https://doi.org/10.63181/ujcvs.2025.33(3).75-80
UDC 616.857-073.7:612.13

Valeriy Y. Kalashnikov[1], MD, PhD, Associate Professor of the Department of Ultrasound and Functional Diagnostics, https://orcid.org/0000-0002-7012-1698;

Olexander M. Stoyanov[2], MD, Professor of the Department of Neurology and Neurosurgery, https://orcid.org/0000-0002-3375-0452;

Yevgen V. Oprya[2], MD, Professor, Head of the Department of Psychiatry, Narcology, Medical Psychology and Psychotherapy, https://orcid.org/0000-0001-5232-1891;

Yuriy V. Melnyk[3], MD, neurologist, Director of Consultative and Diagnostic Medical Center Neuro-Cardio LLC Lab., https://orcid.org/0009-0005-6681-1548;

[1] Kharkiv National Medical University, Kharkiv, Ukraine

[2] Odessa National Medical University, Odessa, Ukraine

[3] Consultative and Diagnostic Medical Center Neuro-Cardio LLC Lab., Odessa, Ukraine

Structural-Functional Patterns of Lesions of the Main Arteries of the Head in Patients with Headache

Abstract

Aim. To study the structural and functional features of the main arteries of the head (MAH) in patients with migraine (M), tension-type headache (TTH), and cervicogenic headache (CH).

Materials and Methods. A total of 456 patients (18–44 years old; 203 men, 255 women) with various types of headaches were studied, including M – 124 people, TTH – 186, and CH – 146 people. Using the duplex scanning method, the structure of the MAH, systolic linear blood flow velocity (Vs), and resistance indices (RI) in the common carotid (CCA), external carotid (ECA), internal carotid (ICA), and vertebral arteries (VA) in V2 segments were assessed.

Results. Extravasal compression of the vertebral arteries was significantly more prevalent in patients with CH (43.1 %) and M (29.0 %), while hypoplasia of the vertebral arteries was found equally in these groups. In all types of headaches, a decrease in velocity indicators and an increase in resistance index values in the VA were noted. In patients with migraine with aura (MA), extravasal compression and hypoplasia of the vertebral arteries predominated, and Vs indicators in this group were significantly reduced. Signs of extravasal compression and the associated decrease in VA hemodynamics were observed in all variants of TTH. Furthermore, signs of extravasal compression of the VA were detected in a significant proportion of patients with CH, especially those with cervicocranialgia (CCrA) and Barré-Liéou syndrome (BLS). In BLS, signs of pathological tortuosity and hypoplasia of the VA predominated. Velocity indices in extracranial segments of the VA were reduced in patients with CCrA and BLS, and a significant increase in RI values was also observed in the BLS group (0.87 ± 0.05; CG – 0.65 ± 0.06; $p < 0.05$).

Conclusions. 1. Patients with M were characterized by the presence of extravasal compressions and a decrease in Vs in the VA.
2. Hypoplasia of the VA was more common in the group of patients with MA than in M without aura.
3. Patients with TTH had a tendency towards reduced velocity indices in extracranial segments of the VA.
4. Patients with CH manifested extravasal compression of the vertebral arteries.
5. Tortuosity and hypoplasia of the VA, in combination with an increase in RI indices, were characteristic of patients with BLS

Keywords*: main arteries of the head, cerebral hemodynamics, Doppler sonoography, migraine, tension type headache, Barré-Liéou syndrome.*

Introduction. Headache is among the most frequently reported symptoms associated with various pathological conditions in contemporary settings. The modern classification of headache (ICHD-III, 2018) distinguishes primary headaches, which are intrinsic to the disease itself (migraine, tension-type headache, cluster headaches), from secondary headaches, in which the headache is a symptom of a specific pathological process, for example, cervicogenic headache [1]. Among primary headaches, migraine (M) and tension-type headache (TTH) are cur-

rently distinguished by prevalence, whereas among secondary headaches, cervicogenic headache (CH) is prominent. At the present time, the use of ultrasound diagnostic methods in the study of various headache types is highly relevant [2].The features of cerebral hemodynamic disorders in patients with migraine, with and without aura, both during interictal periods and attacks, have been studied extensively [3–6]. In patients with M, changes in arterial vascular tone, reduced reserves of cerebral blood flow autoregulation, and signs of venous dysgemia have been documented [7–10]. In TTH, increased tone in extracranial arteries, decreased tone in intracranial vessels, reduced cerebral blood flow reserves, and signs of venous dyscirculation are more commonly observed [11–13]. In patients with CH, phenomena of reduced perfusion in the vertebral and basilar arteries have been reported [14], a finding that was confirmed in our studies [15]. Certain studies of migraine have also identified structural changes in the vessels of the vertebrobasilar basin (hypoplasia), which are considered contributing factors in migraine pathogenesis [16].

