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HEMODYNAMIC AND TOMOGRAPHIC COMPARISONS IN PATIENTS WITH MIGRAINE

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Abstract

A comprehensive clinical and instrumental examination of 104 patients with migraine aged 18 to 44 years was performed using transcranial duplex scanning and magnetic resonance imaging in the groups of patients with migraine without aura (59 patients) and with migraine with aura (45 patients). In migraine with aura, according to magnetic resonance imaging, the presence of hyperintense on T2VI and predominantly isointense on T1VI foci with a diameter of 3 to 12 mm was noted in 53.3% of patients, in the group of migraine without aura, these changes were observed in 28.8% of cases. The predominant localization of the foci was the white matter of the temporal areas of the brain (41.6% of patients with migraine with aura and 35.2% of patients with migraine without aura). Cerebral hemodynamics in the middle cerebral arteries during migraine attacks is characterized by a vasospasm pattern in migraine without aura and a pattern of impaired perfusion in migraine with aura. These changes are mainly observed in patients with 2-3 or more hyperintense foci according to MRI. Also, patients in both groups had excessive blood filling of the superior ophthalmic veins, basal veins of Rosenthal,

and direct sinus. Therefore, authors concluded that data obtained emphasize the fundamental diagnostic importance of brain damage comparative evaluation in patients with migraine using informative high-resolution methods of transcranial duplex scanning and magnetic resonance imaging.

Key words: transcranial duplex scanning; magnetic resonance imaging; cerebral hemodynamics; migraine.

Migraine is one of the most common forms of headache, the prevalence of which can reach 22% in women and 16% in men [1]. Interest in this problem is caused by its high prevalence, increasing incidence in young, working-age individuals, as well as difficulties in diagnosis and therapy [2]. The use of modern methods of diagnosis and differential diagnosis of migraine is becoming relevant for further study of the features of this pathology [3, 4].

At the current level, the use of magnetic resonance imaging (MRI) and transcranial duplex scanning (TCD) in the diagnosis of various variants of migraine is relevant [5, 6]. According to literature data, focal changes on MRI in migraine are statistically more common compared to people without headache [7, 8]. Hyperintense foci on T2-weighted images (VI) are twice as common in patients with migraine with aura (40%) as in migraine without aura (20%) [9, 10].

Studies have shown that chronic silent cerebral infarcts measuring 2 mm to 21 mm are found in 7.1% of migraine cases [11]. The number of infarcts in the vertebrobasilar basin was significantly higher in women with migraine (5.4%) compared with the control group (0.7%). In the absolute majority of cases (96.7%) ischemic foci of the vertebrobasilar basin were localized in the cerebellum and were more common in migraine with aura (8.1%) compared with migraine without aura (2.2%) [12, 13].

According to studies in women with migraine, the total volume of hyperintense T2-VI foci of the white matter of the brain was significantly greater than in healthy volunteers. Focal changes in the white matter of the brain in migraine were noted almost 4 times more often than in the control group of the study [14].

Currently, the issue of studying cerebral hemodynamics in patients with migraine is relevant. The TCD method is used to diagnose lesions of the intracranial departments of the main arteries [6, 15].

Recently, a fairly large number of works have been published devoted to the study of cerebral hemodynamic disorders in patients with migraine with and without aura, in the period between attacks and during the attack. Bloodflow indicators in the ophthalmic artery and external carotid artery when assessed by ultrasound were found to be increased. In patients with migraine without aura, an increase in blood flow velocity and a decrease in the pulsation index in the arteries of the base of the brain were noted, and in the group of people with migraine with aura, a decrease in velocity and an increase in peripheral resistance indices [15-17].

There are no data in the available publications on the results of the combined use of MRI and TCD in patients with different types of migraine paroxysms (migraine without aura and migraine with aura).

The aim of the work is to investigate state of brain matter and cerebral hemodynamics using MRI and TCDS in patients with different types of migraine paroxysms.

Material and methods

A comprehensive examination of 104 patients aged 16 to 45 years (41 men and 63 women) was conducted. All patients wrote informed consent before the beginning of the study which allowed to use their test results for scientific purposes.

The criteria for inclusion of patients in the study were: migraine without aura (MwoA) (group 1 - 59 patients), migraine with aura (MA) (group 2 - 45 patients) in accordance with the conditions of the international classification of headache. Control group (CG) – 50 clinically healthy volunteers of both sexes of the appropriate age. All patients underwent a clinical and neurological examination.

The intensity of the cephalgic syndrome was assessed using a visual analog scale and a headache diary filled in by the patient himself. In order to determine the severity of the condition at the time of the attack, the MIDAS scale was used, which characterizes the degree of decrease in the functional activity of a patient with migraine. A score of 20 or more points characterizes a severe form of migraine.

