

Modified Ultrafiltration and Acute Kidney Injury in Patients Undergoing Open Heart Surgery Using Cardiopulmonary Bypass

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ABSTRACT

Objective: To determine the incidence of acute kidney injury (AKI) in patients undergoing open heart surgery using cardiopulmonary bypass (CPB) with and without modified ultrafiltration (MUF).

Materials and Methods: A total of 150 patients who underwent open heart surgery using CPB in our hospital from Jan-2022 to Dec-2022. In group A patients MUF was performed during the CPB and at least 1000 ml of volume was removed using MUF. While in group B patients, no filtration was performed during CPB. In ICU all patients were followed till three days after surgery to determine the incidence of AKI.

Results: Mean age was 53.4±10.9 years in MUF group versus 55.6±11.8 years in control group, p-value 0.23. Majority, 53 (70.7%) patients were male in MUF and 57 (76%) in control group, p-value 0.55. Mean CPB time was 101.6±45.2 mins in MUF and 96.5±39.1 mins in control group, p-value 0.46. Mean X-clamp time was 47.5±19.3 mins in MUF and 51.4±21.6 mins in control group, p-value 0.43. The incidence of AKI was comparable, with frequency rate of 3 (4.0%) in MUF group versus 1 (1.3%) in control group, p-value 0.31.

Conclusion: In present study, the incidence of AKI in MUF and control group was almost similar. So according to the results of present study, the use of MUF has no role in preventing or aggravating AKI in patients undergoing CPB.

Keywords: Acute kidney injury, cardiopulmonary bypass, modified ultrafiltration.

INTRODUCTION

The use of cardiopulmonary bypass (CPB) during cardiac operations might be to blame for the increased risk of postoperative complications as it triggers a widespread inflammatory response (SIRS) throughout the body.^{1, 2} Extracorporeal circulation has a wide range of effects that have been linked to the development of the SIRS state. Body temperature shifts, ischemia, non-pulsatile flow, and reperfusion of end organs are some of the consequences of CPB that have been linked to the origin of the systemic inflammatory state.³ It is now thought that during bypass, cellular and humoral components like as cytokines may be triggered, resulting in organ damage.³ The clinical signs of SIRS include malfunction in the respiratory, hepatic, cardiac, and renal systems as well as neurological dysfunction, a propensity for bleeding, and possibly failure of several organ systems.^{4, 5} AKI happens in 18.2% to 30% of patients who have CPB surgery.^{6, 7} Reduced blood supply to the kidneys, inflammation of the kidneys, or pigment nephropathy are all potential root causes of acute kidney injury. It is an important predictor of morbidity and death after cardiac surgery.^{8, 9} The two leading causes of AKI [20] are septic shock and cardiopulmonary bypass surgery.¹⁰ Acute kidney injury (AKI) has been linked to worse outcomes, longer hospital admissions, higher mortality, and stroke in patients undergoing cardiopulmonary bypass.^{11, 12} It was found that the risk of death while hospitalized increased by a factor of 8.2 for patients who experienced AKI after cardiopulmonary bypass.⁷

The therapeutic maneuver of modified ultrafiltration (MUF) has recently become increasingly popular, and it is one of the proposed maneuvers to minimize the effects of AKI. After being disconnected from cardiopulmonary bypass, the process begins with the extraction of water and compounds with a low molecular weight while being subjected to a hydrostatic pressure gradient. In youngsters, it has been established that this approach can both produce hemoconcentration and minimize bleeding while simultaneously reducing total body water accumulation.¹³ Further researches have linked MUF to enhanced post-perfusion end-organ function and reduced morbidity following pediatric heart

surgeries. MUF has the ability to lessen tissue edema and get rid of inflammatory mediators, both of which counteract the consequences of tissue swelling, which is why it has this ability.^{14, 15}

The aim of proposed study is to determine the frequency of AKI in patients undergoing CPB with and without modified ultrafiltration.

METHODS

This study included 150 patients who underwent open heart surgery using CPB in our hospital from Jan-2022 to Dec-2022. Patients of age >30 years who underwent either coronary bypass surgery alone or along with concomitant valvular surgery were included. Patients who underwent congenital heart surgeries and with preexisting renal disease were excluded. Approval of study was obtained from hospital ethical committee.

All procedures were performed under general anesthesia. Central venous, venous and arterial access was achieved in all patients. In all patients standard monitoring of invasive blood pressure, oxygen saturation, and patients temperature was performed. All patients went on CPB using centrally placed Cannulae.

There were two groups of patients who were stratified using draw randomization. In group A patients MUF was performed during the CPB and at least 1000 ml of volume was removed using MUF. While in group B patients, no filtration was performed during CPB or after shifting the patient in ICU.

