

ACUTE RENAL FAILURE AFTER CARDIOPULMONARY BYPASS SURGERY

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Background: Acute renal failure (urine output <0.5ml/kg/hr.) following cardiopulmonary bypass is an uncommon but highly lethal complication which arises in the setting of inadequate cardiac function and may be associated with multi-organ failure. Acute renal failure (ARF) after cardiopulmonary bypass occurs in about 8% of adult cardiac surgical patients with some preoperative renal impairment and in about 3-4% of patients with normal preoperative renal parameters. This study was conducted to determine the frequency of acute renal failure after cardiopulmonary bypass operations and to find possible risks factors. **Methods:** We analyzed the data of 500 consecutive patients who survived the first 24 hours after open heart surgery at Punjab Institute of Cardiology, Lahore as this is the minimum time to evaluate post-operative renal function, their morbidity, mortality and the main contributing risk factors, from July 2000 to Dec. 2000. The association between preoperative, intra-operative and postoperative variables and the development of ARF was assessed by multivariate logistic regression. **Results:** Of the 500 consecutive patients 35 (7%) patients developed acute renal failure (serum creatinine>2.5 mg/dl) and 102 (20.4%) patients developed acute renal dysfunction (serum creatinine 1.6-2.4 mg/dl). Positive risk factors noted in the development of ARF were age, raised preoperative blood urea and creatinine, diabetes mellitus, low cardiac output state, oligurea, total CPB time, total cross clamp time and significant hypotension during the procedure or during intensive care unit (ICU) stay. Mortality rate for established ARF was extremely poor (88.8 %) and there were only four (4) survivors among those requiring dialysis. **Conclusions:** Prevention of this disastrous complication appears to be better than treatment once it is fully established. However newer aggressive forms of early renal replacement / transplant therapies may have some promise.

Key words: Acute Renal failure, CABG, Cardiopulmonary bypass surgery

INTRODUCTION

Acute renal failure, although uncommon, is one of the major complications after cardiopulmonary bypass (CPB) for open heart surgery. It occurs in about 7-8% of adult patients^{1,2,3} and is more common in older patients and in those with low cardiac output, oligurea or renal dysfunction preoperatively. Low cardiac output is thought to be the primary cause of renal failure after open heart surgery. Measures that elevate cardiac output generally improve renal blood flow, however epinephrine in doses over 1.5 µg/kg/min and dopamine over 12µg/kg/min cause renal vasoconstriction and reduce renal cortical blood flow. If urine output exceeds 0.5 ml/kg/hr after cardiac surgery and cardiac output is 2.4 L/m² / min or more, renal function is probably adequate. Acute tubular necrosis is a serious complication of cardiopulmonary bypass and is associated with increased mortality.⁴ It usually occurs following a period of prolonged hypotension that results in nephron ischemia and reduced renal cortical blood flow. Other causes of renal failure, such as renal vascular diseases (either embolic or thrombotic) or obstructive diseases are rare following open heart surgery. During bypass, renal blood flow may be reduced by periods of low perfusion flow, hypotension, vasoconstriction (e.g., nor-epinephrine etc.) and micro emboli. Excessive plasma hemoglobin filtered by the glomeruli precipitates in the renal tubules when the urine is acid.⁵ Adequate perfusion rates, hemodilution, diuresis during bypass, and maintenance of alkaline urine have made the intraoperative instances of renal failure less common. The major concern is that occurrence of postoperative ARF is still associated with a high mortality rate ranging from 24% to 70%. The multifactorial nature of the postoperative ARF and its independent ability as a predictor of mortality is also well established. However, the large numbers of classifications of ARF make

comparative evaluation of results difficult. This study was undertaken to evaluate the proportion of patients developing postoperative ARF, their mortality and morbidity with a view to aid in subsequent patient management.

MATERIAL AND METHODS

This study was carried out at the Punjab institute of Cardiology, Lahore, which is a tertiary care referral hospital, dedicated to the treatment of cardiac diseases. From July 2000 to December 2000, we studied 500 consecutive adult patients who underwent cardiac operation with cardiopulmonary bypass. Patients who died within the first twenty-four hours after the operation (minimum time required for laboratory assessment of renal function) were excluded from the study. The data were recorded in the cardiac surgical database, which is in order since July 2000. In every patient following variables were recorded.

