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CLINICAL AND NON-HEMORRHAGIC NEUROIMAGING INDICATORS OF PROBABLE CEREBRAL AMYLOID ANGIOPATHY AS A CAUSE OF NON-TRAUMATIC LOBAR HEMATOMAS

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КЛИНИЧЕСКИЕ И НЕГЕМОРРАГИЧЕСКИЕ НЕЙРОВИЗУАЛИЗАЦИОННЫЕ ИНДИКАТОРЫ ВЕРОЯТНОЙ ЦЕРЕБРАЛЬНОЙ АМИЛОИДНОЙ АНГИОПАТИИ КАК ПРИЧИНЫ НЕТРАВМАТИЧЕСКИХ ЛОБАРНЫХ ГЕМАТОМ

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Objective. To identify clinical and non-hemorrhagic neuroimaging indicators of probable CAA in patients with acute non-traumatic lobar hematomas. Cerebral amyloid angiopathy (CAA) is a microangiopathy affecting the leptomeningial and cortical vessels of the brain due to the deposition of pathological β-amyloid in them. The most common clinical manifestation of CAA is lobar hematomas (LH) – spontaneous intracerebral hemorrhages localized between the cerebral cortex and basal ganglia. LH can also occur in hypertensive cere-

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bral microangiopathy (hCMA) in patients with arterial hypertension. Since the tactics of managing patients with CAA and hCMA differ, it is important to determine the genesis of LH correctly.

Materials and methods. A comparative analysis of clinical and neuroimaging characteristics of acute non-traumatic hypertension in 32 patients with probable CAA and hCMA was carried out. Along with neurological examination and neuroimaging, all patients underwent a study using the Montreal Cognitive Assessment Scale and the Benson Complex Figure Test to reveal visuospatial impairments. The diagnosis of probable CAA was carried out in accordance with the updated Boston criteria of 2010, the diagnosis of hCMA was based on clinical data, anamnesis and results of neuroimaging of the brain.

Results. Probable CAA was diagnosed in 16 patients, and in all these cases it was combined with hCMA (1st subgroup). Isolated hCMA as a cause of LH was also observed in 16 patients (2nd subgroup). Patients of subgroup 1 were statistically significantly more likely to have clinically pronounced visual impairments, performed the MoCA subtest and the Benson Complex Figure Test worse, and the overall assessment of their cognitive functions according to Mo SA was lower than in patients of subgroup 2. According to neuroimaging data, in the 1st subgroup of patients, an expansion of perivascular spaces in the semi-oval center and a zero or negative value of the front-occipital gradient were more often detected. The application of the logistic regression method made it possible to integrate potential CAA indicators and create a prognostic model for revealing this pathology in patients with hypertension.

Conclusions. Clinically pronounced disorders of primary and higher visual functions, a negative front-occipital gradient and expansion of perivascular spaces in the semi-oval centers can serve as indicators of probable CAA in patients with acute lobar hematoma. On admission of such patients to the vascular center, it is advisable to include iron-sensitive pulse sequences in the neuroimaging screening protocol to verify the diagnosis of CAA.

Keywords. Cerebral amyloid angiopathy, lobar hematoma, intracerebral hemorrhage, hypertensive microangiopathy, perivascular spaces, front-occipital gradient.

Цель. Выявление клинических и негеморрагических нейровизуализационных индикаторов вероятной церебральной амилоидной ангиопатии у пациентов с острыми нетравматическими лобарными гематомами. Церебральная амилоидная ангиопатия (ЦАА) – микроангиопатия, поражающая лептоменингиальные и кортикальные сосуды головного мозга вследствие отложения в них патологического β-амилоида. Наиболее частое клиническое проявление ЦАА – лобарные гематомы (ЛГ), т.е. спонтанные внутримозговые кровоизлияния, локализующиеся между корой головного мозга и базальными ганглиями. ЛГ также встречаются и при гипертензивной церебральной микроангиопатии (гЦМА) у больных артериальной гипертензией. Поскольку тактика ведения пациентов с ЦАА и гЦМА различается важно правильно определить генез ЛГ.

Материалы и методы. Проведен сравнительный анализ клинико-нейровизуализационных характеристик острых нетравматических ЛГ у 32 человек с вероятной ЦАА и гЦМА. Наряду с неврологическим осмотром и нейровизуализацией всем пациентам проводилось исследование с применением шкалы МоСА и теста сложной фигуры Бенсона для выявления зрительно-пространственных нарушений. Диагностика вероятной ЦАА осуществлялась в соответствии с обновленными Бостонскими критериями 2010 г., диагностика гЦМА основывалась на клинико-анамнестических данных и результатах нейровизуализации.

