Original Article

Effects of Modified Ultrafiltration on Arterial Blood Gas After Cardiopulmonary Bypass in Children

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ABSTRACT

Background: Conventional ultrafiltration (CUF) and modified ultrafiltration (MUF) are routinely used in pediatric cardiac operations to reduce fluid retention in the body. Further amounts of fluids can usually be retracted through MUF than CUF. The aim of this study was to evaluate the effects of MUF on arterial blood gas in children after cardiopulmonary bypass (CPB).

Methods: Forty-two patients that underwent cardiac surgery with CPB were divided into 2 groups of CUF+MUF (n=21) and CUF (n=21). Arterial blood gas, chest tube drainage, blood transfusion, and dysrhythmias were assessed before the induction of anesthesia, at the start of CPB, at the end of CPB, at the end of MUF, on intensive care unit admission and 2, 4, 6, 8, 10, 12, 24, and 48 hours after surgery.

Results: Our study showed statistically significant differences at the end of MUF between the CUF+MUF and CUF groups regarding the levels of hematocrit (P=0.02), PO_2 (P<0.01), lactate (P<0.05), hemoglobin, O_2 saturation, and blood sugar. There were also significant differences between the groups over the 48 hours in chest tube drainage (P=0.01), blood transfusion (P=0.04), and dysrhythmia (P=0.005). The blood levels of electrolytes (K, Na, Ca, and Cl) and other parameters of arterial blood gas were similar between the 2 groups.

Conclusions: The administration of CUF+MUF was effectively able to decrease bleeding and reduce transfusion requirement. Additionally, it significantly augmented the parameters of arterial blood gas after surgery. ***(Iranian Heart Journal 2017; 18(2):6-16)***

Keywords: Cardiopulmonary bypass, Ultrafiltration, Arterial blood gas, Electrolyte

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Cardiopulmonary bypass (CPB) is an essential prerequisite for performing open heart surgery in children. [1] CPB is a non-physiological procedure associated with hemodilution and immune responses that could disrupt the function of different organs. [2] These effects of CPB are almost caused by the inflammatory response syndrome of the whole body, which leads to the leakage of fluid from the capillaries, which in turn provides grounds for tissue edema. This condition reduces pulmonary capacity and the transfer of gases in the lungs and may even affect the proper functioning of the heart. Therefore, there is a need for different methods to reduce the fluid accumulation out of the blood vessels. These methods include but are not limited to reducing the time of CPB, decreasing the priming volume, using ultrafiltration during the rewarming phase, and using anti-inflammatory agents (eg, prednisolone and furosemide) during and after surgery. [3-5] Among the therapeutic approaches proposed for the reduction of the inflammatory response syndrome and edema after surgery, the administration of various ultrafiltration methods has been highly regarded. [3-5] Ultrafiltration is routinely used in pediatric cardiac surgery to reduce fluid accumulation in the body. However, using conventional ultrafiltration (CUF) has some limitations in terms of the retraction of the fluids from the patient's body during surgery. As this method is performed during CPB in the rewarming phase, the fluid volume that is separated from the system through this method depends on the volume of the CPB circuit; the existence of enough volume in the venous reservoir is necessary to supply the arterial output current. Due to the limitations of this method, there is an undeniable need to a modified ultrafiltration (MUF) that can be performed after the end of CPB and be independent of the volume of the CPB circuit. Due to technical differences in the time of these 2 ultrafiltration methods, more liquid can usually be retracted through the MUF method than the CUF method. [6-9] A number of studies have shown that the use of MUF improves the function of the heart, lungs, and brain and is effective in reducing the undesirable effects of hemodilution and inflammatory factors. [3, 10-11] Furthermore, due to the comprehensive effects of MUF on the body, especially blood, numerous studies have been performed on the correlation between these techniques and arterial blood gas and blood electrolytes, most of which have been associated with contradictory results. [8, 12-14] The aim of this study was to evaluate the effects of MUF on arterial blood gas parameters in children after CPB.

