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CLINICAL SIGNIFICANCE AND EFFECTIVENESS OF NEUROCOMPENSATORY MECHANISMS IN STROKE REHABILITATION

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Abstract. *The relevance of rehabilitation after stroke is that acute circulatory disorders in the brain remain one of the most important medical and socio-economic problems today. As part of the study, 242 patients with ischemic and hemorrhagic stroke were examined and the importance of compensatory-adaptogenic mechanisms of the brain was assessed. At the same time, it was found that compensatory-adaptogenic mechanisms of the brain play a decisive role in the process of restoring lost functions.*

Keywords: *acute circulatory disorders in the brain, ischemic stroke, hemorrhagic stroke, rehabilitation, compensatory-adaptogenic mechanisms of the brain.*

Acute circulatory disorders in the brain (stroke) are one of the main causes of disability and social maladaptation in modern medicine. According to the World Health Organization, after a stroke, the majority of patients remain with varying degrees of motor, cognitive and psychoemotional disorders.

Every year, 16 million people worldwide suffer from primary stroke, and 5.7 million die from it. 31% of patients require constant care, 20% of patients cannot move independently, and only 8% of patients can continue their previous activities. The death rate from stroke was 6.7 million in 2015, and it is expected to reach 7.8 million in 2030. In the Russian Federation, 400-450 thousand strokes are observed annually, and in Uzbekistan - 55-60 thousand. According to the statistics of the Ministry of Health of the Republic of Uzbekistan, stroke mortality accounts for 39% of all vascular diseases and 23.4% of all deaths. According to the results of the study, the mortality rate is 10–35%, and cerebrovascular diseases are the second most common cause of death after heart disease and cancer, and in economically developed countries it is 11–12% (Rizaev A.J., Khaidarov N.K.). Modern goals and approaches According to the WHO program documents, the main goal is to achieve functional independence in at least 70% of patients within 3 months after a stroke. The main factor in achieving this goal is the activation of compensatory-adaptogenic mechanisms.

The purpose of the study. To develop a scientific and practical approach to assessing the functional state of compensatory-adaptogenic mechanisms of the brain in post-stroke patients using clinical, instrumental, neurophysiological and functional scales and to correlate these indicators with the effectiveness of rehabilitation.

Research materials and methods. To solve the scientific goals and objectives of our research, 242 patients were recruited from the Bukhara branch of the Republican Scientific Center for Emergency Medical Care, who were admitted and treated with a diagnosis of ischemic stroke in the neuroanimation and emergency neurology departments in 2024-2025.

Patients with ischemic stroke who were involved in the study were divided into 2 groups: II- (ischemic stroke) and GI- (hemorrhagic stroke). Each group was divided into two subgroups. II 1 group - 74 patients with ischemic stroke and early rehabilitation measures were performed, and II 2 group - 64 patients with ischemic stroke and early rehabilitation measures were not performed. Also, hemorrhagic stroke group GI 1 group - 58 patients with hemorrhagic stroke and early rehabilitation

measures were performed and GI 2 group - 46 patients with hemorrhagic stroke without early rehabilitation measures.

Analysis and results. We conducted the study from the acute phase of ischemic stroke to the early recovery period. The following patients were excluded from the study: patients with impaired consciousness and coma, cerebral hemorrhage, body temperature above 37.2 °C, systolic blood pressure above 160 mm Hg, diastolic blood pressure above 100 mm Hg, severe heart failure, myocardial infarction, pulmonary embolism. At the same time, patients with fractures of the spine, pelvis and legs, head injuries, and those who were not amenable to early rehabilitation were also not included in the study.

