FEATURES OF PROGNOSTIC FUNCTION IN PATIENTS WITH ISCHEMIC STROKE OF FRONTAL LOCALIZATION IN THE EARLY RECOVERY PERIOD

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Abstract
The article presents the results of the research of the features of the anticipation and prognostic function in patients with ischemic stroke of frontal localization in the early recovery period.
Material and methods. *The total sample group was represented by 60 patients who had suffered an ischemic stroke of frontal or parietal localization. The average age of the research subjects was 53.00 ± 5.44 years. The study was conducted with the use of functional neuropsychological tests (by A.R. Luria, L.S. Tsvetkova), methods of predictive function research (time estimation test, spatial anticipation test, Maze test, London Tower test, "incomplete images" test), as well as statistical methods of quantitative and qualitative data processing.*
Results. *In patients with prefrontal localization of ischemic stroke a specific impairment of prognostic function and a non-specific decrease in anticipation were revealed. It is due to disorders of mental activity purposefulness and preliminary orientation in the conditions of the task. When the lesion was localized in the premotor areas, a less significant decrease in the rate and accuracy of the prognostic function due to the inertia of the mental processes was revealed. In the localization of ischemic stroke in the associative parietal cortex, a specific decrease in the rate and accuracy of sensorimotor, perceptual, and temporal anticipation was revealed, as well as a non-specific decrease in the rate of planning, while maintaining its accuracy of implementation.*
Conclusion. *In terms of practical significance, taking into account the features of prognostic function that have arisen in a particular form of brain damage can serve as a basis for restoring other gnostic or motor impaired functions, increasing the effectiveness of correctional and rehabilitation measures.*

Keywords: prognostic function; acute cerebral circulatory disorders; ischemic stroke; early recovery period.

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ОСОБЕННОСТИ ПРОГНОСТИЧЕСКОЙ ФУНКЦИИ У ПАЦИЕНТОВ С ИШЕМИЧЕСКИМ ИНСУЛЬТОМ ЛОБНОЙ ЛОКАЛИЗАЦИИ В РАННЕМ ВОССТАНОВИТЕЛЬНОМ ПЕРИОДЕ

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Резюме
В статье представлены результаты исследования особенностей антиципационно-прогностической функции у пациентов с ишемическим инсультом лобной локализации в раннем восстановительном периоде.
Материал и методы. *Общий объем выборки составил 60 пациентов, перенесших ишемический инсульт лобной или теменной локализации. Средний возраст испытуемых — 53,00 ± 5,44 года. Исследование осуществлялось с использованием функциональных нейропсихологических проб (А.Р. Лурия. Л.С. Цветкова), методов исследования прогностической функции (тест оценки времени, тест пространственной антиципации, лабиринт, задачи Лондонской башни, «незавершенные изображения»), а также статистических методов количественной и качественной обработки данных.*
Результаты. *У пациентов с префронтальной локализацией ишемического инсульта выявлено специфическое нарушение прогностической функции и неспецифическое снижение антиципации, что обусловлено нарушени-*

ем целенаправленности психической деятельности и фактором нарушения предварительной ориентировки в условиях задачи. При локализации очага поражения в премоторных отделах выявлено менее значительное снижение темпа и точности прогностической функции, обусловленное инертностью психических процессов. При локализации ишемического инсульта в области ассоциативной теменной коры выявлено специфическое снижение темпа и точности сенсомоторной, перцептивной, временной антиципации и неспецифическое снижение темпа планирования при сохранной его точности осуществления.

Заключение. *В аспекте практической значимости учет особенностей прогностической функции, возникших при той или иной форме поражений головного мозга может выступать в качестве основания восстановления нарушений иных гностических или моторных функций, повысив эффективность коррекционных и реабилитационных мероприятий.*

Ключевые слова: прогностическая функция; острые нарушения мозгового кровообращения; ишемический инсульт; ранний восстановительный период.

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Abbreviations: APF — anticipation and prognostic function; IS — ischemic stroke.

Introduction. One of the symptoms of cognitive deficiency after acute cerebrovascular disease is an impairment in ability to predict and plan. Its decrease has a negative impact on human life. Without the ability to plan effectively, there may be problems in achieving daily or professional goals. Taking into account the features of the anticipation and prognostic function (APF) in various brain lesions makes it possible to effectively build a strategy for restorative learning that can increase the effectiveness of rehabilitation measures.

