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**Original Research Article**

# Intraoperative haemofiltration during on-pump cardiac surgery at Queen Alia Heart Institute

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## ABSTRACT

**Background:** Objective of the study was to determine the frequency, indications and benefits of utilizing haemofiltration during cardiopulmonary bypass in adult cardiac surgical patients.
**Methods:** This is a prospective observational analysis of data of adult cardiac surgical patients presented for on-pump cardiac surgery in the period between September 2023 and December 2023 at Queen Alia Heart Institute. Data was collected using Google Forms online and was subsequently recorded on Excel sheaths. Patients were divided into two groups: the haemofiltration group and the non-haemofiltration group. Both groups were compared according to perioperative laboratory and clinical variables. Statistical analysis of results using Microsoft excel followed data collection. Ethical committee approval was obtained.
**Results:** Data from 130 adult cardiac surgical patients (105 males and 25 females) enrolled in this analysis showed that haemofiltration was used in 25 patients (19.2%). The most frequent indication for intraoperative haemofiltration was haemodilution in 14 patients (56%). Blood transfusion was needed in 17 (68%) of patients who had haemofiltration and in 35 (33.4%) of patients who did not need haemofiltration. Patients from the haemofiltration group were extubated 5 hours earlier than patients from the non-haemofiltration group, as the duration of mechanical ventilation in the ICU was 17.9 hours in the haemofiltration group versus 24.9 hours in the non-haemofiltration group. The average overall hospital stay was 3 days less in the haemofiltration group.
**Conclusions:** Haemofiltration during cardiopulmonary bypass main indications were severe haemodilution, hyperkalaemia and preoperative renal impairment. The use of haemofiltration during CPB was associated with earlier tracheal extubation and shorter hospital stay.

**Keywords:** Anaesthesia, Cardiac, Cardiopulmonary bypass, Extubation, Haemofiltration

## INTRODUCTION

The aims of renal replacement therapies (RRT) are solute and water removal, correction of electrolyte disorders, and normalization of acid–base disturbances.[1] This is accomplished by processes of diffusion or convection which is, respectively, referred to as haemodialysis or haemofiltration. Haemofiltration is a convective process whereby a hydrostatic pressure gradient is used to filter water, plasma, and solute across a membrane. This is analogous to the process within the renal corpuscle. The underlying mechanism is that of 'solute drag' where appropriately sized molecules are pulled along with the mass movement of solvent, traditionally termed ultrafiltration (UF).[2]

Hemofiltration used in conjunction with cardiac surgery and cardiopulmonary bypass (CPB) was first reported in 1976. Since then, the technology has been routinely used in this context.[3] The haemofilter is normally connected to

the CPB machine circuit which precludes the need of a haemofiltration machine.

UF is a technique commonly used during CPB for volume management and/or filtration of blood to reduce deleterious components.[4] It is commonly used to optimize homeostasis during CPB especially when excess amounts of cardioplegia were needed to arrest the heart during prolonged periods of aortic clamping resulting in hyperkalaemia and profound haemodilution, or in patients with pre-operative renal impairment.

The haematocrit (HCT) value is low during cardiac surgery with CPB because of the surgical blood loss, positive fluid balance as a result of pre-bypass fluid loading, prime fluids of CPB and crystalloid cardioplegia returned into the pump, and to keep haemoglobin levels above 7 g/dl in patients during CPB either by transfusing blood or by doing hemofiltration.[5] However, profound haemodilution and subsequent sudden severe anaemia reduces oxygen-carrying capacity of the blood and impairs oxygen transport through the body tissues, leading to postoperative multi-organ failure.

However, the role of HF during CPB in adult cardiac surgery is somewhat controversial. It may be beneficial during prolonged CPB in high-risk surgery or in renal failure (RF). However, several studies have reported some adverse effects such as metabolic acidosis, elevated lactate levels and increased need for inotropes. For these reasons, recent literature recommends careful consideration of the indications of using HF.[6] The aim of this analysis is to determine the frequency of use of haemofiltration during CPB, indications and benefits of utilizing haemofiltration during CPB in adult cardiac surgical patients.

