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ASSESSMENT OF COGNITIVE FUNCTIONS IN PATIENTS WITH BRAIN TUMOR

Brain tumors is leading to an extreme influence on life quality and an increase in mortality, are becoming as common diagnose in the world. The identification of individual differences in cognition and well-being along with integration of modern approaches in early diagnosis of brain tumors, presurgical preparation and postsurgical rehabilitation significantly impact on the treatment of brain tumors. Existing literature showed that individual differences and personality profile influence cognitive functions preservation after surgery rehabilitation. Along with various methodological approaches to the study of brain tumors at the structural, functional, behavioral, psychophysiological levels we used psychometric measurements of cognitive functions and well-being in patients with brain tumors.

In our empirical part of the study the reliability parameters of psychometric tests in Russian and Kazakh languages were analyzed. The relationships between the parameters of emotional well-being and mental state were found: the higher the emotional well-being than the lower the likelihood of problems with thinking and understanding.

The results obtained can be used for better planning of postsurgical rehabilitation of brain tumor patients.

Key words: brain tumors, EEG, personality traits, diagnostic tests.

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Миында ісігі бар науқастардың когнитивті функцияларын бағалау

Өмір сапасының күрт төмендеуіне және өлім-жітімнің өсуіне әкелетін ми ісіктері әлемдегі ең көп таралған аурулардың біріне айналуда. Ми ісігі бар науқастарды ерте диагностикалауда, операция алдындағы дайындықта және операциядан кейінгі оңалтуда заманауи тәсілдерді біріктірумен қатар, когнитивті функциялардағы индивидуалды айырмашылықтарды анықтау ми ісіктерін емдеуге айтарлықтай әсер етуі мүмкін. Ғылыми әдебиеттерді талдау индивидуалды айырмашылықтар мен жеке тұлғаның профилі операциядан кейінгі оңалтудағы когнитивті функциялардың сақталуына әсер ететіндігін анықтады. Құрылымдық, функционалдық, мінез-құлық, психофизиологиялық деңгейлерде ми ісіктерін зерттеудің әртүрлі әдістемелік тәсілдерімен қатар біз миында ісіктері бар науқастарда когнитивті функциялар мен әл-ауқаттың психометриялық өлшемдерін қолдандық.

Зерттеудің эмпирикалық бөлімінде орыс және қазақ тілдеріндегі психометриялық тесттердің сенімділік параметрлері талданды. Эмоциялық әл-ауқат пен когнитивті функциялардың параметрлері арасында байланыс табылды: эмоциялық әл-ауқат неғұрлым жоғары болса, ойлау мен түсінуде болатын проблемалар соғұрлым төмен болады.

Нәтижелер миында ісіктері бар науқастарды операциядан кейінгі оңалтуды жақсырақ жоспарлау үшін пайдаланылуы мүмкін.

Түйін сөздер: ми ісіктері, ЭЭГ, тұлғаның ерекшеліктері, диагностикалық тесттер.

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Оценка когнитивных функций у пациентов с опухолью мозга

Опухоли головного мозга, приводящие к экстремальному снижению качества жизни и росту смертности, становятся одними из самых распространенных заболеваний в мире. Выявление индивидуальных различий в когнитивных функциях наряду с интеграцией современных подходов в ранней диагностике, предоперационной подготовке и послеоперационной реабилитации пациентов с опухолями головного мозга могут оказать существенное влияние на лечение опухолей головного мозга. Анализ научной литературы выявил факт того, что индивидуальные различия и профиль личности влияют на сохранность когнитивных функций в постоперационной реабилитации. Наряду с различными методическими подходами к изучению опухолей головного мозга на структурном, функциональном, поведенческом, психофизиологическом уровнях мы использовали психометрические измерения когнитивных функций и благополучия у пациентов с опухолями головного мозга.