However, existing studies have not examined how structural changes in the main arteries of the head vary according to headache type or compared these changes with hemodynamic factors.

Aim. To investigate the structural abnormalities and hemodynamic parameters of the main arteries of the head in young patients with migraine, tension-type headache, and cervicogenic headache.

Materials and Methods. A total of 456 patients (18-44 years old; 201 men, 255 women) with various types of headaches were studied, including: migraine – 124 patients (migraine without aura [MwoA] – 63 patients; migraine with aura [MA] – 61 patients), tension-type headache – 186 patients (infrequent episodic TTH [IETTH] – 68 patients; frequent episodic TTH [FETTH] – 64 patients; chronic TTH [CTTH] – 54 patients), and cervicogenic headache – 146 patients (cervicocranialgia [CCrA] – 82 patients; posterior cervical sympathetic Barré-Liéou syndrome [BLS] – 64 patients). The structure of the MAH was studied in triplex mode using an Ultima-PA ultrasound scanner (RADMIR, Ukraine). Peak systolic blood flow velocity (Vs) and resistance indices (RI) were measured in the common (CCA), external (ECA), internal carotid (ICA), and vertebral arteries (VA, V2 segment). The main hemodynamic indicators were compared across the different clinical groups for each type of headache.

The control group (CG) consisted of 50 clinically healthy volunteers of both sexes, matched for age. Statistical analysis was performed using the «Statistica 6.0» software package. Differences compared with the CG were considered statistically significant at $p < 0.05$.

Results and Discussion. Intima-media thickness (IMT) was observed in a small proportion of patients (M – 12.9 %, TTH – 7.5 %, CH – 9.6 %), with similar patterns noted for the prevalence of small atherosclerotic plaques (AP) (M – 5.6 %, TTH – 2.7 %, CH – 6.0 %). Extravasal compression of the vertebral arteries was significantly more prevalent in patients with CH (43.1 %) and M (29.0 %), supporting the influence of vertebral artery changes on the development of migraine attacks. In patients with M and CH, hypoplasia of the vertebral arteries was observed at similar rates (M – 11.2 %, CH – 11.6 %), further corroborating this observation. Hypoplasia of the carotid arteries, as well as tortuosity of the carotid and vertebral arteries, were observed in individual cases (Table 1).

Table 1

Structure of MAH lesions in patients with headache

	M N = 124	TTH N = 186	CH N = 146
Intima-media thickness	16 (12.9 %)	14 (7.5 %)	14 (9.6 %)
Hemodynamically minor APs in the carotid arteries	7 (5.6 %)	5 (2.7 %)	9 (6.0 %)
Extravasal compression of the vertebral arteries	36 (29.0 %)	16 (8.6 %)	63 (43.1 %)
Pathological tortuosity of the carotid arteries	4 (3.2 %)	1 (0.5 %)	5 (3.3 %)
Pathological tortuosity of the vertebral arteries	1 (0.8 %)	1 (0.5 %)	9 (6.2 %)
Hypoplasia of the carotid arteries	3 (2.4 %)	2 (1.1 %)	2 (1.4 %)
Hypoplasia of the vertebral arteries	14 (11.2 %)	5 (2.7 %)	17 (11.6 %)

Vs and RI values in the MAH are presented in Table 2. In patients of all groups, the Vs and RI values in the CCA and ICA did not differ significantly from the reference values. The hemodynamic values in the ECA in patients with TTH and CH generally coincided with the normative values, the flow rate in patients with M was slightly reduced. In all clinical groups, a decrease in the velocity values and an increase in the resistance index values in the VA (M – Vs – 39.8 ± 10 cm/s, RI – 0.73 ± 0.06; TTH – Vs – 36.4 ± 7.2 cm/s, RI – 0.74 ± 0.06; CH – Vs. – 38.1 ± 7.5 cm/s, RI – 0.74 ± 0.07; CG – 47.8 ± 10.4, 0.65 ± 0.06). Changes in hemodynamics in segments V2 may be due to extravasal compression and hypoplasia of the VA.

