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MEDICINE

HEMODYNAMICALLY SIGNIFICANT PATENT DUCTUS ARTERIOSUS AND FUNCTIONAL STATE OF THE MYOCARDIUM IN PRETERM CHILDREN

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Abstract. *The study involved examination of 125 newborns at gestational age of 24-37 weeks. According to Doppler echocardiography findings preterm infants with hemodynamically significant patent ductus arteriosus (HSPDA) were found to have dilation of the left ventricle with hypertrophy of the wall and ventricular septum in 75.9% (p<0.05), dilation of the right ventricular cavity in 82.8% (p<0.05), dilation of the left atrium in 100% (p<0.05), 1st-2nd degree tricuspid and pulmonic regurgitation in 65.5% (p<0.05), Pmean AP>34 mm Hg in 79.3% (p<0.05), disorders of diastolic function of the left and right ventricles (delayed relaxation) were observed in 100% children. Newborns with HSPDA were shown to have lower rates of velocity of fibrous rings and an increased index of global myocardial function. Advanced DEchoCG criteria for HSPDA diagnosis can be effective as part of the plan for screening preterm infants. Tissue Doppler imaging in preterm infants with HSPDA is useful in assessing the global function of the myocardium.*

Keywords: *preterm infants, hemodynamically significant patent ductus arteriosus, neonatal period.*

Patent ductus arteriosus remains an urgent problem in caring for premature infants, especially with an extremely low and very low body weight. For many years, much attention has been paid to the aspects of determining the hemodynamic significance of patent ductus arteriosus (HSPDA), whereas disputes over its evaluation still continue. The number of randomized controlled trials for treating patients with HSPDA and its treatment is not sufficient.

A relatively high level of spontaneous closure of PDA [1, 2, 3, 4] leads to heterogeneity in management and treatment. Consequently, early detection of Doppler echocardiographic (DEchoCG) markers of HSPDA can prevent complications and reduce mortality.

The purpose of the study: to determine Doppler echocardiographic criteria for hemodynamically significant open ductus arteriosus in premature children in the neonatal period.

Materials and methods of the study: The study involved examination of 125 newborns (52% boys, 48% girls) at gestational age of 24-37 weeks. DEchoCG was performed on "MyLab25Gold" unit manufactured by the company "Esaote" (Italy) with determination of central hemodynamics indices, evaluation of diastolic function of the ventricles, with the assessment of cerebral, renal and mesenteric blood flow. All the newborns underwent DEchoCG examination on the first day of life and after 48 hours. The newborns diagnosed with "Hemodynamically significant PDA" underwent DEchoCG examination on the daily basis up to stabilization of the patient's condition or surgical correction of the abnormality.

Newborns were divided into the following groups: Group 1 (n=29) included children with extremely low body weight (birth weight 779.5±63.4 g), gestation period 24-29 weeks. Group 2 (n=25) comprised newborns with very low body mass (1296.1±115.6 g) at 30-34 weeks of gestation, Group 3 (n=34) with low body weight (1859.1±118.1 g) at 31-35 weeks of gestation; Group 4 (n=37) newborns at 34-37 weeks of gestation, weight at birth 2250.0±141.2 g.

The findings were processed using the non-parametric Mann-Whitney test. The difference in rates was considered to be significant at $p<0.05$.

Results of the study and their discussion. HSPDA was diagnosed according to the criteria elaborated by Sehgal A, McNamara PJ. (2009) [5]. Additionally, we identified and used the following criteria for the hemodynamic significance of PDA: vascular resistance index in the anterior cerebral artery and/or medial cerebral artery > 0.8, steal syndrome in the renal and/or mesenteric artery, or vascular resistance index in the renal and / or mesenteric artery > 0.85, and/or reverse blood flow in the abdominal aorta, increase in the linear size of the left ventricle and/or atrium by 10% or more from the initial size with moderate hypertrophy of the interventricular septum and the posterior wall of the left ventricle; cardiothoracic index > 60%, FiO2 ≥40%.

According to DEchoCG and clinical examination findings, 55.2% (p<0.05) of Group 1 children were diagnosed with HSPDA. Premature infants with HSPDA were found to have dilation of the left ventricle with hypertrophy of the wall and interventricular septum in 75.9% (p1\2; 1/3; 1/4 <0.05); dilation of the right ventricle in 82.8% (p1\2 ; 1/3; 1/4 <0.05), dilation of the left atrium in 100% (p1\2; 1/3; 1/4<0.05), 1-2 degree transcuspid and transpulmonary regurgitation in 65.5% (p1\2; 1/3; 1/4<0.05); Pmean AP > 34 mm Hg in 79.3% (p1\2; 1/3; 1/4<0.05).

