

Comparison of sympathomimetic effectiveness in children with congenital heart diseases after cardiopulmonary bypass surgery

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The current work evaluates the application of sympathomimetic drugs in infants with congenital heart diseases after cardiopulmonary bypass surgery. The comparison between adrenaline and dopamine in the treatment of postoperative myocardial dysfunction, the frequency of postoperative complications and the length of stay in the intensive care unit was accomplished.

Key words: *adrenaline, dopamine, sympathomimetics, children, congenital heart disease, cardiopulmonary bypass.*

In the context of cardiac surgery the syndrome of low cardiac output and the vascular tone dysregulation are the most common causes of morbidity and mortality of newborns and infants in the early postoperative period. This category of patients is very sensitive to the difference between the pulmonary and systemic vascular tone [1]. Currently there are no consensus guidelines or evidence based medicine regarding the use of vasoactive drugs in pediatric patients [2].

It should be noted that always in the postoperative period there is a certain level of myocardial diastolic or systolic dysfunction as a result of systemic inflammatory response and ischemic-reperfusion lesions [3,4]. Considering preoperative myocardial injury and postoperative myocardial dysfunction postoperative patients often need pharmacological circulation support, the main focus of which is to improve cardiac output by optimizing ventricular contractility, myocardial conduction and ventricular compliance [4].

Usually sympathomimetic drugs such as epinephrine and dopamine are used for pharmacological support in cardiac anesthesiology. It is important to distinguish the activity of drugs that affect the heart and those affecting the peripheral vascular tone. The use of vasoactive drugs is limited by increase in myocardial oxygen consumption, arrhythmogenic effects, neurohormonal activation and desensitization of adrenergic receptors [2].

Dopamine is the most frequently used drug by neonatologists and pediatricians to treat hypotension [5]. Dopamine is used in moderate doses while in cardiogenic shock; high doses are used for hypotension treatment [6,7]. One of the side effects that require special attention from anesthesiologists, is the tendency to increase pulmonary vascular resistance, which in turn increases right ventricular afterload and consequently reduces

myocardial contractility and cardiac output (CO) [5,8]. Recently, more and more practitioners are beginning to avoid the use of dopamine because of its neurotransmitter activity, which is manifested in suppression of pituitary gland function, for instance there is a decrease in the secretion of thyroid stimulating hormone, prolactin, growth hormone and thyroxine [5,6]. It should be noted that children under the age of 6 months have limited supplies of norepinephrine, as their sympathetic innervation is not yet completely formed; therefore it is necessary to consider when dopamine is used, since the drug acts through the release of norepinephrine from sympathetic vesicles [5,9].

Epinephrine is a potent alpha and beta adrenergic agent of direct action with positive inotropic and chronotropic activity. This drug is used in cases of low CO, diminished myocardial contractility and cardiogenic shock [9]. The long-term use leads to depletion of visceral and hepatic blood flow. For the prevention of side effects additional administration of vasodilators is recommended [2].

Objective. To compare the efficiency of adrenaline and dopamine for the treatment of myocardial dysfunction in the postoperative period in children with congenital heart diseases (double outlet right ventricle and tetralogy of Fallot) after cardiopulmonary bypass surgery.

Materials and methods. From 01.01.2014 to 30.06.2016 in the department of newborns and young children of the Amosov National Institute of Cardiovascular Surgery 319 patients with congenital heart diseases (CHD) aged from 1 month to 1 year were hospitalized and operated using cardiopulmonary bypass, among them 30 patients (20 boys and 10 girls) with double outlet right ventricle (DORV) and tetralogy of Fallot (TF) were examined during surgery and in the postoperative period in order to estimate the efficacy of sympathomimetic drugs. Children's age ranged from 1.5

to 11 months, the median was 7.0 months, the interquartile range [Q25; Q75] was from 5 to 9 months. Children's weight ranged from 2.9 to 10.5 kg., the median was 7.1 kg., the interquartile range [Q25; Q75] was from 5.6 to 8.8 kg. As exclusion criteria were considered patients initially infected with concomitant diseases of the respiratory tract or the urinary system, patients with coagulopathy, newborns and children older than 1 year.