METHODS

This double-blinded randomized clinical trial was conducted on the children admitted to Rajaie Cardiovascular, Medical, and Research Center, Iran University of Medical Sciences, Tehran, Iran, for congenital heart surgery under CPB in 2014.

The inclusion criteria were comprised of a pregnancy period over 37 weeks, age of less than 2 years old, and being scheduled for open congenital heart surgery. The exclusion criteria comprised the refusal of the patients' parents for participation in the study, active noncardiac disease affecting the recovery after the surgery, previous sternotomy, body weight of less than 3 kg or over 10 kg, cardiogenic shock, or cardiac arrest during surgery.

Having been scheduled for elective surgery, the patients were enrolled in the study. Written informed consent was obtained from the parents of the patients after they were provided with a full description of the methodology and design of the study. The patients were divided into 2 groups of intervention and control based on block randomization. Sample size calculation was carried out as follows:

$$S_P = 38 \quad \mu_1 = 101 \quad \mu_2 = 139$$

$$N = \frac{2\left(Z_{1-\frac{\alpha}{2}} + Z_{1-\beta}\right)^2 \times (S_P)^2}{(\mu_1 - \mu_2)^2} = 21$$

To double-blind the study, we asked trained nurses, who were not aware of the ultrafiltration methods used for the patients, to collect the data during and after the surgery.

The prime solution consisted of Ringer's lactate (300 to 500 mL), sodium bicarbonate (20 to 30 mEq/L), 25% albumin (12.5 g/250 mL of prime, to a final concentration of 5%), and packed red blood cells sufficient to maintain a hematocrit value of 20% to 25%. CPB was established via ascending aortic (6–10 F) and bicaval (12–18 F) cannulation using a heart-lung machine (SV Roller Pump, Stockert, Munich, Germany or MERAHAS Heart-Lung Machine, Senko Medical Instruments, Tokyo, Japan) and an oxygenator (D901 or D902 Lilliput, Sorin Group Italia, Modena, Italy). The CPB flow was maintained at 150 to 180 mL/kg/min for the patients. The body temperature of the patients was gradually cooled to obtain the desired temperature of 30 °C to 32 °C. Additionally, 300 U/kg of heparin was added into the patients' blood prior to the cannulation to maintain ACT over 480 seconds. The alpha-stat method was used to maintain the acid-base balance for all the patients. The prime solution was prepared without blood for all the patients except the neonates. Myocardial protection was obtained by intermittent antegrade crystalloid cardioplegia (Modified St. Thomas' solution, 20 mL/kg at initial injection followed by 10 mL/kg for maintenance), which was given every 20 minutes.

In the CUF group, CUF was performed during CPB. The recirculation line from the arterial filter was connected to the inlet of the polysulfone hemofilter (Capiox HC 11S, Terumo Corporation, Tokyo, Japan). The outlet of the hemofilter was drained into the venous reservoir. CUF was stopped if the venous reservoir level decreased. In the CUF+MUF group, CUF was performed during CPB as the CUF group and arteriovenous MUF was performed after the termination of CPB. For MUF, blood was drained from the purge line of the aorta through the Luer lock connector from the outlet of the oxygenator to the inlet of the hemofilter. The outlet of the hemofilter was connected via another venous line to the right atrium. [15] During MUF, we tried to avoid any air embolism and monitored the color of the patients' urine for hemolysis.

Systolic and diastolic arterial pressures were monitored during MUF, and a decrease in systolic arterial pressure of more than 20% from the start of MUF was treated by infusing blood through the aortic cannula to maintain a central venous pressure of 5 to 6 mm Hg.

A line was linked from the oxygenator outlet to the filter inlet, and a line was returned from the venous reservoir to the filter outlet in the conventional ultrafiltration method. Next, the arterial cannula was linked to the filter inlet through the arterial line and blood was passed through the filter with at a speed of 10 to 15 mL/kg/min. Thereafter, cardioplegia cannula was linked to the filter outlet. Finally, blood was returned from the cardioplegia route, as a returning intravenous route, to the right atrium in the MUF method.

