

Effect of Modified Ultrafiltration (MUF) on Lactate Levels in Pediatric Patients Undergoing Cardiac Surgery

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ABSTRACT

Objective: To determine the effect of MUF on pre and post MUF lactate levels.

Study Design: Analytical Cross-sectional study.

Place and Duration of Study: Pediatric Operation Theater at Armed Forces Institute of Cardiology/National Institute of Heart Disease, Rawalpindi Pakistan from Oct 2021 to Dec 2021.

Methodology: It was descriptive cross-sectional study and non-probability consecutive sampling technique was used. Data was collected during Oct 2021 to Dec 2021, from Tertiary Care Hospital, Rawalpindi Pakistan. Current study was conducted in pediatric OT at Armed Forces Institute of Cardiology/National Institute of Heart Disease. MUF technique was applied to 115 pediatric patients during congenital cardiac surgeries. Pre and post MUF lactate levels were noted. Inferential statistics were applied with the help of test of significance (Paired T-Test), p value ≤ 0.05 was considered statistically significant at 95% Confidence Interval (CI) with margin of error 5%. Collected data was analyzed by IBM SPSS version 25.

Result: Significant decrease in post MUF lactate level ($p < 0.05$) was observed. This result revealed that MUF had significant effect on lactate levels. Out of 115 study participants, 46(40%) were female and 69(60%) were male patients having mean age 3.44 ± 2.25 years, mean height 95.60 ± 18.78 cm, mean weight 15.06 ± 5.18 kg, mean body surface area 0.63 ± 0.17 m² CPB time 127.95 ± 36.78 minutes and cross clamp time 92.60 ± 40.49 minutes. Paired t-test was applied to check the mean difference between pre and post lactate levels and it revealed statistically significant findings (p -value < 0.05).

Conclusion: Current result revealed that use of MUF caused decrease in lactate levels. MUF technique showed beneficial effects in maintaining normal physiology of the body. Current results encouraged the use of MUF technique in every cardiac surgery.

Keywords: Cardiopulmonary bypass, Lactate levels, Modified ultrafiltration.

How to Cite This Article: Azam J, Asghar I, Ali N, Umer S, Khalil H, Azad N, Azam F, Muneer A, Khatoon Z, Naeem W. Effect of Modified Ultrafiltration (MUF) on Lactate Levels in Pediatric Patients Undergoing Cardiac Surgery. *Pak Armed Forces Med J* 2022; 72(Suppl-3): S618-622.

DOI: <https://doi.org/10.51253/pafmj.v72iSUPPL-3.9567>

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INTRODUCTION

Ultrafiltration is a technique used to remove excess plasma water and soluble solutes like K⁺, urea, small protein molecules and inflammatory mediators from blood through semipermeable membrane. The driving force for filtration is mainly trans-membrane pressure. Naturally in human body it occurs in human kidney. In kidney trans-membrane pressure which is about 25 mm of Hg, developed across glomerulus tubules and Bowman's capsule.¹ Artificially we are using Modified Ultrafiltration (MUF) during cardiac surgery soon after coming off from Cardiopulmonary Bypass (CPB) in order to maintain normal lactate levels that elevates during CPB. Cardiopulmonary Bypass (CPB) is a technique in which extracorporeal circuit is established using heart and lung machine in order to maintain blood circulation and body physiology during cardiac surgery. In CPB venous blood is drained

into reservoir and pumped into aorta through oxygenator after oxygenation. The first concept of CPB was introduced by John Gibbon in 1952.²

First step of CPB is fitting and priming of circuit. Priming of CPB circuit is required for de-airing which results in hemodilution. Hemodilution improves peripheral perfusion. However hemodilution induces many complications in the body i.e., Hyperlactatemia, Hemoglobin (Hb) drop, volume overload, water accumulation in body causing edema, ascites, atelectasis, pH disturbance, electrolytes imbalance and left ventricle dysfunction.³ Our main concern is with elevated lactate levels i.e., Hyperlactatemia that results in vital organs damage & delay in post-operative recovery time.