Frontal lobe dysfunction and impaired "control functions" include: slow thinking, difficulty concentrating, impaired voluntary attention, increased distractibility, perseverance, impulsivity, decreased analytical abilities, decreased planning ability and control of activities.

The prefrontal cortex and the hippocampus play a key role in predicting over long-time scales. The main structures for the formation of short-term expectations are the parietal and premotor cortex. It should also be noted the fact of the connection of the prognosis with the following structures: anterior cingulate gyrus, insular lobe, basal ganglia, amygdala [1]. A meta-analysis of studies revealing brain structures involved in emotional prediction concluded that the perception of predictable stimuli triggers activation in the right parahippocampal gyrus, prefrontal cortex, left anterior cingulate gyrus, left premotor cortex, and amygdala [2].

Studies of prognostic function are presented in the framework of modern cognitive-behavioral theories developed by T. McMorris, P. Buser, G. Pezzulo, M. Butz, E. Talving, R. Rosen [3; 4]. We consider anticipation and forecasting as a unified APF. Their association is based on the concept of the anticipation-prognostic system of R. Rosen [4]. On the one hand, such a designation of this function indicates its orientation that means the inclusion *in situ*ations with the requirements for the implementation of any type of anticipatory-prognostic activity. On the other hand, it allows distinguishing the scope of the components that make up this function.

APF in accordance with the principles of dynamic localization, functional multitasking and double dissociation of mental functions (according to A.R. Luria [5]), is a dynamic system, a functional system, which is carried out by the joint action of many brain areas. If one of the sections of this system is damaged, the peculiarities of its functioning in the form of preservation and disorders of certain links will be observed. As a definition of the APF, we accept the definition of P.K. Anokhin — the ability of the brain, which is expressed in the foresight of the future, in the formulation of hypotheses about the future, in various prognostic assessments [6]. Within the framework of the theory of functional systems, the principle of activity was also introduced — the action of any individual is aimed towards the future, which is determined by the goal (the result model).

Based on the concept of anticipatory systems by G. Pezullo [3], which distinguished two blocks of anticipatory function (dynamic and probabilistic anticipation), we correlated subsensory, sensorimotor and perceptual anticipation (described by B.F. Lomov [7; 8]) to the first block, and creative and speech-thinking to the second. The actions of the first block are based on direct contact of a person with a problem situation. Based on the synthesis and assimilation of the sensory parameters of the environment, sensorimotor, temporal and spatial anticipation is performed by the extrapolation mechanism. Probabilistic anticipation (forecasting) is implemented as a situational type of anticipation. As anticipatory-prognostic activity, we denote the result of the action of the investigated function, which manifests itself at the levels of movements and perception.

The study of the activity of the prefrontal cortex regions showed the connection of the orbitofrontal cortex with target setting. It also transmits information to the ventrolateral region, which moves the image of the future result into the concept of the action plan through the dorsolateral frontal cortex. In addition, the number of actions necessary to achieve the goal is encoded with the use of the medial prefrontal cortex. When predicting events, the activity of neurons in the frontal ventrolateral region can be observed. High activity in both areas is directly related to the formulation of an action plan. The functional specialization of the right and left parts of the dorsolateral cortex was also revealed. This is related to the factors of the goal hierarchy (left side) and search depth (right side) in the planning process [9]. Specific characteristics of dorsolateral cortex asymmetry are observed, arising with reduced efficiency and planning speed. When the right dorsolateral cortex is disturbed, more severe prediction disorders can be seen (planning ability is reduced with increased speech activity), while with the focus located in the left hemisphere, these disorders are less notable.

The involvement of the prefrontal cortex in the prognosis error recording process and in spatial planning was shown. This is possible by communication with the hippocampus responsible for transmitting information on the spatial location of objects in order to form a more efficient route [10].

When planning significant events for a person, the prefrontal cortex uses the areas involved in the processing of rewards. During the research process, the decisive role of the prefrontal cortex in the formation of emotional response was discovered. Effective prediction has been shown to provide direct efferent connections of the prefrontal cortex to the temporal cortex and amygdala. Bilateral amygdala activity is directly associated with activation in the medial prefrontal cortex.

In case of the prefrontal region disorder, the sensorimotor evaluation of movements for their correction can be activated as a compensatory mechanism [11; 12].

Motor planning includes the following implementation mechanism: the virtual action plan of the dorsolateral prefrontal cortex becomes the motor action plan of the dorsal premotor cortex. The parietal lobe is involved in the preparation and correction of movements. The temporo-parietal transition is responsible for creating an image when predicting future events [13; 14].

