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The Correlation between Cerebral Oximetry and Mean Arterial Pressure (MAP) Values during the Pediatric Cardiac Surgery

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Abstract

Background: Multimodal cerebral monitoring can reduce the incidence of neurological complications as well as the hospital costs associated with caring for cardiac surgery patients. Given the prevalence of cardiac surgeries, the need for cardiopulmonary bypass devices and the few studies in this area, further studies are needed. In this study, we aimed to investigate the correlation between cerebral oximetry and mean arterial pressure during pediatric cardiac surgery.

Method: The present study is a descriptive correlational one. To obtain the results, the cerebral oximetry monitoring and blood pressure were established and baseline values were recorded. Patients were then anesthetized under the same monitoring and anesthesia method, and the cerebral oximetry and blood pressure were recorded in a checklist prepared by the researcher before, during and after the cardiopulmonary pump. Data was analyzed by SPSS software (version 25).

Results: 58 children undergoing cardiac surgery were included in the study, 51.7% of whom were male. At the study time, the mean age of the patients was 1.92±2.05 years; and their mean weight was 9.86 ± 4.86 kg. A significant relationship was found between the mean arterial pressures (MAP) and the right and left cerebral oximetry.

Conclusion: According to the findings, there is a significant relationship between MAP and cerebral oximetry in pediatric cardiac surgery. This study shows that by increasing MAP during cardiopulmonary pump, the brain perfusion and oxygenation of the brain can be increased. Peripheral oximetry also plays an important role in reducing hospital costs related to the care of cardiac surgery patients.

Key Words: Cerebral Oximetry, Mean Arterial Pressure, Pediatric Heart Surgery.

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1- INTRODUCTION

Pediatric cardiac surgeries are performed in two main forms, open and closed. In all types of open cardiac surgery, it is necessary to stop cardiac function to repair internal and external cardiac lesions, and these surgeries need a cardiopulmonary bypass (CPB) to create extracorporeal circulation (1).

Circulation must be supported by CPB in an open cardiac surgery. It maintains cellular circulation and meets the needs for cellular respiration even during surgery. CPB mechanically oxygenates and circulates blood so that it bypasses the heart and lungs and does not enter into them (2, 3).

All open cardiac surgeries have some risks associated with the use of cardiopulmonary bypass. Cardiovascular bypass safety has improved significantly over the years. The major side effects are now very rare. Bypassing is well tolerated for 4 to 8 hours. The dangers of bypass include the insufficient oxygenation of organs and tissues, activation of systemic inflammatory response, and air or particle embolization, especially for the possibility of embolization to the brain, but this risk is very low (less than 1% in most cases) (2, 4).

Due to the nature of heart disease and the use of CBP, transient or permanent neurological complications may occur during or after pediatric cardiac surgery. In a study in Iran, the frequency of acute neurological complications after cardiac surgery to treat coronary heart diseases (CHD) was 9.06%, and they included seizures (3.84%), movement disorders (1.65%), simultaneous seizures and movement disorders (0.82%), visual disturbances (0.54%), headaches (28/28), and hydrocephalus (0.28%) (5, 6).

Multimodal brain monitoring can reduce neurological complications as well as hospital costs associated with caring for cardiac surgery patients. Furthermore, monitoring the brain during surgery provides useful information about brain function, circulation rate, and metabolism and may play a role in guiding anesthesia (7, 8). There is a need for more studies in this field due to the prevalence of cardiac surgeries, the need for cardiopulmonary bypass devices, and the limited number of studies. Therefore, the current study sought to investigate the relationship between cerebral oximetry and arterial pressure values during pediatric cardiac surgeries.

2- MATERIALS AND METHODS

This descriptive-correlational study was conducted using a sequential convenience sampling method. The sample size was equal to 61 with $\alpha=0.05$ and the expected correlation coefficient of $r=0.35$.

Children under 12 years of age, non-cyanotic, and candidates for open cardiac surgery to repair congenital heart defects entered the study. The participants with decisions to perform palliative surgery instead of complete repair surgery and suffering from a decrease in arterial blood oxygen saturation were excluded from the study. After obtaining consent, the participants were transferred to the operating room. All the patients were anesthetized under the same monitoring and similar anesthesia. The patients underwent anesthesia using Thiopental Sodium (3-4 mg/kg), Pancuronium Bromide (1 mg / kg) and Fentanyl (5 g / kg) and followed by anesthesia with Isoflurane (1 MAC).), fentanyl (2 µg/kg/h) and Midazolam (2 µg/kg/min).

