3.819	0.795	18.35
DM	0.408	0.472	0.492	1.504	0.469	4.825
Pre-op urea	0.65	0.45	0.32	1.88	0.43	1.78
Pre-op creatinine	0.27	0.67	0.65	1.93	0.74	1.84
CPB time	0.012	0.73	0.393	1.012	0.985	1.039
Cross clamp time	-0.038	5.333	0.021	1.962	0.932	0.994
MAP	-0.028	0.083	0.774	0.973	0.805	1.176
MFR	-0.05	0.005	0.946	0.951	0.22	4.105
Lowest hematocrit on CPB	0.64	2.847	0.092	1.896	0.902	3.986
Constant	-14.135	1.356	0.244	0		

DM: Diabetes Mellitus, CPB: cardiopulmonary bypass, MAP: mean arterial pressure, MFR: mean flow rate.

DISCUSSION

Acute kidney injury is a well know complication of cardiac surgery with an incidence of 5 to 8% reported in different studies internationally.[7]Acute kidney injury (AKI) not only increases the length of stay in the intensive care unit but also associated with increased mortality and thus poor outcome. Our study looked into preoperative and intraoperative variables in Pakistani population undergoing cardiac surgery with the use of cardiopulmonary bypass. Since very little work on acute kidney injury after cardiac surgery is done in Pakistani population, our understanding of the behavior of this complication in our population is still limited.

The incidence observed in this study was 6.5%. Depending upon the definition, the incidence varies from 5 to 40%[8]. Various classification systems exist for AKI namely RIFLE (an acronym for risk, injury, failure, loss, end-stage kidney disease) criteria and AKIN (Acute Kidney Injury Network) criteria[9]. Both systems define AKI in terms of progression stages and outcome.Two other local studies stated the incidence of AKI as 7% and 13%[10,11]. This shows that the incidence in our study is consistent with the internationally quoted as well as local figures. Many factors act together to cause postoperative AKI.Various studies have considered different risk factors and predictors for postoperative AKI. Their interplay leads to the final pathological mechanism which is tubular cells ischemia, to cause AKI[7].

Diabetes mellitus has been identified as a predictor of AKI in cardiac surgery patientsby many studies[12,13]. It causes generalized vasculopathy and that is why these patients are more prone to AKI after cardiac surgery. The exact mechanism is still not known. Further research is needed in this regard.

Our study showed a strong predictive value of hypertension with postoperative AKI. Gong et al showed that patients with hypertension are at increased risk for postoperative AKI[14]. Hypertensive nephropathy is a well-known factor and may render the patient at increased risk of postoperative AKI.

Preoperative deranged renal function is probably the most predictive factor for postoperative AKI. A twofold increase in serum creatinine against the preoperative levels cause a 10-20% increased risk for AKI.[15]our study showed that an increase in serum urea and creatinine preoperatively are strongly associated with postoperative AKI. Cardiopulmonary bypass adds to the ischemic injury in the already damaged kidney tubular cells. This leads to higher mortality, longer stay in the intensive care unit, and also increased risk for infections postoperatively. Several mechanisms have been described for this finding. CPB stimulates several complements, other cytokines, and oxygen free radicals. These inflammatory mediators lead to leukocyte extravasation and edema, causing kidney injury[15].

Cardiopulmonary bypass is associated with many untoward effects on the body physiology. It results in the formation of free hemoglobin and Iron in the blood which act as free radicals and damage the tubular cells.[16]A prolonged time on cardiopulmonary bypass was identified as an independent predictor of AKI in our study. CPB flow rates and the perfusion pressure are important factors in this regard[17]. An increased CPB time has been identified as predictor of AKI by Palmer et al[18]. A CPB time of more than 90 min was shown to be a predictor of AKI by Sethi et al[19]. Similarly an increased cross clamp time has been shown to be associated with augmented risk of AKI postoperatively. Our study confirmed this finding. Rosner et al found a correlation between increased cross clamp time and this important postoperative complication[20]. Thenon-pulsatile flow and the below

normal flow rate on CPB are important etiological factors in this regard.

Our study does confirm that valve related procedures when done on CPB are associated with AKI postoperatively more than coronary surgery. But the predictive model does not show a strong correlation. Previous studies however show a significant impact of valve related procedures on the occurrence of AKI[21].

During CPB, the organ tissues are at risk of ischemia because of hypothermia and hypo perfusion. For this reason, the blood viscosity is decreased through hemodilution on pump.[22]This study shows that the lowest hematocrit on pump is a strong predictor of AKI in the postoperative period. Studies on this subject have shown that decreasing hematocrit below 25% is associated with an increased risk of postoperative AKI[23].

Our study is one of the few initial studies in Pakistan taking on this important issue is cardiac surgery. It does have a few limitations. Although prospective, the study was a single center study.Secondly, it considers only the preoperative and per-operative variables. Although the model developed from this study shows a significant association between AKI and the independent predictors, it doesn't show causality and that is why we can't recommend pharmacological interventions for the perioperative management which may reduce the occurrence of this complication in the first place. But the study does help in identifying patients at high risk of AKI postoperatively and thus preventive measures can be taken. More research on the subject which considers postoperative factors as well as other variables like the timing from coronary angiogram to surgery may give more accurate predictive models for AKI postoperatively.

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