Patients were divided into 2 groups: the group I consisted of 16 patients, who received dopamine in the intraoperative and postoperative period; the group II consisted of 14 patients with adrenaline administration in the intraoperative and postoperative period. The sympathomimetic drugs were administered by intravenous infusion, the dopamine dose was $7,5 \pm 2,5$ mcg/kg/min, and the adrenaline dose was 0.03 ± 0.02 mg/kg/min.

The comparison of the sympathomimetic drug's effectiveness was carried out according to relevant evaluation criteria: hemodynamic parameters such as systolic, diastolic, mean arterial and pulse blood pressure (BP), heart rate (HR), central venous pressure (CVP), stroke volume (SV), cardiac output (CO), cardiac index (CI), systemic vascular resistance (SVR), and other parameters as hourly diuresis, duration of stay in the intensive care unit (ICU), the incidence of postoperative complications. To calculate hemodynamic parameters the following equations were used [10]:

$$\text{Fick's equation: } CB = \frac{VO_2}{CaO_2 - CvO_2}.$$

where CaO_2 i CvO_2 – oxygen content in the arterial and venous blood,

VO_2 – oxygen consumption.

The equation for SVR calculation:

$$SVR = \frac{BP_{mean} - CVP}{CO} \cdot 80$$

Hemodynamic parameters were measured by Drager Infinity Delta XL monitor (Germany).

Statistical data analysis was performed with the computer program SPSS v. 17 (Statistical Package for the Social Sciences, Chicago, IL, USA). The Kolmogorov-Smirnov criterion was used for evaluation of normal law of data distribution. t-Student test for independent samples was used for comparison of two independent samples. Differences were considered statistically significant at $p < 0.05$. The risk level is established with a confidence interval (CI) of 95%.

Results and discussion. 30 patients with DORV and TF operated in the department of surgery of newborns and young children from 01.01.2014 to 30.06.2016 were examined, a comparison between the main hemodynamic parameters, length of stay in the ICU, hourly diuresis and postoperative complications was accomplished. The comparisons between the groups I and II were carried out. The data obtained by comparison of the groups I and II are presented in Table 1.

As the table shows, the difference between hemodynamic parameters such as systolic BP, diastolic BP, mean BP, pulse BP, and HR, CVP, SV, CO, CI is not statistically significant ($p > 0,1$), this means that the administration of dopamine or epinephrine in the postoperative period equally influence on this parameters.

The data from Table 1 indicates that the difference between length of stay of patients in ICU for the groups is

Table 1

Hemodynamic parameters, hourly diuresis and length of stay in the ICU for patients of the groups I and II

Parameter	Group I (N = 16) M (SD)	Group II (N = 14) M (SD)	Difference between the parameters (%)	df	p
Systolic BP (mm Hg)	77,1 (7,5)	83,2 (11,7)	3,8	28	0,1
Diastolic BP (mm Hg)	50,5 (6,8)	55,1 (8,0)	4,6	28	0,1
Mean BP (mm Hg)	59,4 (5,7)	64,5 (8,2)	4,1	28	0,07
Pulse BP (mm Hg)	26,6 (8,6)	28,1 (9,9)	2,7	28	>0,1
HR (beats/min)	144 (18)	151 (21)	2,4	28	>0,1
CVP (mm Hg)	8,6 (2,6)	9,5 (2,8)	4,9	28	>0,1
SVR (dyn·sec·cm ⁻⁵)	4103 (2249)	3102 (992)	13,9	28	<0,05
SV (ml/beat)	8,4 (4,1)	8,7 (2,8)	1,8	28	>0,1
CO (l/min)	1,2 (0,5)	1,4 (0,5)	7,7	28	>0,1
CI (l/min/m ²)	3,3 (0,8)	3,4 (1,1)	1,5	28	>0,1
Hourly diuresis	3,8 (1,6)	2,9 (1,0)	13,4	28	<0,05
TICU (days)	7,3 (5,9)	4,8 (2,3)	20,7	28	<0,05

* Statistical abbreviations: *M* – average value; *SD* – standard deviation; *df* – degrees of freedom; *p* – significance level; *CI* – confidence interval.

