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COVID-19 KEÇİRMİŞ XƏSTƏLƏRDƏ BEYİN HEMODİNAMİKASININ XÜSUSİYYƏTLƏRİ

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Xülasə. Məqalədə COVID-19 keçirmiş 74 xəstədə beyin damarlarının dopplerografiyasının nəticələri təqdim edilib (psixi pozuntusu olan 39 nəfər – I qrup, normal psixikaya malik, 35 nəfər – II qrup). Orta beyin arteriyaları (OBA) arasındakı qan axınının dəqiqlik həcmnin (QADH) asimmetriya dərəcəsi və beyin venalarının görüntülənməsi araşdırılmışdır. QADH asimmetriyası 20%-dən az həddə I qrupda 8 (20,5±6,5%) və II qrupda 18 (51,4±8,4%) xəstədə ($p<0,01$), 21-40% həddə – 15 (38,5±7,8%) və 12 (34,3±8,0%) xəstədə, 40%-dən çox həddə – 16 (41,0±7,9%) və 5 (14,3±5,9%) xəstədə ($p<0,01$) müşahidə edilmişdir. Göstərilmişdir ki, Rosenthal venası I qrupda 36 (92,3±4,3%), II qrupda 25 (71,4) xəstədə ($p<0,05$), orta beyin venası – 32 (82,1±6,1%) və 19 (54,3±6,3%) xəstədə ($p<0,05$), düz sinus – 35 (89,7±4,9%) və 21 (60,0±8,3%) xəstədə ($p<0,01$) görüntülənib.

Tədqiqatın nəticələri göstərir ki, psixika pozulması olan Covid-19 keçirmiş xəstələrdə orta beyin arteriyaları arasındakı qan axınının dəqiqlik həcmnin 40%-dən çox asimmetriyası və beyin venalarının görüntülənmə tezliyi psixika pozulması olmayanlara nisbətən daha tez-tez ($p<0,01$) qeydə alınır.

Açar sözlər: COVID-19, beyin hemodinamikası, psixika pozulmaları, dopplerografiya

Ключевые слова: COVID-19, церебральная гемодинамика, психические расстройства, доплерография

Key words: COVID-19, cerebral hemodynamics, mental disorders, dooplerography

CHARACTERISTICS OF CEREBRAL HEMODYNAMICS IN PATIENTS RECOVERED FROM COVID-19

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Summary. The article presents the results of cerebral vessels Dopplerography in 74 patients with COVID-19 (39 with mental disorders – group I, 35 without them - group II). The degree of asymmetry of the minute blood flow (MBF) between the middle cerebral arteries (MCA) and the frequency of visualization of cerebral veins were determined. Asymmetry of the minute flow volume (MFV) within less than 20% was observed in 8 (20.5 ± 6.5%) patients of group I and 18 (51.4 ± 8.4%) of group II ($p<0.01$), in the range of 21-40% – in 15 (38.5 ± 7.8%) and 12 (34.3 ± 8.0%) patients, in the range of more than 40% – in 16 (41.0 ± 7.9%) and 5 (14.3 ± 5.9%) patients ($p<0.01$). It was shown that the vein of Rosenthal was visualized in 36 (92.3±4.3%) patients of group I, in 25 (71.4) patients of group II ($p<0.05$), the middle cerebral vein – in 32 (82.1±6.1%) and 19 (54.3±6.1%) patients ($p<0.05$), the straight sinus – in 35 (89.7±4.9%) and 21 (60.0±8.3%) patients ($p<0.01$).

The results of the study show that the asymmetry of the minute flow volume between the middle cerebral arteries within more than 40% and visualization of the cerebral veins in patients who have had COVID-19 with mental disorders are observed more often ($p < 0.01$) than in people without mental disorders.

The World Health Organization (WHO) has defined the COVID-19 epidemic as a global health emergency and, on March 11, 2020, as a global pandemic [1]. The COVID-19 pandemic is one of the largest global crises, which has had serious negative consequences for human health, health systems, economies and societies. As of 5 October 2020, there were more than 35 million confirmed cases of severe acute respiratory syndrome coronavirus [2, 3]. In addition to respiratory symptoms, patients with COVID-19 often experience gastrointestinal disorders, cardiac dysfunction, and hypercoagulability with thromboembolic complications, including ischemic stroke. Mao L, et al. (2020) divided all neurological symptoms of patients with COVID-19 into 3 categories: 1) symptoms of damage to the central nervous system - dizziness, headache, impaired consciousness, acute cerebrovascular accident, ataxia and seizures; 2) symptoms of damage to the peripheral nervous system - impaired taste, smell and vision, as well as nerve pain; 3) the appearance of signs of damage to skeletal muscles [4].

