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Changes in Cerebral Hemodynamics in Children with Type 1 Diabetes with Cognitive Impairments

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Abstract This article presents changes in cerebral hemodynamics in children with type 1 diabetes mellitus, with a history of the disease of 3 years or more. The earliest diagnosis and adequate correction will prevent the worsening of cerebral disorders in this category of patients with diabetes.

Keywords Diabetes mellitus, Hemodynamics, Cognitive impairment, Children

1. Introduction

Diabetes mellitus (DM) is considered to be an endocrine autoimmune pathology that develops as a result of an absolute or relative deficiency of insulin caused by the destruction of beta cells of the pancreas. At the present stage, diabetes is a serious medical and social problem, as it remains one of the leading causes of decreased quality of life and the occurrence of early disability due to the formation of long-term complications [5].

Chronic high glycemia inherent in diabetes mellitus causes functional and structural disorders of organs and systems of the body, most often the organs of vision, cardiovascular system, kidneys and especially the nervous system are affected. This fact of the negative and sustainable impact of increased glycemia on the formation, frequency and severity of possible complications in diabetes was discovered and proven by scientists back in the middle of the last century [1,3,4].

Currently, there is no doubt about the role of type 1 diabetes mellitus (DM) in the occurrence of vascular pathology of the brain with an increase in the likelihood of developing acute and chronic cerebrovascular accidents by 2-6 times. The main mechanisms for the development of cerebral vascular pathology in diabetes in childhood are cerebral chronic metabolic disorders and microcirculation disorders caused by changes in the structure of the walls of blood vessels, the biochemical composition of the blood and fluctuations in blood pressure [2].

2. Purpose of the Study

The earliest diagnosis and adequate correction can prevent the worsening of cerebral disorders in this category of patients with diabetes.

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3. Materials and Methods of Research

We examined 102 patients with type 1 diabetes mellitus, with a history of the disease of 3 years or more. The studies were conducted in the children's department of the Republican Scientific and Practical Medical Center in 2022-2024 in children aged 7-18 years. A clinical and neurological examination of the children was carried out and anamnestic information about the severity of diabetes and the number of comatose states suffered was clarified.

The study of cerebral hemodynamics was carried out according to standard methods using an ultrasonic Doppler device “Multi-Dop” T2 DWL – 2.55 MDT from Elektronische Systeme GmbH with a set of sensors generating ultrasonic waves with a frequency of 2; 4 and 8 Hz.

Using transcranial Dopplerography (TCDG), indicators of cerebral blood flow were studied in the arteries of the base of the brain: paired 62 midcerebral (MCA), forebrain (AF) and basilar artery (BA), as well as in deep intracranial venous collectors (basal veins and straight sinus); at the extracranial level, indicators of cerebral hemodynamics were determined in the vertebral arteries (VA), as well as in the superior orbital veins, vertebral and internal jugular veins. In the studied arterial vessels, the components of linear blood flow velocity (LBV) were recorded: peak systolic (Vs), end-diastolic (Vd) and average (Vm); The index of peripheral vascular resistance (IR) was calculated using the generally accepted formula: IR = (Vs-Vd)/Vs. In the venous collectors, the intensity of venous outflow was assessed by the value of the maximum BSC in them (Vmax), and the direction of blood flow, in particular, along the orbital veins, was also taken into account.

4. Results and Discussions

To identify changes in cerebral hemodynamics, we created 3 groups of children depending on the length of the disease. Group I with a disease experience of up to 3 years, Group II from 3 to 6 years and Group III more than 6 years. 25 healthy children were also studied to compare the data. The results of changes in cerebral hemodynamics are presented in Fig. 1.