Arterial blood gas parameters were measured before anesthesia induction, at the start of bypass pump, at the end of bypass pump, 15 minutes after bypass pump (end of MUF), on the intensive care unit (ICU) admission, and 2, 4, 6, 8, 10, 12, 24, and 48 hours after the surgery. The values of Ca, Cl, Lac, and BS were measured before the anesthesia induction, at the start of bypass pump, at the end of bypass pump, and 15 minutes after the pump bypass (end of MUF). Also, the number and types of cardiac dysrhythmias and the amount of chest tube drainage during the first 48 hours after surgery, the duration for chest tube requirement in the ICU, and the amounts of the utilized blood products (red blood cells [RBCs], fresh frozen plasma [FFP], platelet, and albumin) in the 48-hour period after surgery were measured.

Data analysis was performed using SPSS, version 20.0. Descriptive statistics—including the indicators of central tendency and dispersion (mean and standard deviation)—and the frequency distribution were used to describe the specifications of research units in both groups. Statistical methods of the χ^2 test, independent samples *t*-test, and repeated-measures ANOVA were used for the statistical analysis of the results.

RESULTS

The demographic and baseline data of the patients are depicted in Table 1. Both groups were comparable regarding sex, age, height, body surface area, and the CPB flow rate. The patients' weight ranged between 5.5 and 9.8 kg (Table 1).

The distribution of the patients according to the surgery type was not statistically significant. There were no significant differences in the blood flow rate, priming volume, fluid added to CPB, cross-clamp time, CPB time, and urine output between the 2 groups. The mean volume of the ultrafiltrate collected during CUF was not significantly different between the 2 groups. The mean volume of the ultrafiltrate removed during MUF was 148.8 mL (Table 2).

In the MUF group, hematocrit was improved from 26.6% to 36.7% immediately after MUF. Hematocrit was significantly high in the MUF group at the end of MUF, on admission to the ICU, and 2 hours after surgery compared to the control group (*P*=0.02). However, no significant difference was observed in hematocrit at 4, 6, 8, 10, 12, 24, and 48 hours from admission to the ICU between the control and MUF groups (Fig. 1).

In the intervention group, the mean hemoglobin level showed a significant increase immediately after MUF (from 8.70 [0.84] gr/dL to 11.75 [1.15] gr/dL) (*P*=0.01), but hemoglobin in the control group changed from 8.13 (0.53) gr/dL to 8.35 (0.73) gr/dL, which was not significant. The hemoglobin level was significantly high in the MUF group at the end of MUF, on admission to the ICU, and 2 hours after surgery compared to the control group (*P*<0.05). Nonetheless, no significant difference was observed in the hemoglobin level at other times between the 2 groups.

The mean levels of electrolytes (Na, K, Ca, and Cl) remained stable in the 2 groups, and there were not significant changes until the end of MUF. Nevertheless, the difference was not statistically significant. The blood level of lactate was low in the intervention group at the end of MUF compared to the control group (1.08 [0.52] mmol/lit vs 2.89 [1.57] mmol/lit) (*P*=0.001). The mean blood sugar at the end of MUF was significantly different between the CUF+MUF and CUF groups (108.71 [22.95] mmol/lit vs 146.76 [38.00] mmol/lit) (*P*=0.001) (Table 3).

