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Original Article

Impact of Per-Operative Hematocrit on Postoperative Acute Kidney Injury following Cardiopulmonary Bypass

Syed Golam Azam[1], Tawfiq Ahmed[1], AM Asif Rahim[2], Ferdous Ara Fatima[1], Golam Mokthader Khan[1], Kamrun Nahar[1], ASM Hossain Kabir[1], Nazneen Nawal[3]

[1]Department of Vascular Surgery, Sir Salimullah Medical College, Dhaka, [2]Department of Cardiac Surgery, Chittagong Medical College, Chattagram, [3]Shahid Suhrawardy Medical College, Dhaka

Abstract

Background: *Acute kidney injury (AKI) is a common serious complication of cardiac surgery. A low hematocrit during cardiopulmonary bypass is associated with an increased risk of acute kidney injury, mainly due to a low oxygen delivery. Hemodilution is required for effective function of cardiopulmonary bypass during cardiac operations and moderate hemodilution is found to be beneficial for renal protection. But extreme per-operative low hematocrit is linked to adverse renal outcome. The main objective of this study was to determine the utility of per-operative hematocrit level in predicting AKI following cardiopulmonary bypass.*

Methods: *It was a cross sectional study involving fifty patients who underwent cardiac surgery supported by cardiopulmonary bypass. Group A (25 patients) had hematocrit level e" 24 % and group B (25 patients) had hematocrit level <24% during cardiopulmonary bypass. Each patient was categorized by Acute Kidney Injury Network (AKIN) criteria based on creatinine changes within the first 48 hours. The independent impact of lower hematocrit on post-operative acute kidney injury was assessed.*

Results: *In this study of the 50 patients, 30% were diagnosed with AKI. Among those 15 patients, 4 were from group A and 11 were from group B (p= 0.031). Most of the patients developed stage 1 AKI according to AKIN criteria (80%). None developed stage 3. Post-operative creatinine was significantly higher in group B than group A. When considering baseline characteristics, we found no difference in age, gender, pre-operative LVEF, diabetes and hypertension. Regarding the intraoperative characteristics, we found no relation with CPB time and cross clamp time (p value 0.982 and 0.596 respectively) with CSA-AKI. Postoperative urine output was not also significantly involved with post-operative AKI.*

Conclusion: *Patients with per-operative hematocrit level above 24% during cardiopulmonary bypass had good postoperative renal function than patients with per-operative hematocrit level below 24%.*

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Introduction

Cardiac surgery, including Coronary Artery Bypass Grafting (CABG) and surgery for valvular disease, represents one of the most common surgical procedures, with over 2 million surgeries performed per year worldwide. With the advent of cardiopulmonary bypass, cardiac surgery has made much advances.[1] For the prevention of postoperative AKI, several pharmacological approaches such as sodium bicarbonate, statins, mannitol, N-Acetylcysteine etc. have been shown to have beneficial role in renal protection.[1]

Cardiac surgery-associated acute kidney injury (CSA-AKI) is a common and serious postoperative complication of cardiac surgery that employs cardiopulmonary bypass (CPB).[2] It is the second most common cause of AKI in the intensive care unit (ICU). CSA-AKI results from deterioration

Address of Correspondence: Dr. Syed Golam Azam, Department of Vascular Surgery, Sir Salimullah Medical College Hospital, Dhaka, Bangladesh. Email: himel.m43@gmail.com

in renal function expressed as a significant decrease in glomerular filtration rate (GFR). CSA-AKI in severe form requires renal replacement therapy (RRT), occurring in up to 4%.[3]

Cardiopulmonary bypass (CPB) provides circulatory and respiratory support with management of temperature facilitating surgery of the heart and great vessels. The use of CPB has been associated with decrease in the renal perfusion pressure up to 30% and, hence, increasing the ischemic–reperfusion injury.[4] Hemodilution or low hematocrit level during the cardiopulmonary bypass also has been associated with disturbances in the relationship between oxygen supply and demand. It is also believed to precipitate acute renal injury in the setting of renal medullary hypoxia.[5] Moreover, numerous studies have pointed out the potential disadvantages of low hematocrit during CPB.[4]