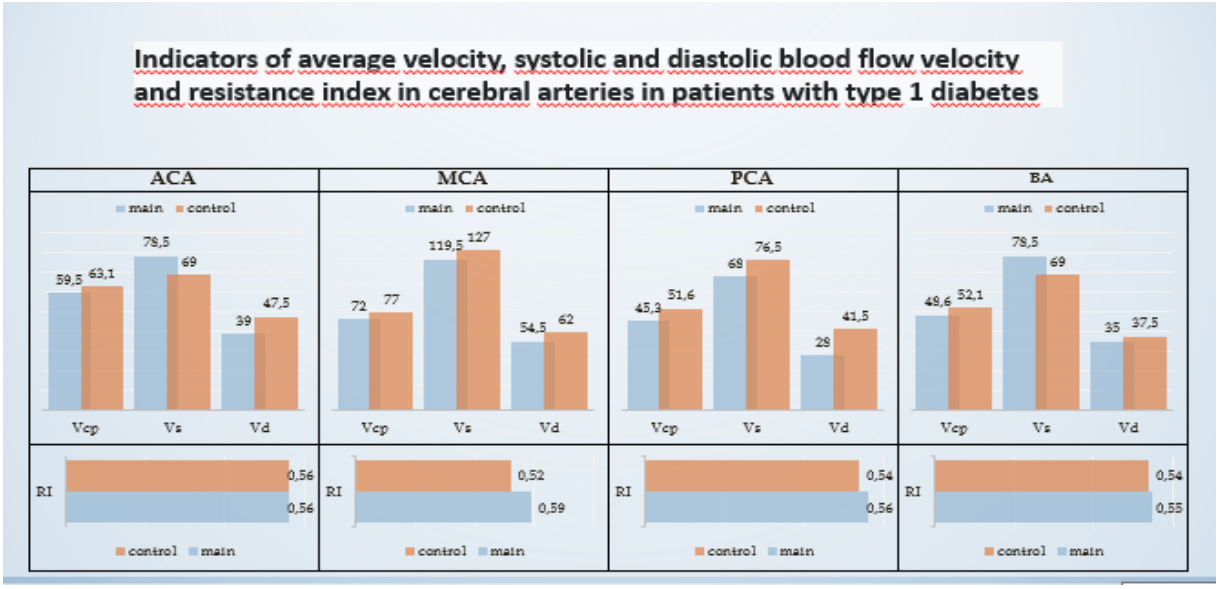

Figure 1. * – differences in indicators are statistically significant ($p < 0.05$)

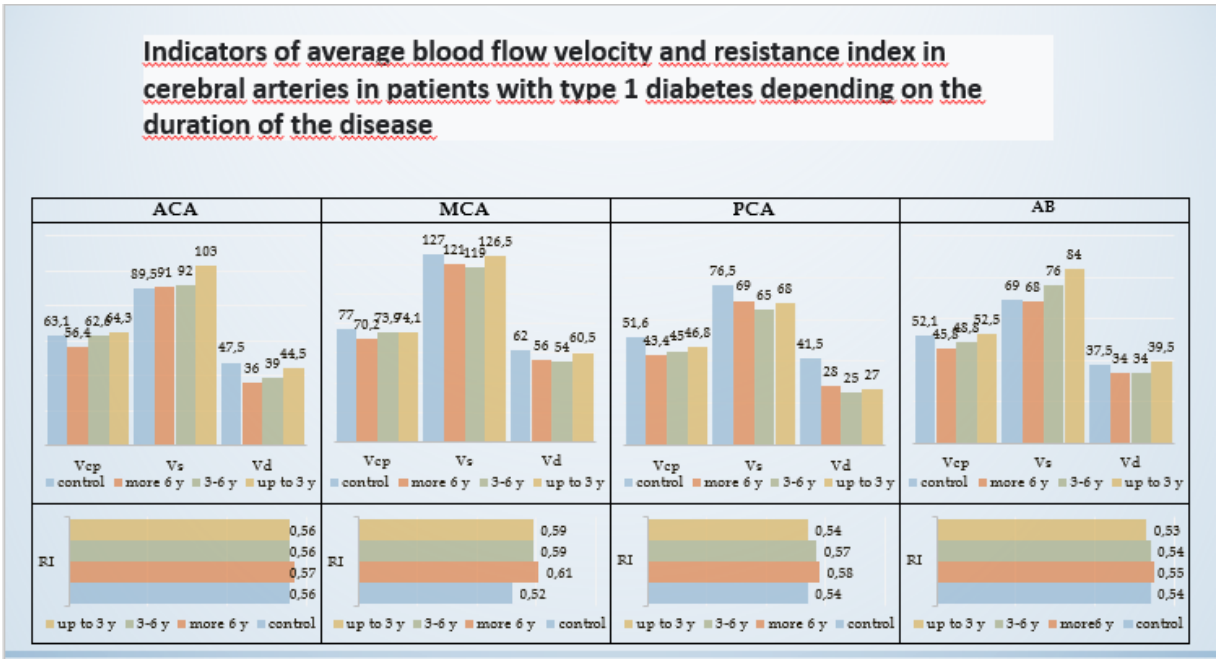

Figure 2. * – differences in indicators are statistically significant ($p < 0.05$)