The state of hemodynamics in extra- and intracranial arteries and veins was studied using an ultrasound device “Ultima PA” (RADMIR, Ukraine). The time-averaged maximum blood flow velocity (TAMX), resistance indices (RI) and pulsation indices (PI) in the siphons of the internal carotid (ICA), middle cerebral (MCA), posterior cerebral (PCA), V4 segments of the vertebral arteries (XA), as well as the maximum systolic blood flow velocity (Vmax) in the superior ophthalmic (SOV), basal veins (BV) of Rosenthal, and straight sinus (SS) were studied.

MRI of the brain was performed on a “Signa HDe” device with a magnetic field strength of 1.5T (General Electric, USA). A standard scanning protocol was used, including the following pulse sequences: T1 FSE, T2 FSE, T2 FLA IR or TIRM in three projections.

Statistical analysis and processing of the material was carried out using the software package “Statistica 6.0”. Differences with CG indicators were considered statistically significant at p value <0.05.

Results

The characteristics of the pain syndrome during the period in patients with migraine have the following features. In both groups, the frontal-occipital-temporal localization of pain prevailed (92.6% in the 1st group, 97.4% in the 2nd group) – in 15.5% and 11.3%.

Predominantly left-sided localization of the pain attack occurred in 38.4% of patients in the 1st group and in 29.6% of patients in the 2nd group, predominantly right-sided – in 31.2% and 43.7%, 60%, respectively. Attacks upon awakening were noted in 46.9% of patients in the 1st group and in 31.2% of patients in the 2nd group, daytime attacks - in 40.6% and 53.4% of cases, respectively, night attacks - in 12.5% and 15.4%.

Signs of photophobia were found in 81.3% and 88.4% of patients, fear of sound - in 77.2 and 80.8%, a feeling of pulsation in the head - in 56.3% and 49.7%, nausea and vomiting - in 48.9% and 57.4%, dizziness - in 45.2% and 40.6%.

Attacks were treated with combinations of analgesics and antimigraine drugs of the triptan series (44.9% and 48.6%), spontaneous disappearance of the attack during sleep was less common (31.8 and 38.6%). The average duration of the disease was 10.7±6.8 years.

The frequency of migraine attacks was 4.8±2.6 per month, duration - 13.4±9.7 hours. In 15.7% at the time of the attack, very high intensity of headache was noted, in 61.1% - high, in 27.6% - moderate, in 2.2% - weak.

The average score on the MIDAS scale was 25.7, which corresponded to a significant decrease in overall performance and daily activity.

According to MRI, structural changes in the white matter of the brain were detected in 17 (28.8%) patients of the 1st group and 24 (53.3%) patients of the 2nd group. These changes were characterized by hyperintense on T2VI and mainly isointense on T1VI foci, the sizes of which did not exceed lacunar infarction (no more than 15 mm) and ranged from 3 to 12 mm, which correlated with the literature data.

No foci in the subcortical nuclei (caudate nuclei, putamen, globus pallidus) and optic chiasms, characteristic of lacunar infarctions of the basin of the perforating arteries of the middle and posterior cerebral arteries, were found in our study. Single foci were noted in

21.4% of cases (group 1 - 17.2%, group 2 - 4.2%), 2-3 foci - in 51.6% (group 1 - 29.4%, group 2 - 22.2%), more - group 1 - 25.6%, group 2 - 1.6%. Most often, the foci were localized in the temporal (38.6%, group 1 - 35.4%, group 2 - 40.2%) and frontal (31.4%, group 1 - 31.7%, group 2 - 30.1%). Expansion of Virchov-Robin spaces was detected in 47.5% of patients (group 1 - 47.8%, group 2 - 29.7%).

Studies of velocity indicators in cerebral arteries revealed the following patterns. In patients of both groups, TAMX and RI indicators for ICA did not differ from the normative indicators, RI indicators for VA also did not differ from the norm in both groups, in group 1, blood flow indicators for MCA slightly exceeded those in the control group, while RI values were lower than the normative ones.

Also in this group, most patients (58.9%) had flow velocity asymmetries (25-30%) in the MCA and VA (Fig. 1, 2).

