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CHARACTERISTICS OF CEREBRAL HEMODYNAMICS IN ADOLESCENTS DEPENDING ON THE KIND OF VOLATILE SOLVENT USED

The paper studied cerebral circulation in adolescents using a variety of volatile solvents (VS). The results indicate that, depending on the type of inhalant used, cerebral circulation undergoes multidirectional changes, among which are declining values of pulse volume and volumetric blood flow in all groups of users compared to the control group and reduction of blood filling in large, medium and small arteries, which is particularly pronounced in internal carotid arteries.

Keywords: *adolescent, cerebral hemodynamics, psychoactive substances, volatile solvents.*

Substance abuse in children and adolescents has been one of the most negative phenomena in recent years. As new forms of drug dependence are becoming more common, there has been an increase in the number of minors using toxic substances, in particular volatile solvents [11, 13, 14].

Volatile solvents (VS) are highly active biological structures characterized by pronounced lipophilicity and reactivity in biological media, membranes and cellular structures. They change the structure and functional state of biological membranes, provide direct and indirect metabolite-mediated toxic effect, influence the correlation of biochemical substrates and enzymes and cause disturbances at the molecular and system levels: cellular, organ and organism ones [1, 3, 7]. Inhalants depress the central nervous system (CNS) by affecting, at first, the cerebral cortex and then, with growing concentration in the blood, the brain stem structures [1, 4, 5]. As a result, adolescents tend to develop symptoms and changes in the body associated with the use of VS more quickly [8, 15].

Unfortunately, scientific literature provides limited data on the VS effects on the physiological systems of children [6, 15]. Thus, the aim of this study was to determine changes in cerebral hemodynamics in adolescents depending on the type of VS used.

Materials and methods

We studied 300 children (212 boys and 88 girls) aged from 11 to 16 years, students of comprehensive schools in Arkhangelsk, Russia. The updated ICD-10 classification was used, where all types of chemical dependence are listed under the F18 rubric “Mental and behavioral disorders due to psychoactive substance use”. The subjects were divided into 2 groups: the control group, consisting of 112 apparently healthy adolescents without acute or chronic diseases of the respiratory and cardiovascular systems and not familiar with VS, and the main group, consisting of adolescents using VS and observed by a child addiction psychiatrist at the Arkhangelsk Regional Mental Clinic with the diagnosis “mental and behavioral disorders due to use of volatile solvents, without dependence syndrome” (F 18.1). The main group used various household chemicals as VS. We took into account the overall duration of VS abuse with short-term remission periods of 1–2 weeks.

The mean age of the control group (13.93 ± 0.13) and of the main group (14.36 ± 0.27) did not differ significantly ($p>0.05$).

To study cerebral circulation we applied rheoencephalography (REG) technique using the hardware-software complex "Valenta + 3.48" intended for recording, processing and analysis of signals coming from the brain vessels, which allows us to explore not only the hemodynamics of the entire brain, but also blood supply to its certain areas. REG has a number of advantages: it is non-invasive, safe for both the patient and researcher, painless and can be used multiple times to examine cerebral circulation even in debilitated patients and children. REG allows us to determine the state of blood filling, vascular resistance, and tonic-elastic properties of the vessel wall throughout the arterial and venous beds in the right and left internal carotid and vertebral arteries [2].

The research was conducted in a doctor's room, the patient sitting in an armchair with armrests and a headrest in order to relax the neck and shoulder area. Rheogram was registered during the shallow exhalation phase. Rheoencephalogram was recorded in the frontal-mastoidal (FM) and occipital-mastoidal leads (OM).

The following parameters were analysed: rheographic index (RI), rheographic wave propagation period (Qa), anacrotic limb period (α), catacrotic limb period (β) dicrotic index (DCI), diastolic index (DSI), blood volume pulse (Pr).

The data obtained were subjected to a comprehensive statistical analysis on Pentium IV using EXCEL 7.0 spreadsheets for Windows 2000 with standard software programs. Significance of differences was estimated using Student's *t*-test with significance level of 95 % ($p<0.05$).