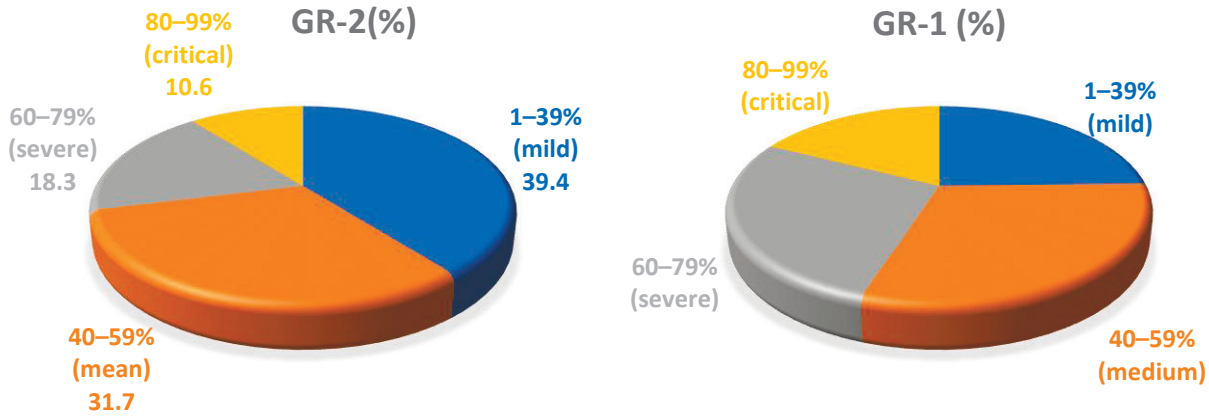
The examination methods included clinical and neurological examinations: neurostatus, clinical scales NIHSS - neurological deficit assessment scale, Modified Rankin Scale - functional independence scale, Barthel Index - daily activity index, FIM - complex functional assessment index.

In neuropsychological assessment, MMSE, MoCA, HADS scales are used to assess the level of cognitive adaptation; optoclinostatic test, Kerdo index to assess vegetative status; The paralyzed arm was monitored using a special ARAT (The Action Research Arm Test) test. The verticalization procedure was performed on the basis of the results of low-stress functional tests of easy apnea, easy hyperventilation, passive semi-orthostatic test and orthostatic test. Laboratory methods: general blood and urine analysis, coagulogram, biochemical blood tests were examined.

In addition, multifocal computed tomography (MCCT) and magnetic resonance imaging (MPT), ultrasonographic dopplerography (BTsT UTDG) of the brain, electroencephalography (EEG) and electroencephalography (ECG) were performed.

Results of a comparative evaluation of the hemodynamics of pachyocephalic atypia in the Ulpatovush duplex cannulation trial.

In order to evaluate the state of cerebral hemodynamics, the three methods of ultrasound Doppler examination (UTDG) + brain duplex cannulation and tympanic Doppler examination (TKDG) were used. Pancreatic dopplerography was performed on the day before admission.



1-picture. A three-step study in the research group of ecctpakpanial aptopiyalap ctonosis.

Ultrasound duplex scanning (UDS) is an important instrumental method for assessing cerebral hemodynamics and predicting compensatory-adaptogenic mechanisms in patients with stroke. In particular, the degree of internal carotid artery (ICA) stenosis is one of the main hemodynamic factors determining the effectiveness of rehabilitation.

Dynamics of somatic and neurological conditions in the course of traditional treatment. When analyzing the anamnestic data of the examined patients, the time from the onset of the stroke to the start of the examination was 11.6 hours. It was found that the majority of patients have been treated for hypertension for 8-10 years, but only 45-55 percent of them regularly take antihypertensive drugs.

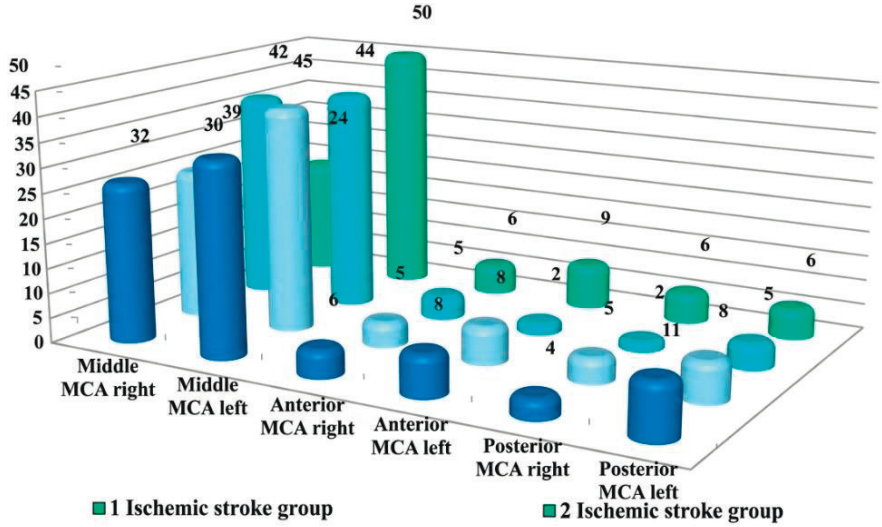
Table 1.

