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FEATURES OF CEREBRAL BLOOD FLOW REACTIVITY IN PATIENTS WITH POST-TRAUMATIC EPILEPSY

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Abstract: Transcranial Doppler ultrasonography was used to examine 65 young patients with symptomatic posttraumatic partial epilepsy. Cerebral arterial blood flow velocity and reactivity to functional stress were assessed. Hyporeactivity to vasoconstrictor stress was observed in all clinical groups. Depletion of vasodilator responses was observed in patients with subcompensation and decompensation of the disease. Patients with frequent epileptic seizures showed a significant decrease in reactivity to orthostatic stress. Mild hyperreactivity to the antiorthostatic test was detected in the group of patients with clinical compensation. The hyporeactivity to functional stress in patients with epilepsy is due to the possible parasympathetic influence of the suprasegmental autonomic nervous system.

Keywords: *Transcranial Doppler sonography, cerebrovascular reactivity, posttraumatic epilepsy, cerebral hemodynamics.*

Introduction

One of the most common consequences of traumatic brain injury (TBI) is posttraumatic epilepsy (PTE), which develops within 3 to 18 months from the time of injury, whether first or repeated [1,2]. Worldwide, TBI is the leading identified cause of symptomatic epilepsy in young adults.

Convulsions in PTE are accompanied by changes functional indicators organisms that are regulated autonomic nervous system (ANS) [3,4]. Violations regulations precede hemodynamic , metabolic , energetic violation and can be early prognostic sign probabilities development of PTE due to suffered TBI [5].

The state of cerebral hemodynamics in patients with PTE is an important mechanism for ensuring the vital activity of the brain.

An epileptic seizure occurs as a result of excessive neural discharges that can affect either part of the brain or spread to the entire brain [6]. The presence of changes in cerebral hemodynamics in patients with epilepsy makes the use of Transcranial Doppler Sonography (TDS) relevant, since the method allows obtaining reliable information on the velocity characteristics of the flow in cerebral vessels and the state of cerebral hemodynamics [7]. The use of TDS with the application of various functional loads of physical and chemical nature seems promising [8].

Today, it seems valuable to study cerebrovascular reactivity in young patients with PTE.

Objective

To study the state of cerebral hemodynamics and vascular regulation using the TDS method.

Materials and Methods

A total of 65 patients with PTE aged 20 to 45 years were examined. According to the frequency of partial epileptic seizures, patients were divided into 3 groups: Group 1 – 22 patients with a frequency of 2-3 seizures per month; Group 2 – 24 patients with a frequency of 1 seizure every 1.5 – 2 months; Group 3 – 19 patients with clinical remission for 6 months.

The control group (CG) consisted of 20 healthy subjects of the same gender and age. Cerebral hemodynamics were studied using an Ultima - PA ultrasound scanner manufactured by RADMIR (Kharkiv, Ukraine). Time-averaged maximum blood flow velocity (TAMX) was measured in the anterior (ACA), middle (MCA), posterior (PCA), vertebral (VA), and basilar (BA) arteries. A pulsed transducer with a carrier frequency of 2 MHz (for transcranial imaging) was used.

The state of cerebrovascular reactivity was assessed using the following functional loads:

1) hypercapnic load – voluntary breath holding for 40-60 sec; using the reactivity coefficient to hypercapnic load – CrCO2.

2) hyperventilation load – intensive breathing for one minute; using the reactivity coefficient to hypocapnic load – CrO2.

3) orthostatic and antiorthostatic loads using the reactivity coefficients for orthostatic and antiorthostatic loads - CrOL and CrAOL.

Young patients with no history of cerebrovascular diseases or focal brain pathology (according to MRI data) were selected for the study.

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Results and Discussion

The study of TAMX velocity indicators in cerebral arteries revealed the following patterns (Table 1).

