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ORIGINAL ARTICLE

Outcome of Prolonged Cardiopulmonary Bypass Time (CPBT) on Renal Function in Patients Undergoing Open Heart Surgery

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Abstract:

Objective: *To observe changes of renal function from the preoperative period to that of the postoperative period in cardiac surgical patients with prolonged cardiopulmonary bypass time.*

Background: *Cardiopulmonary bypass (CPB) is considered responsible for kidney damage. By using markers like blood urea, serum creatinine, creatinine clearance rate and 24 hours urine output we assessed whether the length of CPB influences kidney function.*

Methods: *60 consecutive cardiac operation patients with CPB time of more than 90 minutes were studied. Blood urea, serum creatinine, creatinine clearance rate and 24 hours urine output was measured preoperatively and on the 1st, 2nd and 7th postoperative days in the intensive care unit.*

Result: *Acute renal failure developed in 5 patients (8.3%). Dialysis for acute renal failure was required in 2 (3.33 %) patients. Deep sternal wound infection occurred in 5 patients (8.3%). Respiratory tract infection developed in 6 (10 %) patients. No patient required prolonged ventilation > 48 hours. One patient (1.66%) died on 6th post operative day (POD) due to multi organ failure.*

Conclusion: *Patients with prolonged cardiopulmonary bypass time have detrimental effect on renal function with some other mortality and morbidity in the perioperative period.*

Key words: *Cardiopulmonary bypass, Cross clamp time, Extracorporeal circulation time.*

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Introduction:

Cardiopulmonary bypass (CPB) is a technique by which pumping action of the heart and the gas exchange functions of the lungs are replaced temporarily by a mechanical device, the pump oxygenator, attached to a patient's vascular system. CPB represents one of the most important biomedical inventions in the history of health care[1]. About 80% of routine cardiac surgical procedures are performed world wide using CPB[2].

Renal dysfunction in the postoperative period of open heart surgery is a risk factor for hospital mortality[3,4]. It is a frequent complication in the postoperative period of open heart surgery with a reported incidence of between 1% and 31%. [5,6]

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Incidence of acute renal failure (ARF) requiring dialysis is 0.7%- 5% and mortality rate of patients with ARF after open heart surgery is 28%-63%.[7]

The goal of CPB is to maintain regional perfusion at a level that supports optimum cellular and organ function. Thus any decrease in renal perfusion during CPB depending upon its magnitude and duration can lead to significant cellular injury [8].

Prolonged CPB time is defined as extra corporeal circulation time longer than 80 minutes[9] or, it is longer than 98 minutes [10-11]. Adhesion of blood corpuscles to endothelial cells are increased producing progressive alteration of renal plasma flow by increased duration of CPB[12].

It has been shown that inflammatory response increases significantly beyond 80 minutes of CPB time. As degree of inflammation appears to be correlated with alterations in the organ function, CPB time of more than 80 minutes may affect splanchnic organ function more pronouncedly than CPB time less than 70 minutes[13].

National Institute of Cardiovascular Diseases (NICVD), Dhaka, Bangladesh has been performing the central role in the field of cardiac surgery in our country. This study was designed with the objective to evaluate the influence of prolonged cardiopulmonary bypass time on renal function on patients of open heart surgery in NICVD. This will contribute to develop strategies for prevention of renal complications following open heart surgery at NICVD.

Materials and methods

This cross sectional study was done in the National Institute of Cardiovascular Diseases (NICVD), Dhaka from January 2015 to December 2016.

Patients undergoing cardiac surgery under CPB were enrolled in this study. Their renal functions were evaluated by obtaining blood sample preoperatively as well as postoperatively on 1st POD, 2nd POD and on 7th POD. Normal preoperative values of Blood urea, Serum creatinine, Creatinine clearance rate and 24 hours urine output was considered as parameters for evaluation of renal function. Known case of renal dysfunction (S.creatinine >1.5 mg/dl), Patients with uncontrolled diabetes mellitus, hypertension and patients needing re-establishment of CPB were excluded from the study.

During peroperative period, operation type, extracorporeal circulation time, Cross clamp time, Mean arterial blood pressure, CVP and total ICU stay were recorded in each patient.

All the relevant collected data are compiled on a master sheet first and then organized by using scientific calculator and standard statistical formulas. Statistical analyses of the result were done by computer software device as statistical packages for social scientist (SPSS).The results were presented in tables, figures and diagrams etc. To see correlation between prolonged cardiopulmonary bypass time and renal function, the study outcomes were evaluated regarding unpaired 't' test and multiple regression analysis was done. A "p" value <0.001 was considered as significant.