Lactate is produced as a result of improper oxidation of glucose. During CPB normal physiology of the body gets disturbed resulting in impaired oxidation of glucose which causes over production of lactate.⁴ Drop in Mean Arterial Pressures (MAP), Hypothermia & drugs like vasopressor use during CPB induce lactate elevation.

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Vasopressor drugs like Phenylephrine and Norepinephrine etc. that are used during CPB constrict blood vessels in order to increase Mean Arterial Pressure (MAP) and also limit blood flow. Limited blood flow limits oxygen supply to the cell which in turn reduces oxidation of glucose resulting in production of lactate during CPB.⁵

Normal range of lactate is 0-2mmol/L. Level of lactate more than 2mmol/L is referred as hyperlactatemia. Prolonged hyperlactatemia has devastating effects on vital organs. In order to normalize lactate levels we use MUF.

Modified Ultrafiltration (MUF) was introduced in 1991. In MUF blood is passed through hemoconcentrator. When blood passes through semipermeable hollow tubes of hemoconcentrator water, solutes and other small particles move across semipermeable membrane due to hydrostatic pressure gradient and blood get concentrated. In MUF technique blood is oxygenated, concentrated and pumped back into the body.² MUF has many beneficial effects in maintaining hemodynamics i.e Increases hematocrit, reduces lactate levels and reducing blood glucose level.⁶

METHODOLOGY

This was an analytical cross sectional study, carried out in OT of pediatric cardiac surgery department of Armed Forces Institute of Cardiology/ National Institute of Heart Diseases (AFIC/NIHD), a tertiary care hospital in Rawalpindi Pakistan.

Sample Size: A sample of 115 patients was collected, taking prevalence 9.3% by Khokhar *et al.*⁷ using WHO sample size calculator by taking CI 95% and 5% margin of error.

Inclusion Criteria: Pediatric patients of both genders with age ≤ 12 years undergoing on pump surgery were included in the study.

Exclusion Criteria: Patients of Redo, emergency and multiple surgeries (Appendectomy, Pleurodesis etc.) were excluded from the study.

Data was collected through non-probability consecutive sampling technique. All the data was collected on daily basis from pediatric OT during October, 2021 to December, 2021.

Arterio-Venous MUF technique was applied on the patients included in our study for 10-20 minutes, soon after coming off from CPB. Blood is drained from aorta through aortic cannula, after MUF through hemoconcentrator it is pumped back into right atrium through venous cannula. Arterial Blood Gases (ABGs)

were performed before and after MUF. Pre and post MUF lactate levels were noted from ABGs.

The sampling technique used for this research was non-probability consecutive sampling. Data collection tool was designed to collect. The demographic variables included age, height, weight, body surface area (BSA). Main variables included Pre-MUF lactate levels and Post-MUF lactate levels. Other variables were cardiopulmonary bypass time (CPB time), aortic cross clamp time.

Informed consent was obtained from the patient and final approval was taken from Institutional Ethical Review Board (IERB) respectively before initiation of study in order to keep the patient's and institutional information confidential and to ensure the use of data only for study purpose and welfare of humanity.

RESULTS

A total of 115 patients having mean age 3.44±2.25 years out of which 46(40%) were female and 69(60%) were male having mean height 95.60±18.78cm, mean weight 15.06±5.18kg, mean BSA 0.63±0.17m², mean CPB time 127.95±36.78 minutes and cross clamp time 92.60±40.49 minutes undergone congenital surgery and MUF technique was applied on them. As presented in Table-I.