Basing on the theoretical and methodological analysis, we have formed the scheme of the conceptual model of the study of prognostic function in patients with ischemic stroke (IS) of frontal localization in the early recovery period (Fig. 1).

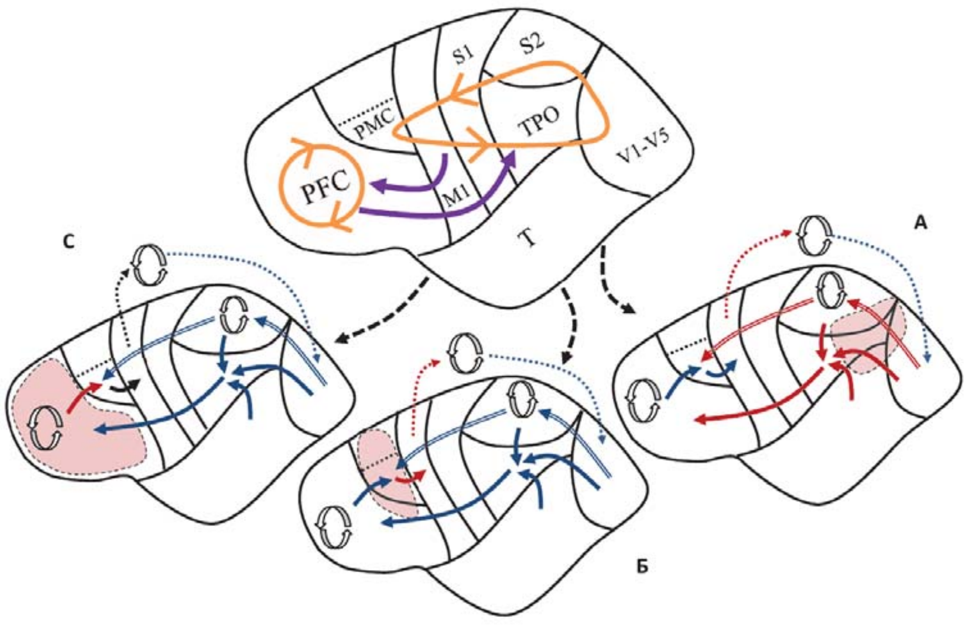

Fig. 1. The authorial scheme of the conceptual model of the study of the features of prognostic function in patients with ischemic stroke of frontal localization in the early recovery period: PFC — prefrontal cortex; PMC — premotor cortex; M1 — primary motor cortex; S1 — primary parietal cortex; S2 — posterior parietal cortex; V1–V5 — occipital lobe fields; TPO zone — intersection of tertiary parietal-temporal-occipital fields; T — parietal lobe

Рис. 1. Авторская схема концептуальной модели исследования особенностей прогностической функции у пациентов при ишемическом инсульте лобной локализации в раннем восстановительном периоде

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In the diagram, the anticipation component is represented by a set of double arrows, and the prediction is represented by a single arrow from the prefrontal to the premotor. The color of the arrows shows the degree of safety of the function (blue — safe, red — impairment). The red field area represents the localization of an IS.

The basis for the construction of the conceptual model is the factor of the connections of the functional system of anticipatory-prognostic function disruption. Anticipation is the first step for the function forecasting.

A.R. Luria [5] developed a structural and functional model, in which each higher mental function is performed due to the work of three brain blocks. According to this theory, there are three main functional blocks of the brain: the first block provides the regulation of tone and wakefulness; the second block is receiving, processing and storing information coming from the outside world; the third block is responsible for programming, regulation and control of mental activity. The upper diagram of the brain shows the main areas involved in the implementation of the function of anticipation: 1) the third functional block of the brain: PFC (prefrontal cortex), PMC (premotor cortex), M1 (primary motor cortex); 2) the second functional block of the brain: S1 (primary parietal cortex), S2 (posterior parietal cortex), V1–V5 (occipital lobe area), TPO zone (intersection of tertiary parietal-temporal-occipital area) and T (parietal lobe). These areas are combined into two ring anticipation systems (PFC-prediction, the second ring-dynamic anticipation). Between the depicted systems, the brain blocks are connected: the prefrontal cortex regulates arbitrary dynamic anticipation; the second block translates sensory information to the forebrain for predictive activity.

Based on the scheme (Fig. 1), we formulated assumptions about the features of APF in the localization of IS in the frontal premotor, frontal prefrontal and parietal associative cortex.