## METHODS

In this prospective observational analysis of cardiac surgical patients presenting for on-pump cardiac surgery in the period between September 2023 and December 2023 at Queen Alia Heart Institute (QAHI) in Amman/ Jordan, data from 130 patients was studied. Patients' demographic data (age, weight, height and BMI), comorbidities, type of cardiac surgery (CABG, valve replacement or repair) indications for haemofiltration, volume of fluid removed through haemofiltration and laboratory values of haematocrit were collected by the investigators using Google forms online and were subsequently recorded on excel sheaths. Statistical analysis was performed using Microsoft Excel. Patients were divided into two groups for comparison: haemofiltration group and non-haemofiltration group.

The type of haemofilter used was Sorin Group®, Italy.

*Placement of the haemofilter*

The haemofilter is set parallel to the CPB circuit as passive shunt from a point of high pressure to lower pressure. The inflow to the haemofilter originates from a connection off the high-pressure arterial line and the outflow returns to lower pressure connection located on the venous reservoir.

Ethical committee approval was obtained.

## RESULTS

130 adult cardiac surgical patients were enrolled in this analysis. Average age of patients was 56.9 years. Male to female ratio was 4.2 to 1. The patients' sociodemographic and clinical data are presented in Table 1. Coronary artery bypass grafting (CABG) was performed in 106 patients (81.5%) and valve repair or replacement was performed in 24 patients (18.5%).

**Table 1: Patients' sociodemographic and clinical characteristics.**

| Characteristics | Frequency (%) |
|---|---|
| **Number of patients** | 130 |
| **Mean age (years)** | 56.9 |
| **Males** | 105 (80.8) |
| **Females** | 25 (19.2) |
| **Weight (kg)** | 82.4 |
| **Height (cm)** | 170.3 |
| **BMI (kg/cm$^2$)** | 28.4 |
| **HTN** | 97 (74.6) |
| **DM** | 72 (55.4) |
| **Ischaemic heart disease** | 112 (86.2) |
| **Old CVA** | 2 (1.5) |
| **Kidney disease** | 6 (4.6) |
| **Thyroid disease** | 2 (1.5) |
| **Peripheral vascular disease** | 2 (1.5) |
| **Smoking** | 90 (69.2) |
| **Coronary arteries bypass grafting (CABG)** | 106 (81.5) |
| **Valve repair or replacement** | 24 (18.5) |

Average amount filtered was 1542 ml and ranged from 500 ml to 4500 ml.

Haemofiltration was used in 25 patients (19.2%). The most frequent indication for intraoperative haemofiltration was haemodilution in 14 patients (56%). Other indications were hyperkalaemia due to cardioplegia in 8 patients (32%) and preoperative renal impairment in 6 patients (24%). Frequency of indications is shown in Figure 1.

The average preoperative haematocrit of patients who had haemofiltration intraoperatively was 37.1% and the postoperative was 29.5%; while those who did not need haemofiltration had an average preoperative haematocrit of 39.2% and postoperative of 30.4%. Blood transfusion was needed in 17 patients (68%) from the haemofiltration group and in 35 patients (33.4%) of the non-haemofiltration group.

Haemofiltration was more commonly used in surgeries with longer CPB and aortic cross-clamp durations as the average CPB and AXC durations of the haemofiltration group were 121.2 minutes and 66.2 minutes, on the other hand the CPB and AXC durations in the non-haemofiltration group averaged 105.4 and 63.8 minutes respectively (Table 2).

**Table 2: Comparison between haemofiltration and non-haemofiltration group.**

| Variable | Hemo-filtration group | Non-haemo-filtration group |
|---|---|---|
| **Number of patients (%)** | 25 (19.2) | 105 (80.8) |
| **Average age (years)** | 57.5 | 56.8 |
| **Average BMI** | 27.97 | 28.5 |
| **Average amount filtered (ml)** | 1540 | 0 |
| **Pre-operative haematocrit (%)** | 37.1 | 39.2 |
| **Post-operative haematocrit (%)** | 29.5 | 30.4 |
| **Patients receiving blood transfusion n (%)** | 17 (68) | 35 (33.4) |
| **Average amount of blood transfusion (unit/patient)** | 2.3 | 1.71 |
| **Average CPB time (minutes)** | 121.2 | 105.4 |
| **Average AXC time (minutes)** | 66.2 | 63.8 |
| **Duration of mechanical ventilation in ICU (hours)** | 17.9 | 24.9 |
| **Hospital stays (days)** | 9.6 | 12.8 |
| **Mortality, n (%)** | 6 (24) | 8 (7.6) |