Результаты. Вероятная ЦАА была диагностирована у 16 больных, и во всех случаях сочеталась с гЦМА (1-я подгруппа). Изолированная гЦМА как причина ЛГ также отмечалась у 16 больных (2-я подгруппа). Больные 1-й подгруппы статистически значимо чаще имели клинически выраженные зрительные нарушения, хуже выполняли субтест МоСА и тест сложной фигуры Бенсона, общая оценка когнитивных функций по МоСА была ниже, чем во 2-й подгруппе. По данным нейровизуализации в 1-й подгруппе пациентов чаще обнаруживалось расширение периваскулярных пространств в полуовальном центре и нулевое или отрицательное значение фронтоокципитального градиента. Применение метода логистической регрессии позволило интегрировать потенциальные индикаторы ЦАА и создать прогностическую модель для выявления этой патологии у пациентов с ЛГ.

Выводы. Клинически выраженные нарушения первичных и высших зрительных функций, отрицательный фронтоокципитальный градиент и расширение периваскулярных пространств в полуовальных центрах могут служить индикаторами наличия вероятной ЦАА у больных с острой ЛГ. Таким пациентам при поступлении в сосудистый центр в протокол нейровизуализационного обследования целесообразно включать железочувствительные импульсные последовательности для верификации диагноза ЦАА.

Ключевые слова. Церебральная амилоидная ангиопатия, лобарная гематома, внутримозговое кровоизлияние, гипертензивная микроангиопатия, периваскулярные пространства, фронтоокципитальный градиент.

INTRODUCTION

Hemorrhagic stroke accounts for 10–15 % of all types of cerebral circulation disorders, with intracerebral hemorrhages being the primary component. The medical and social significance of intracerebral hemorrhages (non-traumatic intracerebral hematomas) is underscored by a mortality rate that reaches 50 % or higher, while the disability rate among surviving patients exceeds 3.0 per 1000 population [1].

The most common cause of intracerebral hemorrhages (up to 35 %) is arterial hypertension and the associated hypertensive cerebral microangiopathy (hCMA). It is important to differentiate this pathology from cerebral amyloid angiopathy (CAA), which is a less common, but possible (up to 20 %) cause of intracerebral hematomas in the elderly [2].

The importance of diagnosing CAA as a cause of intracerebral hematomas is determined by the specific management strategies for patients and the prognosis of the disease. In particular, with CAA, the risk of recurrent intracerebral hemorrhage is significantly higher, and antihypertensive therapy is not as effective in preventing it compared to hCMA [3]. Furthermore, patients with CAA have restrictions on the use of antithrombotic therapy and statins for the prevention of ischemic stroke, which is also a risk in both CAA and hCMA [4; 5].

Cerebral amyloid angiopathy (CAA) is a pathology of the brain vessels characterized by the deposition of beta-amyloid in the walls of medium and small-caliber arteries (up to 2 mm in diameter), arterioles, and capillaries of the cerebral cortex, leptomeningeal vessels, and some other vessels, and less frequently in venules [6]. CAA is one of the common causes of strokes [7]. Since CAA primarily affects the cortical and leptomeningeal vessels, the most common manifestations of CAA are multiple superficial microhemorrhages and lobar (i.e., localized in the cortical or subcortical areas of the brain) intracerebral hematomas [8].

The diagnosis of CAA is established based on the Modified Boston Criteria of 2010, which include patients' age over 55 years, results from clinical examinations, laboratory data, and neuroimaging findings (CT or MRI of the brain) [9]. According to the currently applicable Modified Boston Criteria, neuroimaging indicators of CAA include only hemorrhagic markers, specifically – single or multiple lobar hematomas (LH), multiple cortical-subcortical microhemorrhages, and focal or disseminated cortical superficial siderosis (cSS).

The identification of LH in a patient based on CT or MRI data increases the likelihood of CAA; however, in the absence of information about cortical microhemorrhages, this is insufficient for the diagnosis of CAA [10]. At the same time, recognizing small cortical hemorrhages and cSS requires the use of additional MRI pulse sequences, which are not employed in most vascular

centers during the initial examination of patients with strokes. All of the above highlights the importance of searching for such signs, the detection of which would indicate the need for additional inclusion of MRI sequences sensitive to microhemorrhages and their transformation products (SWI, SWAN, or T2*GRE) in the neuroimaging assessment of patients with LH [11].