Table 3 shows MAH structure and function data for migraine patients. A reliable relationship between migraine attacks and changes in the vertebral arteries has been shown – mainly with extravasal, usually vertebral, compression, as well as with hypoplasia in migraine with aura.

In patients of both groups, the Vs and RI values in the CCA and ICA did not differ from normative values, nor did the RI values in the VA in the MwoA group. In the MA group, VA velocity decreased and RI increased, with 25–30 % of patients exhibiting flow asymmetries in the CA. Vs values in patients of the MwoA group were also

Table 2

Vs (cm/s) and RI indicators in MAH in patients with headache

	CCA		ICA		ECA		VA (V 2)	
	Vs	RI	Vs	RI	Vs	RI	Vs	RI
M	77.6±9.4	0.72±0.05	68.7±8.3	0.64±0.06	63.5±9.1	0.76±0.04	39.8±10.1	0.73±0.06
TTH	76.4±6.2	0.71±0.04	68.7±9.3	0.64±0.05	68.6±8.4	0.78±0.06	36.4±7.2	0.74±0.06
CH	76.8±9.2	0.71±0.06	68.6±8.3	0.61±0.04	68.4±8.5	0.80±0.04	38.1±7.5	0.74±0.07
CG	75.6±12.2	0.73± 0.05	67.4±14.5	0.6±0.06	69.3± 17.6	0.81±0.07	47.8±10.4	0.65 ±0.06

moderately reduced. These changes in velocity values are likely associated with a higher prevalence of tortuosity and extravasal compression of the VA in patients with migraine compared with the control group. Vs and RI values in the ECA were slightly reduced in both groups, probably due to vessel expansion during the attack and in the post-attack period (Table 4).

Data on the structural state of the MAH in patients with TTH are presented in Table 5.

In patients with TTH, there were no significant changes in MAH. These changes were mainly detected in all groups in isolated cases. It is noteworthy that there were signs of extravasal compression of the CHA in all clinical groups (IETTH group – 5.9 %, FETTH group – 7.8 %, CTTH group – 12.9 %).

This pattern indicates an association between the occurrence of TTH and vertebral pathology, as seen in multiple clinical cases.

Vs and RI indicators in the MAH are presented in Table 6. In patients across all groups, Vs and RI values in the CCA and ICA were generally within normal ranges, with only Vs in the ECA of patients in the CTTH group slightly exceeding that of the control group. In all clinical groups, a decrease in velocity values in the VA was observed (IETTH: 41.3 ± 10.2 cm/s; FETTH: 33.4 ± 8.1 cm/s; CTTH: 32.2 ± 7.6 cm/s; CG: 47.8 ± 10.4 cm/s). These changes in velocity

Table 3

Structure of MAH lesions in patients with migraine

	MwoA N=63	MA N=61
Intima-media thickness	9 (14.3 %)	7 (11.5 %)
Hemodynamically minor APs in the carotid arteries	5 (7.9 %)	2 (3.3 %)
Extravasal compression of the vertebral arteries	15 (23.8 %)	21 (34.4 %)
Pathological tortuosity of the carotid arteries	3 (4.8 %)	1 (1.6 %)
Pathological tortuosity of the vertebral arteries	-	1 (1.6 %)
Hypoplasia of the carotid arteries	1 (1.6 %)	2 (3.2 %)
Hypoplasia of the vertebral arteries	4 (6.3 %)	10 (16.3 %)

Table 4

Vs indicators (cm/s) and RI in MAH in patients with migraine

	CCA		ICA		ECA		VA (V 2)	
	Vs	RI	Vs	RI	Vs	RI	Vs	RI
MwoA	78.8±14.7	0.70±0.07	68.3±13.2	0.7±0.07	62.8±11.5	0.75±0.06	40.1±12.6	0.69±0.06
MA	76.9±11.3	0.71±0.04	70.7±11.2	0.6±0.05	64.8±13.2	0.76±0.05	36.4±9.5	0.78±0.05*
CG	75.6±12.2	0.73±0.05	67.4±14.5	0.6±0.06	69.3±17.6	0.81±0.07	47.8±10.4	0.65±0.06

