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Original Article

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Efficasy of CNS protection methods on aortic arch reconstructive operation in children of the first year of life

Abstract
Aim: In the article have been analised late rezultes of the surgical treatment of the patients with various types of congenital aortic arch pathologies.
Material and Methods: The investigation covered 58 patients, operated in Meshalkin clinic in 2010-2015 years. Taking account of CNS protection method, the patients were divided imto two groups: I group – was used deep hypothermia method (n = 30), II group – selected antegrad cerebral perfusion method (n = 28).
Results: Hospital mortalities and neurological status chance rates were reliably lower in II group, than in deep hypothermia group.
Conclusion: The revealed reliable meaningful results of renal function impairment in selected antegrad cerebral perfusion method group should be undergone for further investigations, determine ethiology of development of these complɪɯctaions, revealing the "trigger" point of the pathogenesis, which allow us improve the CNS protection method in correction of congential malformations.

Keywords: Congenital aortic arch pathology, deep hypothermia, selected antegrad cerebral perfusion, *complications of the treatment*

INTRODUCTION

The fact of necessety of the most adequate CNS protection is undisputable; first of all, it is impotent for protection newborns and infants' brains with congenital aortic arch obstructive pathology in the stage of surgical correction of this malformation. At present in clinical practice are videly used two methods of CNS protection from surgical aggration: deep hypothermic circulatory arrest and selected antegrad cerebral perfusion. Referring to scientific literature, the first deep hypothermic circulatory arrest in pediatric cardiovascular surgical practice was perfomed in the middle of XX century by F. Lewis and M. Tauffic (1).

Today, in the modern stage of development of pediatric cardiovascular surgery the CNS protection stays as a dominant method in carrying out cardiosurgical interventions on aortic arch and vessels of the brachiocephalic trunk (2). The principle of action is the decreasing the methobolic process intensity in the organism and it increases tolerance to progression of hypoxia. At the same time, this protective method has very limited duration of time for safety of organism, also is dangerous with possible neurological complications. The negative characteristics of deep hypothermic circulatory arrest have induced to continue researches for other more safety methods of CNS protection. At the end of XX c. a group of scientists under the guidance of T. Kimura (3), substantiated using the method of periodically cerebral perfusion, but in combination with deep hypothermia. Approximately at that time T. Asou and co-authors (4) sagested using the method of continuous cerebral perfusion for CNS protection. All the above-listed led for production of the current investigation purposes.

Purpose of the investigation

Analyze efficacy and safety in providing CNS protection methods during reconstructive operation on aortic arch of infants.

MATERIAL AND METHODS

During 2010-2015 years in the Pediatric Cardiosurgical and Newborns Surgary Centre of Meshalkin clinic carried out surgical treatment of 58 infant-patients having different variants of congenital aortic arch pathology. The mandatory exclusion criteria for this investigation was presence of hypoplasia syndrom in the left part of heart. Dividing to groups was perfomed depending on CNS protecting method. In I group were included 30 patients, whose CNS protecting was perfomed by deep

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hypothermic circulatory arrest, in II group 28 patients, whose CNS protecting was perfomed by selected antegrad cerebral perfusion (5). Mean ages in the groups were 53.2±51.12 days. Mean ages in I group were 47.8±59.32 days, and in II group 58.8±60.16 days. Assessment of the average body weight in the groups corresponded to 3.9±1.98 kg. In I group this value was 4.35±2.7 kg, but in II group 3.9±1.45 kg. In preoperative period, in order to choose of the surgical correction variant, all patients were undergone non-invasive diagnostic examination (magnetic resonance tomography, echocardiography), assessed blood gases with periferic saturation, perfomed analyses of acid- base state of venous and artery blood, determined presence of the initial changes of neurological status of the patients, signs of renal disfunction in patients in preoperative period.

In investigation were involved patients with different anatomical variants of congenital aortic arch pathology. They are shown in Table 1.