According to the literature, more than half of patients who have recovered from COVID-19 suffer from constant fatigue, anxiety, and depression, regardless of the severity of the disease [5]. Studies show that the risk of developing psychoneurological disorders in the first weeks after the acute phase of COVID-19 is high [6, 7].

The incidence of various psychoneurological symptoms among patients who have had COVID-19 varies widely according to various authors. The most common post-COVID symptoms are anxiety, depression, and bipolar disorder. These symptoms were statistically significantly more common among patients with severe COVID-19 than with mild cases who were treated on an outpatient basis [8-10].

Individuals with mental disorders may be at higher risk of severe COVID-19 outcomes and higher incidence of comorbidities [11].

Since neurological complications are common in COVID-19 patients, various pathophysiological mechanisms have been proposed, including direct invasion of the CNS, activation of coagulation and inflammatory cascades, and the hypoxemic system [12]. Circulating cerebral microemboli leading to stroke or encephalopathy may occur in patients hospitalized with COVID-19, and these microemboli may occur in the absence of severe pulmonary manifestations [13].

Evaluation of cerebral hemodynamics among patients with neurological disorders after COVID-19 is important [14, 15]. Transcranial Dopplerography, being a non-invasive accessible method, allows recording quantitative parameters of blood flow in the main arteries and veins of the brain, thereby assessing the state of hemodynamics [2, 16].

The purpose of the study was to study the features of cerebral hemodynamics in patients who have had COVID-19 using transcranial triplex Dopplerography.

Material and methods. The results of transcranial Doppler ultrasonography were analyzed in 74 patients aged 28–49 years (mean 35.3 ± 4.6 years) who had COVID-19. Of these, 39 had persistent psychoemotional disorders (group I), and 35 had episodic psychoemotional disorders (group II).

Doppler sonography was carried out 2-4 months after suffering from COVID-19 using a Philips HD-11 ultrasound machine with a sector sensor in a frequency mode of 2-4 MHz. Hemodynamic parameters were determined in the middle cerebral artery on both sides of the brain.

Statistical analysis was carried out using the nonparametric Mann-Whitney method. If the p value < 0.05 , the difference between the compared groups was considered statistically significant.

Results. The analysis of psychoneurological clinical symptoms in patients who had COVID-19 was carried out on the basis of previously published scientific works [5]. Table 1 presents the most common clinical symptoms of psychoemotional disorder, which included 6 out of 13, occurring in more than 60% of patients who have had COVID-19.

Table 1. The most common clinical symptoms of psychoemotional disorders in patients who have had COVID-19

Clinical symptoms of psychoemotional disorder	I group (n=39)	II group (n=35)
Sense of anxiety	36 (92,3±4,3%) P<0,001	4 (11,4±5,4%)
Internal tension	28 (71,8±7,2%) P<0,001	6 (17,1±6,4%)
Lowered mood background	27 (69,2±7,4%) P<0,001	5 (14,3±5,9%)
Sleep disorders	26 (66,7±7,5%) P<0,01	8 (22,9±7,1%)
Vegetative hyperactivity	25 (64,1±7,7%) P<0,01	7 (20,0±6,8%)
Inability to self-control anxiety	24 (61,5±7,8%) P<0,001	6 (17,1±6,4%)

Table 2 shows the frequency of visualization of the large veins of the brain. The vein of Galen in group I was visualized in 37 (94.9±3.5%), in group II – in 31 (88.9±5.3%) cases, the vein of Rosenthal – in 36 (92.3±4.3 %) and in 25 (71.4±7.6%) cases (p<0.05), the middle cerebral vein – in 32 (82.1±6.1%) and in 19 (54.3±8, 4%) cases (p<0.05), straight sinus – in 35 (89.7±4.9%) and 21

(60.0±8.3%) cases (p<0.01), respectively.

The diameter of the vein of Galen in group I averaged 6.1±0.5 mm, in group II – 5.2±0.4 mm, the vein of Rosenthal – 4.9±0.4 mm and 3.8±0.3 mm (p<0.05), the middle cerebral vein – 3.5±0.3 mm and 2.4±0.3 mm (p<0.05), the straight sinus – 2.7±0.3 mm and 1.9±0.2 mm (p<0.05), respectively (Fig. 1, 2).