Note:*p<0.05

Table 5

Structure of MAH lesions in patients with TTH

	IETTH N=6 8	FETTH N = 64	CTTH N = 54
Intima-media thickness	4 (5.9 %)	4 (6.25 %)	6 (11.1 %)
Hemodynamically minor APs in the carotid arteries	3 (4.4 %)	1 (1.6 %)	1 (1.9 %)
Extravasal compression of the vertebral arteries	4 (5.9 %)	5 (7.8 %)	7 (12.9 %)
Pathological tortuosity of the carotid arteries	-	-	1 (1.9 %)
Pathological tortuosity of the vertebral arteries	-	-	1 (1.9 %)
Carotid artery hypoplasia	-	1(1.6 %)	1 (1.9 %)
Hypoplasia of the vertebral arteries	2 (2.9 %)	1 (1.6 %)	2 (3.7 %)

Table 6

Indicators Vs (cm/s) and RI in MAH in patients with TTH

	CCA		ICA		ECA		VA (V2)	
	Vs	RI	Vs	RI	Vs	RI	Vs	RI
IETTH	74.3±10.2	0.72±0.04	70.1±9.4	0.67±0.05	66.3±8.9	0.8±0.05	41.3±10.2	0.77±0.08
FETTH	77.2±8.4	0.70±0.03	65.8±10.7	0.58±0.04	67.5±9.1	0.77±0.04	33.4±8.1	0.75±0.04
CTTH	79.7±10.4	0.69±0.06	72.3±7.7	0.72±0.04	70.5±9.3	0.78±0.05	32.2±7.6	0.71±0.06
CG	75.6±12.2	0.73±0.05	67.4±14.5	0.6±0.06	69.3±7.6	0.81±0.07	47.8±10.4	0.65±0.06

Table 7

Structure of MAH lesions in patients with CH

	CCrA N=82	BLS N=64
Intima-media thickness	8 (9.7 %)	6 (9.4 %)
Hemodynamically minor APs in the carotid arteries	6 (7.3 %)	3 (4.7 %)
Extravasal compression of the vertebral arteries	37 (45.1 %)	26 (40.6 %)
Pathological tortuosity of the carotid arteries	2 (2.4 %)	3 (4.7 %)
Pathological tortuosity of the vertebral arteries	4 (4.8 %)	5 (7.8 %)
Hypoplasia of the carotid arteries	2 (2.4 %)	-
Hypoplasia of the vertebral arteries	7 (8.5 %)	10 (15.6 %)

Table 8

Indicators Vs (cm/s) and RI in MAH in patients with CH

	CCA		ICA		ECA		VA (V2)	
	Vs	RI	Vs	RI	Vs	RI	Vs	RI
CCrA	76.4±10.2	0.70±0.07	70.1±9.6	0.61±0.05	70.3±8.1	0.78±0.05	40.1±12.6	0.69±0.06
BLS	77.8±10.3	0.72±0.04	68.3±10.2	0.62±0.05	66.7±10.3	0.79±0.05	36.4±9.5	0.87±0.05*
CG	75.6±12.2	0.73±0.05	67.4±14.5	0.6±0.06	69.3 ±11.5	0.81±0.07	47.8±10.4	0.65±0.06

*Note:*p < 0.05*

may be associated with extravasal compression of the VA in patients with CTTH.

Table 7 presents data on the structural and functional state of the MAH in patients with CHB.

Manifestations of extravasal compression of the spinal cord were observed in a significant proportion of patients in both clinical groups (CCrA – 37 patients, 45.1 %; BLS – 26 patients, 40.6 %). The similar prevalence of this pathology in both groups suggests that vertebrogenic cephalgic syndrome may be indicative of vertebral artery compression syndrome. Notably, the prevalence of pathological tortuosity of the vertebral arteries was higher in the BLS group compared with the CCrA group (7.8 % vs. 4.8 %), as was the prevalence of vertebral artery hypoplasia (15.6 % vs. 8.5 %). This pattern indicates an association of Barré-Liéou syndrome with structural abnormalities of the vertebral arteries and, consequently, with extravasal effects on the spinal vegetative plexus.

