Research Article

Interventional Cardiology

Comparison of hemoglobin before and after modified ultrafiltration in pediatric cardiac surgery

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Received date: July 15, 2021
Accepted date: September 06, 2021
Published date: September 13, 2021

Abstract:

Introduction: Cardiopulmonary bypass (CPB) with hypothermia and hemodilution increases total body water. Hemodilution most frequently causes hypothermia by increasing tissue perfusion during CPB. This is required to prevent ischemic organ damage during periods of low blood flow or circulatory arrest. MUF has another advantage over traditional ultrafiltration. The cardiopulmonary bypass has the potential to restore the contents of the CPB circuit to the patient in a concentrated form. Water retention is common in children, especially in neonates and tiny infants.

Methods: The study was conducted for 6 months from July 2020 to February 2021 at the Department of Cardiac surgery, Rawal general and dental hospital and included thirty patients (n=30) of both genders who were scheduled for pediatric heart surgery and were between the ages of 6 and12.

Results: The mean age was (6.53 ± 3.730), Height (107.63 ± 23.526), Weight (16.87 ± 5.716), Hemoglobin before (9.360 ± 1.1319) and after (11.230 ± 1.1253), Mean Volume of MUF (316.33 ± 68.405), Mean Cross Clamp Time (57.57 ± 30.458), Mean Potassium level (4.067 ± 0.3155).

Conclusion: According to the findings of our study, the use of a hemofilter increases hemoglobin and hematocrit levels when compared to pre-bypass levels, and less blood product is required for transfusion following bypass. It also has a significant impact on the control of postoperative bleeding.

Keywords: Modified ultrafiltration • Atrial septal defect • Ventricular septal defect • Hemoglobin • Hemofilter • Tetralogy of fellots • Cardiopulmonary bypass

Introduction

The total body water level rises during cardiopulmonary bypass (CPB) with hypothermia and hemodilution. In pediatric patients, water retention is very significant. In smaller patients, the prime volume to patient blood volume ratio is higher [1]. Hemodilution improves tissue perfusion and allows hypothermia to be used during CPB. This is required to prevent ischemic organ damage during periods of low blood flow or circulatory arrest. The capacity to return the contents of the CPB circuit to the patient in a concentrated state is another advantage of MUF over conventional ultrafiltration [2]. Water retention is common in children after cardiopulmonary bypass, especially in neonates and tiny infants. Water loss into extravascular compartments is increased when plasma proteins are diluted. Excess total body water can prolong ventilator support and contribute to an extended stay in intensive care [3]. After cardiopulmonary bypass has been stopped, modified ultrafiltration can be employed to remove plasma water from the total circulating volume [4].

During CPB, hemodilution raises the blood requirements of the donor. Dilution of plasma proteins causes extravascular water retention and postoperative blood loss as a result of coagulation problems. [5]. Cardiopulmonary bypass causes a significant inflammatory reaction, and this "whole-body inflammatory response" is particularly pronounced in youngsters [6]. Increased capillary leakage is one of the side effects of this inflammatory response. A rise in total body water is attributed to increased capillary permeability, particularly in the extracellular interstitial compartment. All of these things could hurt the recovery process [7].

In Pakistan, about one percent of all children born alive have congenital cardiac disease. More than 30000 children are projected to be born each year with congenital cardiac abnormalities that require surgery to address [8]. According to the report, 8 to 10% of all newborns in the country have some form of congenital heart disease, with 50% of these dying without treatment [9]. Despite the surgical ability to treat complicated problems in such young neonates, there are occasional restrictions in the outcome due to the systems required for surgical repair. Cardiopulmonary bypasses, in particular, are a risk factor (CPB. During CPB, the patient's heart and lungs are bypassed, and the heartlung machine takes over their function [10].

Crystalloid solutions are used to prime the CPB circuit to eliminate air. These liquids are combined in the patient's circulatory system during bypass, resulting in hemodilution [11].

The decrease in patient's hematocrit level, platelets, and clotting factors due to hemodilution causes increased postoperative bleeding, Blood products are in more demand for transfusions. When crystalloid solutions are mixed with a patient's circulating blood, the colloid osmotic pressure drops. As a result, after CPB in children, fluid flows into the extravascular tissues, causing edema and an increase in total body water. [12]. A positive fluid average of 664 mL was reported, which is equivalent to a 30% weight increase in newborns and babies after arterials witch operation [13].

Cardiopulmonary bypasses (CPB) have a crucial role in the development of postoperative morbidity, particularly in pediatric cardiac surgery. Systemic Inflammatory Response Syndrome (SIRS) arises in pediatric patients as a result of CPB, which causes an increase in total body water and can lead to multi-organ dysfunction. Hypothermia, hemodilution, anticoagulant non-pulsatile blood flow, and blood exposure to nonendothelaized surfaces are the most important aspects of CPB that cause SIRS [14]. Ultrafiltration (UF) is an essential strategy for reducing these adverse effects during and after CPB. Conventional ultrafiltration (CUF) and modified ultrafiltration (MUF) are the two most common pediatric UF procedures.

