ORIGINAL ARTICLE

Neurophysiological and Neuroimaging Correlates of the Consciousness' Dynamic in Acute period of Parenchymal Hemorrhagic Stroke

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ABSTRACT

Background: Hemorragic stroke is the most important medical and social problem both in the world and in the Russian Federation, which is due to high rates of morbidity, mortality and disability.
Aim: To determine the neurophysiological and neuroimaging correlates of consciousness dynamic in the acute period of hemispheric hemorrhagic stroke for the complex estimation of consciousness.
Methods: 58 patients suffering from hemorrhagic stroke of supratentorial localization and 25 persons in control group were examined. The assessment of the level of consciousness, cognitive functions, data of neuroimaging was conducted.
Results: On the basis of the studied characteristics, subgroups of patients were distinguished, differing in the dynamics of the level of consciousness and parameters of P300 potential. The heterogeneity of patients with hemispheric non-traumatic intracerebral hemorrhage has been established; proposed criteria for the dynamics of the course of hemorrhagic stroke for the studied parameters.
Keywords: hemorrhagic stroke, Glasgow coma scale, logit-regression analysis, potential P300, method of hierarchical trees and k-means.

INTRODUCTION

Each year, about 795,000 people experience a first or recurrent stroke. Approximately 610,000 of these are newly diagnosed strokes[1].

Hemorrhagic stroke is the most important medical and social problem both in the world and in the Russian Federation, which is caused by high rates of morbidity, mortality and disability[2].

Clinical problems arising in the process of diagnosis and treatment of hemorrhagic stroke are largely related to the solution of the forecasting problem, that is, a probabilistic judgment on the further course and outcome of the disorder in relation to life, restoration of the patient's function and ability to work[3,4].

The level of impaired consciousness in patients in the acute period of hemorrhagic stroke is an indicator of the severity of the patient's condition, one of the predictors of the further course of the disease, a characteristic that determines the indications and contraindications for surgical treatment. In this case, consciousness can be considered as an integrative psychophysiological function, which is reflected both in the "searchlight" concepts of consciousness and in the concepts of information synthesis. In this regard, the assessment of the dynamics of the level of consciousness in patients with non-traumatic hemisphere hemorrhage is an important applied task, the solution of which should be based not only on clinical indicators, neuroimaging data, but also on neurophysiological indicators reflecting the processes of perception, memory, decision making.

The objective of the study was to establish neurophysiological and neuroimaging correlates of the dynamics of the level of consciousness in patients in the acute period of parenchymal hemorrhagic stroke for its comprehensive assessment.

MATERIALS AND METHODS:

Under observation, there were 58 patients with intracerebral nontraumatic hemorrhages, of which 31 were men and 27 were women, the average age was 67.0 years, and the standard error was 1.41 years. The diagnosis of hemorrhagic stroke was determined on the basis of neuroimaging data, clinical syndromeology and anamnesis - features of the onset and course of the disease, clinical and laboratory data.

As a control group, patients with dorsopathy of the cervical spine with cervicalgia, without neurological prolapse, history of episodes of cerebrovascular accident and signs of compression and hemodynamically significant stenosis of the main vessels of the neck according to ultrasound dopplerography were examined - 25 people, the average age was 66 years, 13 of them are men and 12 women. The criteria for "inclusion" in the study were:

1. Confirmed by computed tomography of the brain, non-traumatic hemispheric hematoma, supratentorial localization.
2. Patients who did not have indications for surgical treatment.
3. Cases where relatives of patients refused surgical treatment.

The criteria for "exclusion" were: 1. Subtentorial localization of hematomas (cerebellar, stem). 2. Subarachnoid hemorrhages, aneurysmal hemorrhages 3. Ventricular hemorrhages. 4. Pregnancy. The level of consciousness was determined on the basis of the Glasgow Coma Scale (GCS), the assessment was carried out on 1, 3, 21 days.