В нашей эмпирической части исследования были проанализированы параметры надежности психометрических тестов на русском и казахском языках. Были обнаружены взаимосвязи между параметрами эмоционального благополучия и когнитивных функций: чем выше эмоциональное благополучие, тем ниже вероятность возникновения проблем с мышлением и пониманием.

Полученные результаты могут быть использованы для лучшего планирования послеоперационной реабилитации пациентов с опухолями головного мозга.

Ключевые слова: опухоли мозга, ЭЭГ, особенности личности, диагностические тесты.

Introduction

One of the most pressing issues in modern neurosurgery are brain tumors (Olszewska, 2015; Pei et al., 2015). Such diseases are characterized by high cognitive dysfunctions in patients, as well as influence on their well-being, social relationships, emotional state and adjustment to the socio-economic aspects of life. Within the framework of the multimodal approach, it is assumed that the presurgical planning should involve the functional MRI for mapping cognitive functions (Lau et al., 2016, Morrison et al., 2016, Silva et al., 2018), diffusion tensor imaging, electroencephalography, as well as behavioral and psychometric measurements of cognitive functions (Lemaitre et al., 2021; Barbara Tomasino et al., 2023). Cognitive dysfunctions associated with brain tumors are observed in 90% of patients. In most cases, these impairments arise not only from the tumor location, but also from surgical intervention, radiation therapy and chemotherapy (Loughan et al., 2019). These side effects of brain tumors are not fully understood. Some cognitive changes are temporary, while others may persist for a long time. Long-term consequences in most cases are cognitive problems associated not with loss of skills, but with problems of slow learning due to deterioration of executive functions. These include working memory, flexible thinking and self-control. Often there is a lack of attention, processing speed and the ability to perform tasks (Lemaitre et al., 2021).

Literature review

Various treatments can directly affect the brain, such as cell growth, inflammation, and blood flow (Lemaitre et al., 2021).

Tumor pressure effects on brain tissues and nerve cells, hemorrhages, and vascular occlusion. Early signs of the tumor are not only physiological symptoms such as headache, vomiting, dizziness, convulsive syndrome, vision problems, but also such cognitive dysfunctions as lack of initiative, aggression, euphoria, hallucinations, causeless cheerfulness, apathy, memory disorders, attention disorders, and thinking problems (Loughan et al., 2019).

According to the diagnostic scheme of the World Health Organization (WHO) (Louis et al., 2007), variety of factors, such as correspondence of tumor cells to normal cells, rate of growth, tumor margins, are the bases of classification of tumors as I, II, III, and IV grades. Among this classification, grade III is characterized by abnormal cells which are infiltrate between neighboring cells, and the most malignant tumor grade IV are rapid proliferated into surrounding tissues (Hill et al., 2002; Kralik et al., 2014). New classification of CNS tumors based on phenotype/genotype expression and growth pattern and behavior (Louis et al.,

2016). Common and lethal form of CNS tumors is glioblastoma (GBM) (Chen, McKay, Parada L.F., 2012), which radiographically reflected by subregions enhanced (ET) and non-enhanced tumors (NET), as well as peritumoral edematous/invasive tissue (ED). GBM creates by glial cells and grows by infiltrating surrounding tissues. The median overall survival GBM patients remains 12–16 months (Chen et al., 2012). An important feature of any brain tumor is the development of a volumetric structure in a limited space. This leads to compression of the brain and causes a serious condition.

Brain tumors significantly worsen well-being and lead to psychological and physical suffering, decreased quality of life, and cognitive dysfunctions. The negative burden of a brain tumor leads to a significant deterioration in a person's life in the personal, educational, work, and social spheres. Adult patients with brain tumors experience problems such as slow cognitive processing, memory deficits, and decreased attention (Loughan et al., 2019).

There are other factors that can affect dysfunction of cognitive processes such as attention, memory, and thinking: medications, anesthesia, infection, hormonal changes, stress, anxiety, or depression, fatigue, sleep disturbances and others (Tomasino et al., 2023).