Table 1. Anatomical variants of congenital aortic arch pathology

Variant	I group	II group
Aortic coarctation with hypoplastic aorta arch	21	19
VSD	4	6
ASD	3	2
TGA	0	4
Total anomalous drainage of pulmonary venous	2	0
SV. Atresia of mitral valve	0	2
Single heart ventricle with double inlet	3	3
Stenosis of aortic valve	3	2
Interrupted aortic arch	4	5
Interrupted aortic arch with VSD	3	3
TGA+ VSD	2	2

In all patients of this investigation were performed surgical treatment of congenital aortic arch pathology. The operative interventions were implemented under the general combined anesthesia. Medical probes of monitors of systemic arterial pressure were placed on the radial and femoral arteries. Saturation from cerebral vessels assessed with INVOS 5100 (Somanetics, US) device. The operative treatment was implemented in condition of artificial circulation with Dideco Lilliput I (Sorin, Italy). The initial volume of the extracorporal contour was filled wih donor's red cell mass (Ht level no less than 30%), plasma, 20% albumin, hydrocarbonate sodium 4%, Mannitol и Heparin 200–220 ml. Surgical approach to the heart and magistral arteries were perfomed through the median sternotomy.

For purpose of systemic perfusion, it was used following method of aortic cannulation: direct connulation of ascending aorta (29 cases) and connulation into heparinized polytetraftoretilen prosthesis. In this case, anastomosis of prosthesis put on with the proximal part of brachiocephalic trunk (29 cases). In presence of interrupted aortic arch in patients, were established two connulas intraoperativly: in ascending aorta or heparinized prosthesis, but second cannula was placed through the arterial duct into descending aorta for the perfusion of lower part of the body. Bicaval connulation was perfomed in all cases. If required drainage of the left ventricle, it was placed into right superior lobar vain. Volume perfusion speed in artificialy circulation was 150 ml/kg, cooling rate of the patient 1°C/ 2 min, temperature reduction in nasopharynx between 18 and 27°C. After performing occlusion of the aorta, in order to protect of myocard into the aortic root by antegrade way injected crystalloid cardioplegic Bretschneider's solution (Custodiol). The main criteria of the basic period of the surgical treatment presented in Table 2.

For CNS protection (brain) was performed deep hypothermia with complete circulatory arrest and selected antegrad cerebral perfusion at 30ml/kg in min.

The methodology of selected antegrad cerebral perfusion was implemented using heparinized prosthesis 3.0–3.5 mm «GoreTex». The first step of the surgical treatment was reconstruction of the aortic arch. In this investigation were used following methods of reconstructions, especially dilating of narrowed areas using patches from ksenopericard and form widened anastomose like "end to side" descenting and ascenting parts of the aorta; in this case was used only autogenous tissues.

This surgical technics was suggested by C. Fraser and R. Mee; and modified by H. Rajasinghe et al. (6,7). Before the bigining to perform cerebral perfusion of the brachiocephalic vessels and descenting aorta were compressed. After this were removed intracardiac defects. After implementing the besic step of operation we began warming the patient at a speed of 1°C/ 3.0–3.5 min. After turning off the cardiopulmonary bypass device were begun modified ultrafiltration using hemocon-centrator BC20 (Maquet, Sweden). Blood gases were assessed every 20 min. and supported pCO_2 in the level of 35– 40 mm Hg. and pH 7.45– 7.50. Statistical data manipulation was implemented using Statistica 6.0 program. Variable values were expressed in mean values ± standard deviation. For the comparison the values in case their normal distribution used student's t-test. $p \leq 0.05$ value was accepted as a statistic value.

RESULTS

Assess of blood gasses was perfomed before and after of the main stage of the operation.

It was found that, level of lactate increased in the both group. So in I group level of lactate varied since 1.48±0.43 to 5.01±1.72 mmol/l ($p<0.01$).

In II group consentration of lactic acid corresponded to 1.51±0.39 – 5.9±1.44 mmol/l ($p<0.01$).

In comparison of the data there were not received significant different values between the groups ($p>0.05$). Carried out changing the temperature (in nasopharynx) during perforing the main stage of congenital aortic arch pathology correction operation. The received values had reliable, significant differences between

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the groups. In patients from I group temperature in nasopharynx at the average was 19.35±1.21 °C, but in patients from II group mean value of temperature recorded in the level of 23.5±1.71 °C; p = 0.0001).