Table 2

Postoperative complications of patients from groups I and II

Postoperative complications	Episodes of a postoperative complication	
	Group I (N = 16)	Group II (N = 14)
Cardiac complications	2 (12,5)	1 (7,1)
Pulmonary complications	4 (25,0)	1 (7,1)
Renal complications	-	1 (7,1)

statistically significant ($p < 0.05$), as the patients from the dopamine group stay in the ICU on average 2,5 days longer in the postoperative period than the patients from the adrenaline group.

SVR is an important hemodynamic indicator. The mean value of SVR in patients receiving dopamine is 4103 ± 2249 dyn · sec · cm⁻⁵, while it is 3102 ± 992 dyn · sec · cm⁻⁵ for the patients receiving adrenaline in the postoperative period. This indicates that patients from the group II show a 13.9% lower SVR than patients from the group I, this difference is statistically significant ($p < 0.05$).

During this work an analysis of postoperative complications was carried out. Among the postoperative complications there are: pulmonary complications, such as prolonged ventilation (> 48 h); cardiac complications, such as decreased myocardial contractility (ejection fraction <50%), arrhythmias and conduction disorders (tachyarrhythmias); renal complications (oliguria, creatinine > 40 mg/l). All data are presented in Table 2.

The Table 2 shows that the incidence of postoperative complications is 37,5% in the group I, and it is 21,3% in the group II. This data indicate that patients who received dopamine in the postoperative period are more likely to develop postoperative complications than patients who received adrenaline in the postoperative period. Postoperative complications in both groups are represented in Fig. 1.

Conclusions

1. The systemic vascular resistance is higher in patients who received dopamine in the postoperative period, in comparison with patients who received adrenaline.
2. Patients with adrenaline administration in the postoperative period have a shorter length of stay in the ICU, compared with patients whom dopamine was administered.
3. The use of adrenaline as a sympathomimetic for hemodynamic support is associated with less postoperative complications, in comparison to dopamine administration.

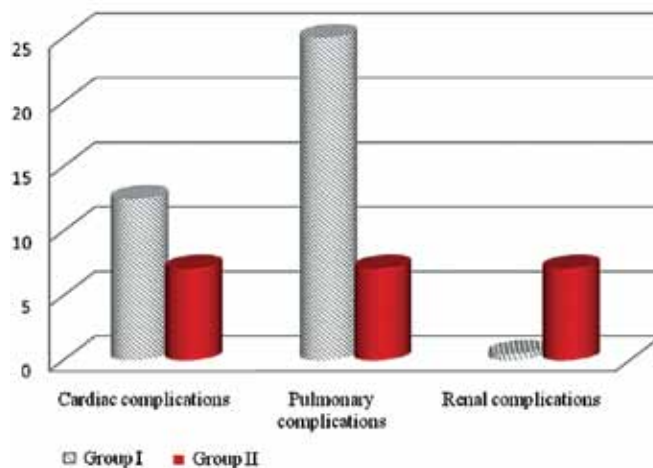


Fig. 1. Postoperative complications of patients from I and II groups

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Порівняння ефективності симпатоміметиків у дітей після операцій зі штучним кровообігом

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В роботі проаналізовано застосування симпатоміметиків у дітей грудного віку з вродженими вадами серця після операцій зі штучним кровообігом. Проведена порівняльна характеристика адреналіну і допаміну в лікуванні післяопераційної міокардіальної дисфункції за частотою виникнення післяопераційних ускладнень, тривалості перебування в реанімаційному відділенні.

Ключові слова: адреналін, допамін, симпатоміметики, діти, вроджені вади серця, штучний кровообіг.

Сравнение эффективности симпатомиметиков у детей после операций с искусственным кровообращением

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В работе проанализировано применение симпатомиметиков у детей грудного возраста с врожденными пороками сердца после операций с искусственным кровообращением. Проведена сравнительная характеристика адреналина и допамина в лечении послеоперационной миокардиальной дисфункции по частоте возникновения послеоперационных осложнений, длительности пребывания в реанимационном отделении.

Ключевые слова: адреналин, допамин, симпатомиметики, дети, врожденные пороки сердца, искусственное кровообращение.