Dynamics of ischemic strokes as a result of neupovisualization multiplexing in patients

Indicator	IS-1 (n=74) Early response	IS-2 (n=64) No response	HS-1 (n=58) Early response	HS-2 (n=46) No response
1–2 days				
Furnace/ >5 cm	18 (24,3%)	15 (23,4%)	19 (32,8%)	16 (34,8%)
Perifocal swelling	33 (44,6%)	28 (43,8%)	26 (44,8%)	20 (43,5%)
Midline shift >3 mm	6 (8,1%)	6 (9,4%)	20 (34,5%)	17 (37,0%)
20–21 days				
Furnace/ size reduction	49 (66,2%)	30 (46,9%)	40 (69,0%)	28 (60,9%)
Tumor regression	55 (74,3%)	41 (64,1%)	38 (65,5%)	21 (45,7%)
Sign of cyst/resorption	32 (43,2%)	20 (31,3%)	20 (34,5%)	13 (28,3%)
Residual mass effect	5 (6,8%)	11 (17,2%)	9 (15,5%)	13 (28,3%)

On days 1–2, the morphological severity is almost the same between the groups, that is, early rehabilitation has not yet affected the morphological indicators. By 20–21 days: in group II-1 (early rehabilitation), infarct size reduction and tumor regression are higher (66–74%), residual mass effect is less (6.8%). In group II-2, morphological regression is relatively slow (46–64%), residual mass effect is more preserved (17.2%).

hen we studied the localization of stroke by group, it was found that in group 1, stroke was more common in the right middle cerebral artery (42.28±2.24), while in group 2, the left middle cerebral artery was affected more often (39.81±4.0). Overall, in group 1, ischemic stroke was observed in the right hemisphere of the brain in 51% of cases, and in the left hemisphere in only 40%. In group 2, this ratio was 39.%47.5.



2- picture. Ischemic focus localization expression (%) in MCCT test.

The diagnosis of hemorrhagic stroke was initially ruled out by the MRI and the localization of the ischemic focus was studied. In both groups, it can be seen that the focus was located predominantly in the middle cerebral artery basin, in front of the left cerebral hemisphere. In cardioembolic type II, a single predominance was observed in the right anterior cerebral artery in the acute group, while a single predominance was observed in the posterior cerebral artery on both sides.

On the first day of the study, the general condition of the patients was checked, and conditions such as consciousness, vision, motor and sensory systems, coordination disorders, gnosis and speech function were assessed using the NIHSS (National Institute of Health Stroke Scale) scale. Patients were examined using the NIHSS scale at 1-2 days, 20-21 days, 2 months and 6 months of the disease, and their condition was compared in dynamics. We divided the patients into moderately severe and severe patients. Here, moderate stroke is understood as a condition in which multiple focal symptoms predominate, severe stroke is understood as a condition in which only mild cognitive impairment occurs, and general cerebral symptoms are more pronounced than focal symptoms.

In dynamics, a gradual improvement in clinical indicators was observed in patients receiving standard treatment. In particular, in patients with ischemic stroke, the index decreased from 13.3±0.4 points on day 1–2 to 7.9±0.3 points on day 21–24. In patients with hemorrhagic stroke, this index decreased from 14.1±0.5 points to 9.6±0.3 points ($p<0.05$).

By day 57–60, NIHSS in the ischemic stroke group decreased to 5.1±0.2 points, while in hemorrhagic stroke it was 6.8±0.3 points. This difference indicates that neurocompensatory-adaptogenic mechanisms are relatively active and effective in ischemic stroke.