The afferent link may be affected in IS of the parietal associative cortex (A) — the transmission of information to the anterior parts of the brain to build a forecast or implement temporal-spatial anticipation on its basis. Patients may experience difficulties in the pace and accuracy of the implementation of anticipation-prognostic activity due to impaired sensory synthesis. Against the background of an afferent link defect, it is possible to observe the preservation of a central one — regulation and activity control. Thus, the primary defect of APF in this group of subjects under study may relate to dynamic anticipation disorder, and secondarily affect the probabilistic anticipation (prediction).

In IS of the premotor division (B) of the frontal cortex, the efferent link may suffer — the control and implementation of the anticipation and prognostic activity on the basis of an already drawn up plan. Patients of this group may experience difficulties in the pace and accuracy of the planned actions while maintaining the assessment of the errors made in the tasks of dynamic anticipation.

The central link may be affected in IS of the prefrontal frontal cortex (C) — the implementation of planning and presentation of the future result. Patients of this group may experience difficulties in forming forecasts against the background of a general decrease in the work of the third block of the brain.

Thus, the subjects may experience a specific decrease in probabilistic anticipation and a non-specific impairment of dynamic anticipation.

The purpose of the study is to identify traits of APF in patients with IS of frontal localization in the early recovery period.

Material and methods. 60 patients were under study. All patients were characterized by two facts: early recovery period (1–6 months after a stroke) and diagnosis in accordance with the ICD-10, "Cerebrovascular diseases (I60–I69)"/"Cerebral infarction caused by cerebral artery thrombosis (I63)". In line with the goal set, three research groups were formed: the first research group included 17 patients (8 women and 9 men; mean age: 52.00 ± 5.48 years) who had suffered an IS in the prefrontal lobe (Group A); the second group involved 24 patients (14 men and 10 women; mean age: 54.00 ± 5.24 years) who suffered IS in the premotor frontal lobe (Group B); 19 patients were examined as the control group (8 women and 11 men; mean age: 57.00 ± 6.30 years), who had IS in the associative parietal cortex (Group C). All patients in research group had lacunar lesions of IS, large lesions were absent. The criteria for exclusion from the study sample were hemorrhagic stroke, as well as IS (lacunar or large-focal) of temporal, occipital, brainstem, and cerebellar localization.

The following groups of methods were used: clinical conversation, archive method (study of anamnesis and medical history), tests for the study of attention, memory, thinking, visual — spatial and color gnosis by A.R. Luria, L.S. Tsvetkova [5]. Methods for estimating the anticipation-predictive function: time estimation test, spatial anticipation test, maze, London Tower problems, "incomplete images".

Methods for assessing APF:

1) time estimation test (Jerison et al., 1957; Piper et al., 2012): based on the estimation of the distance and the speed of movement of a given point on the screen, the subject was asked to predict the moment in time at which this point should potentially reach the goal; the test was complicated by the fact that the point would disappear in the course of its movement;
2) spatial anticipation test (E.N. Surkov [7]): the subjects were asked to indicate the place of possible intersection of straight lines; the execution time was 1 minute;
3) Maze test (S.D. Porteus [15]): it is suggested going through 2 mazes of different complexity as quickly as possible, making the minimum number of mistakes (crossing the contours of the maze with a pencil, entering a dead end of the maze); the time of indicating errors is subtracted from the total time of passing the maze;
4) London Tower test: it was suggested they should transform a combination of three disks strung on

pegs according to the sample; the execution time and the number of completed moves were taken into account; variant of Anderson et al. (2012): 8 tests of different difficulty levels (from 1 to 7 necessary actions to solve the problem), 3 disks of different sizes (all red), 3 columns of the same height, the minimum number of moves is 31, the maximum allowed duration of solving a separate test was 2 minutes; the subject was asked to pass a test with a recommendation to minimize the number of moves; variant of T. Shallice (1982): 8 tests of different difficulty levels (from 2 to 5 actions to solve the problem), 3 disks of the same size, but different colors (red, blue, green), columns of different sizes (1 — accommodates 3 disks, 2 — accommodates 2 disks, 3 — one disk), the number of moves is limited (represented by a scale in each test);

5) "incomplete images" test: the study of gnostic functions when presenting fragments of images of individual objects; the assessment was carried out on a 4-point scale (L.I. Wasserman): from 0 if the task was completed correctly to 3 if it was impossible to complete it [16].