Table 4 illustrates the frequency of dysrhythmia until the first 48 hours after surgery. A significant difference was observed in the frequency of tachycardia (38% in the MUF group vs 80% in the control group; *P*=0.005). There was no significant difference in the frequency of other dysrhythmias between the 2 groups. Postoperative chest tube drainage in the first 48 hours was significantly lower in the MUF group than in the control group (75.95 [40.70] mL vs 219.52 [241.80] mL) (*P*=0.01). The mean duration of chest tube requirement was higher in the control group than in the MUF group; this difference, however, was not statistically different. The volume of blood transfusion in the form of packed RBC concentrate was lower for the MUF group (34.28 [37.85] vs 60.95 [45.37] mL) (*P*=0.04). The volumes of the transfused FFP and platelet concentrate were not significantly different between the 2 groups. Albumin requirement was significantly low in the MUF group compared with the control group (34.04 [64.95] mL vs 74.76 [94.55] mL), respectively (*P*=0.006) (Table 5). In the MUF+CUF group, the mean PO_2 showed an increase immediately after MUF (from 206.00 [65.78] mm Hg to 212.80 [62.21] mm Hg), while PO_2 in the CUF group decreased (from 217.80 [63.01] mm Hg to 154.14 [82.78] mm Hg) (*P*=0.003). The mean PCO_2 at the end of MUF was significantly different between the CUF+MUF and CUF groups (29.85 [6.98] vs 35.00 [8.25]) (*P* =0.03). In addition, pH was high in the intervention group just at the end of MUF compared to the control group (7.37 [0.06] vs 7.29 [0.08]) (*P*=0.04). The differences between the intervention and control groups at the end of MUF were significant in terms of O_2Sat (99.00 [1.34] % vs 96.23 [1.86] %) (*P*=0.02). The mean HCO_3 and BE remained stable in the 2 groups, and there were no significant changes until 48 hours after surgery (Table 6).

Table 1. Demographic data in the 2 groups

Variables	MUF+CUF (n=21)	CUF (n=21)	*P*
Sex			
Male	9	11	0.54
Female	12	10	
Age (mon)	14(5.3)	18(5.2)	0.36
Weight (kg)	7.8(1.3)	8.6(1.4)	0.74
Height (cm)	74.0(6.9)	79.0(5.9)	0.28
BSA (m^2)	0.4(0.1)	0.4(0.2)	0.84
Flow (mL)	1161.4(164)	1261.4(136)	0.37

Values are expressed as means (standard deviations).
CUF, Conventional ultrafiltration; MUF, Modified ultrafiltration; BSA, Body surface aria

Table 2. Operation and ultrafiltration data

Variables	MUF+CUF (n=21)	CUF (n=21)	*P*
Kind of surgery			
VSD	9	4	0.16
VSD+ASD	5	8	
VSD+ASD+PH	3	1	
TAPVC	2	4	
VSD+PH	2	4	
Priming volume(mL)	400.4(157.9)	448.5(78.2)	0.21
Fluid added(mL)	105.1(33.5)	96.2(38.4)	0.24
Cross-clamp(min)	74.0(6.9)	79.0(5.9)	0.13
CPB time(min)	48.7(9.6)	42.9(12.5)	0.23
Urine output(mL)	125.7(52.8)	153.8(60.5)	0.11
Total heparin(mg)	49.4(6.4)	56.1(12.4)	0.34
Total protamine(mg)	49.0(4.0)	53.8(8.3)	0.65
Volume of CUF (mL)	164.7(55.4)	166.9(63.7)	0.93
Volume of MUF (mL)	148.8(33.9)	-	

Values are expressed as means (standard deviations).
CUF, Conventional ultrafiltration; MUF, Modified ultrafiltration; VSD, Ventricular septal defect; ASD, Atrial septal defect; PH, Pulmonary hypertension; TAPVC, Total anomalous pulmonary venous connection; CPB, Cardiopulmonary bypass