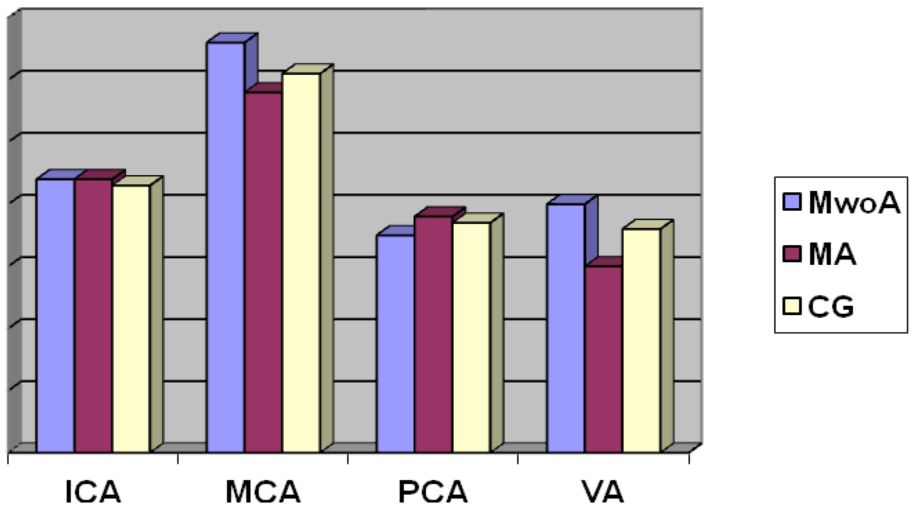

Fig. 1. TAMX indices (sm/s) in patients with migraine

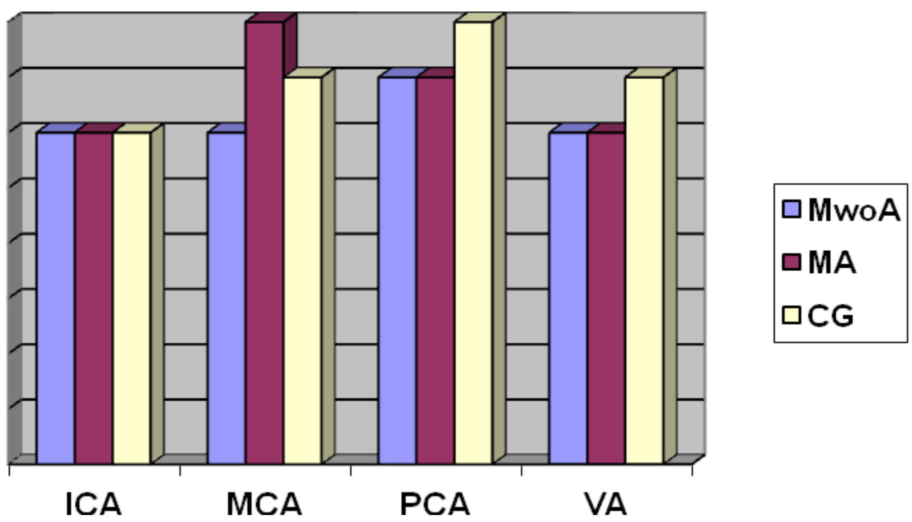

Fig. 2. RI indices in patients with migraine

A comparative analysis of the main hemodynamic parameters in patients was also conducted depending on the nature of structural changes in the white matter of the brain according to MRI data.

Patients with hyperintense on T2WI and predominantly isointense on T1WI foci were divided into three groups: with the presence of single foci – 17 patients, including 12 patients in group 1 and 5 patients in group 2; with the presence of 2-3 foci – 24 patients, including 10 patients in group 1 and 14 patients in group 2; with the presence of more than 3 foci – 11 patients, including 6 patients in group 1 and 5 patients in group 2.

For comparative assessment, hemodynamic parameters in SMA and ZMA were selected as the most indicative in patients with migraine according to the above-described studies (Table 1).

Table 1.

TAMX and PI indexes in intracranial arteries in patients with migraine depending on the nature of structural changes in brain white matter according to MRI data.

Groups of patients	The studied parameters	The value of investigated criteria, M±m			
		MCA		PCA	
		TAMX, sm/s	PI	TAMX, sm/s	PI
Group 1, n=33	Single focus	63.9 ±8.4	0.80 ±0.07	55.1 ±5.2*	0.75 ±0.06
	2-3 foci	77.6±10.8*	0.81 ±0.06	58.3 ±6.9*	0.73 ±0.05
	> 3-d foci	88.3 ±9.7*	0.81 ±0.03	62.8±5.8*	0.75 ±0.07
Group 2, n=24	Single focus	61.6 ±5.9	0. 94±0.04	49.5 ±4.3*	0.74±0.05
	2-3 foci	64.3 ±9.7	0.92 ±0.05	48.2 ±5.6*	0.73±0.07
	>3-d foci	54.8 ±10.6	1.06±0.05*	48.6 ±5.4*	0.73±0.04
CG		62.6 ±10.1	0.89 ±0.06	36.5 ±5.7	0.78±0.06

Note: * - p<0.05 - statistical differences of the investigated parameters compared with the same in the control group

In clinical group 1, the speed indicators in the MCA in subjects with single foci did not significantly differ from the CG data (63.9 ± 8.4 cm/s, CG-62.6 ± 10.1 cm/s), and with an increase in the number of foci they progressively increased (77.6 ± 10.8 cm/s, p <0.05, and 88.3 ± 9.7 cm/s, p <0.05, respectively).