Table-I: Socio-Demographic Variables and Clinical Parameters (n=115)

Demographic variable	Mean±SD
Age(years)	3.44±2.25
Height(cm)	95.60±18.78
Weight(kg)	15.06±5.18
Body Surface Area(m ²)	0.63±0.17
Cardio Pulmonary Bypass Time(minutes)	127.95±36.78
Cross Clamp Time(minutes)	92.60±40.49

Paired sample t-test was applied in order to compare the mean difference between pre-MUF lactate level and post-MUF lactate levels. *p*-value ≤0.05 was considered as statistically significant by taking confidence interval (CI) 95% and margin of error 5% respectively. Pre MUF mean lactate level was 4.01±1.11 mmol/L & post MUF mean lactate level was 2.42±0.62 mmol/L which shows that there is decrease in post MUF lactate value. Paired T-test determined that there is significant difference between pre and post MUF lactate levels as *p*- value is <0.0001 (Table-II).

Table-II: Comparison of Pre & Post MUF Lactate levels

Lactate Levels	Mean ± S.D	<i>p</i> -value
Post-MUF Lactate (mmol/L)	4.01±1.11	<0.0001
	2.42±0.62	

The most frequent disease in the patients included in our study was Tetralogy of Fallot (TOF) 33 (28.7%) and least frequent disease Patent Ductus Arteriosus (PDA) and Double Outlet Right Ventricle (DORV) 4(3.5%). As shown in Figure.

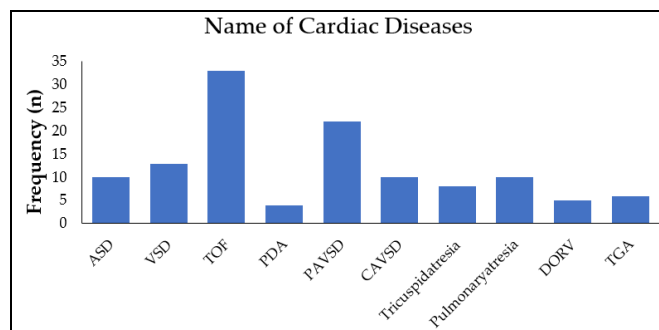


Figure: Frequency distribution of diagnosed Cardiac Defects

DISCUSSION

In many studies use of MUF technique provided beneficial results. Different people used MUF technique for obtaining beneficial results of their interest i.e. hemoconcentration, reduce load on heart, prevention from edema etc If we talk about the study of Planzo *et al.* The study was conducted on patients of weight ≤ 12 kg. He applied MUF technique after and observed that lactate level decreased on application of MUF. Thus study supports our study in terms of inclusion criteria and as well as result.⁸

McNair *et al.* conducted a study in which he divided patients into three groups. Group-1 on-line MUF (ultrafiltration of the patient's entire circulating volume), Group-2 with off-line MUF (ultrafiltration of the residual CPB volume) and Group-3 centrifugation (cell washing of the residual CPB volume) respectively. He concluded that lactate levels of patients of Group 1 and 2 are less than that of Group-3. Hence the study shows that the use of MUF causes decrease in lactate levels.⁹

A study was conducted by Low *et al.* He divided members into two groups. Patients on which MUF was applied were in Group-1 and Group-2 included members on which no MUF was applied. He noticed that the lactate levels of Group-1 members were significantly less than that of Group-2 members.¹⁰

Ziyaeifard *et al.* conducted a study in which he made comparison between effects of Conventional Ultrafiltration(CUF) and MUF he noticed several useful effects as compared to MUF. He observed that lactate level significantly decreased in patients

underwent MUF as compared to the lactate levels of the patients underwent CUF.¹¹

A study was conducted by Rehman *et al.* he applied MUF for better hemodynamic outcomes, he noticed that using MUF lactate levels significantly decreased. He conclude that MUF is beneficial for maintaining better hemodynamics and reduction of serum lactate levels. Hence this study support the outcome our study.⁶

Hiarat, planed a study in order to determine the complications of pediatric CPB and the use of MUF to reduce these complications. He noticed several complications inflammatory mediators. He applied MUF on the patients included in his study. He observed that where all other complications reduced significantly, serum lactate levels also decreased to significant extent. Thus the study resembles our study regarding reduction in lactate levels.¹²