In early postoperative period, mortality rate was 17.24% (10 patients). Death occurred in result of multiple organ failure, progression of heart failure and development of cerebral edema. It was revealed significant difference of values making comparison of the mortality in percent between the groups (p<0.001). In early postoperative period in I group died 17.1% of the patients, in II group 13.2% of the patients. In all cases took place concomitant pathology (severe insufficiency of the mitral and tricuspid valves, anaemia) (Table 2).

Table 2. The main criteria of the basic period of the surgical treatment

showings	I group	II group	Reliability
Time of cardiopulmonary bypass, min	148.43±32.68	129.1±43.31	0.159
Occlusion of aorta, min	55.1±19.03	58.13±19.89	0.79
Circulatory arrest, min	23.9±7.85	22.5±8.91	0.87
Volume of hemotransfusion, ml/кg	24.71±21.54	31.41±30.2	0.71
Volume of blood substitutes, ml/кg	37.48±21.14	43.85±17.81	0.41
Hemorrhage during operation, ml	58.32±25.41	65.1±25.64	0.59
Hemorrhage in early postoperative period, ml	104.61±71.44	107.6±73.03	0.89
Balance of liquid after modified ultrafiltration, ml	17.8±71.70	36.4±90.11	0.07

In early postoperative period the patients had symptoms of cardiopulmonary insufficiency, as a result of this was perfomed infusion of Adrenalin in I group during 124.0±58.1 hour, in II group – 121.1±48.31 hour. Average time of artificial lung ventilation in the groups was 187.4±109.29 hour in I group, and 291.3±179.12 hour in II group. In early postoperative period, neurological complications were revealed in 27.1% of the patients from I group, and 4.7% of the patients from II group (p≤0.004). Neurological complications were characterized with motor dysfunctions (pyramidal insufficiency type), cerebral edema. Development and clinical manifestations of renal dysfunction were more specific for patients from II group. So renal dysfunction were revealed only in 5 patients from I group, but in II group renal dysfunction were revealed in 19 patients. Comparing of the given values between the groups, it has been got statistically significant difference (p≤0.0004). Peritoneal dialysis procedure in I group was performed in 2 patients, but in II group in 9 patients (p≤0.0001). Charecteristic of major non-fatal complications of postoperative period presented in Table 3.

Table 3. Major conplications of the postoperative period

Type of complications	I group	II group
Heart failure	11	14
Pneumonia	5	7
Respiratory failure	3	2
Gastrointestinal insufficiency	1	1
Sepsis	2	2
Mediastinitis	1	-
Osteomyelitis of the sternum	-	1

Echocardiographic examinations were performed pro- and postoperative periods.

Left ventricular ejection fraction was assessed: in patients from I group did not get the significant differences of value before and after surgical treatment (71.82±11.81 and 75.13±5.41%; p≥0.05). In II group ejection fraction also did not change significantly before and after surgical treatment (70.3±7.91 and 75.72±7.89%; p≥0.05). Systolic gradient indicators in the aortic arch was 4.28±2.91 mm. Hg. in I group, but in II group – 5.01±1.95 mm. Hg., significant differences between the groups did not get (p≥0.05). During first 30 days after surgical treatment were assessed clinical indicators of the neurological status iterarivly. It was revealed, neurological symptomatology in 15% of the patients were regressed motor dysfunctions and gained of motion. In 3% of the patients (from each group), verified in early postoperative period cerebral edema, occured death due to wedging of the brain.