Preoperative: Age, hemodynamic instability (Y/N), blood urea & creatinine.

Intraoperative: Duration of CPB, mean CPB flows, perfusion pressures (mean), urine volume during CPB.

Postoperative: Inotropic support, Intra-aortic balloon pump (IABP) used, need of dialysis, days on ventilator, ICU stay, dead or discharged.

During operation, three limb leads I, II, III were continuously monitored and invasive arterial blood pressure monitoring continuously done through a peripheral arterial cannula either in the radial or femoral artery. Central venous catheter was inserted after induction except when required otherwise. Cardiopulmonary bypass was managed with non-pulsatile perfusion. A crystalloid priming solution was used (25ml / kg) with mannitol (0.5 gm / kg) supplementation. Systemic flow was targeted at 2.2 L / min / m² and was varied according to venous return to maintain a mean arterial pressure of about 60 ± 10 mm Hg. These variables were recorded every 15 minutes during CPB. Diuretic therapy was administered whenever urinary output fell below 0.5 ml/kg/hr. In the postoperative period patients with urinary output below 0.5 ml/kg/hr. for three hours or more were considered oliguric and diuretic therapy followed optimization of cardiac output and filling pressures. The adequacy of hemodynamic status during operation and in the ICU was evaluated on the basis of inotropic drug administration. Patients who received dobutamine more than 10 µg / kg / min or adrenaline more than 0.03 µg / kg / min were considered to be in low cardiac output state (LOS). In the ICU this definition was accepted only when these therapies were continued for more than four hours. Intra Aortic Balloon therapy was required when the pharmacologic treatment of the LOS failed to restore a satisfactory cardiac performance. Antibiotic prophylaxis was used in all patients. Cefotaxime 2 gm I.V. was given at induction, repeated on completion of CPB and then every eight hours for 24 hours postoperatively. Vancomycin 1 gm I.V. was given additionally at induction for all valvular operations. Respiratory complications were considered as the necessity for mechanical ventilation for more than 24 hours, or the need for re-intubation for pulmonary reasons. Neurological complications were defined as the occurrence of major cerebral damage causing hemiplegia or coma. Enteric complications comprised gastrointestinal bleeding or unexplained abdominal distension for more than 24 hours. Postoperative renal function was defined as normal if peak postoperative creatinine remained below 1.5 mg/dl, renal dysfunction if creatinine was 1.6-2.5 mg/dl and ARF when creatinine was more than 2.5 mg/dl. In patients with renal dysfunction (creatinine 1.6-2.5 mg/dl) creatinine clearance was calculated and FeNa (fractional excretion of sodium) was determined to validate the findings. Consent was taken from all patients and the hospital committee for medical ethics approved the study. Each variable was compared among the three classes of renal function by the χ^2 test for homogeneity and the one-way analysis of variance with significance at p=0.05. The variables that attained significance were then included in further analysis. Stepwise regression was then used to relate the probability of ARF to other patient attributes. A separate multiple linear regression analysis was done to investigate the relative influence of each postoperative complication on mortality.

RESULTS

Of the 500 patients, 473 (94.6%) patients had normal preoperative creatinine and 27 patients (5.41%) had impaired renal function (Table-1). Among the patients with normal preoperative renal function, 72 (15.2%) patients developed postoperative renal complications. 54 (11.4%) patients had renal dysfunction (creatinine 1.6-2.4) and 18 (3.8%) had ARF (table-2).

Table-1: Renal complications after CPB

	Normal renal parameters		Raised renal parameters		Total	
	No.	%	No.	%	No.	%
No renal dysfunction	401	84.7	0	0.0	401	80.2
Renal dysfunction	54	11.4	18	66.6	72	14.4
Acute renal failure	18	3.8	9	33.3	27	5.4
Total	473	94.6	27	5.4	500	100

Table-2: Complications other than Renal

Complications	Normal Creatinine	Raised Creatinine
Low output state	18.2%	31.7%
Respiratory	8.8%	21.9%
Neurological	3%	19.6%
Infective	2.4%	9.8%
Mortality rate	4.2%	29.6%

The overall mortality rate was 4.2% and ranged from 2.1 % in patients without any renal problems to 18% with postoperative renal impairment. In patients with preoperative renal impairment and worsening after the operation, mortality rose to 29.6%. Mortality increased progressively with the degree of renal impairment. A direct relationship between occurrence of other complications and postoperative renal impairment was also recorded.