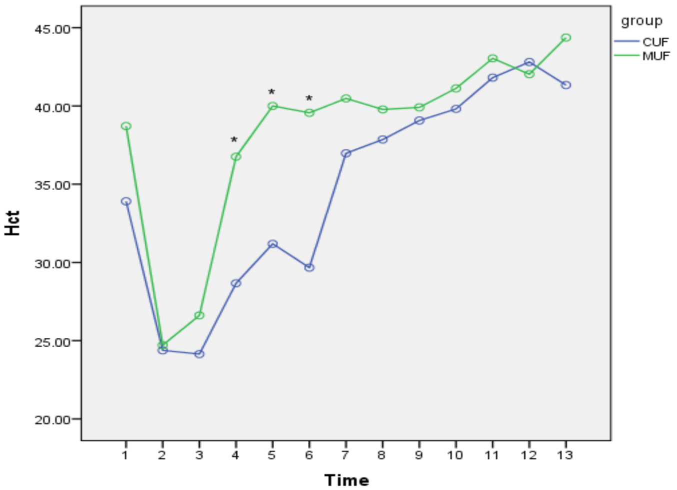

Figure 1. Hematocrit changes in the 2 groups.

Table 3. Comparison of the levels of electrolytes, lactate, and blood sugar between the 2 groups.

Variables	Group(n=21 each)	Induction of Anesthesia	Pre-CPB	Post-CPB	Post-MUF	*P*
Na(mmol/lit)	MUF+CUF CUF	138.95(4.98) 137.90(3.40)	134.38(4.43) 133.90(3.23)	133.90(4.34) 136.47(3.45)	137.38(3.86) 138.42(2.56)	**0.308**
K(mmol/lit)	MUF+CUF CUF	3.79(0.62) 3.59(0.62)	4.43(0.91) 4.96(1.09)	4.72(0.84) 5.22(1.02)	4.20(0.59) 3.97(0.57)	**0.204**
Ca(mmol/lit)	MUF+CUF CUF	1.82(0.44) 1.78(0.36)	1.96(0.28) 2.10(0.16)	1.86(0.38) 2.05(0.13)	1.71(0.29) 1.74(0.35)	**0.740**
Cl(mmol/lit)	MUF+CUF CUF	105.80(7.82) 106.09(5.40)	114.04(5.24) 112.80(4.88)	112.57(6.53) 112.57(2.85)	112.85(5.31) 113.00(5.61)	**0.930**
Lac(mmol/lit)	MUF+CUF CUF	1.17(0.68) 0.98(0.66)	1.80(0.62) 2.68(1.49)	2.85(1.59) 3.60(1.44)	1.08(0.52) 2.89(1.57)	**0.001**
BS(mmol/lit)	MUF+CUF CUF	92.61(19.12) 88.00(35.48)	126.52(7.90) 123.33(5.6)	138.57(43.17) 146.00(42.68)	108.71(22.95) 146.76(38.00)	**0.001**

Values are expressed as means (standard deviations).
CUF, Conventional ultrafiltration; MUF, Modified ultrafiltration; CPB, Cardiopulmonary bypass; Lac, Lactate; BS, Blood sugar

Table 4. Incidence of cardiac arrhythmias in the 2 groups

Variables (arrhythmia)	MUF+CUF (n=21)	CUF (n=21)	*P*
Bradycardia Yes	5	10	0.09
Tachycardia Yes	8	17	0.005
Junctional Rhythm Yes	8	8	0.624

CUF, Conventional ultrafiltration; MUF, Modified ultrafiltration

Table 5. Amounts of bleeding and blood products in the 2 groups [mean (SD)]

Variables	MUF+CUF (n=21)	CUF (n=21)	*P*
Chest tube drainage(mL)	75.95 (40.70)	219.52 (70.85)	0.01
Chest tube time(h)	60.35 (32.64)	73.58 (30.12)	0.18
Packed cell transfusion(mL)	34.28 (37.85)	60.95 (45.37)	
Yes	10	14	0.04
No	11	7	0.02
FFP transfusion (mL)	35.71 (48.12)	45.23 (49.12)	
Yes	10	11	0.52
No	11	10	0.52
Platelet transfusion (mL)	7.14 (17.92)	19.04 (33.45)	
Yes	3	6	0.15
No	18	15	0.29
Albumin transfusion (mL)	34.04 (64.95)	74.76 (94.55)	
Yes	6	10	0.006
No	15	11	<0.05

Values are expressed as means (standard deviations).
CUF, Conventional ultrafiltration; MUF, Modified ultrafiltration; FFP, Fresh frozen plasma