Results:

Base line biochemical variables:

The data of clinical findings shows the base line values of blood urea, serum creatinine, creatinine clearance rate and 24 hours urine output of the study population measured preoperatively. Blood urea (mg/dl), serum creatinine (mg/dl), creatinine clearance rate(ml/min),and 24 hours urine output (ml) was 32.70 ± 8.35, 0.87 ± 0.20, 83.21 ± 06.03 and 1680.37 ± 214.63 respectively.

Table-I

Distribution of study subjects by baseline biochemical variables

Baseline biochemical variables	Mean ± SD
Blood urea (mg/dl)	32.70 ± 8.35
Serum creatinine (mg/dl) rate	0.87 ± 0.20
Creatinine clearance (ml/min)	83.21 ± 06.03
24 hours urine output (ml)	1680.37 ± 214.63

Per operative variables:

The mean extracorporeal circulation time or cardiopulmonary bypass time (CPBT) was 103.07 ± 50.12 min and mean cross clamp time (XCT) was 63.81 ± 30.66 min.

Table-II

Distribution of study subjects by per operative variables

Per operative variables	Mean ± SD
Extracorporeal circulation time (min)	103.07 ± 50.12
Cross clamp time (XCT) (min)	63.81 ± 30.66

Post operative variables of the patients:

The Mean ± SD of duration of mechanical ventilation was 10.37 ± 2.58 hours, Mean ± SD of ICU stay was 3.83 ± 1.37 days and the Mean ± SD of duration of hospital stay was 10.37 ± 2.58 days.

Table-III

Comparison of postoperative events

Variables	Mean ± SD
Period of mechanical ventilation (hours)	13.61 ± 4.45
ICU stay (days)	3.83 ± 1.37
Total hospital stay (days)	10.37 ± 2.58

Correlation between renal parameters in different postoperative days (POD) and Cardiopulmonary bypass time (CPBT):

a) Correlation between blood urea in different postoperative days (POD) and Cardiopulmonary bypass time (CPBT):

Preoperative blood urea was with in normal limit. Mean ± SD blood urea level was32.70 ± 8.35 mg/dl.

By the 1st postoperative day (POD1) blood urea levels were recorded and it was found that the Mean ± SD blood urea level was 67.12 ± 8.81 mg/dl.

On the 2nd post operative day (POD2) Mean ± SD blood urea level was 77.38 ± 10.40 mg/dl.

Similarly, on the 7th postoperative day (POD7) Mean ± SD of blood urea level was 53.07 ± 15.17 mg/dl.

The table shows significant correlation between CPBT and blood urea in different post operative days where, r = .609, .665 and .753 respectively and p value was significant (<.001) in different post operative days.

Table 5: Correlation between serum creatinine (mg/dl) in different postoperative days and Cardiopulmonary bypass time (CPBT):

b) Correlation between serum creatinine (mg/dl) in different postoperative days and Cardiopulmonary bypass time (CPBT):

Preoperative serum creatinine was with in normal limit. Mean ± SD serum creatinine level was .87 ± .20 mg/dl.

By the 1st postoperative day (POD1) serum creatinine levels were recorded and it was found that the Mean ± SD serum creatinine level was 2.36 ± .49 mg/dl.

On the 2nd post operative day (POD2) serum creatinine levels were recorded and was found that Mean ± SD serum creatinine level was 2.41 ± .76 mg/dl.

Similarly, on the 7th postoperative day (POD7) Mean ± SD of serum creatinine level was 1.55 ± 1.03 mg/dl.

The table shows significant correlation between CPBT and serum creatinine in different post operative days where, r = .421, .398 and .436 respectively and p value was <.001 in different post operative days.

c) Correlation between creatinine clearance rate (CCr) (ml/min) in different postoperative days and Cardiopulmonary bypass time (CPBT):

Preoperative creatinine clearance rate (CCr) was with in normal limit. Mean ± SD creatinine clearance rate (CCr) level was 83.21 ± 6.03 ml/min.

By the 1st postoperative day (POD1) creatinine clearance rate (CCr) levels were recorded and it was found that the Mean ± SD creatinine clearance rate (CCr) was 43.97 ± 7.24 ml/min.

On the 2nd post operative day (POD2) creatinine clearance rate (CCr) were recorded and was found that Mean ± SD creatinine clearance rate (CCr) was 44.23 ± 4.85 ml/min.

Similarly, on the 7th postoperative day (POD7) Mean ± SD of creatinine clearance rate (CCr) was 72.96 ± 11.84 ml/min.

The table shows significant negative correlation between CPBT and creatinine clearance rate (CCr) in different post operative days where, r = -.609, -.640 and -.723 and p value was <.001 in different post operative days.

d) Correlation between 24 hours total urine output (ml) in different postoperative days and Cardiopulmonary bypass time (CPBT):

Preoperative 24 hours total urine output (ml) was within normal limit. Mean ± SD 24 hours total urine output (ml) was 1680.37 ± 214.63.