Some studies have found behavioral changes such as irritability, hypoactivity, anticipatory disorders, and lack of interest in 40–50% of patients with brain tumors. It has been found that neuroticism is a strong predictor of postsurgical behavioral disorders, such as hypoactivity (Lemaitre et al., 2021).

Properly organized and timely diagnostics of a brain tumor can significantly reduce negatively effect on patient's physiological state, significantly shorten the treatment and recovery periods.

Key issues in brain tumor diagnosis and treatment are relationship between personality characteristics and brain tumors. Patient's personality traits help to identify main mitigating and an aggravating circumstance feature. Understanding personality disorder development could be by identification connections between personality traits and brain tumors.

Thus, at present, to provide high-quality medical care to brain tumor patients, the study of the relationship between such brain diseases and personality, psychophysiological characteristics is relevant and in demand.

Degree of development of the problem

Even though the issue of treating glial tumors has been well studied, the importance of presurgical planning and diagnostics of several psychophysiological and psychological characteristics of brain tumor patients in Kazakhstan has not yet been sufficiently disclosed. Foreign tests and questionnaires that allow assessing the psychological state of brain tumor patients also remain little known to our specialists. Such psychometric information with behavioral and psychophysiological data allows to personalize the presurgical approach and successful recovery in the postsurgical period. Thus, the introduction of non-invasive methods into clinical practice that allow early detection of CNS tumors, as well as presurgical and postsurgical psychodiagnostics of brain tumor patients, is a pressing issue in modern healthcare.

The aim of this study is translation and primary adaptation of widely known several foreign psychometric tests in the diagnosis of brain tumors, as well as the study of the relationship between psychophysiological and personality traits of brain tumor patients in a Kazakhstani sample.

Materials and methods

The study was conducted at the National Center of Neurosurgery in Astana. This article includes only preliminary results of psychometric and psychophysiological data of the Kazakhstani sample. Study permission was obtained from the Ethics Committee. Participation in the study was voluntary and patients of the National Center of Neurosurgery signed an informed consent form, which informed with aims of the research and possibility to complete participation at any study stage.

The main including criteria in the research were:

a) conformity with the groups' parameters;

b) keeping of motor upper limbs functions (actions with objects, writing, manual skills, non-existence of paresis or paralysis, hyperkinesis, apraxia);

c) maintenance of intelligence;

d) availability of appropriate vision correction (glasses, lenses, etc.);

d) voluntarily participation in all research stages.

The main exclusion criteria from undergoing research were:

a) psychiatric diseases and cognitive disorders diagnosed by a neurologist, preventing the cognitive tasks' performance;

b) instruction violations;

c) voluntary refusal to participate at any stages of the research.

Methods to achieve the aim of the reseaerch:

A) next psychometric questionaries were translated and adapted into Russian and Kazakh languages:

1) The Mini-Mental State Examination, MMSE (Folstein, Folstein and McHugh, 1975) consists of 22 tests to identify (screen) cognitive impairments and to assess the dynamics of the state: orientation in place and time, short-term memory, attention and mental arithmetic, word reproduction and speech, ability to write, read, draw, perceive logical constructions, and perform sequential actions. Based on the results of the Mini-Mental State Examination (MMSE, Folstein, Folstein and McHugh, 1975), a possible decrease or impairment of cognitive function due to brain diseases is determined. Summing up all answers of the subject according to scoring system: 0 points are awarded for an incorrect answer; the correct answer is estimated at 1 point; if the subject does not answer the question, 3 points are awarded; if the subject's answer cannot be interpreted due to some physical limitations, 9 points are awarded. Results' interpretation of the Mini-Mental State Examination (MMSE, Folstein, Folstein and McHugh, 1975) is based not only on the quantitative calculation of points, but also on their qualitative assessment by a specialist. For example, if the quantitative result of the scale is below 13 points, an additional consultation with a neurologist is required in order to exclude dementia, whereas if the total result is equal to or higher than 26 points, this indicates relative preservation of cognitive functions in brain diseases. This widely known scale has also been translated and adapted for the Russian-speaking population, and work is currently underway to translate and adapt the Kazakh-language version;