Basic patient monitoring included electrocardiography, non-invasive blood pressure, pulse oximetry, temperature, and Capnography. After anesthesia, the patients had a central venous catheter implanted and the central venous pressure was monitored. The cerebral oximetry and blood pressure monitoring were carried out and baseline values were recorded. Aggressive blood pressure measurement method was used to measure blood pressure. In this method, after anesthesia, the patients were first measured using arterial catheter number 22 radial artery. After connecting the arterial catheter to the blood pressure transducer, the mean arterial blood pressure was measured and recorded every 10 minutes during the operation using the Alborz B5 model of the Poor Began Rah-e Saādat monitor made in Iran. For measuring cerebral oximetry in children and infants, the Nonin X-100 SenSmart Cerebral Oximetry Systems monitor and SenSmart 8004CB Series regional oximetry sensors made in the United States were used.

After anesthesia of the patients, the sensors were pasted on the forehead and on both sides of the midline, and after connecting to the NONIN X-100 monitor, cerebral oximetry values were measured and recorded every 10 minutes during the operation. The researcher recorded their levels of cerebral oximetry and blood pressure before, during, and after the cardiopulmonary pump in a checklist. The collected data were analyzed using the Pearson correlation coefficient in SPSS. The study proposal was approved by the Faculty of Medicine of Isfahan University of Medical Sciences with the ethics code of (IR.MUI.MED.REC.1398/07/07).

3- RESULTS

We included children who were candidates for cardiac surgery, 51.7% of whom were boys. The patients' mean age was 1.92±2.05 years. The patients' mean weight was 9.86±4.86 kg. The patients' mean age and weight at birth were 37.41±5.56 weeks and 3±0.36 kg, respectively. The central temperature was 37.01±0.13 °C before the operation, 30.89±3.56 °C and 30.87±3.46 °C during the operation, and 36.84±1.32 °C after the operation (**Table 1**).

Table-1: Demographic, clinical, and laboratory information of the participants

Parameter	Patients
Sex N (%)	Male: 30 (51.7%) Female: 28 (48.3%)
Age during the study (years)(Mean±SD)	1.92±2.05
Age weight (Weeks) (Mean±SD)	37.41±5.56
Birth weight (weeks) (Mean±SD)	3±0.36
Central temperature before the operation(Mean±SD)	37.01±0.13
Central temperature during the operation(Mean±SD)	30.89±3.56
Central temperature during the operation(Mean±SD)	30.87±3.46
Central temperature after the operation(Mean±SD)	36.84±1.32

The Pearson correlation coefficient showed a significant correlation between mean arterial pressure (MAP) and cerebral oximetry on the right ($P<0.001$, $r=0.28$) (**Fig. 1**). Furthermore, there was a significant correlation between MAP and cerebral oximetry on the left ($P<0.001$, $r=0.34$) (**Fig. 2**).

4- DISCUSSION

The present study aimed to investigate the correlation between cerebral oximetry and mean arterial pressure values during pediatric cardiac surgeries. We included 28 girls and 30 boys in the study as candidates for cardiac surgeries. The results indicated a significant correlation between mean arterial pressure (MAP) and cerebral oximetry on the right and left (**Fig. 1** and **2**).