From the results obtained, it can be concluded that in ischemic stroke, functional neuroplastic reorganization and restoration of lost functions occur faster than in hemorrhagic stroke. In hemorrhagic stroke, the rate of recovery is relatively slow due to the volume of the initial morphological damage and perifocal acute reactions.

This dynamics confirms the need to use the NIHSS scale as an important monitoring tool in assessing compensatory-adaptogenic capabilities in the rehabilitation process. Subjective complaints, objective condition and neurological status were studied and compared in detail.

The level of occurrence of general cerebral symptoms in patients during the onset of stroke in the study groups was analyzed. The severity of cerebral symptoms in the acute phase of stroke is important because it directly affects the level of activation of neurocompensatory-adaptogenic mechanisms in the subsequent rehabilitation process. In the main group (ischemic stroke, n=138), headache was observed in 48 (34.8%) patients. In the comparison group (hemorrhagic stroke, n=104), this figure was 52 (50.0%) patients. The high frequency of headache in hemorrhagic stroke may be associated with increased intracranial pressure and the subarachnoid component.

Physiotherapy treatments depending on the type of stroke. The study studied the types of stroke and selected physiotherapy treatments appropriate for them. The course of the disease is considered a contraindication to several types of physiotherapy treatments. Taking this into account, modern physiotherapeutic procedures were performed in both cases, which were not contraindicated:

Translingual electronic neurostimulation (TLENS / PoNS type devices)

Translingual electronic neurostimulation device is a neuromodulation device that activates the afferentation of cranial nerves (V - n. trigeminus, VII - n. facialis, IX - n. glossopharyngeus) by delivering low-voltage pulse current through a microelectrode matrix placed on the dorsal surface of the tongue.

Mechanism of action. Impulses transmitted through the tongue activate the cerebellum, trunk and thalamocortical networks.

Strengthening proprioceptive and somatosensory afferentation stimulates neuroplastic reorganization.

Integration with motor-vestibular networks - improves postural control and gait.

Transcranial magnetic stimulation, transcranial micropolarization, amplipulse therapy, electrosonography, sinusoidal modulated current (CMT), electrostimulation and low-frequency magnetotherapy were selected and physiotherapy treatments were performed with their help.

The CORVID (KOR-VID) device is usually used in neurology and rehabilitation practice as a device for assessing the state of the autonomic nervous system and for neurovegetative correction.

It is mainly used in the following areas:

1. Diagnostic capabilities

Evaluation of heart rate variability (HRV)
Determination of the ratio of sympathetic and parasympathetic activity
Evaluation of vegetative tone
Screening of neurovegetative imbalance
2. Use in rehabilitation
Correction of vegetative dysfunction after stroke
Stabilization of blood pressure lability
Control of orthostatic reaction (important in early verticalization)
Reduction of stress-induced neurovegetative disorders.

The Vibrolang device is used in practice as a physiotherapeutic device designed to exert a reflex and microcirculatory effect through vibroacoustic stimulation (mechanical microvibration). Its main task in neurology and rehabilitation is to improve blood circulation in tissues, normalize muscle tone, and stimulate neuromotor reorganization.

Mechanism of action
Microvibration - activates microcirculation and venous drainage
Reflex effect - reduces tone in spastic muscles
Proprioceptive stimulation - stimulates central neuroplasticity
Importance in stroke rehabilitation
Effectiveness of compensatory-adaptogenic mechanisms in strokes.
Spastic hemiparesis - reduction of muscle hypertonia

A contributing factor in the regression of perifocal edema (by improving venolymphatic outflow).

Preparation for early verticalization - improving orthostatic stability.

Enhancement of proprioceptive afferentation - acceleration of functional neuroplastic reorganization.

1) Translingual electronic neurostimulation (TLENS)

Mechanism: low-voltage impulses through the dorsal surface of the tongue - afferentation of nerves V, VII, IX - activation of the brainstem-brainstem-thalamocortical networks - stimulation of neuroplasticity.

Start of use in ischemic stroke: 5–7 days (after hemodynamic stabilization).