Vs and RI values in the CCA, ICA, and ECA were within normal ranges. Velocity indices in the extracranial segments of the VA were reduced in both CCrA (40.1 ± 12.6 cm/s; CG – 47.8 ± 10.4 cm/s) and BLS (36.4 ± 9.5 cm/s; CG – 47.8 ± 10.4 cm/s). Both groups also showed increased RI indices: CCrA – 0.69 ± 0.06 (CG – 0.65 ± 0.06); BLS – 0.87 ± 0.05 (CG – 0.65 ± 0.06; $p < 0.05$). These changes can likely be explained by the high prevalence of extravasal compression, as well as tortuosity and hypoplasia of the extracranial segments of the VA in this patient population (Table 8).

Conclusions

1. Patients with M were characterized by the presence of extravasal compressions and a decrease in Vs in the VA.
2. Hypoplasia of the VA was more common in the group of patients with MA than in M without aura.
3. Patients with TTH had a tendency towards reduced velocity indices in extracranial segments of the VA.
4. Patients with CH manifested extravasal compression of the vertebral arteries.
5. Tortuosity and hypoplasia of the VA in combination with an increase in RI indices were characteristic of patients with BLS.

References

1. Headache Classification Committee of the International Headache Society (IHS). The International Classification of Headache Disorders, 3rd edition. Cephalalgia. 2018;38(1):1-211. https://doi.org/10.1177/0333102417738202
2. Messina R, Christensen RH, Cetta I, Ashina M, Filippi M. Imaging the brain and vascular reactions to headache treatments: a systematic review. J Headache Pain. 2023 May 24;24(1):58. https://doi.org/10.1186/s10194-023-01590-5
3. Hansen JM, Schankin CJ. Cerebral hemodynamics in the different phases of migraine and cluster headache. J Cereb Blood Flow Metab. 2019 Apr;39(4):595-609. https://doi.org/10.1177/0271678X17729783
4. Loehrer E, Vernooij MW, van der Lugt A, Hofman A, Ikram MA. Migraine and cerebral blood flow in the general population. Cephalalgia. 2015 Feb;35(2):190-8. https://doi.org/10.1177/0333102414552531
5. Brunelli N, Altamura C, Mallio CA, Lo Vullo G, Marcosano M, Bach-Pages M, et al. Cerebral hemodynamics, right-to-left shunt and white matter hyperintensities in patients with migraine with aura, young stroke patients and controls. Int J Environ Res Public Health. 2022 Jul 14;19(14):8575. https://doi.org/10.3390/ijerph19148575
6. Xie QQ, Chen X, Tian Y, Fang L, Zhao H. Compromised cerebrovascular reactivity in migraineurs with right-to-left shunts: a potential mechanism of white matter hyperintensities. Neurol Res. 2022. https://doi.org/10.1080/01616412.2022.2051133
7. Khedr EM, Abbas MA, Gamea A, Sadek MA, Zaki AF. Cerebrovascular function in tension-type headache and migraine with or without aura: Transcranial Doppler study. Sci Rep. 2022 Aug 18;12(1):14098. https://doi.org/10.1038/s41598-022-18359-6
8. Kellner-Weldon F, El-Koussy M, Jung S, Jossen M, Klinger-Gratz PP, Wiest R. Cerebellar hypoperfusion in migraine attack: incidence and significance. AJNR Am J Neuroradiol. 2018;39:435-40. https://doi.org/10.3174/ajnr.A5508
9. Ornello R, Tiseo C, Pistoia F, Sacco S. Cerebrovascular reactivity in subjects with migraine: age paradox? J Neurol Sci. 2019 Mar 15;398:202-3. https://doi.org/10.1016/j.jns.2019.01.040
10. Dzator JS, Howe PR, Wong RH. Profiling cerebrovascular function in migraine: a systematic review and meta-analysis. J Cereb Blood Flow Metab. 2021;41(5):919-44. https://doi.org/10.1177/0271678X20964344
11. Karacay Ozkalayci S, Nazliel B, Caglayan HB, Irkec C. Cerebral blood flow velocity in migraine and chronic tension-type headache patients. J Pain Res. 2018;11:661-6. https://doi.org/10.2147/JPR.S144183
12. Ashina M. Neurobiology of chronic tension-type headache. Cephalalgia. 2004 Mar;24(3):161-72. https://doi.org/10.1111/j.1468-2982.2003.00644.x
13. Khedr EM, Abbas MA, Gamea A, Sadek MA, Zaki AF. Cerebrovascular reactivity after functional activation of the brain using photic stimulation in migraine and tension-type headache: a transcranial Doppler ultrasonography study. BMC Neurol. 2023 Mar 17;23(1):110. https://doi.org/10.1186/s12883-023-03153-2
14. Al-Obaidi SM, Asbeutah AM, Alsiri NF. Changes in vertebral artery hemodynamics associated with McKenzie therapeutic cervical movements: an exploration using duplex ultrasound imaging. J Manipulative Physiol Ther. 2019 Jan;42(1):66-74. https://doi.org/10.1016/j.jmpt.2018.09.001
15. Kalashnikov VI. Cerebral hemodynamics and cerebrovascular reactivity in patients with vertebrogenic cervicocranialgia. Inter Collegas. 2016;3(4):185-9. https://doi.org/10.35339/ic.3.4.185-189
16. Santos P, Pucci G, Akita J. Vertebral artery hypoplasia and chronic migraine: is there an association or just an incidental finding? Headache Med. 2021;12:148-51. https://doi.org/10.48208/HeadacheMed.2021.27