In the first group of patients, no significant differences in TAMX values were observed compared to the control group. TAMX asymmetry in the major arteries of the head was observed in 39.6% of patients; in some patients, the degree of TAMX increase indicated vasospasm in individual vascular beds. A tendency toward vasospasm was observed in patients who were examined after seizures and was noted in the MCA in 21.2% of patients and in the VA in 19.5%. A vasospastic reaction was observed only in patients who were examined shortly after the onset of a grand mal seizure or a series of seizures.

In patients of the 2nd group, TAMX in the MCA and ACA did not differ from the normal values. In 30.6% of patients, TAMX asymmetry was detected in the cerebral arteries (25-30%). In 19.3% of patients, TAMX in the BA and one of the VA was moderately increased, in 17.% it was decreased, and in 12.2%, TAMX was increased in both VAs. Asymmetry was observed in the ACA in 8.6% of patients, in the MCA in 13.4%, in the PCA in 14.6%, and in the VA in 18.2%.

In patients of group 3, no significant differences in TAMX parameters from the norm were observed. Vasospastic reactions in the vertebrobasilar system vessels occurred in 16.5% of patients, and vasodilatory reactions occurred in 15.2%. Blood flow asymmetry (25-30%) in the MCA was observed in 13.4% of cases, in the VA – in 16.6%, and in the PCA – in 20.1%.

Table 1. TAMX values (cm/s) in intracranial arteries in patients with epilepsy.

	MCA	ACA	PCA	VA	BA
CG	61.6+11.2	48.9+6.7	38.5+7.7	36.8+10.3	38.5+11.4
Group 1	58.8+9.4	42.8+8.4	40.4+6.2	35.1+12.7	36.7+9.2
Group 2	60.7+9.1	47.4+7.2	43.3+7.4	35.6+6.1	39.8+8.1
Group 3	62.0±7.2	45.4±11.9	44.0±6.3	36.5 ± 7.3	38.8 ± 6.2

* $p < 0.05$

In the subjects of the control group, the CVR indices were: CrOL - 0.87±0.07; CrAOL - 1.15±0.04; CrCO2 - 1.36±0.07; CrO2 - 0.52±0.08. The values of these indices in patients of clinical groups 1, 2 and 3 that were outside the confidence interval in relation to the control group were interpreted as hyperreactivity and hyporeactivity (Table 2). A change in the direction vector of the TAMX reaction during exercise was interpreted as CVR inversion.

The CrCO2 values in the 1st and 2nd groups of patients were lower than those in the control group (1.21±0.05 in the 1st group and 1.22±0.03 in the 2nd group; $p<0.05$). The CrCO2 values in patients of the 3rd group were identical to those in the control group.

Patients exhibit two types of autoregulatory responses to CO2 loading: hyperreactive and hyporeactive. This trend is most pronounced in clinical groups 1 and 2. The hyporeactive response is predominant, occurring in 61.5% of patients in group 1 and 48.4% in group 2. In group 3, normoreactivity was predominant (90.3%).

The CrO2 values were: 0.38±0.05 in group 1, 0.36±0.06 in group 2, and 0.44±0.03 in group 3. Hyporeactivity also predominated in all clinical groups (55.8% in group 1,86.2% in group 2, and 72.7% in group 3). Thus, a moderate decrease in vasoconstrictor reserve was characteristic of all groups of patients with epilepsy, regardless of the degree of compensation. It can also be concluded that a decrease in the vasoconstrictor component reserves is more significant for patients than similar changes in the vasodilator component.

Table 2. Cerebrovascular reactivity indices in patients with epilepsy

	CrCO2	CrO2	CrOL	CrAOL
CG	1.36+0.03	0.52+0.04	0.87+0.04	1.19+0.04
Group 1	1.21+0.05*	0.38+0.05*	0.73+0.05*	1.18+0.04
Group 2	1.22+0.03 *	0.36+0.06 *	0.73+0.04*	1.17+0.06
Group 3	1.31+0.05	0.44+0.03*	0.86+0.05	1.27+0.03*

*$p < 0.05$

The neurogenic mechanism of autoregulation was studied using an orthostatic test. TAMX values in the MCA were compared at rest and during orthostatic loading. A decrease in TAMX in the MCA of more than 10 % was interpreted as "orthostatic instability."