Regimen: 20–30 minutes, 1–2 times a day, 10–15 sessions. Specificity: acceleration of motor-postural integration; strengthening of proprioceptive drive in hemiparesis. Expected dynamics: improvement of NIHSS motor subscale, Berg Balance; faster functional regression in 20–21 days.

Start of use in hemorrhagic stroke: after stabilization of intracranial pressure and hematoma resorption.

Mode: 20–25 minutes, 1 time per day, 8–12 sessions. Specificity: cautious in vestibular-coordination deficit; restriction if mass effect persists. Risk control: AGB, ICB dynamics; predisposition to epilepsy.2) KOR-VID (neurovegetative monitoring/correction)

Mechanism Assessment of sympathetic/parasympathetic balance based on HRV; vegetative correction using biofeedback.

In hypertension, onset: 3–5 days. Session: 15–20 minutes, 1 time per day, 10–14 sessions. Specificity: improvement of orthostatic stability (with early verticalization); reduction of AGB lability.

Indicators: HRV (SDNN, LF/HF), SpO_2, pulse; correlation with NIHSS dynamics.

In hypertension, onset: after hemodynamic stabilization. Session: 10–15 minutes, 1 time per day. Specificity: higher vegetative imbalance; mitigation of sympathoadrenal hyperactivity. Limitation: severe arrhythmia, decompensated UE.

3) BARK VibroLUNG (vibroacoustic respiratory therapy) Mechanism6: low-frequency vibration through the chest wall - mucociliary clearance, venolymphatic drainage -, prevention of hypostatic pneumonia. Onset in hypertension: from 2–3 days (when the cough reflex is weakened). Regimen: 10–15 minutes, 1–2 times per day, 7–10 days. Specificity: improved oxygenation - indirect

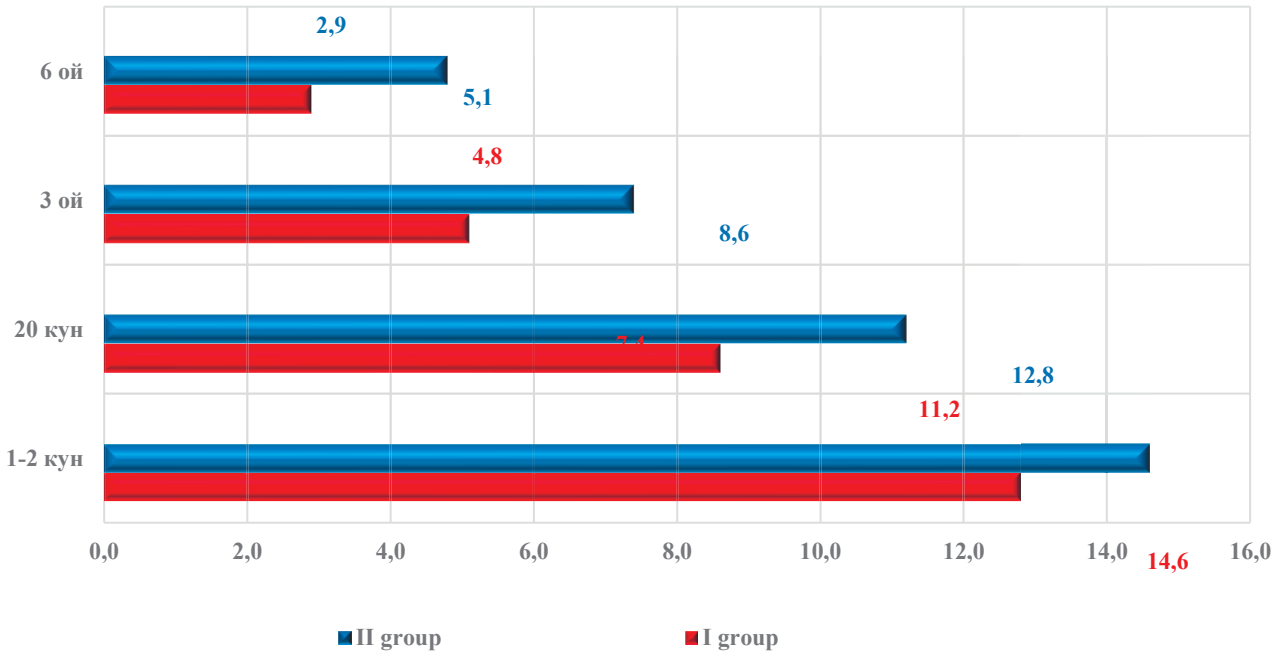
positive effect on neuroplastic processes; Preparation before verticalization. Lacunar lesions were more common in ischemic stroke (n=46; 28.0±2.7%), and relatively less common in hemorrhagic stroke (n=12; 9.3±1.8%). These results indicate that hemorrhagic stroke is characterized by a higher degree of morphological damage, while ischemic stroke is characterized by relatively localized and limited lesions.Mode: 20–25 minutes, 1 time per day, 8–12 sessions. Specificity: cautious in vestibular-coordination deficit; restriction if mass effect persists. Risk control: AGB, ICB dynamics; predisposition to epilepsy.2) KOR-VID (neurovegetative monitoring/correction) Mechanism Assessment of sympathetic/parasympathetic balance based on HRV; vegetative correction using biofeedback.

