The Effects of Ultrafiltration on Postoperative Respiratory Status in Adults Undergoing Coronary Artery Bypass Grafting

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Abstract

Introduction- Systemic inflammatory response syndrome (SIRS) remains one of the major causes of cardiopulmonary bypass-associated organ injury during adult cardiac surgery. This study was designed and performed to assess the short-term effects of this technique on postoperative lung status in such patients.

Methods- In a double-blind, randomized clinical trial, 90 patients scheduled for elective CABG were selected and randomly assigned into 2 groups; the first group had ultrafiltration in their cardiopulmonary bypass circuit.

Results- The case group patients were extubated sooner compared to the control group. The postoperative oxygenation status in the case group was better than the control group.

Conclusions- The results of this study demonstrated that ultrafiltration could improve the postoperative respiratory status of those adults undergoing coronary artery bypass grafting ***(Iranian Heart Journal 2009; 10 (3):12-16).***

Key words: ultrafiltration ■ coronary artery bypass graft surgery ■ respiratory status

Studies have demonstrated that systemic inflammatory response syndrome (SIRS) remains one of the major causes of cardiopulmonary bypass (CPB)-associated organ injury during adult and pediatric cardiac surgery.[1] A number of studies have demonstrated that combined ultrafiltration has beneficial effect on hemodynamics with improvement in ejection fraction (EF) and fractional area change (FAC); it improves hematocrit and decreases chest pulse drainage.[2] Also, it has been shown that ultrafiltration improves global left ventricular systolic function in infants and children following open-heart surgery.[3] Other studies have proposed that the use of MUF after CPB can produce an immediate improvement in lung compliance and gas exchange capacity, which may effectively minimize pulmonary dysfunction post-biventricular repair of congenital heart disease.[4] Also, the combined use of balanced ultrafiltration and modified ultrafiltration can effectively concentrate the blood, modify the increase of some harmful inflammatory mediators, attenuate the lung edema and inflammatory pulmonary injury, and mitigate the impairment of pulmonary function.[5]

However, there are still not many studies assessing the role of this technique on the postoperative respiratory status of adults undergoing coronary artery bypass grafting (CABG). This study was designed and performed to assess the short-term effects of this technique on postoperative lung status in such patients.

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Methods

The protocol of the study was approved by the Institutional Ethics Committee, Deputy of Research Affairs, Shaheed Rajaie Cardiovascular and Research Center, Tehran, Iran.

In a double-blind, randomized clinical trial, the target population was considered as all the patients who were admitted to the operating room during a 12-month period. Among these cases, after power analysis for sample size determination, 90 patients scheduled for elective CABG were selected and randomly assigned into 2 groups; the first group had ultrafiltration in their cardiopulmonary bypass circuit, while the other group did not. The selected cases were a representative of the total CABG cases of the center. The number of female and male patients was nearly equal in the main hospital setting.

Inclusion criteria were elective CABG cases with informed written consent aged 30-65 years with a left ventricular ejection fraction equal or more than 25%. Those enrolled in the study as the case group received ultrafiltration according to the following protocol. The excluded patients were those who refused to enter the study, had any history of pulmonary, central nervous system, gastrointestinal, hematologic, renal, hepatic, metabolic or endocrinologic problem (except for those who had diabetes mellitus controlled with oral hypoglycemic agents).

All the patients were allocated to the 2 groups randomly, according to a computer table of random numbers and were visited the night before the surgery by the same anesthesiologist (among the authors) and were informed regarding the study.

Efforts were made to place both groups under the same method of perioperative care and anesthesia. Also, other variables were kept constant as much as possible. The physician who dealt with the cases in the operating room did not have any contribution to postoperative data collection; meanwhile, the anesthesiologists and ICU staff were unaware of the specific group that each patient belonged to. Also, the patients, though informed of the whole process, did not know to which group they belonged.

A pre-medication dose of morphine was prescribed (0.1 mg/kg intramuscularly) one hour before the surgery, accompanied by a 10 mg diazepam tablet per 70 kg body weight the night before (for lower body weights, the related doses were calculated and 2 or 5 mg tablets were used instead). All the patients were NPO for eight hours, preoperatively.

After initiating standard monitoring (electrocardiography, pulse oxymetry, invasive blood pressure and heart rate), the patients received 500 ml Ringer's solution over 10–15 minutes. General anesthesia was induced with 0.7mcg/Kg intravenous sufentanil, 0.05 mg/Kg midazolam and 0.5 mg/Kg atracurium. Then endotracheal intubation was done and a central venous line was inserted through the left subclavian vein. For maintenance of intravenous anesthesia a combination of 100 mcg sufentanil, 150 mg atracurium and 10 mg midazolam were used. Also, isoflurane with a concentration of 0.2 to 1 % was used to keep the level of anesthesia depth in the range of 40 to 60 from 100 by anesthesia depth monitoring device (BIS monitoring: bispectral index).