Tests of time estimation, the London Tower, and psychomotor alertness were performed using the PEBL 2.1 (The Psychology Experiment Building Language) program [17].

Data processing methods: primary descriptive statistics (mode, median, mean, standard deviation, maximum and minimum values), comparison criteria (U-Mann–Whitney, H-Kruskal–Wallace, T-Wilcoxon), correlation analysis with calculation of Pearson and Spearman correlation criteria.

Results. We have carried out a comparative-empirical analysis of the indicators of attention, mnestic functions, thought processes, visual gnosis, and prognostic function between three groups of subjects. We haven't found significant differences in the groups of patients with premotor, prefrontal and parietal localization of IS when comparing the indicators of subject to color gnosis. Such results eliminate the influence of additional variables when solving the "London Tower" and "incomplete images" samples.

The level of stability and switchability of attention was reduced for the three groups of subjects but did not significantly differ between the study groups. Significant differences between the groups of patients with premotor, prefrontal and parietal localization of IS were not revealed when comparing the level of mnestic processes either. At the same time, there is a decrease in the volume of short-term auditory-speech memory.

In the study of spatial gnosis, patients with parietal localization of IS perform the "Blind Clock" test less effectively than those with premotor localization of the lesion (p = 0.018). The patients with prefrontal localization of IS are less accurate and take longer than other groups to establish the sequence of events (p = 0.036). There were no significant differences between the rate of simple sensorimotor reaction between the three groups (p = 0.076). The longest duration of the reaction rate applies to patients with prefrontal lesions.

Patients with premotor localization most effectively of IS perform temporary anticipation in comparison with the other groups. In this category of subjects, a significantly higher number of hits (p = 0.029) and a lower number of misses (p = 0.027) are detected when solving the time estimation test.

In patients with prefrontal localization of IS, there is a greater number of premature errors of time anticipation (p = 0.028) and in comparison with the other groups. These patients pass the maze faster than the other groups and make a statistically significantly greater number of errors (p = 0.018) than subjects with premotor damage.

Based on the results of the spatial anticipation test it is revealed that the subjects with the localization of IS in the parietal area perform spatial anticipation less effectively than the other groups, regardless of the level of complexity of the visual tasks, provided that the test material is static.

No significant differences were found between the duration of planning for the solution of the London Tower test No. 1 when comparing the three groups. We have found that patients with prefrontal lesions perform this test for a longer time (52.41 sec planning and 334.52 sec execution) than the other groups. Patients with promoter stroke are the fastest to solve such tests (58.45 sec planning and 261.25 sec execution). At the same time, the following pattern is obvious: the longer planning takes, the less time it takes to complete the task.

Patients with prefrontal localization of IS perform a statistically significant number of actions when solving the "London Tower" No. 1 compared to the other groups (p = 0.034). There is a tendency: patients with premotor localization perform the "incomplete images" test more effectively than those with parietal lesions.

The correlations were evaluated in two stages. The first stage solved the problem to identify the correlation between the indicators of APF in each study group of patients by correlation analysis (Pearson correlation coefficient). The second stage was to find out the correlation between the indicators of visual-spatial gnosis, memory, attention, thinking, and APF in each group of subjects (Spearman correlation coefficient) (Fig. 2).

The correlation analysis has shown that APF in patients with prefrontal localization of IS is based on a decrease in the prognostic component. The group of patients with associative parietal cortex lesion demonstrated a decrease in the anticipatory component. In the group with premotor frontal cortex lesion localization the disturbance of the efferent link of APF was manifested in the form of a decrease in the pace of test execution.

Discussion. For patients with prefrontal localization of the focus of IS, both, a decrease in dynamic anticipation and a decrease in the ability to plan as a result of violation of arbitrary regulation and control of activity, are characteristic. The central link that ensures the implementation of the planning and presentation of future results is disturbed. Patients who experience

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difficulty in forming forecasts with a general decrease of the third brain block function, experience a specific decrease in the probabilistic anticipation and non-specific impairment of dynamic anticipation in the future. In the premotor localization of the focus of IS, a violation of the tempo indicators of dynamic anticipation and prediction is a result of the inertia of mental processes, manifested in the implementation of stereotypical actions. In this case, the efferent link, which is responsible for the control and implementation of anticipation-prognostic activity on the basis of an already compiled plan, is disturbed. Patients of this group have difficulties in pace and accuracy of the planned actions with well-preserved evaluation of produced errors made in dynamic anticipation tasks. Patients with parietal localization of the focus of IS are characterized by pace disorder and accuracy of dynamic anticipation against the background of preserved prognostic activity. Patients have difficulties in the pace and accuracy of anticipatory-prognostic activity due to impaired sensory syntheses. Against the background of a defect in the afferent link, the central link, which regulates and controls the activity, is intact. Thus, the primary defect in APF in this group of patients refers to the disturbance of dynamic anticipation and as a consequence — to exert its effect on probabilistic anticipation (prediction).