Table 2. Frequency of visualization and diameter of cerebral veins in patients with COVID-19

Cerebral veins	I group n=39		II group n=35	
	Visualization frequency, %	Diameter, mm	Visualization frequency, %	Diameter, mm
Vein of Galena	37 (94,9±3,5%)	6,1±0,5	31 (88,9±5,3%)	5,2±0,4
Vein of Rosenthal	36 (92,3±4,3%) P<0,05	4,9±0,4 P<0,05	25 (71,4±7,6%)	3,8±0,3
Middle cerebral vein	32 (82,1±6,1%) P<0,05	3,5±0,3 P<0,05	19 (54,3±8,4%)	2,4±0,3
The straight sinus	35 (89,7±4,9%) P<0,01	2,7±0,3 P<0,05	21 (60,0±8,3%)	1,9±0,2

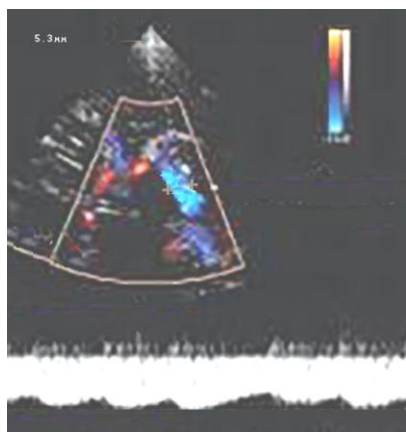


Fig. 1. Registration of the Rosenthal vein in a patient who had recovered from Covid-19 with psychoemotional disorders. The vein diameter is 5.3 mm.

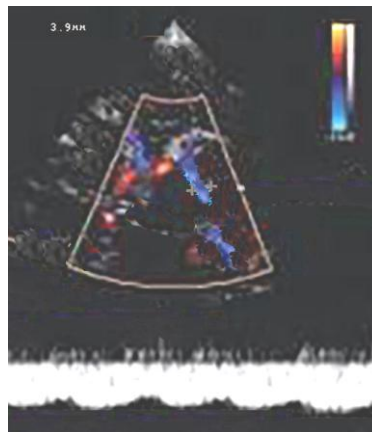


Fig. 2. Registration of the Rosenthal vein in a patient who had recovered from COVID-19 without psychoemotional disorders. The vein diameter is 3.9 mm.

Table 3. Asymmetry degree of minute flow volume between MCA in patients who suffered COVID-19

Degree of asymmetry of the MVF between the MCA, %	I group	II group
< 20%	8 (20,5±6,5%)	18 (51,4±8,4%) P<0,01
21-40%	15 (38,5±7,8%)	12 (34,3±8,0%)
> 40%	16 (41,0±7,9%) P<0,01	5 (14,3±5,9%)

Table 3 presents data on the degree of asymmetry of the minute blood flow volume (MFV) between left and right middle cerebral arteries in patients with and without psycho-neurological disorders. We assessed the degree of asymmetry as minimal (up to 20%),

moderate (from 21% to 40%), and significant (more than 40%). Asymmetry of MBF within less than 20% was observed in 8 (20.5±6.5%) patients in group 1 and 18 (51.4±8.4%) patients in group 2 ($p<0.01$), in the range of 21-40% – in 15 (38.5±7.8%) and 12 (34.3±8.0%) patients, in the range of more than 40% – in 16 (41.0±7.9%) and 5 (14.3±5.9%) patients ($p<0.01$).

The value of the MVF in the middle cerebral arteries depended on the average blood flow velocity, the number of heartbeats, and the oviddiameter and tone of the vessels. In patients who had recovered from COVID-19 with severe psychoemotional disorders, these indicators in the left and right middle cerebral arteries differed more than in patients with minimal psychoemotional disorders (Fig. 3, 4).

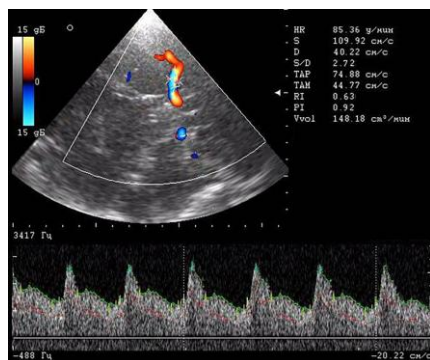


Fig. 3. Registration of blood flow in the left middle cerebral artery in a patient who has had COVID-19 with clinical symptoms of mental and emotional disorders. 101cm³/min, RI – 0,63, PI – 0,92.