The perfusionist in charge of each case started ultrafiltration throughout the cardiopulmonary bypass period, while in the control group, ultrafiltration was not used. All the patients were anesthetized and operated on in exactly the same manner, except for using ultrafiltration or not. Each patient received 15 mL/Kg of the crystalloid cardioplegia solution which contained 20 mmol/L of ionic potassium and 8.12 mmol/L of ionic magnesium. Also, the priming solution included lactated Ringer's which contained 4mEq/L of ionic potassium, 50 mL of 5% albumin and 150 mL of 10% warmed mannitol solution. This formula was the same in the 2 groups.

The patients were transferred while intubated to the postoperative cardiac intensive care unit; in the ICU they were monitored with standard DII and V5 ECG leads, continuous pulse

oxymetry and continuous invasive blood pressure monitoring. All the patients were weaned from artificial ventilation based on the standard criteria for weaning. Intravenous propofol was used in the ICU for postoperative sedation with a dosage of 25µg/Kg/min to keep patients asleep until criteria for extubation were met. For postoperative supplementary analgesia, 0.1 mg/Kg intravenous morphine sulphate was used whenever a VAS pain score> 3 of 10 was detected.

Each case was extubated after meeting the standard clinical criteria for extubation, and then all the patients received supplemental oxygen by face mask or nasal prongs. During the postoperative period, time of operation from the incision to the skin closure, aortic clamp time, pump time and the total time each patient was intubated were documented case by case.

Throughout the study, the patients' personal data were kept fully confidential, the grouping of the patients was not revealed and the patients could decide to leave the study just by informing one of the researchers.

Data entry and analysis were performed by SPSS software (version 12). For data analysis, Student t test and Chi square test were used. To present the results, mean ± SD were used and a P value less than 0.05 was considered significant.

Results

There was no difference between the 2 groups regarding basic variables (Tables I and II).

Table I. Demographics of the patients in the two groups.*

	Case	Control	*P* value
Age (years)	50 (14)	49 (13)	*P* >0.05
Body weight (Kg)	71 (10)	69 (9)	*P* >0.05
Duration of surgery (min)	185 (19)	182 (20)	*P* >0.05
Aortic cross clamp (min)	62 (23)	60 (21)	*P* >0.05
ECC (Extracorporeal Circulation) (min)	89 (28)	91 (26.5)	*P* >0.05

*Data are presented as mean±(standard deviation)

The case group patients were extubated sooner compared to the control group (Table III).

Table II. Distribution of sex in the two groups (total 90 cases).

	Case	Control
Male	24	25
Female	21	20

Chi-square test, degree of freedom = 1, *P* >0.05

Table III. Postoperative time (in minutes) between patient entry to the ICU and extubation.

Case	Control	*P* value
312 (44)	324 (36)	<0.001

*Data are presented as mean±(standard deviation)

The postoperative oxygenation status assessed by the partial pressure of the arterial oxygen (PaO2) revealed a significant difference: 6 hours after postoperative extubation (using room air), PaO2 was higher in the case group than the control group (P value < 0.001). Also, 12 hours after postoperative extubation (using room air), PaO2 was still higher in the control group; both of these measurements (Table IV) demonstrated a significant difference between the two groups regarding postoperative extubation PaO2 (P value < 0.01).

Table IV. Post-operative partial arterial pressure of oxygen (PaO2) in mmHg between the two groups (using room air)

	Case	Control	*P*-value
6 hours after extubation	115 (24)	95 (28)	P < 0.001
12 hours after extubation	92 (23)	78(19)	P < 0.01

*Data are presented as mean±(standard deviation)

Discussion

The results of this study demonstrated that ultrafiltration could improve the postoperative

respiratory status of those adults undergoing coronary artery bypass grafting (CABG).

This study demonstrated that in elective CABG cases, ultrafiltration is an efficient modality that can be used as a therapeutic technique to improve the arterial oxygen partial pressure (i.e. PaO2). This is in concordance with the other similar studies that have been performed on children undergoing cardiac surgery with cardiopulmonary bypass, to assess the acute postoperative respiratory status.[1,2]

Ultrafiltration is often used as a routine practice in the population of pediatric cases, but the methods used to reverse hemodilution are not frequently used in adults. There are data from a number of small clinical trials that are unblended and have suggested that the use of ultrafiltration can decrease the amount of released inflammatory mediators, improve the function of the myocardium, and can alleviate the effect of CPB on hemodilution.[6-8] Also, these studies have suggested a significant reduction in postoperative blood transfusions and reduced amount of bleeding in adults undergoing cardiac surgery when using ultrafiltration. It is necessary to evaluate the efficacy and cost-effectiveness of ultrafiltration as a method of blood conservation in a large, randomized, double-blinded study, but it remains a novelty found in this paper that the use of ultrafiltration has beneficial effects on postoperative pulmonary function.

There are a number of limitations in this study. For example, the patients are exceptionally young for a cohort of general CABG patients, including nearly half females. This could be due to the issue that our center is a tertiary referral center and perhaps the more complicated cases, including the younger and female patients (with poor collaterals and runoff) have been referred to this center. Also, had the inflammatory mediators released during the cardiopulmonary bypass been assessed, it could have helped to define a more precise role for ultrafiltration in detection of its effects on the patients undergoing surgery with CPB.

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Conflict of Interest

No conflicts of interest have been claimed by the authors.

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