By the 1st postoperative day (POD1) 24 hours total urine output (ml) were recorded and it was found that the Mean ± SD 24 hours total urine output (ml) was 1546.15 ± 225.78.

On the 2nd post operative day (POD2) 24 hours total urine output (ml) were recorded and was found that Mean ± SD 24 hours total urine output (ml) was 1507.60 ± 278.62.

Similarly, on the 7th postoperative day (POD7) Mean ± SD 24 hours total urine output (ml) was 1624.67 ± 386.30.

The table shows significant negative correlation between CPBT and 24 hours total urine output (ml) in different post operative days where, r = -.421, -.511 and -.448 and p value is <.001 in different post operative days.

Table-IV

Comparison of post operative complications

Acute renal failure	No	Percentage
Yes	5	8.3
No	55	91.6
Need for dialysis		
Yes	2	3.33
No	58	96.66
Deep sternal wound infection		
Yes	5	8.3
No	55	91.6
Respiratory tract infection		
Yes	6	10
No	54	90
prolonged ventilation > 48 hours		
Yes	0	0
No	60	100
Death		
Yes	1	1.66
No	59	98.33

Comparison of post operative complications: Acute renal failure developed in 5 patients (8.3%). Dialysis for acute renal failure was required in 2 (3.33 %) patients. Deep sternal wound infection occurred in 5 patients (8.3%). Respiratory tract infection developed in 6 (10 %) patients. No patient required prolonged ventilation > 48 hours. One patient (1.66%) died on 6th POD due to multi organ failure.

Table-V

Multiple regression analysis considering Cardiopulmonary bypass time (CPBT) as dependent variable and age, sex and blood urea as independent variable

Variable	Standardized Coefficients (β)	p value	95% Confidence Interval for β	
			Lower Bound	Upper Bound
(Constant)		.005	-86.275	-16.051
Age	.326	<.001	.530	1.601
Sex	.096	.215	-5.710	24.790
Blood urea	.637	<.001	1.506	2.545

The above table shows significant correlation of age and blood urea with cardiopulmonary bypass time. p value is <.001 for each variable.

Table-VI

Multiple regression analysis considering Cardiopulmonary bypass time (CPBT) as dependent variable and age, sex and Creatinine clearance rate (CCr) as independent variable:

Variable	Standardized Coefficients (β)	p value	95% Confidence Interval for β	
			Lower Bound	Upper Bound
(Constant)		.000	175.057	305.797
Age	.334	<.001	.523	1.659
Sex	.105	.201	-5.709	26.543
CCr	-.603	<.001	-3.283	-1.820

The above table shows significant correlation of age and Creatinine clearance rate (CCr) with cardiopulmonary bypass time. p value is <.001 for each variable.

Table-VII

Multiple regression analysis considering Cardiopulmonary bypass time (CPBT) as dependent variable and age, sex and Serum Creatinine as independent variable

Variable	Standardized Coefficients (β)	p value	95% Confidence Interval for β	
			Lower Bound	Upper Bound
(Constant)		309	-18.216	56.545
Age	.489	<.001	.923	2.274
Sex	.065	.525	-13.778	26.685
S. creatinine	.337	<.001	6.350	26.397

The above table shows significant correlation of age and serum creatinine with cardiopulmonary bypass time. p value is <.001 for each variable.

Table-VIII

Multiple regression analysis considering Cardiopulmonary bypass time (CPBT) as dependent variable and age, sex and 24 hours urine output as independent variable

Variable	Standardized Coefficients (β)	p value	95% Confidence Interval for β	
			Lower Bound	Upper Bound
(Constant)		.001	45.386	173.339
Age	.459	<.001	.789	2.212
Sex	.083	.427	-12.389	28.869
24 hrs urine output	-.305	<.001	-.068	-.011

The above table shows significant correlation of age and 24 hrs urine output with cardio-pulmonary bypass time. p value is <.001 for each variable.

Discussion:

The patients were stratified in the following age groups: 30 years and less, 31-40 years, 41-50 years and more than 50 years. (Shown in table 1). Maximum numbers (33) of cases (55%) were found in <30 years of age group followed by 16.7% (10) between 41-50 years, 15% (9) more than 50 years and 13.3% (8) 41-40 years. About 52% (31) were female and about 48% (29) were male in the study population.

Most (46.7%) of patients had repair of congenital anomalies, 20% experienced mitral valve replacement, 13.3% CABG, 13.3% aortic valve replacement, CABG with MVR, CABG with DVR and repair of RASV each comprised of 1.7%.

Based on preoperative (baseline) biochemical variables it has been shown that blood urea, serum creatinine, creatinine clearance and 24 hours urine output were within normal value. Among the peroperative variables, the mean extracorporeal circulation time (ECCT) and mean cross-clamp time (XCT) were recorded for each patients.