Table 6. Arterial blood gas parameters observed at various stages in the 2 groups

Variables (time)		pH	Pa O_2	$PaCO_2$	O_2Sat	Hco3	BE
Before anesthesia induction	CUF+MUF CUF	7.30 7.33	165.71 146.33	40 37.80	98.23 98.80	20.19 20.52	-3.47 -5.61
Start of CPB	CUF+MUF CUF	7.35 7.34	288.47 258.00	37.80 31.14	99.57 100	19.42 18.57	-5.19 -7.47
End of CPB	CUF+MUF CUF	7.39 7.42	206.00 217.80	35.09 27.61	99.19 99.47	20.66 18.90	-4.04 -6.23
End of MUF	CUF+MUF CUF	7.37 7.29	212.80 154.14	29.85 35.00	99 96.23	18.09 18.76	-5.47 -6.33
Entering the ICU	CUF+MUF CUF	7.38 7.39	196.85 141.80	28.57 3.85	97.42 97.71	16.85 17.47	-5.90 -6.09
2 hours after surgery	CUF+MUF CUF	7.37 7.35	178.90 168.04	31.33 32.71	97.95 96.38	17.47 17.71	-6.00 -6.28
4 hours after surgery	CUF+MUF CUF	7.37 7.35	156.85 159.33	35.38 34.66	97.38 97.19	19.19 18.19	-4.66 -5.19
6 hours after surgery	CUF+MUF CUF	7.41 7.36	186.66 149.95	31.47 34.90	98.42 97.66	18.85 19.61	-3.76 -4.42
8 hours after surgery	CUF+MUF CUF	7.38 7.37	150.42 140.00	32.19 34.66	96.47 96.52	19.28 20.00	-4.00 -3.66
10 hours after surgery	CUF+MUF CUF	7.38 7.36	156.33 127.76	35.14 35.61	97 97.85	20.90 20.71	-2.47 -3.28
12 hours after surgery	CUF+MUF CUF	7.42 7.37	149.33 127.76	33.52 35.61	97.90 97.52	19.85 19.76	-2.47 -3.70
24 hours after surgery	CUF+MUF CUF	7.37 7.40	153.23 111.09	35.23 35.90	97.04 95.47	20.14 22.14	-2.57 -0.30
48 hours after surgery	CUF+MUF CUF	7.39 7.41	120.47 108.28	37.52 37.00	96.14 95.90	22.09 24.52	-0.33 1.80

DISCUSSION

In the present study, the effects of using MUF on the various parameters of arterial blood gas were examined. Using MUF in our study significantly increased the patients' hemoglobin and hematocrit levels at the early hours after surgery for more than 10%. Consequently, the number of patients who required blood transfusion in the CUF+MUF group was lower than that in the CUF group. In some other studies, similar results have been achieved. Aggarwal and colleagues, [16] examining the effects of MUF on children aged between 1 and 5 years on CPB, showed an increase of 10 to 11% in the hematocrit levels of these patients after performing MUF. [16] Kotani et al [17] also reported that using MUF increased the hematocrit of children undergoing arterial switch surgery for about 13%. Additionally, the authors reported that postoperative bleeding and the need for blood decreased using MUF, which was similar to the results obtained from the present study. Kiziltepe et al [6] also mentioned an increase of 5.7% in the hematocrit level of their patients after using MUF. Bando and colleagues [18] used MUF in pediatric high-risk patients and did not observe a significant difference in the postoperative hematocrit levels. The administration of the Veno-Venus MUF method and probable failure in providing the necessary pressure for proper filtration might be the reason for the absence of a difference between the patients' hematocrit levels in their study.

In the current study, we observed an average increase of 3 g/dL in the hemoglobin level in the intervention group after ending MUF. In contrast, Luciani et al [11] reported that the use of MUF did not make any significant change in the hemoglobin level of their patients.