Wu *et al.* performed study on 86 patients in order to study the effects of blood saving strategies on comprehensive post-operative recovery. He applied MUF on these patients. He observed ABGs and noticed that levels of potassium, glucose, and lactate in the blood were decreased ($p=0.006$, $p=0.008$, and $p=0.023$, respectively). A significant decrease in the partial pressure of carbon dioxide (PaCO₂) ($p=0.004$) and increase in partial pressure of oxygen (PaO₂) ($p=0.042$) were observed after MUF. His study empowers the result of our study regarding reduction in lactate levels.¹³

Dieu and Momeni, in his study claimed that with the application of MUF several beneficial effects i.e increase hemoglobin, reduction in lactate levels, reduced positive fluid balance and reduced transfusion of allogeneic blood products were obtained. Their study supports our study regarding reduction in lactate levels. Hence study empowers the use of MUF for reduction of lactate levels.¹⁴

WU *et al.* performed study on n=90 patients. He divided the patients into three groups (A, B and C) 30 in each group respectively. In Group-A stored blood was added into reservoir for priming and Zero-Balanced Ultrafiltration (ZBUF) technique was applied, In Group-B stored blood was first cleaned by cell saver then added into reservoir and in Group-C MUF was applied immediately after coming off from bypass. He noticed that Group-C showed significant decrease in interleukins & lactate levels. Hence this study encourages the use of MUF for reduction of lactate levels.¹⁵

Li *et al.* performed study on n=16 patients and study the effect of MUF on oxygen supply (DO₂) and systemic oxygenation consumption (VO₂). He noticed that use of MUF maintained balanced between DO₂ and VO₂ resulting in decrease in level of lactate.¹⁶

Boodhwani *et al.* he conducted study in order to determine the feasibility of using MUF as a blood conservation technique. He noticed increase in blood hemoglobin level, increased blood PO₂ along with decrease in lactate levels. He recommended the use of MUF during CPB.¹⁷

Ziyaeifard *et al.* concluded from his study that use of MUF showed many beneficial effects in pediatric patients underwent CPB regarding hemodynamic, hemoconcentration and lactate level reduction. This study resembles our study regarding lactate level reduction.¹⁸

Mahmoud *et al.* performed study on 40 patients. He observed that CPB decreased lungs gaseous exchange capacity. After application of MUF he observed increased blood oxygenation, lactate reduction and increase pulmonary function i.e increase gaseous exchange capacity of lungs. Hence this study supports our study with respect to reduction in lactate levels.¹⁹

In our study MUF was applied on (n=115) pediatric patients of age >12 years undergoing cardiac surgery. Calculated *p*-value was <0.0001 that showed significant result. It was concluded from our study that the value of lactate level decreased significantly with the application of MUF.

LIMITATIONS OF STUDY

Current study was concise and confined to Armed Forces Institute of Cardiology/ National Institute of Heart Diseases Pakistan with small sample size, limited time duration and limited use of MUF in different institutions. Moreover this study was only confined to pediatric patients.

CONCLUSION

The current study reveals that there is significant difference in pre and post MUF lactate levels. As lactate level decreased significantly with the application of MUF. Hence we conclude that the use of MUF is beneficial for reduction of lactate levels. Hence the reduction of lactate levels prevents from vital organs damage and reduces postoperative recovery time.

Conflict of Interest: None.

Author's Contribution

Following authors have made substantial contributions to the manuscript as under:

JA: Manuscript writing, drafting, concept and editing

MIA: Intellectual contribution, concept and final approval

NA: Intellectual contribution, concept and final approval

SU: Study design, concept and critical review

NA: Analysis, manuscript writing and proof reading

HK: Formatting, critical review and proof reading

FA: Analysis, manuscript writing and proof reading

AM: Analysis, manuscript writing and proof reading

ZK: Proof reading, Intellectual contribution, final approval

WN: Review of article, formatting and critical review

Authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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