DISCUSSION

Up to now, there have not been the unified approach to CNS (the brain) protection in performing operations on aortic arch. First of all this is related with absence of multicenter randomized prospective research studies, which would substantiate convincingly advantages any of these CNS protection method both of adult and pediatric populations. The available data at moment are results from modern scientific literature, usually summarizing local research studies in clinics, which do not allow to compare results of used deep hypothermic circulatory arrest and correctly and antegrad cerebral perfusion. However, achieved recent results of research studies, which are available in literature confirm that using selective antegrad cerebral perfusion method

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decreases complications of the neurological status significantly and thereby improves early postoperative period, comparing with used deep hypothermic circulatory arrest. In this investigation high mortality rate in early postoperative period is related to that; more of the patients since hospitalization initially were in severe and critical condition, which as is known, it increases risk of fatal development and early mortality. In performing hypothermic circulatory arrest as a method for CNS protection in newborns and infants undergone reconstruction aorta arch operation, up to now neurological complecations stay as the main problems required urgent solution. Due to high frequency of neurological complecations in performing this method, Asou and colleagues are suggested selective antegrad prfusion (8). Comparative analysis peformed by these investigators showed that comparing with deep hypothermic circulatory arrest development percent of neurological complecations were decreased. Achieved results of the investigation do not contradict to Asou's studies (9). Analysis of the results showed that, development of neurological complecations in the deep hypothermic circulatory arrest group were more frequent. In 155 cases motor dysfunction regressed to completely rehabilitation of moving functions of the limbs during first 30 days after surgical treatment. These results is possible to compare with results described by G. Nollert in his works (10). Development of renal dysfunctions was other frequent complication performing as after deep hypothermic circulatory arrest, as well as after selective antegrad cerebral perfusion (11).

In assessment of the results, it was established most percent of renal dysfunction cases were in patients, whom used selective antegrad cerebral perfusion method. In the same group renal dysfunction cases required peritoneal dialysis procedure were more than in I group. One of the causes less renal dysfunction percent of the patients in I group is explainable with lower temperature regime, which allow decreasing of ischemic damage of kidney tissue. This fact is also confimed with that, changes in acid-base state of patients from I group are not so meaningful, comparing with antegrad perfusion group. The impotent cause of renal complications may be considered the positive fluid balance, more expressed in II group after performing modified ultrafiltration procedure. In literature there are well substantiate data testifying presence of the positive fluid balance launches the development mechanism of renal dysfuncsion after the reconstructive aortic arch operation. According to the literature data, selective antegrad cerebral perfusion or perfusion with «Lowflow», often lead to the positive fluid balance, than hypothermic circulatory arrest (12). In our investigation, using as CNS protection method the selective antegrad cerebral perfusion in reconstructive aortic arch operation, demonstrate his higher protective properties. This fact is confirmed by minor percent of neurological complications in case of using this method. However, remains unsolved the task of decreasing frequency kidney complications.

Conflict of Interests: The author declares that there are no conflict of interests.

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Data Availability Statement: The data that support the findings of this study are available from the corresponding author upon reasonable request.

REFERENCES

1. Lewis FJ, Tauffic M. J Surg. 1953;32:52-9.
2. Ломиворотов ВН. Патология кровообращения и кардиохи- ругия. 2010;3:7-10.
3. Jonas RA. J Heart views. 2001;10:385-92.
4. Kimura T, Muraoka R, Chiba Y. et al. J Tho- Rac Cardiovasc Surg 1994;108:658-63.
5. Asou T, Kado H, Imoto Y. et al. J Ann Tho- Rac Surg. 1996;61:1546-48.
6. Fraser C, Mee RJ. Ann Thorac Surg. 1995;60:546-9.
7. Rajasinghe HA, Reddy VM, van Son JAM, et al. J Ann Thorac Surg. 1996;61:840-4.
8. Ceriana P, Barzaghi N, Locatelli A. J Cardio- Vasc Surg. 1998;39:337-42.
9. Lim C, Kim W, Kim S. Eur J Cardiothorac Surg. 2003;23:149-55.
10. Постнов ВГ, Караськов АМ, Ломиворотов ВН. Патология кровообращения и кардиохирургия. 2010;3:23-9.
11. Nollert G, Nagashima M, Bucerius J. et al. J. Thorac Cardiovasc Surg. 1999;117:1172-79.
12. Salazar JD, Coleman RD, Se- lective S. J Ann Thorac Surg. 2009;88:162-9.