During CPB, hemodilution decreases blood viscosity, improving regional blood flow in the setting of hypoperfusion and hypothermia, and minimizes the need for blood transfusion. The intraoperative hematocrit <24% was significantly associated with an increased risk of CSA-AKI.[6] In some studies, postoperative kidney injury and tissue hypoxemia (lactate) markers were higher in the low-hematocrit group (<24%). These studies suggest that a hematocrit level of <24% is associated with an increased risk of CSA-AKI.[5]

The preoperative risk factors for CSA-AKI include advanced age, female gender, reduced left ventricular function or congestive heart failure, diabetes mellitus, peripheral vascular disease, chronic obstructive pulmonary disease, emergency surgery, and elevated serum creatinine.[7] The postoperative AKI is also associated with prolonged intensive care unit (ICU) and hospital stays, resource use.[6]

Acute kidney injury is a not an uncommon problem following cardiac surgery. It is associated with increased morbidity, mortality and duration of hospital stay. Hemodilution during cardiopulmonary bypass is found to be beneficial for reducing risk of kidney injury but extreme hemodilution (hematocrit <24%) is supposed to cause adverse outcome. So assessing and controlling hemodilution related AKI is precious to improve the quality outcomes after cardiac surgeries using cardiopulmonary bypass. This study aimed to evaluate the impact of the hematocrit during CPB in the development of postoperative AKI following cardiac surgery. No such study had been done previously in our country. So my hypothesis is Per-operative low hematocrit level (<24%) is associated with postoperative acute kidney injury following cardiopulmonary bypass.

Methods

This cross sectional study were carried out in the Department of Cardiac Surgery, Bangabandhu Sheikh Mujib Medical University, Dhaka from March 2020 to September 2021.General objectives of this study was to determine the impact of per-operative hematocrit level in predicting AKI following cardiopulmonary bypass. Specific Objectives were to compare the effect of per-operative hematocrit level between 2 groups of patients undergoing cardiac surgery (cut off value 24%) And to observe the effect of cardiopulmonary bypass on renal function in the postoperative period. Fifty patients were selected who underwent cardiac surgery supported by cardiopulmonary bypass. Twenty-five in each group. Group A had hematocrit level e" 24 % and group B had hematocrit level <24% during cardiopulmonary bypass with Inclusion criteria includes Patients undergoing elective cardiac surgery with cardiopulmonary bypass. Exclusion criteria were abnormal renal function at admission (a new kidney injury), cardiac failure at the time of preoperative evaluation, left ventricular ejection fraction <30% prior to surgery, off-pump surgery, emergency cardiac surgery, previous history of any cardiac surgery and known bleeding disorder and hepatic impairment.

AKI was defined by the Acute Kidney Injury Network (AKIN) classification criteria: sudden decrease (in 48 h) of renal function, defined by an increase in absolute serum creatinine of at least 26.5 ìmol/L (0.3 mg/dL) or by a percentage increase in serum creatinine e"50% (1.5× baseline value), or by a decrease in the Urine output (UO) (documented oliguria <0.5 mL/kg/h for more than 6 h)

The AKIN classification/staging system of acute kidney injury: *f*

Stage	Serum creatinine	Urinary output
1	↑serum creatinine ≥26.5 ìmol/L (≥ 0.3 mg/dL) or ‘! serum creatinine ≥150 - 200% (1.5 - 2×)	<0.5 mL/kg/h (>6 h)
2	↑serum creatinine >200 - 300% (>2 - 3×)	<0.5 mL/kg/h (>12 h)
3*	↑serum creatinine >300% (>3×) or if baseline serum creatinine ≥353.6 ìmol/L (≥4 mg/dL) ↑serum creatinine ≥44.2 ìmol/L (≥0.5 mg/dL)	<0.3 mL/kg/h (24 h) or anuria (12 h)

***** Stage 3 also includes patients requiring RRT independent of the stage (defined by serum creatinine and/or UO) they are in at the moment they initiate RRT.