The flow velocity in the PCA in patients of group 1 was increased in all subgroups, with maximum severity in patients with 3 or more foci (55.1 ± 5.2 cm/s, $p < 0.05$; 58.3 ± 6.9 cm/s, $p < 0.05$; 62.8 ± 5.8 cm/s, $p < 0.05$, respectively; CG 36.5 ± 5.7 cm/s) (Fig. 3).

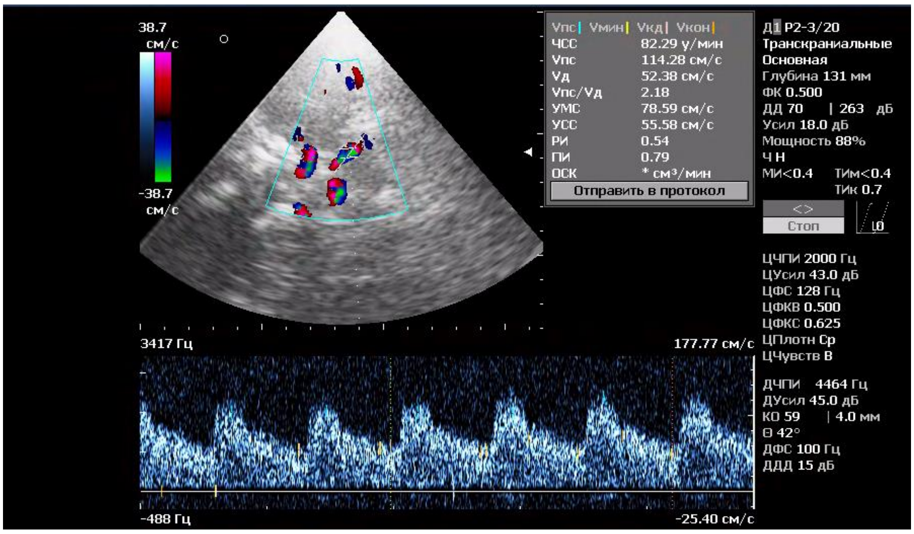

Fig.3. Increased blood flow velocity in the PCA in a patient with migraine.

The pulsatility index was reduced in all subgroups, mainly in MCA (0.8±0.07, 0.81±0.06, 0.81±0.03 cm/s, respectively; CG 0.89 ±0.06 cm/s) and, to a lesser extent, in PCA (0.75±0.06, 0.73 ±0.05, 0.75 ±0.07 cm/s, respectively; CG- 0.78 ±0.06 cm/s).

In patients of the 2nd clinical group, the velocity indicators in the MCA with single foci and 2-3 foci in the subjects did not differ significantly from the CG data (61.6 ± 5.9 cm/s, 64.3 ± 9.7 cm/s, respectively; CG 62.6 ± 10.1 cm/s), in patients with more than three foci the flow velocity was reduced compared to CG (54.8 ± 10.6 cm/s).

The flow velocity in the MCA in patients of the 2nd group was increased in all subgroups, similarly to the 1st group (49.5 ± 4.3 cm/s, $p < 0.05$; 48.2 ± 5.6 cm/s, $p < 0.05$; 48.6 ± 5.4 cm/s, $p < 0.05$, respectively; CG - 36.5 ± 5.7 cm/s). The pulsatility index in the MCA was increased in all subgroups, with the maximum severity in the subgroup with more than three foci (0.94 ±0.04, 0.92 ±0.05, 1.06 ±0.05 cm/s, $p < 0.05$, respectively; CG- 0.78 ±0.06 cm/s).

Thus, the most important hemodynamic patterns in patients with migraine are excessive perfusion in the middle and posterior cerebral arteries in migraine without aura and impaired perfusion in migraine with aura in the middle cerebral arteries. These changes were most pronounced in patients with 2-3 or more hyperintense T2VI and predominantly isointense T1VI foci according to MRI data.