CUF refers to UF done during CPB, whereas MUF is done after CPB has been stopped. These methods are not mutually exclusive, but rather mutually beneficial MUF was first described in 1991 by Naik, et al. and has since become routine practice in the great majority of cardiac clinics. Several clinical investigations conducted over the last 20 years have shown that MUF can improve clinical results. The following are some of the reported advantages of better hemodynamics [15]. The increase in total body water is caused by hypothermia and hemodilution. To clear this additional volume, the kidneys' workload is enhanced. If the patient's urine production is insufficient, and increasing the volume causes an overload, MUF procedures are used to remove the surplus volume. This study aided in determining the conditions in which the MUF technique should be used, as well as the effect of the MUF technique on Hb levels.

Methodology

The study was conducted at Rawal General and Dental Hospital for 6 months, from July 2020 to February 2021. Pre-structured Performa was used to collect data through non-probability convinent sampling method which includes both open and closed-ended questions. Ethical approval was taken from the ethical committee of Bashir Institute of Health Sciences, Islamabad Pakistan. The trial was carried out following the International Organization for Harmonization criteria for good clinical procedures and the Helsinki declarations [7]. Written informed consent was taken from the patients. After meeting the inclusion criteria, 30 patients were enrolled in the study.

Data Analysis procedure

The data were entered in SPSS version 20. Descriptive statistics were used to calculate means ± SD for quantitative variables i.e. age. Frequencies and percentage were calculated for qualitative variables i.e. gender and procedures.

Results

Demographic profile of enrolled patients

The current study involved thirty (n=30) patients of both genders, ranging in age from six to twelve years, who were scheduled for peadritic heart surgery. In our study, 60% of the participants were men and 40% were women (Table 1). It also shows that 26.7% patients were undergone for ASD closure, 26.7% for VSD closure 30% for TOF and16.7 % for both ASD and VSD closure (Table 2).

Table 1: Gender distribution (n=30).

Variables	Frequency	Percentage
Male	18	60%
Female	12	40%

Table 2: Surgical procedure (n=30).

Variables	Frequency	Percentage
ASD	8	26.7%
VSD	8	26.7%
TOF	9	30%
Both ASD and VSD	5	16%

Baseline characteristics

Mean age of the patients (6.53 ± 3.730), mean height (107.63 ± 23.526), Weight (16.87 ± 5.716), Hemoglobin Before (9.360 ± 1.1319) and after (11.230 ± 1.1253), Mean Volume of MUF (316.33 ± 68.405), Mean Cross Clamp Time (57.57 ± 30.458), Mean Potassium level (4.067 ± 0.3155), Mean Bypass Time (89.20 ± 36.829), Mean Extubation Time (2.59 ± 1.451), and Mean Hospital Stay (4.93 ± 0.944) (Table 3).

Table 3:Base line Characteristics of the Patients (n=30).

Variables	Mean	SD
Age of the patients	6.53	± 3.730
Height in cm	107.63	± 23.526
weight in kg	16.87	± 5.716
Hemoglobin value Before	9.36	± 1.1319
Hemoglobin value After	11.23	± 1.1253
Volume of MUF in ml	316.33	± 68.405
cross clamp time in minute	57.57	± 30.458
potassium level	4.067	± 0.3155
Bypass time in minute	89.2	± 36.829
Extubation time in hours	2.59	± 1.451
Hospital Stay in days	4.93	± 0.944

Discussion

The total body water level rises during cardiopulmonary bypass (CPB) with hypothermia and hemodilution. In pediatric patients, water retention is very significant. In smaller patients, the prime volume to patient blood volume ratio is higher. Hemodilution improves tissue perfusion during CPB and allows for the use of hypothermia, which is necessary to avoid ischemic organ damage during periods of low flow or circulatory arrest. The capacity to return the contents of the CPB circuit to the patient in a concentrated state is another advantage of MUF over conventional ultrafiltration.

In children, especially neonates and young infants, cardiopulmonary bypass causes significant water retention. Water loss into extravascular compartments is increased when plasma proteins are diluted [16]. Excessive total body water may prolong ventilatory support and may contribute to a prolongation of intensive care convalescence. After discontinuation of cardiopulmonary bypass, modified ultrafiltration can be used to withdraw plasma water from the total circulating volume [17].