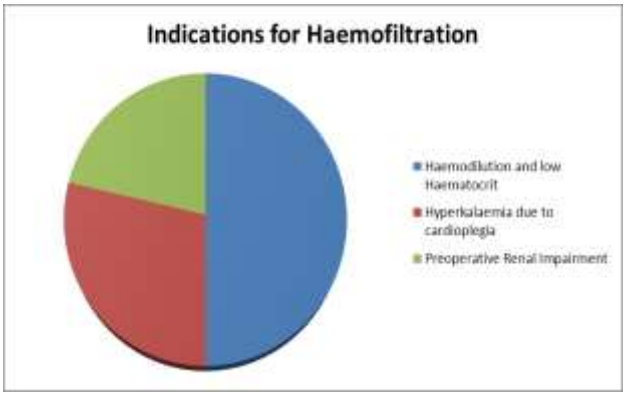


**Figure 1: Indications for haemofiltration during cardiopulmonary bypass.**

Patients from the haemofiltration group were extubated 5 hours faster than those from the non-haemofiltration group, as the duration of mechanical ventilation in the ICU was 17.9 hours in the haemofiltration group versus 24.9 hours in the non-haemofiltration group. Moreover, the overall hospital stay was more than 3 days less in the haemofiltration group (Table 2).

## DISCUSSION

One fifth of adult cardiac patients presented for cardiac surgery in the duration of this study in our centre needed HF during CPB. The most common indication for HF during CPB was excessive haemodilution (56% of indications) which is characterized by low haematocrit (below 24%) and haemoglobin (below 8 g/dl) values in association with large volume of blood in the venous reservoir of the CPB machine. Causes of haemodilution are multiple and include infusion of large volumes of crystalloid solutions before CPB, excessive amounts of cardioplegia to protect the myocardium in prolonged durations of aortic cross-clamping (AXC) or preoperative anaemia or pre-CPB significant surgical bleeding resuscitated with large volumes of crystalloid solutions. Although some degree of haemodilution can be accepted during CPB; severe haemodilution and restoration of haematocrit and haemoglobin is best managed with HF before weaning the patient from CPB.[7] This decreases the incidence of massive blood transfusion and its related multiple complications. In this study, the haemofiltration group had an average of 2.3 red blood cells units transfused per patient which was higher than the non-haemofiltration group of 1.7 red blood cells units transfused per patient.

The second in frequency indication for HF is hyperkalaemia (32%) which is usually due to repeated use of large volumes of potassium based cardioplegia solutions to arrest the heart in diastole for myocardial protection especially during prolonged aortic cross-clamping. It is also imperative that a normal renal perfusion pressure remains maintained during CPB to ensure natural diuresis. Despite that another novice types of cardioplegia that are not based on potassium (such as custadiol) exist; their use is very limited due to high cost.[8]

The third in frequency indication for HF during CPB is the planned use in oliguric or anuric patients with end-stage kidney disease (ESKD) (24% of indications). In this subgroup of patients who are on regular haemodialysis, the use of HF during CPB can delay the need for dialysis in the early postoperative period avoiding the haemodynamic instability and anticoagulation associated with the conventional haemodialysis.

Patients who had haemofiltration during CPB were found to have shorter durations of postoperative mechanical ventilation as they were extubated 5 hours earlier on average (Table 2). Similar results were found in a prospective, randomized double-blind trial by Oliver et al. reported earlier tracheal extubation after cardiac surgery when haemofiltration is used during cardiopulmonary bypass due to attenuation of the inflammatory response.[9] Other benefits of continuous HF reported by García-Camacho et al are reduction of lactatemia implied a reduction in intubation time, a decrease in morbidity and

mortality in the intensive care unit and a shorter hospital stay.[10]

The higher mortality in the haemofiltration group can be attributed to longer CPB and AXC durations.[11-13] Prolonged CPB times could predict postoperative clinical events, in particular mortality.[14]

In our study, the postoperative benefits of using haemofiltration during CPB were earlier tracheal extubation and shorter hospital stay (Table 2).

Limitation of this study includes the observational character of the study and that it is a single centre study.

## CONCLUSION

Haemofiltration during cardiopulmonary bypass main indications are severe haemodilution, hyperkalaemia and preoperative renal impairment. The use of haemofiltration during CPB was associated with earlier tracheal extubation and shorter hospital stay.

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