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Blood flow parameters in the arteries of the eye in premature children

Parametry przepływu krwi w tętnicach oka u wcześniaków

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Summary: Purpose: of the study was to evaluate blood flow in the arteries of the eye in preterm neonates. Material and methods: Color Doppler imaging (CDI) of ophthalmic artery, central retinal artery and posterior ciliary arteries was performed in 36 preterm infants and 19 full-term infants. Maximal systolic velocity, end-diastolic velocity, resistance index- RI and pulsatility index- PI were assessed for the studied vessels. Results: There were no significant differences in ophthalmic artery blood flow between preterm and normal newborns. End-diastolic velocity in central retinal artery and posterior ciliary arteries in preterm infants was significantly lower and resistant index and pulsatility index was higher. The Doppler color ultrasonography is a non-invasive technique which can be useful for the estimation of the hemodynamic parameters in the arteries of the eye in the prematures. Conclusions: The recorded changes in the ultrasound measurements of the blood flow in the eye arteries in premature children comparing to the normal newborns, can be the evidence for the immaturity of the vessel system in the preterm born neonates.

Słowa kluczowe: wcześniactwo, kolorowa ultrasonografia dopplerowska, przepływ krwi w tętnicach oka.

Key words: prematurity, color Doppler ultrasound, blood flow in the arteries of the eye.

Haemodynamic factors are regarded more and more important in the pathomechanism of numerous diseases of the eye. Studies with the application of color Doppler ultrasound (USG-CD) play an important role in the evaluation of changes in the eye vessel system, in the pre-clinical stage and enable better understanding of various pathological conditions. This method allows for determination of specific therapy and prognosis of long-term treatment (1). Recently many publications have been devoted to the parameters of normal blood flow in the arteries of the eye (2,3,4). However, reports on the haemodynamics of the vessel system in the eye of children, and in particular preterm children, are rare (5,6,7).

The aim of the study was evaluation of blood flow in the arteries of the eye in preterm neonates, with assessment of parameters dependent on the gestational age. The obtained results will be part of further analysis of blood flow in the arteries of the eye in children with retinopathy of prematurity.

Material and methods

The study comprised 33 preterm newborns (58 eyes): 14 girls (24 eyes) and 19 boys (34 eyes), treated in the Unit of Anaesthesiology and Intensive Care, and in the Ophthalmologic Outpatient Clinic, Institute of Paediatrics, Medical University of Łódź, between 2003-

2004. The study was conducted in children in various clinical condition, with accompanying disorders of the respiratory, circulatory, digestive and central nervous systems, typical for prematurity. The control group comprised 19 neonates born at term (38 eyes). All children were subjected to complete ophthalmologic examination, which excluded organic changes in the eyes. To evaluate blood flow in the eye vessels, USG-CD examination was performed, using the ATL 3500 HDI apparatus with a linear phased-array transducer for frequencies 7-12 MHz. The transducer was applied in a typical way, to the closed eyelids. The children were examined between their 1 and 4 weeks of life, during normal sleep, six of them on mechanical ventilation with stabilised circulatory and respiratory parameters. The spectrum of blood flow was registered in the ophthalmic artery, central retinal artery and posterior ciliary arteries. The measurements comprised maximal systolic velocity (Vmax), end-diastolic velocity (Vmin), resistance index (RI) and pulsatility index (PI). The ophthalmic artery was visualised 8-12 mm posterior to the globe, central retinal artery was identified within the optic nerve, 1-3 mm behind the surface of the optic nerve disk, and posterior ciliary arteries both at the nasal and temporal side of the optic nerve, 1-4 mm behind the globe. In all children the measurements were repeated three times, and the analysis was performed on mean values of all three measurements. To

determine the values of parameters in particular range of gestational age, the studied preterm neonates were divided into four groups: born between 24-26 weeks of gestational age (hbd), 27-29 hbd, 30-32 hbd and 33-36 hbd.

The results were subjected to statistical analysis using computer programme Statgraphics Plus. The studied values were presented as means \pm standard deviation. The normality of distribution was checked to compare the mean values. The obtained distribution did not differ significantly from normal distribution, and thus comparison of mean values was done with t-student test for independent variables.