Since CAA is characterized by LH, which are more often localized in the posterior regions of the brain, the corresponding "indicator" clinical signs of a high likelihood of CAA may include acutely occurring visual and visuospatial disturbances. As non-hemorrhagic neuroimaging biomarkers indicative of a high probability of CAA, it is appropriate to discuss the enlargement of perivascular spaces (PVS) in the centrum semiovale, as well as the predominance of white matter hyperintensity (WMH) in the posterior parts of the brain, evidenced by a negative fronto-occipital gradient (FOG). At the same time, the informativeness of the listed signs for differentiating CAA and hCMA as causes of LH has not been studied [12].

The objective of the study was to identify clinical and non-hemorrhagic neuroimaging indicators of probable cerebral amyloid angiopathy in patients with acute non-traumatic lobar hematomas.

MATERIALS AND METHODS

Thirty-two patients diagnosed with acute hemorrhagic stroke were observed during examination and treatment at the Nizhny Novgorod Regional Vascular Center. The diagnosis of "probable CAA" was made according to the Modified Boston Criteria of 2010, based on the presence of the following signs: age over 55 years; presence of multiple hemorrhagic cerebral lesions; restricted localization of hemorrhages in cortical and subcortical (lobar) regions of the brain; and the absence of other causes of bleeding (arteriovenous malformation, traumatic brain injury, brain tumour, vasculitis, anticoagulation, etc.) [9].

The diagnosis of hCMA was established in the presence of a verified history of arterial hypertension, clinical and neuroimaging signs of cerebral microangiopathy, and the establishment of a causal relationship between them, while the manifestations of the disease did not comply with the Boston criteria for CAA [9].

All patients underwent neurological examination, neuropsychological assessment, and neuroimaging studies. The neurological examination was supplemented by a quantitative assessment of impairments using the NIHSS scale. Based on the collection of complaints, analysis of anamnesis, and neurological evaluation, the presence of motor impairments (paresis), somatic sensory disturbances (hypoaesthesia), coordination disorders, and cranial nerve dysfunctions were considered for each patient. Special attention during the examination and neuropsychological assessment was given to identifying potential clinical indicators of likely CAA, such as visual disturbances of varying levels (hemianopsia, central metamorphopsia, visual agnosias, visuospatial disorders) [13].

For the quantitative assessment of visuospatial praxis and gnosis, a cube copying task was used as a component of the MoCA

test (0 points – no impairments in cube copying, 1 point – impairments in cube copying), as well as the Benson Complex Figure Test [14]. The Benson Complex Figure Test is a simplified version of the Rey-Osterrieth Complex Figure Test used to assess visuoconstructive abilities and visual memory. A patient was asked to copy the figure and then reproduce it from memory after 10–15 minutes [15]. Each element of the figure in this test is scored out of 2 points if the element is accurately drawn and correctly positioned on the figure (1 point for accuracy, 1 point for placement). 1 point is awarded if the element is poorly drawn but correctly placed, or accurately drawn but not in its correct position, and 0 points is given if the element is neither drawn nor placed correctly. A bonus point is awarded when the figure is well-drawn (i.e. each element must be accurately drawn, all elements must be correctly placed, all elements must be drawn in proper proportions, all connections between elements must be clear, and no extraneous lines should be present). The total score is calculated, with a maximum possible value of 17 points [15].

For the quantitative integral assessment of the degree of cognitive dysfunction, the Montreal Cognitive Assessment (MoCA) scale was used [16].

The neuroimaging study was conducted using a General Electric Signa Infinity HiSpeed Plus MRI scanner with a magnetic field strength of 1.5 T. The research protocol included T2, T1, and FLAIR pulse sequences in three planes, as well as a T2*GRE pulse sequence to verify areas of hemoglobin derivative deposits (including regions of microhemorrhages).

To determine the nature and localization of the brain lesion, all patients underwent CT and MRI of the brain.

Neuroimaging data were used to assess the presence of LH, microhemorrhages, cSS, and PVS. Additionally, the frontal-occipital gradient (FOG) was calculated to evaluate the varying degrees of T2 hyperintensities in white matter between the frontal and occipital lobes.