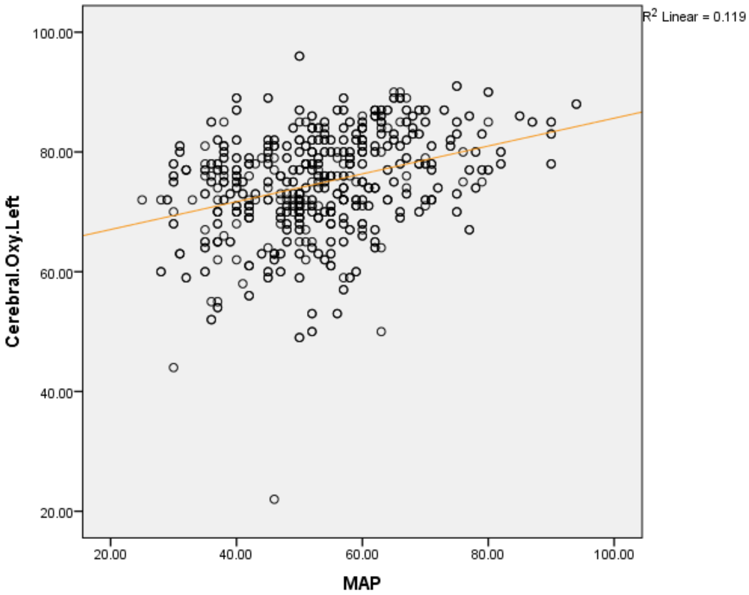

Fig. 1: Correlation between mean arterial pressure (MAP) and cerebral oximetry on the right

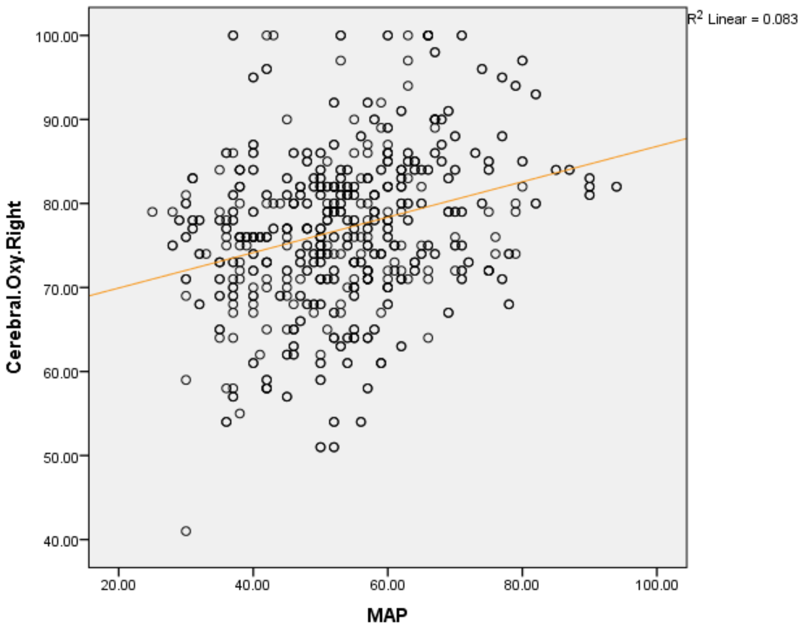

Fig. 2: Correlation between mean arterial pressure (MAP) and cerebral oximetry on the left

The results are comparable to previous studies. In a study by Quarti et al. (2010), 40 patients underwent cardiac surgeries using the cardiopulmonary bypass (CPB) (9). Using the INVOS device, pH, O_2 saturation, and CO_2 were recorded before, during, and after connecting to CPB. The parameters were assessed according to age and amounts of preoperative oxygen saturation. Based on their age, the patients were divided into two groups of younger than 1 year and older than 1 year; and based on oxygen saturation, they were divided into two groups of less than 92% and more than 92%. In all groups, the amounts of cerebral oxygen decreased during surgery probably due to a lack of contractile circulation. Throughout the CPB, the brain oxygen was lower in cyanotic patients (oxygen saturation below 92%) than in acyanotic patients. There was a significant relationship between age and brain oxygen levels. The cerebral oximetry decreased with loss of pulsed flow regardless of mean arterial pressure, and it was not directly related to hematocrit in patients with lower pulmonary flow. These findings are contrary to the results of this study because the present study well indicated a significant relationship between MAP and cerebral oximetry. In another similar study by Yagi et al. (2017), 30 children underwent Hemi-Fontan or Glenn operation by a surgeon in one place (10). The cerebral oxygen of all patients was recorded by the INVOS device at the beginning and end of the surgery. The cerebral perfusion pressure (CPP) was calculated by separating the central arterial pressure from the mean arterial pressure. The hemoglobin concentration and arterial oxygen saturation affected the cerebral oximetry levels in Glenn and Fontan surgery. Their results are consistent with the present study and confirm our findings regarding a significant relationship between MAP and cerebral oximetry.