In the control group, orthostatic stability (OS) was noted in 91.7 %, in the 1st group in 57.8%, in the 2nd group in 66.8%, in the 3rd group in 84.9%.

A decrease in the prevalence of OU in this category of patients indicates changes in the functional state of the brain stem structures that carry out central regulation of blood circulation.

The CrOL in the control group was 0.87±0.04. In patients of groups 1 and 2, CrOL levels were reduced and amounted to 0.73±0.05 and 0.73±0.04, respectively. These changes were most likely due to the significant parasympathetic influence present in

this category of patients. Significant decrease in CrOL levels in patients in Group 3 compared to the control group (0.86±0.05). This result correlates with the autonomic support indicators, indicating the absence of signs parasympathicotonia in the 3rd clinical group.

CrAOL values in groups 1 and 2 (1.18±0.04 and 1.17±0.06) did not differ significantly from those in the control group (1.19±0.04). Mild hyperreactivity to the antiorthostatic load was observed in group 3 patients (1.27±0.03). This hyperreactivity is most likely due to sympathicotonia , which was observed in a significant proportion of patients in group 3 according to the autonomic status study.

Thus, patients from all clinical groups showed changes in reactivity to hypercapnic, hypocapnic , orthostatic and antiorthostatic loads in both vascular basins, which is associated with disturbances in the metabolic and neurogenic circuits of cerebral blood flow regulation.

Conclusions

1. A study of background cerebral hemodynamics in epilepsy patients revealed no statistically significant changes in arterial blood flow. Some patients, primarily after frequently recurring seizures, experienced functional asymmetries in cerebral blood flow velocity and vasospastic reactions.

2. Hyporeactivity to vasoconstrictor loads was observed in all clinical groups. Depletion of vasodilator responses was observed in patients with subcompensated and decompensated disease.

3. In patients with frequent epileptic seizures, a significant decrease in reactivity to orthostatic stress was observed.

4. The hyporeactive response to functional loads in patients with epilepsy is probably due to the possible parasympathetic influence of the suprasegmental autonomic nervous system.

Conflict of interest

The authors of the manuscript consciously declare that there is no actual or potential conflict of interest regarding the results of this work with pharmaceutical companies, biomedical device manufacturers, other organizations whose products, services, financial support may be related to the subject of the materials provided, or who sponsored the research conducted.

Compliance with ethical standards

The authors of the manuscript consciously certify that the study was conducted using data from primary medical records and included clinical observations of patients. The study was conducted in accordance with the ethical standards of the Declaration of Helsinki of the World Medical Association on the ethical principles of conducting scientific medical research involving human subjects, the European Society Directive 86/609 on the participation of humans in biomedical research, as well as the Order of the Ministry of Health of Ukraine No 690 of September 23, 2009. Informed consent to participate in the study was obtained from all participants after providing them with clear, complete and accessible information about the purpose, design and methodology of the study, its potential risks, expected benefits and possible alternatives. All participants confirmed their voluntary participation by signing an informed consent document. Participants had the right to refuse participation at any time without giving reasons. In accordance with confidentiality regulations, all data was collected anonymously and processed in compliance with applicable data protection legislation. All information was used exclusively for this study and was summarized for further analysis of the results.

Primary data and materials

The authors of the manuscript consciously declare that the work uses the results of their own clinical studies, which were systematized and analyzed by the authors. Primary data include generalized patient indicators, laboratory results, protocols and obtained quantitative characteristics. All materials are stored in the archive of the research group and can be provided upon reasonable request to the corresponding author, taking into account the requirements of confidentiality and ethical norms.

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