The localization of intracerebral hematomas (lobar vs deep) was determined according to the approach of G.J. Falcone et al. (2013). A lobar (subcortical) hematoma was defined as an intracerebral hemorrhage localized in the cortex and the adjacent subcortical area, while a deep hematoma was defined as a hemorrhage affecting only the thalamus, basal ganglia, internal capsule, and deep periventricular white matter [10]. In addition, the localization of lobar hematomas was conditionally divided into two categories: the first – frontal, parietal, and frontoparietal localization of hematomas; the second – temporal, occipital, and temporo-occipital.

Cerebral superficial microhemorrhages and their count were assessed using axial T2*-weighted images. The number of microhemorrhages was classified as small (0–4), medium (5–9), and large (≥10). Similarly, the evaluation of deep microhemorrhages (located in the deep white matter) was performed in the same manner.

Cortical superficial siderosis (cSS) was assessed based on MRI results in T2* mode (gradient echo) as follows: 0 points – no

cSS, 1 point – focal, limited to involvement of 1–2 sulci of the brain, 2 points – multifocal, involving 3 or more sulci of the brain [17]. The detection of multiple microhemorrhages and cSS was necessary for diagnosing CAA according to its criteria.

Alongside this, the analysis included those non-hemorrhagic neuroimaging markers that, although not included in the current Boston criteria for diagnosing CAA, may be important for differentiating it from hCMA, namely PVS and FOG.

To determine the FOG, images in FLAIR mode were used in the axial plane. Calculations were performed using the method by Zhu et al. (2012) [18]. For this purpose, the scores (each of which could range from 0 to 2 points on the Zhu scale) of hyperintensity in the periventricular, juxtacortical, and deep white matter were first summed in the frontal region, then in the occipital region, after which the difference in total scores in the specified areas was calculated. The total FOG score can range from -6 to +6 points.

The perivascular spaces (PVS) were assessed using the method by F.N. Doubal et al. (2010) with clarifications by A. Charidimou et al. (2019) on axial T2-weighted images (T2-WI), separately in the basal ganglia and separately in the semioval centre of each hemisphere. The presence of visualised PVS was regarded as a sign of their expansion. The assessment was carried out using a 4-point visual rating scale as follows: 0 points – no visualised PVS, 1 point – ≤ 10 PVS, 2 points – 11–20, 3 points – 21–40, and 4 points – ≥ 40 visualised PVS [17]. All relevant slices were reviewed, and the presence of PVS on each side of the brain was assessed, after which a score corresponding to the side and slice with the highest number of identified PVS was assigned [19].

Statistical analysis of the data was conducted using the SPSS 23 software package. Normality testing for quantitative variables was not performed due to the small sample size and the established groups. Therefore, within the framework of descriptive statistics, the median and interquartile range (*Me* [Q1; Q3]) were calculated for all quantitative and ordinal parameters. Qualitative (binary) variables were described by calculating the proportions (%) of individual categories of patients in the studied sample and in the groups. Pairwise comparisons of groups for quantitative and ordinal parameters were conducted using the Mann-Whitney U test. The assessment of differences in binary traits was conducted using the analysis of contingency tables. Differences in binary variables were assessed using chi-squared (χ^2) tests and Fisher's exact test (when the values in the cells of the contingency tables were less than 5). Differences were considered statistically significant at $p < 0.050$.

To provide an integral assessment of the prognostic ability of the identified predictors of CAA in patients with LH, a binary classifier was developed based on the use of a logistic regression model. For training, specialized libraries of the Python programming language (Pandas[1], Numpy [20], Scikit-Learn[2])

[1] pandas-dev/pandas: Pandas. Zenodo, available at: https://zenodo.org/records/10426137

were used, as well as the software package AutoStatPack (Certificate of state registration of the computer program No. 2020663190).

RESULTS AND DISCUSSION

The medical history data and cardiological examination results indicated the presence of stage III hypertension in all 32 examined individuals. Signs of probable CAA, according to the modified Boston criteria, were observed in 16 patients. In all these cases, CAA was associated with hCMA. Patients with LH against the background of combined CAA and hCMA comprised the first subgroup (8 men and 8 women, mean age 68.5 [67.0; 82.2] years). The second subgroup included 16 individuals with LH against the background of isolated hCMA (9 men and 7 women; median age 67.5 [63.0; 73.5] years). The groups did not have statistically significant differences in age and sex, nor in the frequency of motor, coordination, and somatic sensory disturbances.