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3- picture. Dynamics of NIHSS scale indicators.

According to the results of dynamic observation on the NIHSS scale, in group I (ischemic stroke, n=164) the neurological deficit on average was 12.8±2.4 points on days 1–2. By 20 days this indicator decreased to 8.6±1.9 points, by 3 months it decreased to 5.1±1.6 points and by 6 months it

decreased to 2.9±1.2 points. This indicates that in ischemic stroke the activity of neurocompensatory-adaptive mechanisms is higher and functional recovery occurs faster. In group II (hemorrhagic stroke, n=128) the NIHSS index on days 1–2 was 14.6±2.8 points, and a more severe neurological condition was observed compared to the ischemic group. By 20 days, this indicator decreased to 11.2±2.3 points, by 3 months to 7.4±2.0 points, and by 6 months to 4.8±1.7 points. However, the dynamics were slower than in the ischemic group, and the residual neurological deficit remained higher. In general, the dynamic analysis according to the NIHSS scale shows that the effectiveness of neurocompensatory-adaptive mechanisms is higher in ischemic stroke, while in hemorrhagic stroke, the recovery process is relatively slow.

Table 2.

Dynamic indicators of the MoCA scale in stroke patients

Indicator	IS-1 (n=74) Early response	IS-2 (n=64) No response	HS-1 (n=58) Early response	HS-2 (n=46) No response
1–2 days	17,8±1,2	17,1±1,3	15,4±1,1	14,9±1,2
20–21 days	21,9±1,4	18,8±1,5	18,7±1,3	16,5±1,4
3 month	24,8±1,3	21,2±1,4	21,3±1,5	18,4±1,5
6 month	26,7±1,2	22,9±1,3	23,8±1,4	20,1±1,4

The results of the dynamic assessment of cognitive functions using the MoCA scale showed that the cognitive recovery rate was significantly higher in the groups that underwent early rehabilitation. In particular, in the II-1 group, the MoCA index was 17.8±1.2 points on days 1–2, but by days 20–21 it increased to 21.9±1.4 points and reached 26.7±1.2 points within 6 months. In the II-2 group, these indicators increased from 17.1±1.3 points to 22.9±1.3 points, and the dynamics of recovery was relatively slow ($p<0.05$).

Cognitive impairments were more severe in the initial period in patients with hemorrhagic stroke. In the GI-1 group, the MoCA score improved from 15.4±1.1 points to 23.8±1.4 points, while in the GI-2 group it increased from 14.9±1.2 points to only 20.1±1.4 points. Thus, even in hemorrhagic stroke, early rehabilitation had a positive effect on the recovery of cognitive functions, but the recovery rate was slower than in ischemic stroke. The results obtained confirm that neurocompensatory-adaptive mechanisms are more active in ischemic stroke, and early rehabilitation contributes to a faster and more effective recovery of cognitive functions.