When assessing the connection between the indicators of APF in patients with prefrontal localization of the focus of IS, multiple correlations between the indicators of prognostic activity were revealed. The decline in predictive ability has an impact on the results of each relevant sample. In patients with premotor localization of IS focus, the frequency of correlations is low and does not relate to a specific component of APF. The correlation between the indicators of dynamic anticipation in patients with parietal localization of IS focus indicates a decrease in the ability to assimilate the temporal-spatial characteristics of the environment and their implementation in a proactive action.

Assessing the connection between the indicators of visual-spatial gnosis, memory, attention, thinking and APF, patients with prefrontal localization of the focus of IS have a direct correlation between the indicators of probabilistic anticipation and thinking. When the focus of IS is localized in the premotor areas, significant correlations between the indicators of attention, memory, thinking, visual-spatial perception and APF are not found. In patients with parietal localization of the focus of IS, there is a direct correlation between the indicators of dynamic anticipation and visual-spatial perception.

Based on the results of the analysis in the group of subjects with prefrontal localization of stroke, it

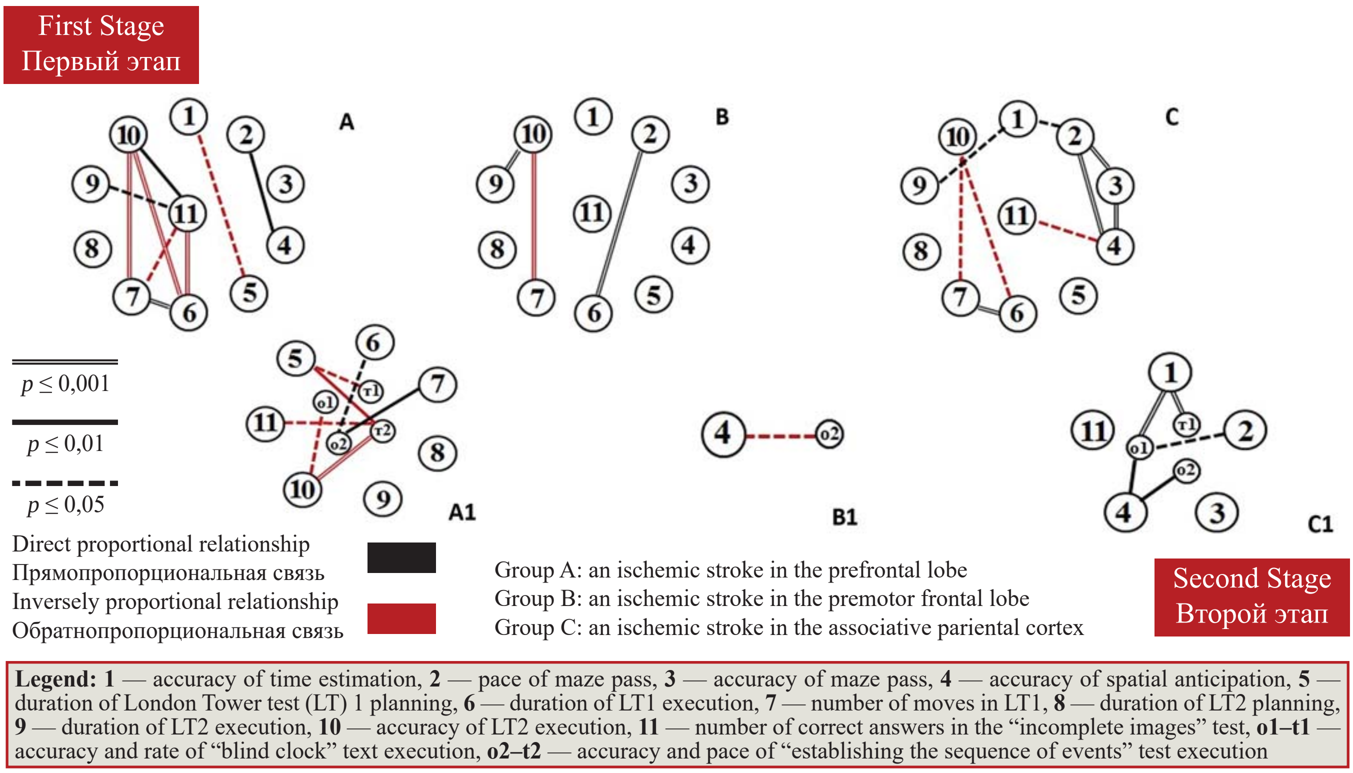

Fig. 2. A graphical representation of the correlation analysis of the correlation between the studied indicators in each study group.
Рис. 2. Графическое представление корреляционного анализа взаимосвязей между исследуемыми показателями в каждой исследуемой группе: 1 — точность оценки времени; 2 — темп прохождения лабиринта; 3 — точность прохождения лабиринта; 4 — точность пространственной антиципации; 5 — длительность планирования ЛБ1; 6 — длительность выполнения ЛБ1; 7 — количество ходов в ЛБ1; 8 — длительность планирования ЛБ2; 9 — длительность выполнения ЛБ2; 10 — точность выполнения ЛБ2; 11 — количество верных ответов в пробе «незавершенные изображения»; о1–т1 — точность и темп выполнения пробы «слепые часы», о2–т2 — точность и темп выполнения пробы «установление последовательности событий»; группа А — ишемический инсульт в префронтальной доле; группа В — ишемический инсульт в премоторной лобной доле; группа С — ишемический инсульт в ассоциативной теменной коре