Results

The analysis of blood flow spectrum in preterm neonates in the ophthalmic artery showed that Vmax achieved from 20.0 to 34.7 cm/s, Vmin from 2.6 to 7.8 cm/s, RI from 0.68 to 0.89 and PI from 1.26 to 2.55. Mean values of the studied parameters did not differ

statistically significantly from results obtained in children from the control group (born at term). However, detailed analysis revealed a proportional for gestational age increase in the value of Vmax, RI and PI in children born between 24 and 32 weeks of gestation. Beginning from 33 weeks these parameters stabilised at the level similar to that in children born at term (Tab. I, II).

In the studied preterm newborns Vmax in the central retinal artery was within the range 5.5 to 11 cm/s, Vmin between 1.6 and 4 cm/s, RI 0.50 to 0.81 and PI 0.84 to 1.50. The measurements revealed statistically significantly lower values of Vmin and higher RI in preterm children, as compared with full-term children. The values of Vmax were similar in all age groups of preterm children, while Vmin increased and RI and PI decreased proportionally with gestational age (Tab. III, IV).

In posterior ciliary arteries of preterm newborns Vmax did not differ statistically significantly from that of children born at term and was within the range 10.8 to 15.7 cm/s. However, Vmin in these ves-

	Vmax (cm/s)	Vmin (cm/s)	RI	PI
Preterm children	27.52 \pm 1.03	5.03 \pm 0.34	0.81 \pm 0.01	2.07 \pm 0.09
Full-term children	27.27 \pm 0.93	5.02 \pm 0.38	0.81 \pm 0.02	2.01 \pm 0.13
Statistic significance	No significance	No significance	No significance	No significance

Tab. I. Blood flow parameters in the ophthalmic artery.

Gestational age	Vmax (cm/s)	Vmin (cm/s)	RI	PI
24- 26 hbd	26.26 \pm 2.11	5.53 \pm 1.07	0.79 \pm 0.04	1.86 \pm 0.19
27- 29 hbd	27.13 \pm 2.52	4.93 \pm 0.92	0.81 \pm 0.03	1.96 \pm 0.13
30- 32 hbd	28.79 \pm 2.67	4.52 \pm 0.76	0.84 \pm 0.02	2.31 \pm 0.18
33- 36 hbd	27.47 \pm 1.76	5.12 \pm 0.43	0.81 \pm 0.02	2.09 \pm 0.16
Full-term children	27.26 \pm 0.93	5.06 \pm 0.59	0.81 \pm 0.02	2.01 \pm 0.13

Tab. II. Blood flow parameters in the ophthalmic artery in preterm children at different gestational age as compared with full-term children.

	Vmax (cm/s)	Vmin (cm/s)	RI	PI
Preterm children	7.89 \pm 1.07	2.70 \pm 0.13	0.65 \pm 0.02	1.16 \pm 0.04
Full-term children	7.80 \pm 0.39	3.04 \pm 0.22	0.62 \pm 0.03	1.11 \pm 0.06
Statistic significance	No significance	Significance	Significance	No significance

Tab. III. Blood flow parameters in the central artery.

Gestational age	Vmax (cm/s)	Vmin (cm/s)	RI	PI
24- 26 hbd	7.71 \pm 0.77	2.18 \pm 0.25	0.71 \pm 0.05	1.27 \pm 0.09
27- 29 hbd	7.95 \pm 0.49	2.65 \pm 0.24	0.66 \pm 0.03	1.14 \pm 0.08
30- 32 hbd	8.03 \pm 0.56	2.70 \pm 0.22	0.66 \pm 0.02	1.19 \pm 0.07
33- 36 hbd	7.87 \pm 0.58	2.97 \pm 0.22	0.61 \pm 0.02	1.10 \pm 0.06
Full-term children	7.80 \pm 0.39	3.04 \pm 0.27	0.62 \pm 0.03	1.10 \pm 0.06

Tab. IV. Blood flow parameters in the central artery in preterm children at different gestational age as compared with full-term children.

