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Magnetic Resonance Imaging of Cerebral Hemorrhagic Stroke

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Abstract— *A study was made of the diagnostic effectiveness of the method of magnetic resonance imaging (MRI) in the diagnosis of hemorrhagic stroke in the acute phase. An analysis of the data of 50 patients with hemorrhagic stroke at the age of 52-67 years was carried out. As a result of the study, it was shown that in the diagnosis of intracerebral hemorrhage, the T2* - weighted mode is most informative, which allows visualizing the presence of blood in the early stages of the development of a stroke. It is shown that the use of this regimen should be included in the protocol of MRI studies of patients with acute cerebrovascular accident. The conclusion is made about the wide possibilities of using MRI as a method of choice in the study of patients with suspected hemorrhagic stroke from the first hours from the onset of the disease.*

Keywords— *hemorrhagic stroke, magnetic resonance imaging, diagnostic efficiency, neuroimaging.*

I. INTRODUCTION

The current state of the diagnosis and treatment of stroke in the acute stage is characterized by a transition to a qualitatively new level, in which improving treatment technologies dictate the need for early recognition of signs of cerebral hemorrhage. To date, criteria have been developed for the diagnosis of all types of hemorrhagic stroke using computed tomography (CT) [1]. However, in the subacute period, the diagnostic capabilities of CT compared with magnetic resonance imaging (MRI) are reduced due to the transition of the hematoma to the isointense stage, and in the long term hemorrhagic stroke by signs of computed tomography it is almost impossible to determine the nature of previously suffered acute cerebrovascular accident (stroke) [2].

In recent years, the possibilities of MRI in the early recognition of stroke have been intensively studied [1, 3-6]. A study of intracerebral hemorrhages revealed a pronounced heterogeneity of the MRI indices of the lesion depending on many factors (primarily the time from the onset of the disease), which made researchers turn to the physical basics of the phenomenon of magnetic resonance in relation to this form of pathology. In particular, it was found that hemorrhages look hyper- or hypointense on T1 weighted or T2 weighted scans, depending on the duration of the hematoma, the integrity of the red blood cell membrane and a number of additional factors [4,5].

In a number of medical institutions, MRI is used as the main research method for acute stroke, but a clear algorithm for MRI examination of a patient with stroke is not yet developed. This fully applies to the acute stage of hemorrhagic stroke.

Purpose of the study: to evaluate the diagnostic effectiveness of MRI diagnosis of hemorrhagic stroke in the acute and acute periods.

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II. MATERIAL AND METHODS.

The analysis of MRI data of patients admitted for treatment in the intense care unit was performed. 50 patients with hemorrhagic stroke of supratentorial localization were examined. The age of the patients was 52-67 years (mean age 59.5±5.4 years), 32 of them were men (64%) and 18 women (36%). Patients were admitted to the vascular center during the first 48 hours from the onset of the disease. Time revenue was 18.2 ± 4.9 hours

MRI was performed in dynamics (upon admission, up to 3 days and after 3 days after admission) on a Magnetom Harmony tomograph (Siemens, Germany). Magnetic induction was 1.0 Tesla. In all cases, hypertensive intracerebral hemorrhages of supratentorial localization with hematomas of various sizes were revealed.

When intracerebral hemorrhage was detected, supradentorial localization of MRI included the use of standard modes: T1weighted, T2weighted, T2-FLAIR. T2*weighted, and diffuse-weighted MRI (DW-MRI) were also performed to obtain functional images. According to MPT in patients with hemorrhagic stroke, the localization and volume of hematoma were calculated using each standard and T2* weighted scans. The study was carried out in dynamics, the ratio of hematoma and adjacent brain structures was evaluated, the displacement of these structures relative to the midline. In FLAIR mode, the volume of the ventricles was calculated in dynamics - upon admission and after 3 days. At the same time, the state of the zone of perifocal changes was evaluated (T2-weighted and T2-FLAIR modes were used).

Measurement of the volume of damage (hematoma or perifocal zone) was performed according to Kothari and a geometric semi-automatic method.

The operational characteristics of the diagnostic methods were calculated: sensitivity, specificity, predictive value of the area under the curve (AUROC), predictive value of a positive result (PVPR), predictive value of a negative result (PVNR), diagnostic accuracy (DA). ROC-curves were constructed, with the help of which the diagnostic accuracy of determining the hemorrhage zone of isone of perifocal changes at BMC was estimated. The informativeness of the method is the value of the area under the ROC curve (AUROC), which can be in the range from 0 to 1. When comparing diagnostic methods, the method for which AUROC more is considered more accurate.