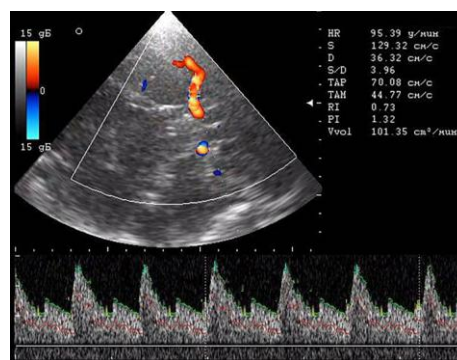


Fig. 4. Same patient. Registration of blood flow in the right middle cerebral artery. Vs - 101 cm³/min, RI – 0,73, PI – 1,32.

Discussion. In addition to respiratory symptoms, patients with COVID-19 also develop gastrointestinal disorders, cardiac dysfunction, and hypoglycemia with thromboembolic events, including ischemic stroke [4, 17, 18]. Psychoemotional disorders occupy an important place in the structure of manifestations of post-COVID syndrome. Despite the achievement of control over the spread of the virus, the incidence of mental disorders in the general population, as well as among people who have recovered from COVID 19, will increase [19].

Transcranial Doppler (TCD) allows to assess the state of cerebral arterial and venous hemodynamics [16]. Circulating microemboli in cerebral arteries can be detected in real time using ultrasound waves, which appear as high-intensity transient signals in the Doppler spectrum [20]. The feasibility of studying cerebral hemodynamics using TCD in patients with COVID-19 has been demonstrated by obtaining basic cerebrovascular parameters. TCD-based assessment provides reliable estimates that can be used in further studies of these patients, especially in the context of prospective studies of COVID complications often associated with delirium, cognitive decline, and ischemic impairment [21, 22].

We have studied cerebral venous hemodynamics in previous studies in acute ischemic stroke [23]. We have found an increase in the diameter of the main cerebral veins as a response to impaired arterial blood flow. Analysis of the Doppler venous spect-

rum in patients with psychoemotional disorders as a result of COVID-19 revealed a reliable difference in the diameter of the veins compared to patients who had Covid-19 without psychoemotional disorders. In addition to venous blood flow, we studied the features of arterial blood flow in the vessels of the Circle of Willis. A significant asymmetry (more than 40%) of the minute blood flow between the left and right middle cerebral arteries was revealed in patients who had Covid-19 with psychoemotional disorders. The degree of asymmetry of blood flow between the left and right middle cerebral arteries in patients without psychoemotional disorders was minimal (less than 20%).

Conclusions

1. Among patients who had COVID-19 with psychoemotional disorders, the degree of asymmetry of the minute blood flow volume between the left and right middle cerebral arteries is significantly ($P < 0.01$) higher than in patients who had COVID-19 without psychoemotional disorders.

2. The diameter of the main cerebral veins in patients who had COVID-19 with psychoemotional disorders is significantly higher ($P < 0.05$) than in patients without clinical symptoms of psychoemotional disorders. An increase in the diameter of the veins contributed to an improvement in their visualization, which was significantly ($P < 0.05$) more often in patients with psychoemotional disorders.

Conflict of interest

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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ОСОБЕННОСТИ ЦЕРЕБРАЛЬНОЙ ГЕМОДИНАМИКИ У БОЛЬНЫХ ПЕРЕНЕСШИХ COVID-19

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Резюме. В статье представлены результаты доплерографии сосудов головного мозга у 74 пациентов с COVID-19 (39 с психическими расстройствами – I групп, 35 без них – II группа). Определяли степень асимметрии минутного объема кровотока (МОК) между средними мозговыми артериями (СМА) и частоту визуализации мозговых вен. Асимметрия МОК в пределах менее 20% наблюдалась у 8 (20,5±6,5%) больных I группы и 18 (51,4±8,4%) II группы (p<0,01), в диапазоне 21-

40% - у 15 ($38,5 \pm 7,8\%$) и у 12 ($34,3 \pm 8,0\%$) больных, в диапазоне более 40% – у 16 ($41,0 \pm 7,9\%$) и у 5 ($14,3 \pm 5,9\%$) больных ($p < 0,01$). Показано, что вена Розенталя визуализировалась у 36 ($92,3 \pm 4,3\%$) больных I группы, у 25 (71,4) больных II группы ($p < 0,05$), средняя мозговая вена – у 32 ($82,1 \pm 6,1\%$) и у 19 ($54,3 \pm 6,1\%$) больных ($p < 0,05$), прямой синус – у 35 ($89,7 \pm 4,9\%$) и 21 ($60,0 \pm 8,3\%$) больных ($p < 0,01$).

Результаты исследования показывают, что асимметрия минутного объема кровотока между средними мозговыми артериями в пределах более 40% и визуализация мозговых вен у пациентов перенесших COVID-19 с психическими расстройствами наблюдается чаще ($p < 0,01$), чем у людей без психических расстройств.

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