The volume of the transfused RBCs in the intervention and control groups was respectively 34.28 mL and 60.95 mL at 48 hours after surgery, which was significantly different. Similar results have also been obtained in various studies, all of which imply the positive effects of MUF on reducing blood transfusion requirement during the postoperative period. Bando et al, [18] evaluating 100 pediatric patients who underwent cardiac surgery, suggested that MUF was able to reduce blood transfusion requirement in their patients. These findings are in line with the results obtained from our study. Also, the total amount of the coagulation products used in their study significantly decreased following using MUF, which is inconsistent with our study. The consumption of coagulation products was not significantly different between the groups in our study, but the overall consumption of FFP, platelet, and cryoprecipitate in the MUF group was lower in their study. Thompson and colleagues [19] did not observe a significant difference in the use of FFP and platelet in the period after surgery following MUF.

Ootaki et al [20] showed that albumin, platelet, and coagulation factors (fibrinogen, prothrombin, and VII) significantly increased immediately after MUF, which might have been due to the retraction of the excess fluid from the body. El-Tahan and colleagues, [21] in patients with liver dysfunction undergoing cardiac valve surgery, demonstrated that the use of MUF increased the blood levels of albumin, platelet, and other coagulation factors and also significantly reduced the level of bilirubin and liver enzymes.

The incidence of cardiac dysrhythmias was also examined in the present study up to 48 hours after surgery. The incidence rate of tachycardia was significantly lower in the patients of the MUF group, but there was no significant difference between the 2 groups apropos the rest of dysrhythmias. In a similar research on adults, Luciani et al [11] could not find any significant difference in the incidence rate of dysrhythmias and the use of MUF did not reduce the incidence of dysrhythmia in their study.

In the study of Kotani and colleagues, [17] PO_2 significantly increased (from 170 mm Hg to 258 mm Hg) using MUF and respiratory gas exchange in the patients improved, which in turn significantly reduced the length of ICU stay. Also, Schlunzen et al [22] in a study performed on children weighing between 2 and 20 kg, who underwent MUF, concluded that PO_2 in the patients significantly improved. The amount of PO_2 has been reported to be significantly better using MUF in many other studies as well. [8, 23-24] Similar to our study, Mahmoud et al [25] divided their patients into 2 groups of CUF+MUF and CUF and compared pulmonary function in these patients. The authors reported improvement in pulmonary compliance in the CUF+MUF group. Hiramatsu et al [26] also compared the pulmonary effects of CUF alone against the use of MUF+ dilutional ultrafiltration in adult patients and reported that the pulmonary vascular resistance was lower in the MUF group patients. In general, the results obtained from our study, which was conducted on children weighing less than 10 kg, chime in with most of the previous studies and confirm the beneficial effects of the use of MUF in short periods after surgery.

Our study showed that the use of MUF prevented a rise in blood sugar and lactate levels postoperatively and even significantly reduced them compared to the control group. Torina et al [2] conducted that in adult patients scheduled for CABG, there was no significant difference in blood glucose and lactate levels between the 2 groups, which may have been due to the more efficient effects of MUF on children than on adults.

Some studies have reported that the administration of MUF significantly reduces the blood concentrations of potassium but not magnesium. [25, 26] In contrast, Mohanlal et al [24] did not observe a significant change in the concentration of potassium using either of veno-arterial modified ultrafiltration and arteriovenous modified ultrafiltration. Further, no significant change was observed in the concentrations of Na, Cl, and Ca in the present study and that by Mohanlal et al, which might be interpreted as minimal adverse impacts of MUF on the patients of these 2 studies.

CONCLUSIONS

Using MUF at the end of CPB in our pediatric cardiac surgery patients was able to improve clinical status and arterial blood gas parameters in the postoperative period. It was also able to augment blood electrolyte balance and reduce the need for blood product transfusion.

Limitations

The major limitation of our study is its small sample size (n=21). Also, the present study was performed only in a single hospital; multicenter studies with more patients might yield more powerful results.

Conflict of Interest: None.

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