can be concluded that a feature APF of these subjects is a decrease in probabilistic anticipation against the background of a preserved anticipatory component associated with a dynamic assessment of the situation and the formation of anticipatory action. This position is confirmed by multiple correlations of indicators of reduction in the duration and accuracy of planning in the "London Tower" tests. A different situation occurs in patients with premotor lesion in violation of the executive link of APF. These patients perform stereotypical actions, get stuck on complex tests, relaying in their activity a solution strategy that was effective in the previous tests. In patients with the associative parietal cortex localization of the stroke the correlations indicate a mutual change in the pace and accuracy parameters in the dynamic anticipation tests. In case of violation of the specified component of APF, a decrease in the effectiveness of ocular and sensorimotor reactions is observed in all relevant tests.

Conclusion. The study has shown that patients with prefrontal localization of IS have a specific violation of prognostic function and a non-specific decrease in anticipation. This feature is associated with disorders of the purposefulness of mental activity and the pre-orientation impairment factor in the task conditions. A feature of APF of premotor patients is a less significant decrease in the rate and accuracy of the implementation of the anticipatory-prognostic function. This feature is due to the inertia of the mental processes of the patients in the operating conditions.

In addition to APF disorders in the research groups, the features of this function were identified in the localization of IS in the associative parietal cortex, which were manifested in a specific decrease in the rate and accuracy of sensorimotor, perceptual, and temporal anticipation and a non-specific decrease in the rate of planning with its preserved accuracy of implementation. Such results are due to the occurrence in the control group of patients with visual-spatial perception disorders.

As a practical significance of the results of the study, it should be noted that taking into account the features of APF that have arisen in a particular form of brain damage can act as a basis for restoring other gnostic or motor impaired functions, increasing the effectiveness of corrective measures. Knowing these features makes it possible to develop rehabilitation programs that would fully correspond to the patient's condition and potential capabilities. After evaluating this function, the specialist is able to make recommendations for the relatives of the victim. These recommendations will be helpful for the patient's family members as the observed features of APF prevent possible adverse consequences that may occur outside the medical institution.