A semi structured questionnaire was used. Data collection tool was developed this includes face to face interview, history sheets, related investigation reports of both pre and post-operative variables were collected during perioperative period. All Data collected were analyzed and conducted by latest version of Statistical Package for Social Science (SPSS). All collected data were analyzed and interpreted by using different statistical techniques (e.g. mean, percentage, etc.). The results were presented in tables. Comparisons between groups were made with independent Student’s t-test for continuous data and Chi-Square test or Fisher’s Exact Test for categorical data. Observations were recorded as statistically significant if a p-value d”0.05.

Results

Among study population, the mean age in group A 36.00 ± 14.32 years and in group B 36.88 ± 11.44 years. Majority of populations of both groups are within 18-28 years and 29-38 years age group. The difference in age between two groups was not statistically significant (p>0.05). There was no statistical significance of gender between the two study groups (p>0.05). Females were predominant in both groups, in group A 13 and in group B 15. The difference between the groups was not statistically significant. Distribution of patient’s risk factors revealed that six patients in Group A and four patients in Group B had DM. On the other hand, seven and four patients had hypertension in Group A and B respectively. Both findings are statistically insignificant. In comparison of preoperative data preoperative LVEF of both groups. Mean ± SD, LVEF (%) of group A and B was 62.56 ± 6.35 and 53.2 ± 13.36 respectively, p value is 0.067 which is statistically not significant. Preoperative mean serum creatinine in group A was 0.89 ±0.18 and 0.97 ±0.15 in group B. The difference was not statistically significant. Comparison of peroperative data shows mean duration of cross clamp time 57.64 ± 41.3 min in group A and 84.96 ± 48.15 min in group B. The mean duration of total cardiopulmonary bypass time (CPB) in group A was 95.28 ± 53.14 min and in group B 140.56 ± 67.53min. The difference between the group regarding cross clamp time and CPB time was not statistically significant. Outcome distribution of patients shows post-operative urine output in ml/kg/hour of both groups. Mean ± SD, of group A and B was 1.65 ± 0.3 and 1.65 ± 0.33 respectively, p value was 0.743 which is statistically not significant.

Table-I

Comparison of postoperative serum creatinine (N=50)

Serum creatinine	Group A (n=25) Mean±SD	Group B (n=25) Mean±SD	p-value
1st POD	1.07±0.27	1.39±0.49	0.006s
2nd POD	0.98±0.23	1.35±0.48	0.001s
Post-Operative AKI	4 (16%)	11 (44%)	0.031s

Data was presented as Mean ± SD. Unpaired t-test was done to compare between the means. p≤0.05 was considered to be significant. s= significant. SD= standard deviation

Table I shows the postoperative serum creatinine level between the groups. On 1st POD mean serum creatinine in group A was 1.07±0.27 and in group B 1.39±0.49. On 2nd POD the mean serum creatinine in group A was 0.98±0.23 and 1.35±0.48 in group B. The differences were significant on both 1st and 2nd POD. Four patients (16%) in group A and eleven patients (44%) in group B developed postoperative AKI which was statistically significant.

Distribution of the patients according to AKI stage: Among 50 patients, 30% developed AKI. Among those who developed AKI, 80% had stage 1 of AKI, 20% had stage 2 and no patient developed stage 3 AKI. No patient needed peritoneal or hemodialysis.

Table-II

Distribution of the patients according to outcome (N=50)

	Frequency	Percentage
AKI	15	30
Stage 1	12	80
Stage 2	3	20
Stage 3	0	0

Discussion:

Cardiopulmonary bypass and hemodilution are necessary parts of cardiac surgery. But they are not devoid of complications amongst which is acute kidney injury (AKI). This study was performed to find the impact of per-operative hematocrit level on post-operative acute kidney injury after cardiac surgery supported by cardiopulmonary bypass.