Patients with CAA had statistically significantly more frequent LH localized in the temporal, occipital, and temporo-occipital regions compared to those with hCMA (Table 1). This fact appears to be quite logical, as it has previously been established that intracerebral hemorrhages in the occipital and parietal lobes are more characteristic of CAA [21]. Some authors attribute this to the fact that occipital vessels, for some reason, have thicker walls and can therefore accommodate significantly more amyloid compared to vessels in other areas of the brain [3; 8].

Alongside this, patients in the first subgroup exhibited statistically significantly more frequent visual disturbances, such as hemianopsia, metamorphopsia, visual agnosia, and spatial apraxia, compared to those in the second subgroup. There were also statistically significant differences in the results of tasks involving cube copying, figure copying, and memory drawing of the Benson figure and MoCA (see Table 1). Such a high frequency of primary visual function and visuospatial disturbances can be explained by the predominant involvement of the posterior regions of the brain in CAA [22]. Our data are supported by the findings of the study by Y. Su et al. (2021), which discovered that clinically detectable visuospatial dysfunction may serve as an independent marker for the presence of CAA in non-demented patients [22].

In the first subgroup of patients, multiple visible (i.e., enlarged) perivascular spaces (PVS) in the centrum semiovale were also more frequently detected than in the second subgroup (see Table 1). In this regard, it should be noted that several authors point out the nonspecific nature of PVS enlargement, which can be observed with aging and arterial hypertension, not only in cases of CAA [23]. However, our data suggest the potential use of this indicator as a neuroimaging marker of CAA, which aligns with the opinion of A. Charidimou et al. (2019), who even propose including it in the new version of the Boston criteria for CAA diagnosis.

[2] scikit-learn/scikit-learn: Scikit-learn 1.3.2. Zenodo, available at: https://zenodo.org/records/10039710

Table 1

Comparative characteristics of patients

Parameter	Overall group, $n = 32$	CAA patients (1), $n = 16$	hCMA patients (2), $n = 16$	p
Age, years, *Me* [Q_1; Q_3]	68.0 [63.2; 74.0]	68.5 [67.0; 82.2]	67.5 [63.0; 73.5]	0.450
Women, abs. (%)	15 (46.9)	8 (50.0)	7 (43.8)	1.000
Men, abs. (%)	17 (53.1)	8 (50.0)	9 (56.2)	1.000
Localization				
Frontal, parietal, fronto-parietal, abs. (%)	20 (62.5)	8 (50.0)	12 (75.0)	0.144
Temporal, occipital, and temporo-occipital, abs. (%)	18 (56.3)	13 (81.3)	5 (31.3)	0.011
Clinically manifest visual disturbances, abs. (%)	16 (50.0)	12 (75.0)	4 (25.0)	0.012
Neuropsychological tests				
Cube copying test, number of patients with disturbances (%)	19 (59.4)	14 (87.5)	5 (31.2)	0.003
Benson test, points: *Me* [Q_1; Q_3]	16 [14.0; 17.0]	14 [14.0; 15.8]	17 [16.0; 17.0]	< 0.001
Benson test after 10 minutes, points: *Me* [Q_1; Q_3]	8.5 [7.25; 12.5]	8.0 [6.0; 8.0]	12.5 [10.0; 14.0]	< 0.001
MoCA, points: *Me* [Q_1; Q_3]	18.0 [12.0; 20.0]	12.0 [10.0; 18.0]	20.0 [18.0; 24.3]	< 0.001
Non-hemorrhagic neuroimaging markers				
Enlarged perivascular spaces (PVS) in the centrum semiovale, abs. (%)	18 (56.3)	16 (100.0)	2 (12.5)	< 0.001
Fronto-occipital gradient (FOG) greater than 0, abs. (%)	9 (28.1)	0 (0.0)	9 (56.3)	0.001

The values of FOG in the first subgroup ranged from 0 to -4, while in the second subgroup, they ranged from 1 to 5 points.

These results contradict the findings of S. Phuach et al. (2022), who did not find a predominance of white matter hyperintensity (WMH) in the posterior parts of the brain in cases of CAA, but are consistent with the opinion of A. Charidimou et al. (2016), who consider negative values of FOG to be typical for CAA, in which white matter damage predominates in the occipital regions of the brain and in the periventricular white matter around the posterior horns of the lateral ventricles [24; 25]. In contrast, with hypertensive cerebral microangiopathy (hCMA), WMH, according to neuroimaging data, is uniformly expressed throughout the entire periventricular region [25].

