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**Evaluation of noninvasive monitoring of cerebral oxygenation in the surgical treatment of hypoplastic aortic arch using antegrade cerebral perfusion for newborns and infants**

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The results of monitoring of cerebral oxygenation and other parameters (perfusion pressure, pulse oximetry, thermometry, levels of lactate, blood gas analyses) are reflected in this article. 9 children with hypoplasia of all segments of the aortic arch with coarctation of the aorta and concomitant intracardiac pathologies using after surgical treatment with antegrade cerebral perfusion were monitored.

Keywords: antegrade cerebral perfusion, non-invasive monitoring of the cerebral oxygenation, neurological complications.

Introduction: One of the dangerous moments in aortic arch surgery is the period of circulatory arrest, during which there is a high probability of neurological complications such as brain swelling as a result of wedging, ischemic and hemorrhagic circulatory disorders of the brain. In this regard, various authors proposed various methods of brain protection.

For the first time in pediatric cardiac surgery misperfusion method of brain protection, which is used in terms of circulatory arrest with deep hypothermia (body temperature, 18 ° C) was used in 1953 by F. Lewis and M. Tauffic [1-3]. It currently remains the main method of ensuring operations on the aortic arch, allowing to reduce the intensity of metabolic processes in the body and contributes to hypoxia tolerance. But this method was limited by high mortality and cerebrovascular disease [4-5]. T. Kimura and others in 1994 proposed a method of periodic cerebral perfusion combined with deep hypothermia [6], and in 1996, T. Asou proposed the method of continuous perfusion of the brain [7].

For monitoring of the cerebral oxygenation the following methods are used: determination of the oxygen saturation of hemoglobin in the jugular vein, the determination of the oxygen level in the brain tissue by the direct method, microdialysis of the brain tissue and cerebral oximetry, the main advantage of which was its noninvasiveness.

Objective: to evaluate the indicators of cerebral oxygenation as prognostic factors in children with hypoplasia of the aortic arch, which were operated on the aortic arch using antegrade cerebral perfusion.

Materials and methods. From 2011 to 2015 in the National Institute of Cardiovascular Surgery of the Academy of Medical Sciences of Ukraine M.M. AMOSOV in conditions of cardiopulmonary bypass (CPB) with antegrade cerebral perfusion, 9 children with hypoplasia of all segments of the aortic arch with coarctation of the aorta and the presence of associated intracardiac pathology were operated. The age of patients ranged from 1 day to 1 year, and their body weight ranged from 2.1 to 10 kg.

Preoperative examination of all patients included echocardiography, electrocardiography, measurement of blood pressure (BP) parameters, pulse oximetry and neurosonography data. According to neurosonography all patients did not reveal structural changes in the brain.

All children were subjected to endotracheal anesthesia with an inhalation anesthetic (sevoflurane) at a dose of about 6-8 vol.% for induction and 0.8-1 vol.% for maintenance, relaxation was achieved with pipecuronium bromide at a dose 0.08-0.1 mg/kg and analgesia was maintained with fentanyl at a dose 15-40 µg/kg/hour.

After induction, two sensors for the monitoring of SctO2 using Somenetics corp INVOS.(USA) were superimposed on the frontal region of the patient from two sides. Other indicators such as: blood pressure (right radial and femoral artery), pulse oximetry, thermometry, and gas composition of blood were measured at different stages of the operation.

After the midpoint sternotomy, cannulation of the ascending aorta and the venae cavae, the beginning of cardiopulmonary bypass, cooling to 15-18°C, the antegrade cerebral perfusion was carrid our trough the brachiocephaly trunk.

Results and discussion: the use of cerebral oximetry allowed us to estimate the oxygen saturation of the brain tissue while antegrade selective perfusion is being carried out (tab. 1)

Table 1.

**Oxygen saturation of hemoglobin, saturation of venous blood of the brain and perfusion pressure in patients at different stages of the operation.**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Indicators | |  |  | | --- | --- | | Output data |  | | Cardiopulmonary bypass | Cardiac arrest | The end of CPB | The end of operation |
| SctO2, % | 65±2,6 | 68±2,3 | 63±2,1 | 68±2,6 | 64±1,8 |
| BP average., mm Hg. | 66±2,3 | 54±4,1 | 52±2,1 | 60±2,7 | 70±3,0 |
| SрO2, % | 98±1 | 99±1,1 | 98±1,2 | 99±0,9 | 99±0,7 |

The preoperative values of venous saturation and during the preparation for the main phase of the operation were within the normal range – 65 ± 2,6%. Perfusion pressure was maintained at 50 ± 4,1 mm Hg. Normal carbon dioxide levels were maintained and signs of hypoperfusion of tissues were not observed (lactate remained at the level of 2 mmol/l).

During the circulatory arrest, which is a critical point of the main phase of the operation with regard to cerebral protection and the prevention of neurological complications, the venous saturation of the brain remained at the level of initial values of 63 ± 2,1%.

Circulatory arrest with antegrade perfusion of the brain did not exceed 45±17 min, and cardiopulmonary bypass was 147±41 min (tab. 2).

Table 2.

Intraoperative parameters of patients operated with cardiopulmonary bypass (n=9)

|  |  |
| --- | --- |
| Indicator | The average value (± SD) |
| Duration of surgery (min.) | 223±57 |
| Time of CPB (min). | 147± 41 |
| The aortic cross-clamping time (min.) | 81±25 |
| Time of antegrade cerebral perfusion | 45±17 |
| Duration of mechanical ventilation (hrs.) | 74,8±18,4 |
| Temperature of the cooling fluid during the main stage (°C) | 16,5±1,7 |

SD – standard deviation

After the main stage, cardiac resuscitation, rewarming the patient to a temperature of 36,7°C and after stopping the CPB, it was observed that the parameters of the venous saturation of the brain remained at the level of the original values 64 ± 1,8%.

In the postoperative phase, the patient stayed in the intensive care unit, the duration of mechanical ventilation was 74,8±18,4 hours.

Clinical data didn’t exhibit any neurological disorders, and according to neurosonography there were no signs of edema and structural changes in the brain.

Postoperative mortality of one patient was caused by bilateral polysegmental pneumonia, sepsis, multiple organ failure at 75 days after surgery.

Conclusions: Intraoperative cerebral oximetry as a noninvasive method of control of the regional oxygen saturation of hemoglobin in the cortex of the brain, at normal ranges of registered indicators at all stages of the operation and at normal values of other parameters, considering the neurosonography data carried out before and after the operation, and the absence of clinical data about neurological complications, evidence in favor of the antegrade cerebral perfusion as an effective method of brain protection in newborns and infants during surgical treatment of the hypoplastic aortic arch.

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