The potential associated with the P300 event was recorded on the first day after the onset of the disease using the Neuro-MVP.Net software and hardware complex of Neurosoft LLC in the oddball paradigm (if the patient could not respond to the stimulus, different stimuli were delivered without pressing a button). The potential of P300 was recorded within the framework of the probabilistic paradigm of the appearance of a significant stimulus (tone 2000 Hz) and an insignificant stimulus (tone 1000 Hz). The probability of occurrence of a significant stimulus was 30%, insignificant 70%, the duration of the stimulus was 50 ms, the intensity was 70 dB SPL, and headphones were used. Recording and averaging of the response was performed using leads F3, Fz, F4, C3, Cz, C4, P3, Pz, P4 with reference electrodes A1 and A2. The passband ranged from 0.5 Hz to 30 Hz.

Descriptive statistics suggested a description of the median, lower and upper quartile [Me; LQ; UQ]. A comparative analysis was carried out using the non-parametric Mann-Whitney test (using normal approximation - Z), the analysis of correlations using the Spearman rank non-parametric test (R).

To assess the probability of the distribution of practically healthy individuals or patients with hemorrhagic stroke, the logit regression analysis was used, the regression analysis equation is presented in the form Y = b0+ b1 *X1+b2 *X2+bn *Xn; where Y is a dependent variable, b0 is a constant (free term), b1, b2 . bn are the regression coefficients for independent factors; X1, X2 Xn are independent factors (predictors), the probability of the distribution of patients into groups is estimated by the formula 1-P (y)=1- (1/ (1 + e-y)); to assess the convergence (reliability) of the model, the chi-square (chi2) criterion was used, with the error significance level less than 0.05[5].

RESULTS

Based on the cluster analysis, 2 groups of patients were identified: with initially relatively favorable dynamics (group 1) of the level of consciousness (34 patients) and initial depression of consciousness to a deep coma (group 2 - 24 patients) (Table 1).

To further evaluate neurophysiological parameters in groups of patients with hemorrhagic stroke, they were compared with the control group. On the whole, in the group of patients with hemorrhagic stroke, a regularly higher latency of the main components of the P300 potential and a lower amplitude were revealed in comparison with the control group (table 1).

Indicators Control Group of patients with hemorrhagic stroke Z p. As follows from the table, in the group of patients with a relatively safe level of consciousness, a higher amplitude of the N2P3 potential in the frontal, central and parietal leads is determined; in the same group, significantly lower latency of these components is determined.

In a group of patients with non-traumatic intracerebral hematomas in 58% of cases they were localized in the left hemisphere, in 42% in the right hemisphere; while in 11% lobar hematomas were revealed on the left (frontal, temporal, frontoparietal), in 22% lateral subcortical hematomas, in 26% medial (thalamic) subcortical hematomas; in 13% of cases lobar hematomas were revealed on the right, in 13% lateral subcortical hematomas on the right, in 15% of cases medial subcortical hematomas on the right.

When analyzing neuroimaging indicators, significant differences were revealed in terms of hematoma volume indicators between groups: in group 1 Me; LQ; UQ 10; 6; 15 ml; in group 2 Me; LQ; UQ 40; 26; 77 ml; Z = -3.8; p = 0.001, that is, a significantly larger volume of hematomas was determined in group 2.

Given the clearly expressed polarity of the groups according to the level of consciousness, in addition to the group of patients with relatively intact consciousness (group 1), 2 subgroups were distinguished: with restoration of consciousness to a clear dynamic (subgroup 1 - 18 people) and a subgroup of patients with stable depression of consciousness to deep stunning (8 patients) or negative dynamics of the level of consciousness (8 patients) (subgroup 2 - a total of 16 patients).

No significant differences in hematoma volume between subgroups were detected. We proposed a model of logit-regression analysis to identify the relationship between the group number (type of dynamics of the level of consciousness) and indicators of the potential of P300 and the volume of hematoma. The indicators of the model are presented in table 3.

Characteristics of the model: Chi-square 18.9; p = 0.0001; the percentage of correct decisions in group 1 94%, in group 2 76%. This model also demonstrated satisfactory characteristics (chi-square criterion 16.2; p = 0.0003; with 90% correct probability of distribution of patients in groups when assessed for 1 day of observation. Differences in the potential indicators of P300 in groups in patients with hemorrhagic stroke are presented in table 2.