At the next stage of the work, an analysis was performed on the predictive value of the clinical and non-hemorrhagic neuroimaging indicators that demonstrated statistically significant intergroup differences and could therefore serve as potential indicators of CAA in patients with LH. For this purpose, the entire group of patients was divided into training and testing samples in a ratio of 60/40 (19 and 13 patients, respectively). The proportion of patients with CAA (coded as 1) in the training sample was 53 % compared to 46 % in the testing sample. Structural differences in the specified samples regarding the presence of CAA were not significant ($p = 0.570$). The predictive model was constructed using data from the training sample, and the quality of the model was evaluated on the testing

sample. The resulting equation of the logistic regression model is as follows:

$$P = \frac{1}{1 + e^{-(-0,23+0,51 \cdot X_1 + 0,64 \cdot X_2 + 0,15 \cdot X_3 - 0,5 \cdot X_4 - 0,43 \cdot X_5 - X_6 + 0,79 \cdot X_7)}},$$

where P is the probability of the presence of CAA (coded as 1) in a patient, x1–7 are the values of the predictors in the model (see Table 2).

The decision regarding the presence of CAA in a patient was made when $P \geq 0,5$, and for the absence of CAA when $P < 0,5$. The accuracy of the model was 100 [84.3; 100] % for the test sample, indicating excellent classification quality. However, it should be understood that the performance of the model may decline in real clinical practice (within the confidence interval) when non-classical cases arise that may not have been present in the training and test samples during model development. Given the small size of the training and test samples, additional evaluation of the model's prognostic ability and correction of binary classification quality metric values are required when analyzing an expanded data set.

From the data in Table 3, it follows that the obtained model, which includes the clinical and neuroimaging indicators we selected, provides a high quality of personalized diagnosis of probable CAA in a patient.

Conclusion

Data from the patients with lobar hematomas and probable CAA differed from those in the patients with hypertensive cerebral microangiopathy by a more frequent occurrence of primary visual function impairments and visuospatial disturbances

Table 2

Clinical and neuroimaging indicators included as predictors in the logistic regression model for predicting CAA = 1

Code	Description and Data Entry Format	Feature Type
X_1	Temporo-occipital localization: yes – 1, no – 0	Binary
X_2	Visual disturbances: yes – 1, no – 0	Binary
X_3	Cube copying test: yes – 1, no – 0	Binary
X_4	Benson test, points	Quantitative
X_5	MoCA, points	Quantitative
X_6	Fronto-occipital gradient	Quantitative
X_7	Perivascular spaces, enlargement – 1, no enlargement – 0	Binary

Table 3

Prediction quality metrics

Sl.№	Metrics, %	Metric value [95 % confidence interval]
1	Accuracy	100 [84.3; 100]
2	Sensitivity	100 [84.3; 100]
3	Specificity	100 [84.3; 100]
4	Positive Predictive Value (PPV)	100 [84.3; 100]
5	Negative Predictive Value (NPV)	100 [84.3; 100]

in the clinical presentation of the disease, as well as a more pronounced overall decline in cognitive functions.

Lobar hematomas, associated with CAA, compared to hypertensive lobar hematomas, were statistically significantly more likely to have temporo-occipital localization and were more frequently associated with the enlargement of perivascular spaces in the semioval centers of the cerebral hemispheres and with a negative fronto-occipital gradient of hyperintensity of white matter.

Clinically significant impairments of primary and higher visual functions, a negative fronto-occipital gradient, and the enlargement of perivascular spaces in the semioval centers may serve as indicators of probable CAA in patients with acute lobar hematoma. An integral logistic regression model that included these indicators as predictors provided excellent quality in predicting CAA with an accuracy of 100 [84.3; 100] %. For patients with a high suspicion index of CAA based on the application of the proposed model, it is advisable to additionally include iron-sensitive pulse sequences in the neuroimaging protocol upon admission to a vascular center for verification of the corresponding diagnosis.

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Novosadova O.A. – problem formulation, development of the research concept, preparation and editing of the text, patient recruitment, conducting a comprehensive neurological examination, and assessment using the MoCA and NIHSS scales, administration of the Benson test, approval of the final version of the work.

Grigoryeva V.N. – problem formulation, development of the research concept, preparation and editing of the text, involvement in the scientific design, approval of the final version of the work, consultation.

Astanin P.A. – conducting statistical analysis, resource provision for the study.

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