This study was carried out with an aim to observe the demographic characteristics regarding age, sex, preoperative risk factors, peroperative variables, postoperative outcome such as postoperative serum creatinine, urine output, AKI and stages of AKI.

The demographic attributes of the participating patients were recorded and analyzed. Most patients were in 18-28 years and 29-38 years group. The difference in age distribution was not statistically significant (p>0.05). In a previous study Ranucci and colleague found that age was significantly (p value =0.001) involved with CSA-AKI. Their sample size was 16,790 and study duration was 14 years which were greater than this study. That's why it couldn't establish any relation with age.[8]

The distribution of gender between two groups were not statistically significant (p=0.569). Total male were 22 (44%) and female were 28 (56%). Michelle and colleagues observed that 31.83% of 15,221 patients were women and insignificantly associated with AKI following CPB (p value=0.2).[9]

This study found mean pre-operative left ventricular ejection fraction and preoperative serum creatinine was statistically insignificant (p value 0.067 and 0.103 respectively). Six patients in group A and four patients in group B had diabetes Mellitus and seven patients in group A and four patients in group B had hypertension. p value of both DM and HTN is statistically insignificant, 0.48 and 0.306 respectively. Findings were similar and consistent with study conducted by Swaminathan and colleagues except DM. They found DM significantly associated with post-operative AKI, p value =0.01.[2] Ranucci and colleagues also found significant involvement of lower LVEF (p value 0.001) and DM (p value 0.015). But as this study population is small and mostly from younger people, it couldn't establish such relationship.[9]

In this study mean of cross clamp time and mean of total CPB time were observed and analyzed, p-value was not statistically significant in both cross clamp time and CPB time. Findings are similar with Vellinga et al.[10] Whereas Karkouti and colleagues found significant association of CPB time (p value <0.001). As this study has smaller sample size and most of the surgeries were of shorter duration, no such association couldn't be established.[11]

Mean of post-operative urine output in ml/kg/hour is 1.63±0.4 in group A and 1.58±0.36 in group B (p = 0.743). Ranucci and colleagues found significant involvement of urine output, but in our ICU, urine output is manipulated with use of diuretics.[9]

In this study the difference of post-operative serum creatinine on 1st and 2nd post-operative day were found significant between the groups (p-value 0.006 and 0.001 respectively). But mean serum creatinine was higher in patients with lower hematocrit level (group B).[9]

Out of 50 patients 15 (30%) patients had acute kidney injury following cardiopulmonary bypass in this study among them 80% had stage 1 AKI, 20% had stage 2 and no patient had stage 3 AKI. Out of 15 patients who developed AKI, four patients were (16%) in group A and eleven patients (44%) in group B which was statistically significant, p value 0.031. No patient needed peritoneal or hemodialysis. In previous study by Vellinga et al.,[10] acute kidney injury was observed in 83 (14.11%) patients. Swaminathon et al. also found significant p value of 0.04 in their study.[2] In a previous study by Ranucci et al. it was seen that 8.8% was Stage 1 of AKI, 4.7% was stage 2 or 3 of AKI.[9]

In this study, AKI was significantly associated with low hematocrit (<24%) during cardiopulmonary bypass (p value ≤0.05).

Conclusion:

This study revealed that, patients with per-operative hematocrit level above 24% during cardiopulmonary bypass had good postoperative renal function than patients with per-operative hematocrit level below 24%. So, keeping per-operative hematocrit level within upper range can be a routine practice to prevent post-operative AKI.

Limitations of the study:

This study evaluated a small population of patients for a limited period of time. This analysis was done in a single center of Bangladesh and the sample only represents a small fraction of patients undergoing cardiac surgery. No follow-up was conducted after the discharge of the patient.

Recommendations:

Keeping per-operative hematocrit level above 24% during cardiopulmonary bypass will be a good practice to minimize post-operative AKI as well as improving post-operative outcomes.

Multicenter based larger prospective study is needed to validate the findings of the study.

Conflict of Interest - None.

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