Disorders of diastolic function of the left and right ventricles (delayed relaxation) were observed in 100% (p1\2; 1/3; 1/4<0.05) children with HSPDA. It was accompanied by prolonged deceleration of early diastolic filling (deceleration time >76 ms) and isovolumic relaxation (IVRT>57 ms), E/A<1. Tissue Doppler imaging showed a decrease in velocity of fibrous rings of mitral and tricuspid valves in Group 1 newborns as compared to healthy full-term infants (p<0.05). The difference between the indices in the groups is represented in Table 1.

Table 1. Velocity of fibrous rings of mitral and tricuspid valves in preterm children with PDA in the neonatal period according to tissue Doppler imaging

	Group 1 (n=29)	Group 2 (n=25)	Group 3 (n=34)	Group 4 (n = 37)
LV, lateral segment				
S, cm/s	5.76±0.90 (p1/4≤0.05)	7.10±1.34	7.18±1.40	7.82±1.11
E', cm/s	6.32±1.16	7.01±1.06	7.25±1.01	7.79±1.12
A', cm/s	6.90±1.16 (p1/4≤0.05)	9.41±1.90 (p1/2≤0.05)	9.74±1.96 (p1/3≤0.05)	10.68±1.10
E'/A', un.	0.98±0.11	0.86±0.33	0.91±0.30	0.76±0.19
LV, septal segment				
S, cm/s	4.99±0.55 (p1/4≤0.05)	6.90±0.36	6.90±0.32	8.11±0.76
E', cm/s	6.06±1.14	6.54±1.62	6.58±1.16	7.21±1.47
A', cm/s	6.44±1.08 (p1/4≤0.05)	8.56±1.58	8.59±1.68	10.76±1.77
E'/A', un.	0.78±0.20	0.87±0.34	0.83±0.25	0.71±0.22
RV, lateral segment				
S, cm/s	6.71±1.17 (p1/4≤0.05)	7.04±0.97	7.81±0.98	9.09±1.34
E', cm/s	7.01±1.12	7.89±1.14	7.87±1.02	8.75±1.35
A', cm/s	7.05±1.21 (p1/4≤0.05)	10.96±1.81 (p1/2≤0.05)	10.96±1.80 (p1/3≤0.05)	12.66±1.92
E'/A', un.	0.72±0.04	0.75±0.17	0.75±0.15	0.71±0.13

Note: * $p_{1, 2, 3, 4}$ - validity of the difference between the indices in the groups
S - peak systolic velocity, cm/s,
E - highest velocity of transmitral/transcuspid blood flow, cm/s;
E ' - velocity of early diastolic relaxation, cm/s,
A '- peak velocity in the atrial systole phase, cm/s

Group 1 and 2 newborns were found to have hypokinetic type of central hemodynamics (systolic index (SI) - 1.8±0.6 and 2.4±0.4 l/min×m^2, (p≤0.01) respectively, mainly in patients with a serious condition with clinical signs of HSPDA complications. There was a tendency to a decrease in contractile ability of the myocardium in Groups 1 and 2 (ejection fraction (EF) (65.1±5.6% and 65.7±5.8% respectively) as compared to Groups 3 and 4 (71.7±6.7% and 71.9±6.1%). In Group 1 Tei index was 0.36±0.11 in LV and 0.34±0.11 in RV, in Group 2 Tei index was 0.33±0.09 in LV and 0.30±0.08 in RV, in Groups 3 and 4 Tei index was 0.30±0.10 in LV and 0.30±0.09 in RV respectively. Group 1 children were shown to have lower rates of velocity of fibrous rings and an increased index of global myocardial function. The latter indicated the presence of systolic and diastolic dysfunction of the myocardium.

In 100% of newborns, the functioning of PDA the diameter of which was in downstream direction of the pulmonary artery, was as follows: 2.5±0.6 mm in Group 1, 2.4±0.6 mm in Group 2, 2.2±0.4 mm and 2.1±0.6 mm in group 3 and 4.

We had some difficulties in determining the hemodynamic significance of PDA in patients with artificial ventilation of the lungs. DEchoCG in newborns on artificial ventilation with FiO2≥40% could show a false-negative result due to temporary functional closure of PDA. This resulted in absence of visualization of PDA flow in the pulmonary artery in color pulse-wave Doppler imaging secondary to pulmonary hypertension. In order to prevent the development of HSPDA complications DEchoCG was performed daily in the volume described above [6, 7]. This had a positive effect in diagnosing HSPDA and preventing the development of its complications.

Conclusions: 1. Advanced DEchoCG criteria for HSPDA diagnosis can be effective as part of the plan for screening preterm infants with a weight less than 1500 grams.

2. Tissue Doppler imaging in preterm infants with HSPDA is useful in assessing the global function of the myocardium.

3. We consider it expedient to conduct further research to confirm our results and determine their clinical significance.

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