The present study aimed to reevaluate the importance of MUF as a part of a combined ultrafiltration strategy on early clinical outcomes in infants undergoing pediatric cardiac surgery within conditions of decreased use of hypothermia and mitigation of hemodilution [18]. As far as we are aware, this is the first prospective study that evaluates the significance of MUF within these new CPB characteristics. Previous studies that compared CUF to CUF+MUF were characterized by significant utilization of hypothermia and deep hypothermic circulatory arrest [19].

Within our group of patients, deep hypothermia with circulatory arrest, isolated myocardial, and cerebral perfusion are designated exclusively for infants who require aortic arch and ascending aorta restoration (e.g., Hypoplastic heart syndrome, interrupted aortic arch) [20]. Furthermore, by reducing the CPB circuit and allowing for continuous in-line Hct and arterial blood gas monitoring (CDI 500, Terumo Cardiovascular, Ann Arbor, MI, USA), the hemodilution degree was reduced. We dedicated special attention to newborns and infants weighing less than 5 kg in our prospective, randomized study, where the effects of MUF are likely to be more obvious [21].

Many of the early pro-MUF studies used considerable hemodilution and compared MUF groups to control groups that did not get any ultrafiltration. CPB care without ultrafiltration is unfathomable nowadays and would not reflect current clinical practice [22]. Another important issue with interpreting study results is the wide range of ultrafiltration techniques used, as well as the retrospective nonrandomized nature of many of these publications [23]. According to the findings of our study, 60 percent of the participants were male and 40% were female. It also indicates the frequency and proportion of procedures performed, showing that in our study, 26.7 percent of patients had ASD closure, 26.7 percent had VSD closure, 30 percent had TOF, and 16.7 percent had both ASD and VSD closure. The mean age of patients (6.53 ± 3.730), Height mean (107.63 ± 23.526), Weight (16.87 ± 5.716), Hemoglobin Before (9.360 ± 1.1319) and after (11.230 ± 1.1253), Mean Volume of MUF (316.33 ± 68.405), Mean Cross Clamp Time (57.57 ± 30.458), Mean Potassium level (4.067 ± 0.3155), Mean Bypass Time (89.20 ± 36.829), Mean Extubation Time (2.59 ± 1.451), And Mean Hospital Stay (4.93 ± 0.944). When analyzing our CPB and ultrafiltration data, it's critical to understand why the priming volumes for both cohorts differ. Because the cardioplegia solution had to be flushed out of the line before initiating MUF, the MUF group's priming volume was much higher [24]. This causes up to 100 mL of blood to be transferred from the venous reservoir to the cardioplegia line, which must be replaced with new blood [20]. Our percussionists have a philosophy of having more priming volume that will be processed with pre-bypass ultrafiltration to contribute as little volume as feasible during CPB. This is preferable to infusing more blood or crystalloids before or during MUF [25].

Limitations of study

It was included only a peads patients not included adults. It has a limited sample size and collect data from only one hospital.

Conclusion

The use of a hemofilter during cardiopulmonary bypass has a good impact on the maintenance of hemoglobin levels during and after the procedure. According to the findings of our study, the use of a hemofilter increases hemoglobin and hematocrit levels when compared to pre-bypass levels, and less blood product is required for transfusion post bypass. And it also has a significant impact on the control of postoperative bleeding.

Conflict of Interest

We hereby confirm that there is no conflict of interest associated with publication.

Acknowledgement

The authors would like to express their gratitude to the Rawal General and Dental Hospital's Department of Cardiac Surgery for their assistance with data collecting.

Author's Contributions

AHK conceived the study, produced the first draft of the manuscript, carried out the statistical analysis, and oversaw the entire project. MA gathered the data and assisted in the revision of the manuscript. HA aided with the formulation and design of the study. IB assisted in the final editing of the manuscript. The final version of the work has been read and approved by all of the authors.

