CONVENTIONAL ULTRAFILTRATION IN PEDIATRIC OPEN HEART SURGERY

ERDEM SILISTRELI, HUDAI CATALYUREK, ISMAIL YUREKLI, CENK ERDAL, OZALP KARABAY, H. IBRAHIM ALGIN, GOKHAN ALBAYRAK, UNAL ACIKEL

From:
Department of Cardiovascular Surgery, University of Dokuz Eylül, School of Medicine, Izmir, TURKEY

Address for reprints:
Erdem SILISTRELI,MD
Mithatpasa Cad. No: 257/5
35340 Balcova, Izmir / TURKEY
Tel: +90 232 4123207
Fax: +90 232 4123210
E-mail: silistreli@yahoo.com

Background: *Cardiopulmonary bypass in the pediatric age group leads to some undesirable effects, such as significant water retension and dilution of plasma proteins, hence resulting in water loss into the extravascular compartments. Activation of inflammatory mediators and complement system can cause cardiodepressive effects and clotting disturbances. Conventional ultrafiltration is sometimes used to withdraw plasma water, inflammatory materials and complement from the total circulating volume, in order to provide a more comfortable and physiologic postoperative period.*

Methods: *In this study, we compared two groups of 30 patients each, who underwent pediatric cardiac operations within a period of three years in our institution. In one group conventional ultrafiltration was performed, while in the other ultrafiltration was not used. The effects of conventional ultrafiltration are evaluated on perioperative and postoperative donor blood use, postoperative chest drainage, perioperative urine output, perioperative and postoperative hematocrit levels, and blood pressure levels.*

Results: *Conventional ultrafiltration resulted in a significant increase in hematocrit levels, postoperative blood pressure levels, and a significantly lower amount of chest drainage within the first 24 hours. However, the total and perioperative donor transfusion requirement was higher than the control group. Perioperative urine output did not differ between the two groups.*

Conclusions: *This study could demonstrate some beneficial effects of conventional ultrafiltration, besides a dysadvantageous effect in a peidatric cardiac surgical patient group.*

Key words: *conventional, ultrafiltration, pediatric cardiac surgery, cardiopulmonary baypass*

Some undesirable effects of cardiopulmonary bypass (CPB) may lead to the dysfunction of vital organ systems, resulting from capillary leak and increased body water (1). Hemodilution has an advantage of reducing blood transfusion requirement during CPB, in the other hand, dilution of plasma proteins increases water loss into the extravascular compartment and postoperative blood loss as a result of clotting disturbances (2). Water retension is especially important in neonates and infants. The ratio of prime volume to the total blood volume is greater in this group. While the development of edema increases the risk of morbidity, cytokines and other inflammatory mediators can lead to other catastrophic processes, such as reperfusion injury, myocardial disfunction, and ischemia (1,3). All of these factors may have negative consequences in the postoperative period.

The advantages of the ultrafiltration procedures include the improvements in myocardial, pulmonary and some other organ functions especially in high-risk cardiac surgery patients (3,4). The protection of these organ systems can reduce some complications such as perioperative myocardial infarction, low cardiac output syndrome, and pulmonary edema. Many studies have shown the beneficial effects of either modified or conventional ultrafiltration. In our study, we investigated some effects of conventional ultrafiltration.

In this study, we compared two groups of 30 patients each, who underwent pediatric cardiac operations in our institution. In one group conventional ultrafiltration was performed, while in the other ultrafiltration was not used. The effects of conventional ultrafiltration are evaluated on perioperative and postoperative donor blood use, postoperative chest drainage, perioperative urine output, perioperative and postoperative hematocrit levels, and blood pressure levels.

MATERIALS AND METHODS

Patient Population and Operation: The study included 60 patients who underwent open surgical procedures within three years between the dates of January 2000 and December 2002 Thirty of the patients consisted the control group, while the other thirty were consisting the conventional ultrafiltration (CUF) group. The two groups were comparable in sex, age, body weight, duration of CPB and aortic cross-clamp (ACC) period. Patient characteristics and general data are shown in Table 1. Methods of cannulation, surgery and anesthetic techniques were not different for both groups during the study period. Arterial, central venous, in addition to rectal and esophageal temperature, as well as urine output were monitored throughout the operation. After a standard midline sternotomy, aortic and bicaval cannulation were done. Aprotinin (Bayer AG, Germany) is not used in our institution for pediatric cardiac operations. Modified ultrafiltration procedures and its effects are not included in the study.

Cardiopulmonary Bypass: The pump circuit consisted of an oxygenator with a 40 Ìm arterial line filter (Dideco, Mirandola, Italy) and a roller pump (Sarns, 3M, Michigan, USA). For patients with a body weight between 5 and 40 kg, Dideco 705 oxygenator was used. The type of the oxygenator was Lilliput (Dideco) for patients with a weight below 5 kg. Ringer's lactate constituted the main substance of prime solution. The prime volume of the CPB circuit was 1200 ml for Dideco 705, and 600 ml for the Lilliput types. If the estimated hematocrit was less than 20 %, packed blood cells were added to the circuit. The flow rates were maintained between 1.2 and 2.4 l.m-2,min-1, depending on the weight. Myocardial preservation was achieved with intermittant cold sangineous crystalloid cardioplegic solution during aortic cross-clamping. Circulatory arrest was not used.