III. RESULTS AND ITS DISCUSSION

A qualitative assessment of supratentorial intracerebral hemorrhage on the 1-2 day of the disease revealed a change in the intensity of the MR signal in various research modes. So, when applying the T2-weightedand T2-FLAIR modes in 54.4% of patients, a hypo-intense signal due to the hematoma characteristic of the acute stage of intracerebral hemorrhage was noted. At the same time, in 35.8% of cases when using these modes, a hyper-intense signal was found that is characteristic of the most acute stage of the intracerebral hemorrhage, in 7.6% of cases a heterogeneous signal was observed, in 2 cases (4%) an iso-intense signal. When using the T1-weightedmode, the last option (iso-intense signal) was detected in 63.0% of patients, the presence of a hematoma could be judged only by indirect signs. The signal was hyperintense in 19 patients (38%) and in only 2 cases (4%) it was heterogeneous.

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In the DWI mode, the majority of patients (69.5%) had a low-intense MR signal from a hematoma, and in 28.3% a heterogeneous signal. In T2* -weightedmode, a heterogeneous decrease in signal intensity in the hemorrhage region was revealed in all patients.

The predictive value of the area index under the intensity curve in the hematoma zone upon admission was 93.1% (AUROC 0.931; 95% DA 0.832-0.995; p<0.001), and on the 3rd day - 95.3% (AUROC 0.953; 95% DA 0.911-1.008; p<0.001).

The data obtained indicate a relatively low information content of this MRI modes with respect to the determination of hemorrhage in the early stages from the onset of the disease.

ROC analysis of the data obtained using the T1-weightedMRI mode showed that the curve of the hematoma signal intensity indicator at the early stage of the study (up to 48 hours from the onset of the development of clinical manifestations of stroke) was 89.7% (AUROC 0.897; 95% DA 0.819 -0.974; p=0.0002), and subsequently - 91.9% (AUROC 0.919; 95% DA 0.868-0.973; p<0.0001).

Thus, T1 weightedscanis also a highly informative mode of MRI research in the initial stage of hematoma (on the 7th and 21st days from the onset of the disease).

The ROC analysis of the data obtained using the T2* -weightedMRI mode showed that the characteristic curve of the hematoma signal intensity during the study up to 48 hours was significant (p = 0.0082). The predictive value of the area indicator under the signal intensity curve for the central region of the hematoma was 79.1%, specificity - 70.5%, sensitivity - 100%.

In the subsequent period of the disease, the value of this indicator decreased, amounting to only 53.4% (p = 0.3713). The central part of the hematoma during this observation period can have both a hypo-intense signal and unchanged signal characteristics.

As known, the volume of hematoma is calculated based on the sum of the areas of the intracerebral hemorrhage on the slices. Moreover, to calculate the area of the intracerebral hemorrhage, a visual assessment of the hematoma area and the zone of perifocal changes is necessary. In cases of massive breakthrough of blood into the ventricular system, it is difficult to assess the boundaries and volume of the intracerebral hemorrhage, since blood does not differ in intensity of the MR signal from blood in the ventricle adjacent to hemorrhage. As a rule, this is observed in the T2-weighted, T2-FLAIR and T2* -weightedmodes in the acute stage of the intracerebral hemorrhage.

In our study, a breakthrough of blood into the cerebrospinal fluid spaces was detected in 28 patients with hemorrhagic stroke, which amounted to 56%. In most cases, the breakthrough was localized in the lateral ventricles (48.1%), in 32.7% of cases in the subarachnoid space, in 19.2% of patients in all parts of the ventricular system.

A blood breakthrough in supratentorial intracerebral hemorrhagepatients was well visualized in almost all MRI modes, and better with T2* -weighted scans.

When assessing the volumetric effect of hemorrhage, a vertical displacement was detected in three cases (3.3%), a lateral displacement was observed in 32 patients (64%), while a degree 1 displacement (2-3 mm)

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was detected in 27 patients (54%), 2nd degree (4-7 mm) - in 14 cases (28%), 3rd degree (> 7 mm) - in 9 patients (18%).

During the quantitative assessment of supratentorial intracerebral hemorrhage, the hematoma volume was calculated based on the images obtained using the T1-weighted, T2-weighted, T2-FLAIR and T2*-weighted study modes. The calculations were performed geometric (semi-automatic) way. 35 patients were examined. One MRI scanincluded four scan modes, an average of 17 slices.

The calculation of the volumes of the zones of perifocal changes was carried out on the basis of images obtained using the MRI modes T2-weighted, as well as T2-FLAIR, in each of which it was necessary to analyze an average of 20 slices.

The volume of the ventricular system was calculated from images obtained with MRI in the T2-FLAIR mode, in which about 20 sections were analyzed. In a quantitative assessment of the intracerebral hemorrhage, including both the area of the hematoma itself and the area of perifocal changes, and to assess the volumetric effect of tissue disorders on the ventricular system, more than 10,000 sections were analyzed.