2) Montreal Cognitive Assessment, MoCA (Nasreddine, 1996) was developed for express screening of cognitive impairments in such areas as attention and concentration, memory, speech, executive functions, visual-constructive skills, counting and orientation. Thus, the maximum possible number of points that a subject can score is 30 points, while the normal indicator is 26 points and above; 25 points or less indicates the presence of cognitive impairments. The questionnaire, consisting of 30 items, has been translated and adapted into 46 languages, including Russian. Translated and adapted into Kazakh;

3) The Culture Fair Intelligence Test CFIT (Cattell, 1958) for determining the features of thinking contains graphic tasks like puzzles and consists of 4 tests (Test 1, Test 2, Test 3, Test 4). Moreover, each test includes from 8 to 14 tasks, and the tasks are arranged in order of increasing complexity. The tests begin with 2-3 trial tasks (examples), which are performed together with the experimenter for the subject to understand the instructions. Then the test tasks are performed by the subject independently. Processing the results of the culturally free CFIT test consists of summing up the raw scores for each of the 4 subtests with their subsequent conversion to an intelligence quotient using age norm tables. Thus, the average norm of the intellectual coefficient is the range from 90 to 110 points, while results below 90 points indicate that the subject has a mental retardation, and indicators exceeding 110 points indicate high intelligence.

4) The Functional Assessment of Cancer Therapy – Brain, FACT-Br (Weitzner et. al., 1995) is measure health-related quality of life in brain tumor patients. Functional assessment depend on statements abouy physical well-being, social and family well-being, emotional well-being and functional well-being, and identifies patient's problems. This questionnaire has undergone linguistic and cultural adaptation for the Russian-speaking population and is available on the website https://loinc.org/LP146506-3/, and has also been translated into Kazakh "FACT-G – oncology and the development of cancer care" and adapted by A.A. Kozhayev (S.Zh. Asfendiyarov Kazakh National Medical University, Almaty Oncology Center).

During statistical data processing, procedures were carried out to confirm the reliability of the tests translated into Russian and Kazakh with the Cronbach's alpha indicator, correlation analysis using the Pearson r-criterion, and one-way ANOVA analysis of variance. The SPSS IBM Statistics 26 program was used for statistical analysis.

Participants

A total of 122 participants aged 23 to 75 years from among patients of the Joint Stock Company "National Center for Neurosurgery" were examined, of which 61 men and 61 women underwent a full examination using all examination methods: 1) neuropsychological diagnostics; 2) performance of cognitive tasks; 3) EEG study. This article reflects only preliminary data of 10 participants of the experimental sample who were examined in Kazakh, 10 participants of the experimental sample who were examined in Russian. The average age of the sample was M = 48.14, SD = 15.35. The study sample was balanced by language and gender and by a certain type of tumor localization (glioma, astrocytoma, benign and malignant forms) in the frontal-parietal regions of the brain. The study of the control sample is ongoing, the data for which are still at the stage of collection and formation. It should be noted that for several objective reasons (urgency of operations, patient refusal to participate at any stage of the study, claustrophobia in the patient, etc.) not all participants completed all stages of the study. Table 1 shows the number of participants who completed each stage of the study.

Table 1 – Quantitative indicators of those examined who completed each stage of the study, reflected in this publication

Research stage	Number of subjects who passed the stage
Neuropsychological diagnostics	21
The lexical decision task in EEG research	31

Results and discussion

The validity and reliability of the obtained data were assessed using the Cronbach alpha coefficient, the results of which confirmed the reliability of the questionnaires. The reproducibility of the research data was ensured by the competent design of the experiment and statistical processing of the obtained data (Table 2).