Conclusions. In the process of post-stroke recovery, compensatory-adaptogenic mechanisms of the brain play an important role, and neuroplastic reorganization and functional adaptation are considered the main biological mechanisms of neurological deficit regression.

In patients with ischemic stroke, functional and cognitive recovery proceeds faster than in hemorrhagic stroke, and reliable positive changes in the dynamics of the NIHSS and MoCA scales were detected.

In groups that underwent early rehabilitation measures, the regression of neurological deficits, cognitive disorders and functional changes was observed to be more effective than in groups that did not undergo rehabilitation.

It was found that the use of translingual electronic neurostimulation, neurovegetative correction and modern physiotherapeutic methods improves sensorimotor integration and increases the effectiveness of post-stroke rehabilitation by activating compensatory-adaptive mechanisms.

REFERENCES

1. Bernhardt J., Hayward K.S., Kwakkel G. et al. Agreed definitions and a shared vision for new standards in stroke recovery research // International Journal of Stroke. – London, 2017. – Vol. 12, №5. – P. 444–450.
2. Cramer S.C., Sur M., Dobkin B.H. et al. Harnessing neuroplasticity for clinical applications // Brain. – Oxford, 2016. – Vol. 134, №6. – P. 1591–1609.
3. Di Pino G., Pellegrino G., Assenza G. et al. Modulation of brain plasticity in stroke rehabilitation // Brain Stimulation. – Amsterdam, 2018. – Vol. 7, №4. – P. 541–548.
4. Feigin V.L., Brainin M., Norrving B. et al. World Stroke Organization global stroke fact sheet 2022 // International Journal of Stroke. – London, 2022. – Vol. 17, №1. – P. 18–29.
5. Grefkes C., Fink G.R. Recovery from stroke: current concepts and future perspectives // Neurological Research and Practice. – Berlin, 2020. – Vol. 2, №17. – P. 1–10.
6. Hatem S.M., Saussez G., Della Faille M. et al. Rehabilitation of motor function after stroke: a multiple systematic review focused on techniques to stimulate upper extremity recovery // Frontiers in Human Neuroscience. – Lausanne, 2016. – Vol. 10. – P. 1–22.
7. Johansson B.B. Brain plasticity and stroke rehabilitation: the Willis lecture // Stroke. – Dallas, 2017. – Vol. 31, №1. – P. 223–230.
8. Kleim J.A., Jones T.A. Principles of experience-dependent neural plasticity: implications for rehabilitation after brain damage // Journal of Speech, Language, and Hearing Research. – Washington, 2018. – Vol. 51, №1. – P. S225–S239.
9. Krakauer J.W., Carmichael S.T., Corbett D. et al. Getting neurorehabilitation right: what can be learned from animal models // Neurorehabilitation and Neural Repair. – New York, 2017. – Vol. 26, №8. – P. 923–931.
10. Langhorne P., Bernhardt J., Kwakkel G. Stroke rehabilitation // Lancet. – London, 2018. – Vol. 377, №9778. – P. 1693–1702.
11. Levin M.F., Kleim J.A., Wolf S.L. What do motor “recovery” and “compensation” mean in patients following stroke? // Neurorehabilitation and Neural Repair. – New York, 2019. – Vol. 23, №4. – P. 313–319.
12. Nudo R.J. Recovery after brain injury: mechanisms and principles // Frontiers in Human Neuroscience. – Lausanne, 2016. – Vol. 7. – P. 1–14.
13. Stinear C.M. Prediction of motor recovery after stroke: advances in biomarkers // Lancet Neurology. – London, 2017. – Vol. 16, №10. – P. 826–836.
14. Teasell R., Hussein N., Foley N. et al. Evidence-based review of stroke rehabilitation // Topics in Stroke Rehabilitation. – Philadelphia, 2020. – Vol. 27, №6. – P. 390–410.
15. Ward N.S. Restoring brain function after stroke — bridging the gap between animals and humans // Nature Reviews Neurology. – London, 2017. – Vol. 13, №4. – P. 244–255.
16. Winstein C.J., Stein J., Arena R. et al. Guidelines for adult stroke rehabilitation and recovery // Stroke. – New York, 2016. – Vol. 47, №6. – P. e98–e169.