In a study by Zanatta et al., 1727 patients underwent cardiac surgery from July 2007 to July 2011 (11); 166 patients and a control group with 1555 patients were compared using multimodal brain monitoring. The preliminary study indicated that multimodal brain monitoring could reduce the incidence of neurological complications as well as the hospital costs of caring for cardiac surgery patients. Furthermore, monitoring the brain during surgery provides useful information about brain function, circulation rate, and metabolism and may be involved in guiding anesthesia. Neurological complications are still well known in pediatric cardiac surgeries. Brain oxygen monitoring is a useful way to identify periods vulnerable to nerve damages. Daubeney et al. monitored 18 children candidates for cardiac surgery by INVOS device; they recorded and analyzed the amount of cerebral oxygen and other hemodynamic parameters (12). Observations indicated that the period before and after being connected to CPB was the most sensitive time for brain damage. According to previous studies, multimodal brain monitoring plays an important role in reducing neurological complications and hospital caring costs for cardiac surgery patients.

5- CONCLUSION

A significant relationship was observed between MAP and cerebral oximetry in pediatric cardiac surgeries. The study indicated that an increase in MAP during the cardiopulmonary pumping could increase cerebral perfusion and brain oxygenation. It also affected the hospital caring costs for cardiac surgery patients; hence, it is essential to take it into consideration and pay attention to its association with patients' vital symptoms.

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7- REFERENCES

1. Lyons-Warren, A.M. Update on palliative care for pediatric neurology. Am J Hosp Palliat Care. 2019; 36(2):154-157.

2. Durandy, Y.D., M. Younes, and B. Mahut. Pediatric warm open heart surgery and prolonged cross-clamp time. Ann Thorac Surg. 2008; 86(6):1941-7.

3. Fiorentino, F., Al Jaaly E, Durham A L, Adcock AM, Lockwood G, Rogers C,et al., Low-frequency ventilation during cardiopulmonary bypass for lung

protection: A randomized controlled trial. J Card Surg. 2019 Jun; 34(6):385-399.

4. Faisal SA, Apatov DA, Ramakrishna H, Weiner MM. Levosimendan in Cardiac Surgery: Evaluating the Evidence. J Cardiothorac Vasc Anesth 2019; 33:1146.

5. Esteghamat S, Esteghamat S, Ashrafi M, Mirza Aghayan M, Tavasoli A. Incidence of Acute Neurologic Complications after Heart Surgery in Children with Congenital Heart Disease. Shefaye Khatam. 2015; 3 (4):73-79 (In Persian).

6. McDonagh DL,Berger M, Mathew JP, Graffagnino C, Milano C A, Newman N F. Neurologic Complications of Cardiac Surgery. Lancet Neurol. 2014; 13(5): 490–502.

7. Quarti, A, Manfrini F, Oggianu A, D'Orfeo F, Genova S, Silvano R, et al. Non-invasive cerebral oximetry monitoring during cardiopulmonary bypass in congenital cardiac surgery: a starting point. Perfusion. 2011; 26(4):289-93.

8. Reagan, EM, Nguyen RT, Ravishankar ST,Chabra V, Fuentes B, Spiegel R, et al. Monitoring the Relationship Between Changes in Cerebral Oxygenation and Electroencephalography Patterns During Cardiopulmonary Resuscitation: A Feasibility Study. Crit Care Med. 2018; 46(5):757-763.

9. Haydin, S, Onan B, Onan IS, Ozturk E, Iyigun M, Yeniterzi M, et al. Cerebral perfusion during cardiopulmonary bypass in children: correlations between near-infrared spectroscopy, temperature, lactate, pump flow, and blood pressure. Artif Organs. 2013; 37(1):87-91.

10. Yagi, Y, Yamamoto M, Saito H, Mori T, Morimoto Y, Oyasu T, et al. Changes of Cerebral Oxygenation in Sequential Glenn and Fontan Procedures in the Same Children. Pediatr Cardiol. 2017; 38(6):1215-1219.

11. Zanatta P, Messerotti Benvenuti S, Bosco E,Baldanzi F, Palomba D, Valfre C. Multimodal brain monitoring reduces major neurologic complications in cardiac surgery. J Cardiothorac Vasc Anesth. 2011; 25(6):1076-85.

12. Daubeney P, Smith DC, Pilkington SN, Lamb RK, Monro JL, Tsang VT, et al. Cerebral oxygenation during paediatric cardiac surgery: identification of vulnerable periods using near infrared spectroscopy. Eur J Cardiothorac Surg. 1998; 13(4):370-7.