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The significance of ultrafiltration methods as a method of regulation of hydrobalance in congenital heart defects in newborn

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Summary
Correction of congenital heart defects in newborns under cardiopulmonary bypass is accompnied by fluid overload. To eliminate this pathological condition, the ultrafiltration method is used. An analysis of the correction of congenital heart defects in newborns operated in the pediatric cardiac surgery departments of the TashPMI and Eramed clinics during MarchiJune 2023 is presented. 20 newborns with congenital heart defects using two methods of ultrafiltration during cardiopulmonary bypass: group 1 (n-10) classical ultrafiltration, modified ultrafiltration cardiopulmonary bypass group (n-10). The data obtained indicate that in the group where the modified ultrafiltration was performed, the index of inotropic support, the need for blood transfusion in the immediate postoperative period, the need for blood transfusion in the immediate postoperative period, the time the patient spent on mechanical ventilation was significantly lower than in the group with classical ultrafiltration.
Key words: congenital heart defects, artificial blood circulation, classical ultrafiltration, modified ultrafiltration,hydrobalance.

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Значение метода ультрафильтрации как метода регулирования гидробаланса при врожденных пороках сердца у новорожденных

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Аннотация
Коррекция врожденных пороков сердца у новорожденных в условиях искусственного кровообращения сопровождается перегрузкой жидкостью. Для устранения этого патологического состояния применяют метод ультрафильтрации. Представлен анализ результатов коррекции врожденных пороков сердца у новорожденных, оперированных в детских кардиохирургических отделениях клиник ТашПМИ и «Эрамед» в марте июня 2023 года. У 20 новорожденных с врожденными пороками сердца использованы два метода ультрафильтрации при искусственном кровообращении: группа 1 (n=10) классической ультрафильтрации, группа модифицированной ультрафильтрации искусственного кровообращения (n=10). Полученные данные свидетельствуют о том, что в группе, где проводилась модифицированная ультрафильтрация, индекс инотропной поддержки, потребность в переливании крови в ближайшем послеоперационном периоде, необходимость в переливании крови в ближайшем послеоперационном периоде, время, проведенное пациентом на механическом вентиляция была достоверно ниже, чем в группе с классической ультрафильтрацией.
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Actuality. Every year, the number of operations performed worldwide to eliminate congenital heart defects, including the number of operations performed in the neonatal period, is increasing day by day. 2022 in Uzbekistan 5.380 out of 120.000 newborns were born with congenital heart defects [1, 2].

One of the main problems faced by the anesthesiologist and perfusionist during the intraoperative period is the problem of hydrobalance disturbance and its correction. The reasons for excessive fluid retention in the body are: physiological characteristics of children (physiological hydrophilicity of tissues, imperfect kidney function, as well as their post-operative damage), artificial blood circulation process (infant blood circulation volume and the initial volume of the artificial blood circulation machine the incompatibility between the introduction of exogenous fluids, the incompatibility of the materials of the artificial circulatory system and the patient's blood, which, in turn, can lead to the activation of the enzymatic cascade and the development of the syndrome of increased capillary permeability [3, 5].

This pathological condition can be eliminated by two methods of ultrafiltration: classic ultrafiltration and modified ultrafiltration (MUF)

According to the sources cited in the literature, ultrafiltration has the following positive effects on the body: a decrease in myocardial swelling, an increase in arterial blood pressure, a decrease in heart rate, a decrease in central venous pressure, a decrease in the heart's need for inotropic substances, an improvement in oxygenation in the lungs, and decreased extravascular fluid in the lungs, decreased postperfusion systemic inflammatory response (decreased pro-inflammatory cytokines in plasma), increased creatinine clearance and decreased total body water, increased hematocrit (Ht) and increased plasma coagulation factors, thus blood transfusion reduces the use of tools.

Currently, several studies are being conducted by cardioanesthesiologists on the widespread use of the ultrafiltration method in pediatric cardiac surgery. It seemed interesting to us to determine and evaluate the effectiveness of ultrafiltration used during anesthesia in babies with congenital heart defects.

The aim of the research. The purpose of the study is to compare the effectiveness of two types of ultrafiltration during anesthesia in babies with congenital heart defects.

Materials and methods. 20 babies with congenital heart defects were included in the study and they underwent surgical practice in the cardiac surgery departments of the Tashkent Pediatric Medical Institute and the Eramed Clinic in March-June 2023. All patients were divided into two groups. The first group consisted of 10 patients who underwent classical ultrafiltration during artificial blood circulation. The second group of patients underwent modified ultrafiltration after the artificial blood circulation stopped.

The technique of classical ultrafiltration during artificial blood circulation: Blood is transferred from the aorta to the reservoir at a speed of 20-40 ml/min, and the return of blood

Table 1.
Distribution of children by age and body weight.

Indicator	Group 1 - KUF n=10	Group 2 - MUF n=10	p
Age, days	13,5 (11,5; 15,0)	5,0 (4,5; 12,5)	<0,05
Body weight, kg	3,28 (2,9; 3,87)	3,33 (2,97; 3,49)	>0,05

Table 2.
Hemoglobin and hematocrit dynamics during the intraoperative period.