Ultrafiltration: An ultrafiltrater (Baxter PSHF400, Irvine, CA, USA) was placed in the pump circuit and it was primed together with the rest of the circuit. The inlet of the ultrafiltrater was connected to the arterial tubing distal to the oxygenator, and the outlet was connected to the cardiotomy reservoir. The procedure was started from the rewarming phase of CPB, with a rate adjusted to reach the venous reservoir level approaching to its minimum level at the termination of CPB. Prefilter and postfilter pressures of circuit were monitored during the procedure. Negative suction pressure was applied to the ultrafiltrate drainage system. The target volume for ultrafiltrate removal was between 100 and 1000 ml, depending on patient body surface area and priming volume.

Data Analysis: The following variables were noted and compared in both groups: Perioperative urine output, donor blood transfusion volume (total amount and the volumes transfused during and in the first 24 hours after the operation), chest drainage in the first 24 hours, hematocrit levels 4 hour after arrival at ICU (Intensive Care Unit), systolic blood pressure levels 4 hour after arrival at ICU.

The statistical calculations were made with the program of SPSS for Windows, Release 10.0.1 Student Version (SPSS Inc., Chicago, IL, USA). Student's t test was used for comparing both independent groups. The probability (p) less than 0.05 was considered significant; all p values were two-tailed. The results in the text and in the tables are expressed as arythmetical mean + standard deviation.

RESULTS

Patients and Operative Data: Patients ranged in age from 45 day to 13 years (mean 41.5 + 34.6 in months), and in weight from 3.5 to 61 kg (mean 13.3 + 9.0 kg). There was no significant difference in any of these variables between patients in the CUF and control group. There was no difference in duration of CPB (66.3 + 33.6 vs 79.8 + 19.3 minutes; p=0.061), aortic cross-clamping (35.2 + 22.6 vs 44.1 + 15.5 minutes; p=0.08) and the mean prime volumes. The demographic and operative data of these two groups are shown in Table 1. The surgical procedures performed were similar (Table 2).

Table I: Demographic and operative data of the patients in the CUF and control group

Charasteristic	No UF	Conventional UF	P Value
Sex (male/female)	15/15	11/19	...
Age (months)	47.6 + 34.5	35.5 + 34.3	0.182
Weight (kg)	14.2 + 10.0	12.3 + 7.8	0.408
CPB time (min.)	66.3 + 33.6	79.8 + 19.3	0.061
ACC time (min.)	35.2 + 22.6	44.1 + 15.5	0.080

Data are presented as n or mean + SD
UF = Ultrafiltration
CPB = Cardiopulmonary bypass
ACC = Aortic cross-clamping

Table 2: Patient diagnoses

Diagnosis	No UF	Conventional UF
ASD	10	6
VSD	11	12
Fontan	1	2
Tetralogy of Fallot	1	5
Aortic stenosis	3	
Aortic insufficiency		
Mitral stenosis	1	1
Mitral insufficiency	1	
IHSS	2	
TAPVC		2
Rastelli		1
ASD+Mitral cleft		1

ASD = atrial septal defect; **VSD** = ventricular septal defect; **IHSS** = idiopathic hypertrophic subaortic stenosis; **TAPVC** = total anomalous pulmonary venous connection

Parameters: The mean ultrafiltrate volume was 67.2 + 48.5 ml/kg in the CUF group. Perioperative urine output was expressed as ml per kg for each case, and did not differ significantly between the two groups.

The mean amount of the perioperatively transfused blood volume was significantly higher in the CUF group (1.78 + 0.7 Units vs 1.38 + 0.5 Units; p=0.025). The mean amount of transfused blood in the first 24 hours after the operation did not differ between the two groups. By the way, total amount of transfusion was again higher in the CUF group (2.19 + 0.9 Units vs 1.78 + 0.6 Units; p=0.048). In the other hand, mean chest drainage in the first 24 hours was significantly lower in the CUF group (133.5 + 81.1 ml vs 217.6 + 192.1 ml; p=0.031)

Mean hematocrit levels significantly increased after the ultrafiltration process in the CUF group (the pre-UF value was 22.8 + 3.1 % and the post-UF value was 30.9 + 4.3 %; p=0.0001). Mean hematocrit levels 4 hour after arrival at ICU (Intensive Care Unit) were not different between the two groups.

Mean systolic blood pressure levels 4 hours after arrival at ICU were significantly different, favoring the CUF group (104.2 + 17.3 ml vs 96.4 + 8.9 ml; p=0.033)

The results and statistical differences are shown in Table 3.