DISCUSSION

On the basis of 600,000 coronary artery bypass graft procedures performed annually throughout the world, and assuming a 7.7% incidence of ARF, Chew and colleges estimated that approximately 46,000 patients will develop postoperative renal dysfunction and that 8000 of these patients will require dialysis. On the basis of these findings, it is clear that postoperative renal dysfunction is relatively common and serious. In the present study, the ARF prevalence and mortality were not different from the generally reported values of 5-8% for ARF and 25-70% for the mortality associated with it. As no such work has been done previously in Pakistan regarding acute renal failure after CPB, probably because of the recent introduction of cardiac surgery in Pakistan, there are no local studies to be compared with, however the results of many international studies are almost comparable to our study in spite of the fact that there are great differences regarding better investigational and hospitalization facilities and better socio-economical status of the patients. The relationship between diuresis during CPB and postoperative renal failure is rather recent.

There have been mixed reports about the association of this parameter with renal failure. Abel and colleagues registered a lower diuresis before CPB in patients with postoperative renal impairment whereas urine output during and after the operation was not different. Slogoff and associates evaluated the incidence of oliguria (output less than 0.5 ml/kg/hr) during CPB and Corwin and associates considered the total intraoperative diuresis: they failed to demonstrate any statistical correlation with postoperative renal outcome. In our study, lower diuresis rate during CPB was one of the earliest perioperative clinical markers of patients at risk of developing postoperative renal failure. It is probable that during CPB the relative renal hypo-perfusion may have unmasked situations of impaired renal reserve that were not detectable by means of the currently used laboratory methods. The other CPB characteristics were not significant as independent predictors of postoperative ARF development. CPB time was univariately correlated with renal complication, but is not important in the multivariate analysis. Similarly CPB flows and CPB pressures were not related to postoperative ARF development as confirmed by Slogoff and colleagues. Relationship of age to the outcome is also a subject of debate. Although a reduced renal functional capacity is documented in the older age, some investigators have found no significant statistical relationship between age and renal outcome. Preoperative renal impairment is also an important predictor of postoperative renal failure. Although the data in our study is small but the correlation is strong as shown by other studies. It has been shown that postoperative renal failure is more common and more pronounced in patients with impaired renal function than in those with fully established chronic renal failure preoperatively.

To summarize, in the present study the proportion of patients developing postoperative acute renal failure and the mortality related to it has been found to be consistent with the current opinion worldwide. The risk factors outlined in the development of ARF include hemodynamic instability and low output state, which aggravates the renal ischemia produced by CPB that may unmask an undetected or underestimated preoperative renal impairment.

Suen and colleagues showed that most patients can be identified before their surgical procedures who are at increased risk for postoperative renal dysfunction. That is patients with advanced age, a previous coronary artery bypass graft, type 1 diabetes mellitus, preoperative hyperglycemia or preexisting renal disease (as manifested by an elevated serum creatinine level) have an increased risk for postoperative renal dysfunction.

This risk approximately doubles with one preoperative risk factor and quadruples with two risk factors. Similarly, Hilberman and colleagues found that acute renal failure developing after renal dysfunction may be averted by hemodynamic recovery in the first week after cardiac surgery. As with the findings of any multicenter study, our findings may not be generalizable to all medical centers. Our analyses are also limited with respect to exploring other potential causes of renal dysfunction especially injury caused by nephrotoxic agents or dyes and exploring the temporal relation between renal dysfunction and other relevant comorbid events. Finally, our data are limited to the postoperative hospitalization stay; the effect of in-hospital renal dysfunction on long-term outcomes remains unknown. So, by all its setbacks and limitations our study helps in identifying a high-risk subset of patients and allows more comprehensive informed consent by way of communication of this risk to the patient and alerts the physician about the therapy with potentially nephrotoxic drugs before, during, and after surgery in patients with one or more risk factors. Further investigations are needed to better define the mechanisms, risk factors, magnitude, and kinetics of postoperative renal dysfunction and to develop clinical and therapeutic strategies to reduce morbidity and mortality related with this devastating problem.

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