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ЛИТЕРАТУРА/REFERENCES

1. Bubic A., von Cramon D.Y., Schubotz R.I. Prediction, cognition and the brain. *Frontiers in human neuroscience*. 2010;4:25. https://doi.org/10.3389/fnhum.2010.00025
2. Ran G., Cao X., Chen X. Emotional prediction: An ALE meta-analysis and MACM analysis. *Consciousness and Cognition.* 2018;58:158–169. https://doi.org/10.1016/j.concog.2017.10.019
3. Pezzulo G. Coordinating with the Future: The Anticipatory Nature of Representation. *Minds and Machines.* 2008;18(2):179–225. https://doi.org/10.1007/s11023-008-9095-5
4. Rosen R. Anticipatory Systems: Philosophical, Mathematical, and Methodological Foundations. S*pringer Science & Business Media*. 2012:313–370. https://books.google.ru/books/about/Anticipatory_Systems.html?hl=ru&id=hZsWs3PBiPwC&redir_esc=y
5. Лурия А.Р. Высшие безусловные функции человека и их нарушения при локальных поражениях головного мозга. 2-е изд., доп. Москва: Изд-во Московского университета, 1969:504 с. [Luria A.R. Higher unconditional human functions and their violations in local brain lesions. 2nd ed., add. Moscow: Publishing house of the Moscow University, 1969:504 p. (In Russian)].
6. Анохин П.К. Избранные труды: Кибернетика функциональных систем. Москва: Медицина, 1998:400 с. [Anokhin P.K. Selected works: Cybernetics of functional systems. Moscow: Meditsina, 1998:400 p. (In Russian)].
7. Ломов Б.Ф., Сурков Е.Н. Антиципация в структуре деятельности. Москва: Наука, 1980:279 с. [Lomov B.F., Surkov E.N. Anticipation in the structure of activity. Moscow: Nauka, 1980:279 p. (In Russian)].
8. Ломов Б.Ф. Психическая регуляция деятельности. Избранные труды. Москва: Институт психологии РАН, 2006:622 с. [Lomov B.F. Mental regulation of activity. Selected Works. Moscow: Institute of Psychology of the Russian Academy of Sciences, 2006:622 p. (In Russian)].
9. Краснов В.С. Теоретический анализ исследований морфофункциональных основ антиципационно-прогностической функции. Психология здоровья и болезни: клинико-психологический подход: материалы IX Всероссийской конференции с международным участием. 21–22 ноября 2019 года. Курск, 2019. (II):136–147. https://www.elibrary.ru/item.asp?id=41471818 [Krasnov V.S. Theoretical analysis of studies on the morphofunctional basis of the anticipation-prognostic function. Psychology of health and disease: clinical and psychological approach: Materials of the IX All-Russian Conference with international participation. November 21–22, 2019. Kursk. 2019. (II):136–147. (In Russian). https://www.elibrary.ru/item.asp?id=41471818]
10. Simon N.W., Wood J., Moghaddam B. Action-outcome relationships are represented differently by medial prefrontal and orbitofrontal cortex neurons during action execution. *Journal of Neurophysiology*. 2015;114(6):3374–85. https://doi.org/10.1152/jn.00884.2015
11. Gerlach K.D., Spreng R.N., Madore K.P., Schacter D.L. Future planning: default network activity couples with frontoparietal control network and reward-processing regions during process and outcome simulations. *Social Cognitive and Affective Neuroscience*. 2014;9(12):1942–51. https://doi.org/10.1093/scan/nsu001
12. Van Overwalle F., Van de Steen F., Mariën P. Dynamic causal modeling of the effective connectivity between the cerebrum and cerebellum in social mentalizing across five studies. *Cognitive, Affective, & Behavioral Neuroscience*. 2019;19:211. https://doi.org/10.3758/s13415-018-00659-y
13. Svoboda K., Li N. Neural mechanisms of movement planning: motor cortex and beyond. *Current Opinion in Neurobiology.* 2018;49:33–41. https://doi.org/10.1016/j.conb.2017.10.023
14. Yomogida Y., Sugiura M., Akimoto Y., Miyauchi C. M., Kawashima R. The neural basis of event simulation: an FMRI study. *PLoS One.* 2014;9(5):e96534. https://doi.org/10.1371/journal.pone.0096534
15. Porteus S.D. Recent Maze Test Studies. *British Journal of Medical Psychology*. 1959;32(1):38–43. https://doi.org/10.1111/j.2044-8341.1959.tb00465.x

DOI 10.30629/2658-7947-2021-26-4-31-38

16. Вассерман Л.И., Дорофеева С.А., Меерсон Я.А. Методы нейропсихологической диагностики: Практическое руководство. СПб.: Стройлеспечать, 1997:360. [Vasserman L.I., Dorofeeva S.A., Meerson Ja.A. Metody nejropsihologicheskoj diagnostiki: Prakticheskoe rukovodstvo. SPb.: Strojlespechat', 1997:360. (Russian)].
17. Mueller Sh.T., Piper B.J. The Psychology Experiment Building Language (PEBL) and PEBL Test Battery. *Journal of Neuroscience Methods*. 2014;222:250–9. https://doi:10.1016/j.jneumeth.2013.10.024

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