As can be seen, in the early stages of the examination, the average volume of intracerebral hemorrhage when using the T2-weightedscan was 16.8 ± 4.3 cm3, and when using the T2* -weightedscan - 17.8 ± 3.5 cm3, apparently the last the mode is the sequence most sensitive to the detection of deoxyhemoglobin. Despite the increase of this indicator by 18.6% when calculating in different modes, no significant differences were found ($p < 0.0001$).

Currently, when assessing the possibilities of using the MRI method in examining patients with hemorrhagic stroke, experts agree that the localization, volume and depth of the hemorrhage are significant indicators of the prognosis of the disease, on the basis of which it is possible to assess the possibility of restoring impaired functions and decide on the feasibility of surgical treatment of hemorrhagic stroke [2, 4, 6]. The duration of the acute stage of hematoma is the first 24 hours from the time of the intracerebral hemorrhage. At this time, the hematoma is visualized on MRI as a zone of an iso-intense signal in the T1-weightedmode, iso-intense or weakly hyper-intense in T2-weightedand T2-FLAIR, and hypo-intense at the periphery - in T2*-weighted (fig 1.).

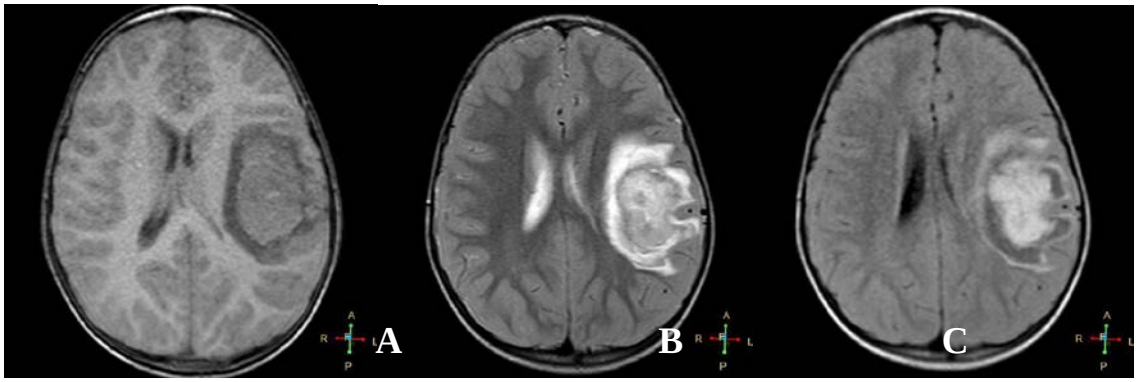

Fig 1. Male, 43 years old. Acute hematoma surrounded by clot retraction and mild edema with mild mass effect upon the ipsilateral lateral ventricle of the left front parietal region due to hemorrhagic stroke. Iso-intense signal of the hematoma in the T1-weightedmode(A), iso-intense or weakly hyper-intense in T2-weighted(B) and T2-FLAIRmode (C).

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The results of the study indicate that T2* -weighted allows blood imaging with high sensitivity and specificity in the early stages after the development of hemorrhagic stroke. This MRI scans is the most informative in relation to the diagnosis of intracerebral hemorrhage, and therefore should be included in the protocol of MRI studies of patients with suspected stroke. It was shown that the T2* -weighted scanis most sensitive to the detection of deoxyhemoglobin.

In our study, most patients were examined in the acute stage of intracerebral hemorrhage, the duration of which is 1-3 days. In the acute stage, oxyhemoglobin in the hemorrhage begins to turn into dezokigemoglobin, the strongest paramagnet that has typical manifestations on MRI. The T2* -weighted scan, which is the most sensitive to deoxyhemoglobin, is determined by a low-intense MP signal over the entire hematoma area. A similar pattern is observed in the T2-weighted and T2-FLAIR modes. In T1-weighted mode, the pathological zone has an iso-intense signal or iso-intense with areas of increased signal, since methemoglobin begins to form at the end of the acute stage.

IV. CONCLUSION

The data obtained confirm that MRI is a reliable method for the diagnosis of hemorrhagic stroke. The most sensitive in the diagnosis of intracerebral hemorrhage in the acute stage of development seems to be the T2* -weighted mode in the pulse sequence gradient echo. Blood breakthrough with supratentorial intracerebral hemorrhage was well visualized on MRI in almost all modes, to a greater extent when using T2* -weighted.

The results of the study indicate the widespread use of MRI as a method of choice in the study of patients with suspected hemorrhagic stroke from the first hours from the onset of the disease. However, our data, as well as reports of other authors, confirm the need for in-depth studies to identify diagnostic capabilities and further improve the algorithms for examining patients with stroke.

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