Cerebral venous hemodynamics in the studied groups was characterized by the presence of increased venous outflow in the superior ophthalmic veins, mainly in patients with migraine with aura, as well as in the basal veins of Rosenthal and the straight sinus, mainly in patients with migraine without aura. The indicators of venous outflow in the vertebral veins did not differ from the normative ones (Fig. 4).

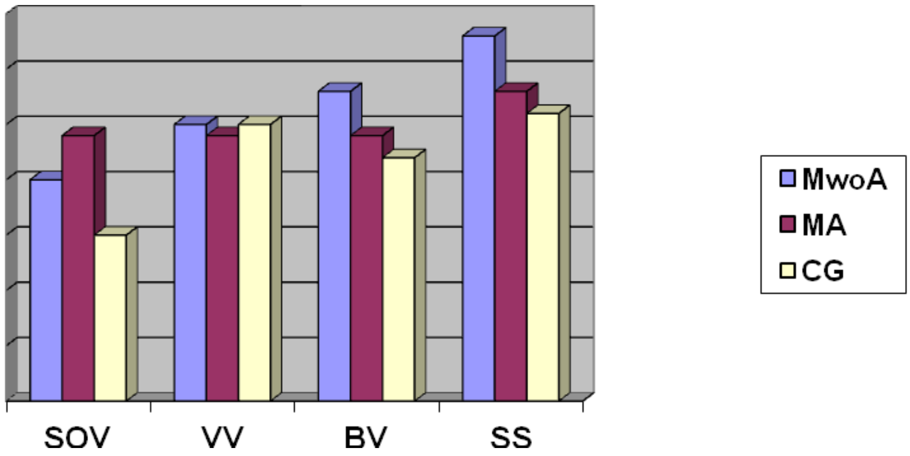

Fig.4. Blood flow parameters in venous collectors in patients with migraine

Discussion

Our data revealed that hyperintense on T2WI and, mainly, isointense on T1WI foci presence is characteristic of patients with migraine. Differences between groups of patients are manifested in a higher prevalence of multiple foci in patients with migraine with aura, which confirms the well-known ideas about the manifestations of migraine with aura in the form of cerebrovascular pathology with a high risk of stroke.

We assessed similar data in patients in the post-COVID period [18, 19].

Our data are important because they showed that foci predominant localization (frontal and temporal regions in both groups) generally coincides with the tendency to localize the pain syndrome [20-22].

The most important hemodynamic patterns in patients with migraine are excessive perfusion in the middle and posterior cerebral arteries in migraine without aura and impaired perfusion in migraine with aura in the middle cerebral arteries.

These changes were most pronounced in patients with 2-3 or more hyperintense T2VI and predominantly isointense T1VI foci on MRI. The hemodynamic feature of migraine with aura is the presence of vasoconstrictor reactions and background hypertonus of resistive vessels.

We would like to stress in this aspect that it is important to take into account the functional state of the autonomic reactivity of patients [23, 24].

Therefore, the data obtained highlight the fundamental diagnostic importance of assessing brain damage in a comparative aspect in patients with migraine using informative high-resolution methods of transcranial duplex scanning and magnetic resonance imaging.

Conclusions

1. In patients with migraine with aura, hyperintense T2VI foci were significantly more frequently detected on MRI, mainly in the white matter of the temporal and frontal regions.

2. Cerebral hemodynamics in the middle cerebral arteries during a migraine attack is characterized by a vasospasm pattern in migraine without aura and a pattern of impaired perfusion in migraine with aura. These changes are mainly observed in patients with 2-3 or more hyperintense foci on MRI.

3. Patients in both clinical groups had excessive perfusion in the superior ophthalmic veins, basal veins of Rosenthal, and the rectus sinus.

4. The data obtained emphasize the fundamental diagnostic importance of brain damage comparative evaluation in patients with migraine using informative high-resolution methods of transcranial duplex scanning and magnetic resonance imaging.

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Author Contributions

Conceptualization, (Kalashnikov V.Y.); methodology, (Stoyanov O.M.); formal analysis, (Kalashnikov V.Y.); data curation, (Stoyanov O.M.); writing - original draft preparation, (Vastyanov R.S.); writing - review and editing, (Vastyanov R.S., Stoyanov O.M.); supervision, (Kalashnikov V.Y.).

All authors have read and agreed to the published version of the manuscript.

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Institutional Review Board Statement

This scientific report did not require IRB approval, any patients were used to receive the information.

Informed Consent Statement

The retrospective analysis of material was used. Written informed consent from the patients was not necessary to publish this paper.

Data Availability Statement

The data presented in this study are available on request from the author.

Conflicts of Interest

The authors declare no conflict of interest.