Results and discussion

The study found that all REG indicators of the control group matched the age norm and did not differ from those in other regions [11, 10].

Quantitative rheoencephalogram (REG) assessment in children using VS helped detect significant differences in some indicators of cerebral hemodynamics from their peers, in both the front-mastoidal (FM) and occipital-mastoidal (OM) rheogram leads.

Indicators of cerebral hemodynamics in boys using VS differed significantly from those in the control group in both FM and OM, right and left leads. There was found a statistically significant decrease in cerebrovascular elasticity, microcirculatory disturbance (in precapillaries) as well as reduced blood supply to the brain area under study [9, 12].

Indicators of cerebral circulation in girls using VS differed significantly from those in the control group in both FM and OM, right and left leads [13]. The girls using VS showed a statistically significant decrease in openability of the vascular bed and an increase in precapillary vascular tone, which allows us to indirectly observe blood flow reduction in the area under study [10].

Having compared hemodynamic performance of boys and girls using VS, we revealed some changes in cerebral hemodynamics in both FM and OM, right and left leads. The girls of the main group showed more significant changes in the vascular tone as compared to the boys of the same group [12, 13].

Our study revealed significant changes in the cerebral hemodynamics of boys depending on the duration of VS use. Particularly significant changes were found when comparing indicators of boys who had been using VS for one year and three years. Based on the data obtained, we could observe that boys using VS had a significant decrease in pulse volume and volumetric blood flow in internal carotid arteries and in the vertebrobasilar system, and the longer the VS use, the more reliable the results [12].

Comparative analysis of cerebral hemodynamics in 11- to 16-year-old boys and girls from the control group revealed no significant differences, allowing us to analyze the state of cerebral circulation in adolescents without having to divide them into groups by gender.

The analysis of brain hemodynamics in adolescents using various types of VS indicated miltidirectional changes in cerebral circulation in terms of the following parameters.

By evaluating Qa (c) rate in the right internal carotid artery to the right (Table), we can observe a decrease in systemic vascular pressure and elasticity of the main arteries from the heart to the internal carotid arteries at the use of all types of VS ($p<0.05$), especially pronounced at the use of petrol ($p<0.001$).

INDICATORS OF CEREBRAL HEMODYNAMICS IN ADOLESCENTS DEPENDING ON THE TYPE OF VOLATILE SOLVENT USED (M ± m)