Indicator	Group 1 - KUF n=10	Group 2 - MUF n=10	p
Hemoglobin, g/l baseline	143,5 (123; 156)	126 (123; 143)	>0,05
After artificial blood circulation	91,5 (89; 110)	136 (113,5; 155,0)	<0,05
Hemotocrit, % baseline	41,5 (34; 46)	38,5 (37,5; 39,5)	>0,05
After artificial blood circulation	26,5 (23; 30)	39,5 (32,5; 43,0)	<0,05

Table 3.
Effect of types of ultrafiltration on the course of the perioperative stage.

Indicator	Group 1 - KUF n=10	Group 2 - MUF n=10	P
Duration of aortic stenosis, min	50,5 (44,5; 53,0)	61 (49; 69)	>0,05
Duration of artificial blood circulation, min	85,5 (79,5; 138,0)	107 (99; 119)	
Duration of artificial lung ventilation, hours	244,5 (213; 336)	124,5 (90,5; 229,5)	<0,05
Length of stay in ICU, hours	288 (260; 333)	190 (128,5; 318,0)	<0,067

is carried out in the venous reservoir. Ultrafiltrate volume was 52,7 (33,1; 77,6) ml/kg in the first group. The classical ultrafiltration process was performed until the hematocrit Ht reached 30%.

MUF technique: after stopping artificial blood circulation, it was performed at a rate of 100-200 ml/min; blood was returned to the vena cava. MUF time 13,5 (11; 15) min. Ultrafiltrate volume – 64,8 (50,0; 94,5) ml/kg. The MUF procedure was terminated when the hematocrit index reached Ht-40%.

In all patients, the defect was completely eliminated with the help of cold blood cardioplegia solution with aortic occlusion in conditions of artificial blood circulation (perfusion index 2,5–3,0 l/min/m2) and moderate hypothermia (32–34 °C).

Patients were given general combined intravenous anesthesia in all cases. Induction Sibazon 0,3 mg/kg and 0,2 mg/kg/h for maintenance of anesthesia, fentanyl 10 mg/kg/h, arduan 0.08 mg/kg for induction and 0.05 mg/kg/h for anesthesia for maintenance, sevoflurane was used in doses of 2-3%/OB to maintain anesthesia. All patients underwent continuous hemodynamic monitoring during the operation.

Hemodynamic and laboratory indicators were constantly evaluated in 5 stages of anesthesia: I - before surgery; II - before artificial blood circulation; III - after artificial blood circulation; IV - after MUF; V - after surgery

Stat Plus Professional statistical software package was used for statistical data processing. As reliable results, indicators were calculated when the level of significance was p<0,05.

Results and discussion. Patients in the studied groups are close to each other in terms of weight, but differ significantly in age (Table 1).

Before the operation, 50% of the patients of the 2nd group needed inotropic support, while in the first group this figure was 10%.

In order to assess the patient's need for inotropic drugs, we used the index of inotropic support (IS) — this indicator is the ratio of the sum of the doses of cardiotonic drugs to the recovery coefficient of mg/kg/min (for dopamine and dobutamine, this coefficient is 1, for adrenaline and for noradrenaline it is equal to the product of -100 ha). After ultrafiltration, this indicator was significantly higher in the second group of patients and remained high for a long time.

Ultrafiltration volume and hydrobalance during the end stage of artificial blood circulation of anesthesia were calculated in ml/kg. Ultrafiltrate volume was not significantly different when compared between groups. 52,7 (33,1; 77,6) ml/kg in the first group, 64,8 (50,0; 94,5) ml/kg in the second. At the end of artificial blood circulation of anesthesia, a negative hydrobalance was obtained in the group where MUF was used, and a positive hydrobalance was obtained in the group where classic ultrafiltration was used. Hydrobalance score obtained at 6 hours postoperatively was positive in both groups and no significant difference was found between them.

The groups did not differ from each other in terms of hemoglobin levels in the pre-circulation stage of anesthesia. Hemoglobin and hematocrit levels were significantly higher in the 2 groups using MUF compared to the first group. (Table 2).

In the first hours after surgery, the rate of transfusion of erythrocyte mass was 90% in the first group and 20% in the second group.

The groups did not differ in terms of artificial blood circulation time and duration of aortic compression time. However, in the second group, this time is slightly less. The duration of artificial lung ventilation (IVL) in postoperative intensive care was less in the second group of patients than in the first group, and therefore the duration of the first group of patients in intensive care lasted longer than that of the second group. (Table 3).

During the study, we found out that in the second group of patients who received MUF, the heart failure clinic and the need for inotropic drugs were less observed. This shows that when the MUF method was applied to patients during surgery, that is, in the second group of patients, we could observe significantly stable hemodynamic parameters, negative hydrobalance, and a significant decrease in myocardial edema, on the contrary, these indicators were more negative in the first group of patients. got the result. According to our results, the use of the MUF procedure significantly increases hemoglobin and hematocrit levels in patients, while reducing the need for blood transfusions.

The reduction in the duration of artificial lung ventilation in the second group determined in the study was due to the reduction of excess fluid outside the pulmonary vessels, the reduction of the total excess fluid in the body, and the improvement of oxygenation in the lungs.

Conclusions.

1. Both methods of hydrobalance regulation in artificial blood circulation in babies born with congenital heart defects are considered very effective and allow to eliminate anemia, but when using the MUF method, the initial hemoglobin and hematocrit indicators it will be possible to reach the level, it will be possible to reduce the need for transfusion of erythrocytes.
2. Using MUF, it is possible to reduce the number of postoperative heart failure clinics, reduce the need for cardiotonic drugs, reduce the duration of postoperative artificial lung ventilation, and prevent long-term stay of patients in intensive care.

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