Renal function was assessed by measuring blood urea, serum creatinine, creatinine clearance and 24 hours urine output. Parameters were evaluated preoperatively and postoperatively on 1st, 2nd and 7th POD. The mean blood urea was 32.70 ± 8.35 mg/dl at baseline which increased sharply to 67.12 ± 8.81 mg/dl at 1st POD and then insidiously to 77.38 ± 10.40 mg/dl at 2nd POD and then decline steeply to 53.03 ± 15.75 mg/dl at 7th POD. The difference of blood urea level in different postoperative days was found statistically significant. Similar types of results were observed [8].

Mean preoperative serum creatinine level was 0.87 ± 0.20 mg/dl. Mean serum creatinine level in the 1st POD, 2nd POD and 7th POD showed significantly higher levels. Here the difference in the postoperative values was statistically significant. A study found that serum creatinine levels increased progressively in both groups from preoperatively to 24 hours postoperatively and there after decreased by 48 hours post operatively.[9] This finding was similar to our observation.

Comparison of creatinine clearance rate (ml/min) was also evaluated preoperatively and on different postoperative days. But significant differences were found in values on 1st, 2nd and 7th postoperative days.

Comparison of 24 hours urine output (ml) were done preoperatively as well as in different post operative days. Here it was observed that in all the periods 24 hours urine output was lower significantly in the post operative periods.

Besides comparing renal parameters time course of renal variables were also observed. Regarding blood urea levels, in course of time values increased on 1st and 2nd POD, declines on consecutive POD but remains elevated in some

cases. But statistically significant difference remained between preoperative blood urea level and value on 7th POD.

Trend of change of serum creatinine level was observed in patients with CPBT >90 min. Serum creatinine was increased on 1st POD. There after creatinine value declined to some extent and did not reach the preoperative value. At each time point (2nd and 7th POD) creatinine value remained elevated. There was highly significant difference between preoperative and 7th POD serum creatinine value.

Change of creatinine clearance rate (CCr) over each point of time was observed. During the postoperative period CCr reduced significantly on 1st and 2nd POD. There after CCr gradually increased over time from 1st POD to 7th POD, but reached a level below the preoperative level.

Several post operative variables have been observed (Shown in Table 10). In this study mean ventilation period 13.61 ± 4.45 hours. Procedures having CPBT <90 minutes are to be better tolerated by the patients; ventilation time was significantly higher in patients with CPBT> 90 minutes.

On the other hand, mean period of total ICU stay were 3.83 ± 1.37 days. These findings were similar to other study where high CPBT group required more ICU stay[8].

Total postoperative hospital stay was10.37 ± 2.58 days, similar to reported length of hospital stay 7.36 ± 3days and 5.84 ± 1.5 days in long CPBT group vs. short CPBT group respectively[9-11]. It was statistically significant (p<0.03).This finding corresponds to our study.

Thus the period of mechanical ventilation, ICU stay, and total postoperative hospital stay were greater. All these reflect definite clinical advantage as well as favorable economic outcome associated with CPBT <90 minutes[12]

In this cross sectional study, the patient was followed up to 30 days. Among the total 60 patients, one patient died on 6th POD due to multi organ failure. Mortality rate was 1.66%.

In the present study, postoperative morbidities were acute renal failure (8.3%), need for dialysis (3.3%), deep sternal wound infection (8.3%), respiratory tract infection (10%). None of them required prolonged ventilation (>48 hours). A study showed that renal complication was 5.4% vs. 3.3%, prolonged ventilation was 6.6% vs. 3.7% in prolonged vs. short CPBT groups respectively[9].Another study reported acute renal failure (15.8% vs. 5.9%), infective complication (7.42% vs. 5.9%) in two groups respectively[13].

The above discussion shows prolonged cardiopulmonary bypass time has statistically significant impact on renal function and post operative morbidity and mortality. The renal parameters showed significant difference in different post operative periods with evidence of significant impact on post operative outcome. So, our data furnish substantial evidence that CPBT> 90 minutes confer significant impact on renal function and postoperative morbidity and mortality.

Conclusion:

This cross sectional study on open heart surgery patients having prolonged cardiopulmonary bypass time revealed significant difference in renal parameters on different postoperative days. The trend of changes in renal parameters on different postoperative days with relation to CPBT. Cardiopulmonary bypass time has more detrimental effect on renal function and requires longer duration of ICU stay and hospital stay and increased incidence of deep sternal wound infection and respiratory tract infection in patients with CPBT > 90 minutes. So, it can be concluded that less cardiopulmonary bypass time offers better preservation of renal function as well as better early post operative outcome in open heart surgery patients.

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