Lead	Group	REG Indicators						
		RI (OM)	Pr (% o)	Qa (c)	α (c)	β (c)	DCI (%)	DSI (%)
FM right	**Control**	1.42 ± 0.12	0.60 ± 0.07	0.19 ± 0.00	0.11 ± 0.01	0.64 ± 0.03	0.63 ± 0.04	0.78 ± 0.03
	"Carat"	1.44 ± 0.05	0.57 ± 0.02	0.18 ± 0.00 *	0.13 ± 0.00	0.65 ± 0.01	0.70 ± 0.01	0.79 ± 0.01
	Paint	1.70 ± 0.32	0.62 ± 0.09	0.18 ± 0.01	0.15 ± 0.02	0.66 ± 0.03	0.76 ± 0.05 *	0.84 ± 0.04
	"Moment"	1.37 ± 0.13	0.56 ± 0.05	0.18 ± 0.00 *	0.13 ± 0.01	0.64 ± 0.02	0.73 ± 0.03 *	0.79 ± 0.03
	Petrol	1.43 ± 0.19	0.56 ± 0.08	0.17 ± 0.00 ***	0.16 ± 0.02 *	0.66 ± 0.03	0.85 ± 0.02 ***	0.90 ± 0.03 **
FM left	**Control**	1.35 ± 0.11	1.05 ± 0.19	0.19 ± 0.00	0.12 ± 0.01	0.63 ± 0.03	0.62 ± 0.05	0.74 ± 0.04
	"Carat"	1.40 ± 0.05	0.56 ± 0.02 *	0.18 ± 0.00	0.13 ± 0.00	0.65 ± 0.01	0.70 ± 0.01	0.79 ± 0.01
	Paint	1.75 ± 0.28	0.59 ± 0.09 *	0.18 ± 0.01	0.14 ± 0.02	0.67 ± 0.03	0.75 ± 0.04 *	0.82 ± 0.03
	"Moment"	1.34 ± 0.14	0.56 ± 0.06 *	0.18 ± 0.08	0.14 ± 0.01	0.64 ± 0.03	0.77 ± 0.03	0.84 ± 0.02 *
	Petrol	1.60 ± 0.19	0.62 ± 0.07 *	0.17 ± 0.00 ***	0.16 ± 0.02 *	0.65 ± 0.03	0.86 ± 0.02 ***	0.93 ± 0.03 ***
OM right	**Control**	1.17 ± 0.16	0.61 ± 0.10	0.19 ± 0.00	0.11 ± 0.01	0.64 ± 0.03	0.60 ± 0.06	0.76 ± 0.05
	"Carat"	1.14 ± 0.06	0.43 ± 0.02	0.18 ± 0.00 **	0.14 ± 0.00	0.64 ± 0.01	0.69 ± 0.02	0.80 ± 0.02
	Paint	1.37 ± 0.28	0.51 ± 0.13	0.18 ± 0.01	0.17 ± 0.02 *	0.65 ± 0.03	0.78 ± 0.08 *	0.91 ± 0.05 *
	"Moment"	1.17 ± 0.10	0.53 ± 0.06	0.17 ± 0.00 *	0.14 ± 0.01 *	0.63 ± 0.03	0.69 ± 0.04	0.81 ± 0.04
	Petrol	1.74 ± 0.53	0.63 ± 0.19	0.17 ± 0.00 **	0.15 ± 0.02 *	0.66 ± 0.03	0.65 ± 0.11	0.74 ± 0.09
OM left	**Control**	1.45 ± 0.27	0.55 ± 0.13	0.19 ± 0.01	0.12 ± 0.01	0.63 ± 0.03	0.59 ± 0.06	0.72 ± 0.04
	"Carat"	1.13 ± 0.06	0.50 ± 0.03	0.18 ± 0.00 **	0.13 ± 0.00	0.65 ± 0.01	0.67 ± 0.02	0.78 ± 0.02
	Paint	1.78 ± 0.04	0.69 ± 0.02	0.18 ± 0.01	0.16 ± 0.02	0.66 ± 0.03	0.82 ± 0.04 **	0.89 ± 0.04 **
	"Moment"	1.45 ± 0.23	0.72 ± 0.14	0.17 ± 0.00 *	0.13 ± 0.01	0.63 ± 0.02	0.70 ± 0.05	0.81 ± 0.05
	Petrol	1.33 ± 0.32	0.45 ± 0.08	0.16 ± 0.00	0.14 ± 0.02	0.67 ± 0.03	0.70 ± 0.11	0.78 ± 0.11

Note: the asterisk marks statistically reliable results between the control and the main group: * – $p<0.05$. ** – $p < 0.01$. *** – $p<0.001$

The rate of α (c), which characterizes vascular distensibility and reflects the tone and elasticity of the vascular wall at the use of all types of VS, was increased. Statistically significant differences ($p<0.05$) as compared to the control group, were detected at the use of petrol.

DCI (%), which characterizes peripheral resistance (precapillary vascular tone) at the use of all types of VS, was increased. Statistically significant differences ($p<0.05$) were detected at the use of paints and "Moment" glue. A particularly significant increase in the vascular tone of the end part of microvasculature was observed at the use of petrol ($p<0.001$).

DSI (%), which reflects the venous tone and the outflow of blood from the arteries to the veins, was increased at the use of various types of VS as compared to the control group. Statistically significant differences were identified at the use of petrol ($p<0.01$).