Table 1: Indicators of amplitude and latency in the studied groups.

Indicator	Control group	Group of patients with hemorrhagic stroke	Z	p
A P2N2 F4, μV	4,5;3,2;8,8	2,5;0,9;4,4	2,04	0,040
A N2P3 F3, μV	1,3;0,4;3,6	1,0;0,2;3,7	2,03	0,042
Лат P3 F3, ms	321;315;332	357;332;375	-2,46	0,014
Лат P3 C3, ms	318;300;326	342;317;369	-2,34	0,019
Лат P3 C4, ms	320;301;336	350;331;368	-3,12	0,002
Лат P3 P3, ms	318;301;327	340;314;365	-2,41	0,016
Лат P3 P4, ms	325;306;350	349;329;361	-2,23	0,026

Note: A - amplitude, Lat – latency

Table 2: P300 amplitude and latency indicators in groups of patients with hemorrhagic stroke

Indicator	Group 1	Group 2	Z	p
A N2P3 Fz, μV	5,9;3,3;8,6	3,2;2,1;4,9	2,03	0,042
A N2P3 Cz, μV	6,4;3,8;7,8	4,4;3,6;5,1	2,18	0,028
A N2P3 Pz, μV	5,7;3,6;7,3	4,0;1,6;4,6	2,28	0,022
A N2P3 P3, μV	5,7;4,5;6,7	2,9;1,7;4,6	2,31	0,020
Лат P3 Fz, ms	351;320;361	379;362;385	-1,98	0,044
Лат P3 F3, ms	349;316;366	378;359;382	-2,44	0,015

Note: A - amplitude, Lat – latency

Table 3. Model logit regression analysis for classification patients in primary groups 1 and 2

Indicators	coefficient	Chi-square	p	Odds ratio
Free Member	0,733	3,9	0,048	8,0
Amplitude N2P3 in Fz	-0,89	4,4	0,041	0,4
Hematoma volume, ml	0,097	4,5	0,035	1,1

DISCUSSION

As follows from the presented results, the heterogeneity of the group of patients in terms of consciousness is naturally associated with the volume of the hematoma, which is determined by both direct damage to the brain tissue and peripheral edema and secondary neurodynamic disorders[6]. The primary result of cluster analysis showed the identification of groups with polar characteristics: patients initially in a deep coma and patients with a relatively preserved level of consciousness. In this regard, subgroups of patients in group 2 were additionally distinguished: with restoration of consciousness to clear and with persistent depression of consciousness (to deep stunning) in the dynamics of observation.

The correlate of both deep depression of consciousness and its unfavorable dynamics was reduced bioelectrogenesis in the associative cortical zones during stimulus recognition and decision-making, while the unfavorable dynamics of the level of consciousness corresponded to a decrease in the amplitude and higher latency of N2 and P3 peaks, reflecting insufficient activation of cortical structures during stimulus recognition making decisions regarding him[7,8,9,10]. The use of these indicators for assessing consciousness in a logit-regression model for dividing primarily isolated polar groups is more likely to be ascertaining; but it can be useful in determining the dynamics of the level of consciousness in subgroups with a relatively safe level.

CONCLUSIONS

The heterogeneity of patients with hemispheric nontraumatic intracerebral hematomas has neurophysiological and neuroimaging correlates, while morphological indicators (hematoma volume) are more important in the description of patients with deep depression of consciousness. In patients with relatively favorable dynamics of the level of consciousness (deep stunning for 1 day), neurophysiological correlates predominate, reflecting the change in the activation of cortical structures during recognition and decision-making in relation to the stimulus. Moreover, in this group, the models of logit-regression analysis make it possible to effectively assess the dynamics of the level of consciousness based on a set of indicators (peak-to-peak amplitude P2N2 P300 and hematoma volume).

Declaration of author's competing interests:: The authors declare no conflict of interest.

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