In ICU all patients were followed till three days after surgery. Serial measurement of patient's urea and creatinine were performed. AKI was labelled if there was increase in creatinine level >0.5 mg/dl at compared to baseline, eGFR<60 ml within 48 hours of surgery, urine output <800 ml/day after surgery.

Data analysis was performed using SPSS v25. Continuous variables were compared using independent sample t-test. Chi-square test was performed to compare the incidence of AKI between the group taking p-value ≤0.05 as significant.

RESULTS

Baseline characteristics of patients were comparable. Mean age was 53.4±10.9 years in MUF group versus 55.6±11.8 years in control group, p-value 0.23. Majority, 53 (70.7%) patients were male in MUF and 57 (76%) in control group, p-value 0.55. Incidence of co-morbidities e.g. diabetes, smoking and hypertension was also almost similar between the groups. 8 (10.7%) patients in MUF and 11 (14.7%) patients in control group underwent emergency procedure, p-value 0.54. Mean CPB time was 101.6±45.2 mins in MUF and 96.5±39.1 mins in control group, p-value 0.46. Mean X-clamp time was 47.5±19.3 mins in MUF and 51.4±21.6 mins in control group, p-value 0.43 (Table 1).

The incidence of AKI was comparable, with frequency rate of 3 (4.0%) in MUF group versus 1 (1.3%) in control group, p-value 0.31 (Table 2).

Table 1: Baseline Characteristics.

	MUF		P-value
	Yes (N=75)	No (N=75)	
Age	53.4±10.9	55.6±11.8	0.23
Male Gender	53 (70.7%)	57 (76%)	0.55
Diabetes	38 (50.7%)	35 (46.7%)	0.20
Hypertension	49 (65.3%)	52 (69.3%)	0.27
Smoking	44 (58.6%)	41 (54.7%)	0.24
Type of Procedure			
Emergency	8 (10.7%)	11 (14.7%)	0.54
Elective	67 (89.3%)	64 (85.3%)	
CPB Time (mins)	101.6±45.2	96.5±39.1	0.46
Total X-clamp Time (mins)	47.5±19.3	51.4±21.6	0.43

Table 2: Comparison of AKI Incidence Between the Groups.

AKI	MUF		P-value
	Yes (N=75)	No (N=75)	
Yes	3 (4.0%)	01 (1.3%)	0.31
No	72 (96%)	74 (98.7%)	

DISCUSSION

Modified ultrafiltration (MUF) has been shown to reduce the incidence of acute kidney injury in patients undergoing cardiac surgery with cardiopulmonary bypass. The procedure involves the use of a circuit that removes excess fluid and inflammatory mediators from the patient's blood after bypass surgery, thereby reducing the risk of acute kidney injury.¹⁶

According to some research, using UF during CPB to remove extra fluid is not kidney protective and may even harm the kidneys if the fluid withdrawn is greater than what is required.¹⁷ Recent evaluations have also cautioned us to avoid AKI by limiting UF in individuals with impaired renal function.¹⁸

Luciani et al. conducted a trial on the use of MUF on clinical outcomes after CPB, the authors reported mean postoperative hemoglobin level 11.1±1.6 g/dl in MUF versus 11.2±1.8 g/dl without MUF (p>0.05). Blood transfusion in the form of PRBC was lower for MUF group; 27% vs. 33% in without MUF. The frequency of AKI was reported as 1.8% with MUF and 2.8% without modified ultrafiltration (p>0.05).¹⁹

A recent trial by Lee et al. evaluated the effect of high ultrafiltration on residual kidney function (RKF) in hemodialysis patients and reported that the use of high rate ultrafiltration is associated with significant loss in RKF.¹⁸

Contrary to this a meta-analysis by Kandil et al. concluded that MUF did not increase the risk of AKI and to some extent MUF is beneficial in preserving renal function even in CKD patients.²⁰

Coşkun et al. Reported that MUF in CKD patients shortens the length of stay and improves hemodynamic profile and improves BUN after surgery in CKD patients.²¹

Moreover, modified ultrafiltration is a low-cost and safe procedure that does not require any additional medical equipment or medication. It is important to note, however, that modified ultrafiltration may not be appropriate or effective for all cardiac

surgery patients and should only be performed by trained medical professionals.²²

Overall, modified ultrafiltration is a promising technique that has the potential to significantly improve patient outcomes and reduce the economic burden associated with acute kidney injury in patients undergoing cardiac surgery. Therefore, it is important for medical professionals to consider the use of modified ultrafiltration as part of their treatment plan for cardiac surgery patients at risk of acute kidney injury.

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