Table 3: Compared parameters of the patients in the CUF and control group

Parameter	No UF	Conventional UF	P Value
perioperative urine output ml/kg	8.81 + 10.1	8.33 + 9.5	0.850
donor blood volume transfused during the operation (U)	1.38 + 0.5	1.78 + 0.7	0.025
donor blood volume transfused in the first 24 hours after the operation (U)	0.40 + 0.4	0.41 + 0.3	0.934
mean total donor blood use (U)	1.78 + 0.6	2.19 + 0.9	0.048
chest drainage in the first 24 hours (ml)	217.6 + 192.1	133.8 + 80.6	0.032
hematocrit levels 4 hour after arrival at ICU	32.3 + 3.3	32.9 + 4.7	0.552
systolic blood pressure levels 4 hour after arrival at ICU	96.4 + 8.9	104.2 + 17.3	0.033

Data are presented as n or mean + SD
UF = Ultrafiltration
CPB = Cardiopulmonary bypass
ACC = Aortic cross-clamping
ICU = Intensive Care Unit

DISCUSSION

Ultrafiltration, used in pediatric cardiac oparations has been described as two different modifications, in other words, separated into modified and conventional techniques according to the connection with the bypass circuit and the time of starting ultrafiltration (5). Although many studies has been advocated the modified ultrafiltration as a more effective method than the conventional one, some recent detailed studies show that the two methods do not differ in terms of hematocrit, hemodynamics, ventricular function, requirement for blood products, postoperative resource and efficacy in removing the inflammatory mediators (3,6,7,8).

A detailed study made by Draaisma AM et al. had reported the beneficial effects of UF in decreasing the blood transfusion requirement. Removing some amount of water from the circulating volume have leaded an increase in hemoglobin and hematocrit levels, decreasing the need for blood transfusion significantly, as does postoperative blood loss (9). Our study also showed the significant increase in hematocrit levels during CUF, in the other hand, mean amount of perioperatively transfused donor blood volume was higher in the CUF group of our patients. This can be explained mainly by volume requirement during the procedure. We do not use cell-saver systems and additional removal of ultrafiltrate volume could be compensated by more donor blood use during CPB. Transfusion requirement in the first 24 hours did not differ between the groups, and with a less significance, total donor blood usage was higher in the CUF group. This finding was again the result of perioperative differences. In the other hand, mean chest drainage amount in the first 24 hours was lessened in the CUF group, as in the literature.

The rise in blood pressure has been observed by others (5,9). This result may be attributable to the rise in blood viscosity, as well as to the removal of inflammatory mediators such as interleukins, tumor necrosis factor, and activated complement components – many of them having negative inotropic effects (3,4,9).

This retrospective study of two comparable cohorts of patients showed significantly lower chest drain blood loss and higher postoperative blood pressure levels after CUF, with the increased donor blood usage, in the other hand. The perioperative and postoperative protocols did not differ during the period of the study. Our study could demonstrate some beneficial effects of CUF, besides a dysadvantageous effect in a peidatric cardiac surgical patient group, despite the shortcoming of not being a prospectively designed one.

REFERENCES

1. Kiziltepe U, Uysalel A, Corapcioglu T, Dalva K, Akan H, Akalin H. Effects of combined conventional and modified ultrafiltration in adult patients.
Ann Thorac Surg. 2001;71:684-93.

2. Kern FH, Morana NJ, Sears JJ, Hicky PR. Coagulation defects in neonates during cardiopulmonary bypass. Ann Thorac Surg 1992;54:541-6.

3. Wang MJ, Chiu IS, Hsu CM, Wang CM, Lin PL, Chang CI, Huang CH, Chu SH. Efficacy of ultrafiltration in removing inflammatory mediators during pediatric cardiac operations. Ann Thorac Surg 1996;61:651-6.

4. Journois D, Pouard P, Greeley WJ, Mauriat P, Vouhé P, Safran D. Hemofiltration during cardiopulmonary bypass in pediatric cardiac surgery. Anestheesiology 1994;81:1181-9.

5. Naik S, Elliott MJ. Ultrafiltration. In: Jonas RA, Elliott MJ, eds. Cardiopulmonary bypass in neonates, infants and young children. 1st ed. Oxford: Butterworth-Heinemann, 1994:150-72.

6. Finn A, Naik S, Klein N, Levinsky RJ, Strobel S, Elliott M. Interleukin-8 release and neutrophil degranulation after pediatric cardiopulmonary bypass. J Thorac Cardiovasc Surg 1993;105:234-41.

7. Kawamura T, Wakusawa R, Okada K, Inada S. Elevation of cytokines during open heart surgery with cardiopulmonary bypass: participation of interleukin 8 and 6 in reperfusion injury. Can J Anaesth 1993;40:1016-21.

8. Thompson LND, McElhinney DB, Findlay P, Miller-Hance W, Chen MJ, Minami M, Petrossian E, Parry AJ, Reddy VM, Hanley FL. A prospective randomized study comparing volume-standardized modified and conventional ultrafiltration in pediatric cardiac surgery. J Thorac Cardiovasc Surg 2001;122:220-8.

9. Draaisma AM, Hazekamp MG, Frank M, Anes N, Schoof PH, Huysmans HA. Modified ultrafiltration after cardiopulmonary bypass in pediatric cardiac surgery. Ann Thorac Surg 1997;64:521-5.
ment.