References

1. Draaisma AM, Hazekamp MG, Frank M, et al. Modified ultrafiltration after cardiopulmonary bypass in pediatric cardiac surgery. Ann Thorac Surg. 64(2): 521-525 (1997).
2. Utley JR, Wachtel C, Cain RB, et al. Effects of hypothermia, hemodilution, and pump oxygenation on organ water content, blood flow and oxygen delivery, and renal function. Ann Thorac Surg. 31(2): 121-33 (1981).
3. Kern FH, Morana NJ, Sears JJ, et al. Coagulation defects in neonates during cardiopulmonary bypass. Ann Thorac Surg. 55(5): 1283-4 (1992).
4. Kirklin JK, Blackstone EH, Kirklin JW. Cardiopulmonary bypass: Studies on its damaging effects. Blood Purif. 5(2-3): 168-78 1987.
5. Naik SK, Knight A, Elliott MJ. A successful modification of ultrafiltration for cardiopulmonary bypass in children. Perfusion. 6(1): 41-50 (1991).
6. Novick WM. Collaborative program between Armed Forces Institute of cardiology and International Children's Heart Foundation to improve pediatric cardiac services: Program overview and initial results. Paper presented at 6thBinnial International Conference of Pakistan Society of Cardiovacsular and Thoracic Surgeons. (2006).
7. Kalimuddin A. Should pediatric cardiac surgery be a national priority? Paper presented at 3rd International symposium of Pakistan Paeditric Cardiology Society. (2003).
8. Maehara T, Novak I, Wyse RK, et al. Perioperative monitoring of total body water by bio-electrical impedance in children undergoing open heart surgery. Eur J Cardiothorac Surg. 5(5): 258-64 (1991).
9. Wernovsky G, Wypij D, Jonas RA, et al. Postoperative course and hemodynamic profile after the arterial switch operation in neonates and infants: a comparison of low-flow cardiopulmonary bypass and circulatory arrest. Circulation. 92(8): 2226-35 (1995).
10. Chew MS, Brandslund I, Brix-Christensen V, et al. Tissue injury and the inflammatory response to pediatric cardiac surgery with cardiopulmonary bypass: A descriptive study. Anesthesiology. 94(5): 745-53 (2001).
11. Radaelli A, Loardi C, Cazzaniga M, et al. Inflammatory activation during coronary artery surgery and its dose-dependent modulation by statin/ACE-inhibitor combination. Arterioscl inflammation: Pathophysiology and treatment. An update. Eur J Cardiothorac Surg. 27(12): 2750-5 (2002).
12. Kotani N, Hashimoto H, Sessler DI, et al. Cardiopulmonary bypass produces greater pulmonary than systemic proinflammatory cytokines. Anesth Analg. 90(5): 1039-45 (2000).
13. Bando K, Vijay P, Turrentine MW, et al. Dilutional and modified ultrafiltration reduces pulmonary hypertension after operations for congenital heart disease: a prospective randomized study. J Thorac Cardiovasc Surg. 115(3): 517-25 (1998).
14. Allen M, Sundararajan S, Pathan N, et al. Anti-inflammatory modalities: Their current use in pediatric cardiac surgery in the United Kingdom and Ireland. Pediatr Crit Care Med. 10(3): 341-5 (2009).
15. McEvoy MD, Sabbagh MJ, Taylor AG, et al. Aprotinin modifies left ventricular contractility and cytokine release after ischemia-reperfusion in a dose-dependent manner in a murine model. Anesth Analg. 108(2): 399-406 (2009).
16. Naik SK, Knight A, Elliott MJ. A successful modification of ultrafiltration for cardiopulmonary bypass in children. Perfusion. 6(1): 41-50 (1991).
17. Brancaccio G, Villa E, Girolami E, et al. Inflammatory cytokines in pediatric cardiac surgery and variable effect of the hemofiltration process. Perfusion. 20(5): 263-8 (2005).
18. Castro R, Croti UA, Machado M, et al. Ultrafiltraçtion convencional com modificaçãotécnica no tratamentocirúrgico dos defeitoscardíacoscongênitos. Rev Bras Cir Cardiovasc. (2006).
19. Luciani GB, Menon T, Vecchi B, et al. Modified ultrafiltration reduces morbidity after adult cardiac operations: A prospective, randomized clinical trial. Circulation. 104(12 Suppl 1): I253-9 (2001).
20. Atkins BZ, Danielson DS, Fitzpatrick CM, et al. Modified ultrafiltration attenuates pulmonary-derived inflammatory mediators in response to cardiopulmonary bypass. Interact Cardiovasc Thorac Surg. 11(5): 599-603 (2010).
21. Gaynor JW. The effect of modified ultrafiltration on the postoperative course in patients with congenital heart disease. Semin Thorac Cardiovasc Surg Pediatr Card Surg Annu. 6: 128-39 (2003).

22. Thompson LD, McElhinney DB, Findlay P, et al. A prospective randomized study comparing volume-standardized modified and conventional ultrafiltration in pediatric cardiac surgery. J Thorac Cardiovasc Surg. 122(2): 220-8 (2001).

23. Naik SK, Knight A, Elliott MJ. A successful modification of ultrafiltration for cardiopulmonary bypass in children. Perfusion. 6: 41-50 (1991).

24. Harvey B, Shann KG, Fitzgerald D, et al. American Society of Extracorporeal Technology's International Consortium for Evidence Based Perfusion and Pediatric Perfusion Committee. International pediatric perfusion practice: 2011 survey results. J Extra Corpor Technol. (2012).

25. Thompson LD, McElhinney DB, Findlay P, et al. A prospective randomized study comparing volume standardized modified and conventional ultrafiltration in pediatric cardiac surgery. J Thorac Cardiovasc Surg. 122(2): 220-8 (2001).