In the left frontal lead, Pr indicator (‰), which reflects the relative blood volume pulse and characterizes blood supply to the area under study, is statistically significantly ($p<0.05$) reduced in all groups of users, compared to the control group.

Qa (c) differed statistically significantly from the control group at the use of petrol ($p<0.01$).

The rate of α (c) in adolescents of the main group was slightly higher than that of the control group. Statistically significant differences were identified at the use of petrol ($p<0.05$), indicating a decrease in vascular wall elasticity of brain vessels.

DCI values (%) in all the groups were increased, which is typical of vascular hypertension of the initial part of microvasculature, arterioles and precapillaries. Statistically significant differences were detected at the use of paints ($p<0.05$), being most pronounced at the use of petrol ($p<0.001$).

DSI values (%) in the main group trended upwards. A particularly significant increase was observed at the use of petrol ($p<0.001$) which may have caused a venous outflow delay. In this case, we can talk about hyperemia.

In the right OM lead, Qa (c) in all the groups under study tended upwards, which indicates a lower systemic vascular tone and declining elasticity of main arteries from the heart to vertebral arteries. Statistically significant differences were detected at the use of "Moment" glue ($p<0.05$), being more pronounced at the use of petrol and "Carat" leather dye ($p<0.01$).

The rate of α (c) was increased as compared to the control group using "Moment" glue, paint and petrol ($p<0.05$), indicating a decrease in elasticity of the vascular wall of brain vessels.

DCI (%) in all the groups under study was increased as compared to the control one, but statistically significant differences were revealed only in the group of paint users ($p<0.05$), indicating increased vascular tone in the initial part of microvasculature, arterioles and precapillaries.

DSI (%) in all main groups was increased; statistically significant differences were observed only at the use of paints ($p<0.05$). In this case, it characterizes increased postcapillary, venule and venous tone.

In the left OM lead, Qa (c) values had statistically significant differences between the groups using "Moment" glue ($p<0.05$) and "Carat" dye ($p<0.01$), which indicates a total hypotonic state of vessels from the heart to the vertebrobasilar system (vertebral arteries) in these groups.

In the group of paint users, we revealed a sharp increase in DCI (%) and DSI (%) in the left OM ($p<0.01$) as compared to the control group, which characterized vascular hypertension of the initial and end parts of microvasculature in vertebral arteries and, consequently, signs of venostasis.

For the rest of the indicators, no statistically significant differences were detected.

Conclusion

The use of different types of VS caused multidirectional changes in cerebral hemodynamics. There was detected a decrease in pulse volume and volumetric blood flow in all groups of VS users, as compared to the control group, reduction of blood filling in large, medium and small arteries, being most pronounced in internal carotid arteries, especially at the use of petrol. There was detected a decline in tone and elasticity of blood vessels throughout the arterial bed, being most pronounced in internal carotid arteries at the use of petrol and in vertebral arteries at the use of paint.

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ХАРАКТЕРИСТИКА ПОКАЗАТЕЛЕЙ МОЗГОВОЙ ГЕМОДИНАМИКИ У НЕСОВЕРШЕННОЛЕТНИХ В ЗАВИСИМОСТИ ОТ ВИДА УПОТРЕБЛЯЕМОГО ЛЕТУЧЕГО РАСТВОРИТЕЛЯ

В статье представлены результаты исследования показателей мозгового кровообращения у подростков, употребляющих различные летучие растворители (ЛР). Полученные данные указывают на то, что происходят разнонаправленные изменения в состоянии церебрального кровообращения в зависимости от вида употребляемого ингалянта: происходит снижение величин пульсового кровенаполнения и объемного кровотока во всех группах, употребляющих ЛР, по сравнению с контрольной, снижение кровенаполнения крупных, средних и мелких артериальных сосудов, наиболее выраженное в бассейне внутренних сонных артерий.

Ключевые слова: *подростки, церебральная гемодинамика, психоактивные вещества, летучие растворители.*

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