In accordance with the presented table, when comparing the indicator "SMA Vsr", the indicator "SMA RI", the indicator "PMA Vsr", the indicator "PMA Vs", the indicator "SMA Vs", the indicator "PCA Vs", the indicator "BA Vs", the indicator "ACA Vd", indicator "SMA Vd", indicator "PCA Vd" depending on the indicator "Patient Group", statistically significant differences were identified ($p = 0.031$, $p < 0.001$, $p < 0.001$, $p = 0.014$, $p = 0.010$, $p < 0.001$, $p = 0.010$, $p = 0.026$, $p = 0.027$, $p < 0.001$, respectively) (methods used: Mann–Whitney U test). When comparing the indicator "PMA Vsr", the indicator "PMA RI", the indicator "PMA RI", the indicator "BA Vsr", the indicator "BA RI", the indicator "BA Vd" depending on the "Patient Group" indicator, we were unable to identify significant differences ($p = 0.373$, $p = 0.299$, $p = 0.063$, $p = 0.333$, $p = 0.469$, $p = 0.682$, respectively) (methods used: Mann–Whitney U test).

Analysis of the studied characteristics of blood flow taking into account the duration of the disease (Fig. 2) demonstrated that in the group with a disease duration of up to 3 years, there was a tendency towards a slight acceleration

of Vav in the ACA and BA compared to the control (p = 0.004*) and a decrease in the PCA (p = 0.002). In the group with 3 to 6 years of diabetes experience, a significant decrease in blood flow velocity compared to the control was detected in the basilar artery (p=0.004*), and an increase in the resistance index in the PCA and BA (p=0.006* and p=0.016*). The most pronounced cerebrovascular changes were observed in the group of long-term (more than 6 years) ill patients, which included a significant decrease in blood flow velocity compared to healthy individuals in all studied arteries (p = 0.020 for the ACA, p = 0.066 for the MCA, p < 0.001 for the PCA and p =0.004 for BA), as well as an increase in the resistance index in the MCA (p=0.002*).

According to the presented table, when assessing the indicator "PMA Vsr", the indicator "PMA RI", the indicator "SMA RI", the indicator "PMA Vsr", the indicator "PMA RI", the indicator "BA Vsr", the indicator "BA RI", the indicator "PMA Vs", the indicator "PCA Vs", the indicator "BA Vs", the indicator "PCA Vd", the indicator "PCA Vd", the indicator "BA Vd" depending on the indicator "Distance of the disease", statistically significant differences were established (p = 0.004, p = 0.015, p = 0.002, p < 0.001, p = 0.006, p = 0.004, p = 0.016, p = 0.011, p < 0.001, p < 0.001, p < 0.001, p < 0.001, p = 0.002 respectively) (methods used: Kruskal–Wallis test). When comparing the “SMA Vcp” indicator, the “SMA Vs” indicator, the “SMA Vd” indicator depending on the “Disease duration” indicator, we were unable to identify significant differences (p = 0.066, p = 0.052, p = 0.117, respectively) (used methods: Kruskal–Wallis test, Kruskal–Wallis test, Kruskal–Wallis test).

Correlation analysis of the relationship between the average blood flow velocity and the duration of the disease revealed the associations presented in Table 1.

Table 1. Correlation analysis of the relationship between the average blood flow velocity and the duration of the disease

Indicators	Characteristics of correlation		
	ρ	Connection tightness on the Chaddock scale	p
PMA Vav	-0,409	Moderate	0,003*
SMA Vav	-0,164	Weak	0,256
BA Vav	-0,506	Noticeable	<0,001*

* – differences in indicators are statistically significant (p < 0.05).

When assessing the relationship between the PMA Vav indicator and the duration of the disease, a moderately strong inverse relationship was established. With an increase in the duration of the disease by 1 year, one should expect a decrease in the “PMA Vav” indicator by 1.075 cm/s.

When assessing the relationship between the SMA Vav indicator and the duration of the disease, a weak inverse relationship was established. With an increase in the duration of the disease by 1 year, one should expect a decrease in the “SMA Vav” indicator by 0.521 cm/s.

When assessing the relationship between the “BA Vav” indicator and the duration of the disease, a noticeably close inverse relationship was established. With an increase in the duration of the disease by 1 year, one should expect a decrease in the “BA Vav” indicator by 1.046 cm/s.

5. Conclusions

Thus, in patients with diabetes in childhood and adolescence, Dopplerographic signs of deterioration in cerebral blood flow, characterized mainly by a hypertensive-hypokinetic type of arterial blood flow and varying degrees of venous discirculation, are significantly more likely than in persons without carbohydrate metabolism disorders. The frequency and severity of these disorders increases with increasing experience of diabetes mellitus.

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