Структурно-функціональні патерни уражень магістральних артерій голови у пацієнтів з головним болем

Калашніков В. Й.[1], Стоянов О. М.[2], Опря Є. В.[2], Мельник Ю. В.[3]

[1]Харківський національний медичний університет, м. Харків, Україна

[2]Одеський національний медичний університет, м. Одеса, Україна

[3]Консультативно-діагностичний медичний центр ТОВ Neuro-Cardio Lab., м. Одеса, Україна

Резюме

Мета. Вивчення структурних та функціональних особливостей магістральних артерій голови (МАГ) у пацієнтів з мігренню (М), головним болем напруги (ГБН) та цервікогенним головним болем (ЦГБ).

Матеріали та методи. Було досліджено 456 пацієнтів молодого віку (18-44 роки; чоловіків – 203, жінок – 255) з різними видами головного болю: М – 124 пацієнти, ГБН – 186 пацієнтів, ЦГБ – 146 пацієнтів. За допомогою методу дуплексного сканування оцінювалася структура МАГ та показники систолічної лінійної швидкості кровотоку (Vs) і індекси резистентності (RI) у загальних (ЗСА), зовнішніх (ЗоСА), внутрішніх сонних (ВСА) і хребетних артеріях (ХА) у сегментах V2.

Результати. Екстравазальна компресія хребетних артерій була значно поширена у пацієнтів з ЦГБ (43,1 %) та М (29,0 %), при цьому гіпоплазія ХА у цих групах спостерігалася однаково часто. При всіх видах головного болю відзначалося зниження швидкісних показників і підвищення значень RI у ХА. У пацієнтів з мігренню з аурою (МА) переважали екстравазальна компресія та гіпоплазія ХА, показники Vs у цій групі були значно знижені. Ознаки екстравазальної компресії та пов'язане з цим зниження гемодинаміки ХА спостерігалися при всіх варіантах ГБН. Також ознаки екстравазальної компресії ХА виявлялися у значної

частини пацієнтів з ЦГБ, зокрема при цервікокраніалгії (ЦКА) та синдромі Барре-Л'єу (СБЛ). При СБЛ переважали ознаки патологічної звивистості та гіпоплазії ХА. Швидкісні показники в екстракраніальних сегментах ХА були знижені у пацієнтів з ЦКА та СБЛ, при цьому спостерігалося достовірне підвищення значень RI у групі СБЛ (0,87 ± 0,05; КГ – 0,65 ± 0,06; $p < 0,05$).

Висновки

1. Для пацієнтів з М характерна наявність екстравазальних компресій та зниження Vs у ХА.
2. У групі пацієнтів з МА гіпоплазія ХА зустрічалася частіше, ніж при М без аури.
3. У пацієнтів із ГБН спостерігається тенденція до зниження швидкісних показників в екстракраніальних сегментах ХА.
4. У пацієнтів з ЦГБ відзначалася наявність екстравазальних компресій ХА.
5. Звивистість і гіпоплазія ХА в поєднанні з підвищенням показників RI були характерні для пацієнтів із СБЛ.

Ключові слова: *магістральні артерії голови, церебральна гемодинаміка, доплерографія, мігрень, головний біль напруги, синдром Барре-Льєу.*

Стаття надійшла в редакцію / Received: 03.07.2025
Після доопрацювання / Revised: 06.08.2025
Прийнято до друку / Accepted: 20.08.2025