In general, the results are quite high Cronbach's α, indicating the consistency and validity of the questionnaires used, except for several indicators (possibly due to the small sample).

We present the data of psychometric tests only for the group of patients, since the collection of data from the group of healthy people is ongoing. Table 3 presents the average data for each of the indicators of psychometric tests for the group of patients.

Table 2 – Cronbach's alpha reliability indicators for the psychometric methods used

Test	Cronbach's alpha reliability indicators	
	Language of testing	
	Kazakh	Russian
The Functional Assessment of Cancer Therapy – Brain (FACT-Br)		
Physical well-being	0,776	0,708
Social/family well-being	0,605	0,727
Functional well-being	0,872	0,768
Montreal Cognitive Assessment, MoCA	0,913	0,684
Culture Free Intellect Test, CFIT		
Test 1	0,698	0,696
Test 2 (graphic tasks)	quality indicator	quality indicator
Test 3	quality indicator	quality indicator
Test 4	quality indicator	quality indicator

Table 3 – Average indicators of psychometric tests

Test		Language of testing	
		Kazakh	Kazakh
The Functional Assessment of Cancer Therapy – Brain (FACT-Br)	Physical well-being	9,29 (6,21)	4,57 (3,27)
	Social/family well-being	20,71 (4,68)	17,57 (5,47)
	Emotional well-being	10,14 (5,49)	6,07 (1,59)
	Functional well-being	18,71 (6,42)	16,07 (6,26)
	Additional concerns	40,43 (7,16)	37,43 (9,10)
Mini-Mental State Examination, MMSE		25,71 (3,15)	24,31 (10,85)
Montreal Cognitive Assessment, MoCA		20,14 (10,19)	22,50 (10,87)

Continuation of the table

Test		Language of testing	
		Kazakh	**Kazakh**
Culture Free Intellect Test, CFIT	Test 1	0,83 (0,75)	0,75 (0,75)
	Test 2 (graphic tasks)	0,67 (0,82)	0,67 (0,89)
	Test 3	1,33 (0,82)	1,50 (1,09)
	Test 4	0,83 (0,98)	0,58 (0,67)
	Total score	3,67 (2,25)	3,50 (2,07)

1. At the next stage were conducted a correlation analysis to testing the hypothesis of relationship between the personality traits of brain tumor patients. Statistically significant correlation results are presented in Table 4.

Data presented in the Table 4, there are reliable significant correlations between the indicators of emotional well-being and mental state (p=0.003), and this relationship is negative: the higher the indicators of emotional well-being, the lower the likelihood of problems with thinking or communication, problems with understanding and amnesia (memory).

2. Next, a correlation analysis of the personal characteristics of patients with EEG data was carried out when performing the lexical task. Correlation analysis did not reveal any significant relationships between the test data and the EEG data.

Table 4 – Significant correlations between psychometric tests (Pearson r-coefficient)

Test	Mini-Mental State Examination, MMSE	Montreal Cognitive Assessment, MoCA	Culture Free Intellect Test, CFIT
Physical well-being (FACT-Br)	-0,442	-0,002	-0,207
Social/family well-being (FACT-Br)	-0,031	-0,011	0,339
Emotional well-being (FACT-Br)	-,634(**)	-0,289	-0,129
Functional well-being (FACT-Br)	-0,273	-0,113	0,04
Additional concerns (FACT-Br)	-0,257	0,31	-0,116

Conclusions

Analysis of the data obtained using the Functional Assessment of Cancer Therapy – Brain (FACT-Br), Mini-Mental State Examination, MMSE, MoCA, CFIT tests showed a statistically significant relationship between the indicators of emotional well-being and mental state.

The data we obtained can be useful in presurgical and postsurgical diagnostics of brain tumor patients using modern foreign tests, measuring electrical activity when performing a cognitive task. Thus, the study showed that a multimodal approach to studying brain tumors allows us to obtain much more information about brain functions in a functional mode.

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