	Vmax (cm/s)	Vmin (cm/s)	RI	PI
Preterm children	12.68±0.28	4.19±0.16	0.66±0.01	1.16±0.04
Full-term children	12.64±0.37	4.72±0.76	0.63±0.02	1.08±0.05
Statistic significance	No significance	Significance	Significance	Significance

Tab. V. Blood flow parameters in posterior ciliary arteries.

Gestational age	Vmax (cm/s)	Vmin (cm/s)	RI	PI
24- 26 hbd	12.39±0.59	4.23±0.29	0.65±0.04	1.07±0.08
27- 29 hbd	12.31±0.64	4.02±0.24	0.66±0.02	1.17±0.09
30- 32 hbd	13.10±0.86	4.06±0.41	0.68±0.02	1.22±0.05
33- 36 hbd	12.89±0.37	4.33±0.31	0.65±0.02	1.17±0.07
Full-term children	12.64±0.37	4.76±0.25	0.63±0.02	1.08±0.05

Tab. VI. Blood flow parameters in posterior ciliary arteries in preterm children at different gestational age as compared with full-term children.

sels was statistically significantly lower in preterm children and was between 3 and 5.2 cm/s, while RI (0.50-0.76) and PI (0.80-1.44) were statistically significantly higher. The determined parameters varied in particular age groups of the studied preterm newborns (Tab. V, VI).

Discussion

In preterm children the process of vascularisation of retina is not complete at birth. In particular this is the case in highly immature children, in whom ophthalmoscopic examination reveals areas of non-vascularised retina in the peripheral fragments of the eye fundus. However, very little is known about haemodynamic maturity of the blood vessels of the eye in preterm children. The conducted studies using USG-CD allowed for safe evaluation of blood flow in the eye vessels in preterm newborns. Minimalisation of pressure of the transducer to the eye by using immersion in gel eliminated possible side effects, including heart arrhythmias.

The obtained values of the studied parameters of blood flow in the ophthalmic artery and central retinal artery were lower than literature norms for adults (2,3,4), but were within range reported in preterm children by other authors (7,8). In available literature there are no reports concerning parameters of blood flow in posterior ciliary arteries in preterm newborns. These vessels are most difficult for visualisation in infants and according to some authors the obtained results are not as repeatable as those obtained for other vessels in the eye (9). The velocities of blood flow in posterior ciliary arteries in this study were within wide normal range for adults (2,3).

In the analysed preterm children there was a proportional to gestational age increase of Vmax in the ophthalmic artery in children born between 24-32 hbd, but it was not statistically significant. Baerts et al. (8) showed similar relationship in preterm children born between 28-37 hbd. However, Romagnoli et al. (5) found significant increase of Vmax and Vmin in the ophthalmic artery and central retinal artery of preterm children between 3 and 7 days after birth. Similar changes were reported also for full-term children (6).

In this study resistance indices in the central retinal artery and in posterior ciliary arteries were significantly higher in preterm children, as compared with full-term children. It may be due to smaller

diameter of these vessels. Such dependency was not seen in the ophthalmic artery.

Evaluation of blood flow parameters in the orbital vessels did not take into account numerous exogenous and endogenous factors commonly affecting preterm newborns, which – according to some authors (8,10,11,12) may influence the haemodynamic state of the vessels. The complexity of these problems was discussed by Yanowitz et al. (13) and Harris et al. (14) who analysed the effect of various systemic factors on the blood flow in the vessels of the eye and brain, and did not find any local vascular response in USG-CD. Thus, monitoring blood flow parameters as the child grows may bring more information on the haemodynamic condition of the vessel system of the eye in preterm children, in particular in the context of retinopathy of prematurity.

Conclusions

The Doppler color ultrasonography is a non-invasive technique which can be useful for the evaluation of haemodynamic parameters in the arteries of the eye in the premature children. The recorded USG-CD changes of the blood flow in the eye arteries in preterm newborns, as compared with full-term newborns, can be the evidence for the immaturity of the vessel system of the eye after birth in these children.

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