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Advances in Multimodal Analysis Applications for Stroke

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Abstract: ***Post-stroke cognitive impairment (PSCI) is one of the more severe clinical manifestations among stroke sequelae, and the cure rate is relatively low if the treatment window is missed. This article reviews the application value of multimodal assessment for post-stroke cognitive impairment from various perspectives, including neuroelectrophysiology, hemodynamic examinations, and cerebral circulation.***

Keywords: Stroke, Cognitive impairment, Multimodal, Magnetic resonance imaging (MRI), Neuroimaging.

1. Introduction

In recent years, with the increasing number of stroke patients, China has become the country with the highest lifetime risk of stroke and the heaviest disease burden [1]. Post-stroke cognitive impairment (PSCI) [2] refers to a clinical syndrome characterized by cognitive deficits that appear after a stroke event and persist for up to six months. As one of the more common sequelae of stroke, approximately one-third [3] of patients experience cognitive impairment, severely affecting their quality of life and survival time. This article reviews the application of published multimodal neuroimaging in the diagnosis of post-stroke cognitive impairment and discusses neuroelectrophysiology, hemodynamic examinations, and cerebral circulation in stroke. It provides recommendations for early detection, progression monitoring, timely treatment response, and optimization of personalized treatment plans for post-stroke cognitive impairment.

2. Neuroelectrophysiology in Stroke

Most scholars currently believe that "brain electrical activity is the sum of postsynaptic potentials from the apical dendrites of cortical pyramidal neurons," while EEG is formed by recording the potential changes of related electrodes on the scalp. EEG has a high reference value in the diagnosis of stroke, and can be used to detect the state of related nerve function conduction. Researchers such as Xu Zhaohui [4] observed EEG changes in 62 stroke patients before and after treatment. The results showed that slow waves in the EEG reflect post-stroke neural functional changes. When a large ischemic band occurs in a stroke patient, the slow wave power of the EEG immediately increases significantly, and the change trend of the neurological deficit score of the patient also changes. On the contrary, the abnormality of the EEG gradually disappears when the brain function gradually improves, suggesting that the EEG can be used as an indicator for the evaluation of neurological function in stroke patients. Xue Hui [5] observed 50 cases of stroke patients after the implementation of neuroelectrophysiological monitoring virtual reality training, the results showed that through the training of patients with cognitive, limb movement, muscle strength and walking ability can be significantly observed to improve, help to improve the quality of life of stroke patients.

3. Hemodynamic Examinations in Stroke

Some researchers [6] have found that there is a certain correlation between cognitive impairment and hemodynamic changes after stroke. The earliest hemodynamic examination of stroke was found to be the hemodynamic examination of cerebral vessels; among them, our most commonly used examination method is transcranial color Doppler ultrasound (TCD), which mainly measures the speed of blood flow in the blood vessel to determine the blood flow of the blood vessel, so as to check the blood supply capacity of the carotid artery, obstruction and blood stealing and other dangerous situations. Lu Ling [7] collected 112 stroke patients. After measuring the mean blood flow velocity, resistance index and pulsation index of bilateral middle cerebral arteries, the TCD breath holding test and functional TCD dynamic evaluation were used to evaluate the relationship between the cerebral blood supply of stroke patients and post-stroke cognitive impairment. The results showed that when patients with cognitive impairment performed general cognitive activities (such as reading), their blood flow velocity was significantly lower than that of patients with normal cognitive function. It can be used to dynamically detect the cognitive control function of stroke patients, which is helpful for the diagnosis of post-stroke cognitive impairment. Wang Jingru, Chen Dezhe et al [8] used TCD detection method to observe the blood flow velocity and direction of middle cerebral artery, basilar artery and other related cerebrovascular vessels in 90 patients with mild cognitive impairment. By monitoring the peak flow velocity, mean flow velocity, systolic-diastolic blood flow velocity and resistance index, the cerebral blood flow of patients with cognitive impairment was evaluated. The results showed that the blood flow velocity of anterior cerebral artery and middle cerebral artery in patients with mild cognitive impairment showed signs of slowing down, while the other indexes increased. Therefore, in clinical practice, we can use this method to timely assess the cerebral blood flow of patients with mild cognitive impairment, and timely and effective intervention measures for patients at risk of cognitive impairment to prevent the further development of the disease. Wu et al [9] collected the results of carotid plaque superb micro-vascular imaging (SMI) and carotid color Doppler flow imaging (CDFI) in 147 patients with acute ischemic stroke during hospitalization, and compared the blood flow indexes such as carotid resistance index, peak systolic velocity, and

end-diastolic velocity to observe the predictive value of SMI and CDFI in the progression of acute ischemic stroke. The results showed that the hemodynamic parameters were abnormal when the patient ‘s carotid plaque was severely blocked. Some studies have found that carotid plaque rupture is an important reason for the further progress of stroke. Therefore, the classification of carotid plaque and hemodynamic parameters detected by SMI and CDFI have certain predictive value for progressive ischemic stroke. Tan Limei [10] observed 80 patients with ischemic stroke, and observed the relevant indicators of cerebral hemodynamics in the acute phase of 3 days and the recovery phase of 3 months by TCD examination. It was observed that the hemodynamic indexes of TCD examination in patients with good prognosis of stroke were significantly higher than those in patients with poor prognosis of stroke, suggesting that hemodynamic indexes can be used to predict the prognosis of stroke patients. When the hemodynamic indexes of the patients in the recovery period increase, the cognitive dysfunction of the patients is more serious than before and the breath holding index decreases, suggesting that the hemodynamic changes are related to the prognosis of the patients with cognitive dysfunction. Therefore, TCD examination can be used to predict the prognosis of cognitive dysfunction after stroke. More and more studies [11] have found that the more serious the degree of carotid atherosclerosis, the higher the risk of stroke, and Lufei et al [12] collected 26 patients with moderate to severe carotid stenosis as the research object, using four-dimensional MRI imaging related parameters to realize the visualization of intravascular blood flow, by observing the study and the control group of patients with vascular hemodynamic changes, to explore the hemodynamic factors that affect carotid atherosclerosis and further lead to cerebrovascular events. The study found that four-dimensional MRI imaging related parameters can be used as a tool for diagnosing atherosclerosis and predicting stroke events.

4. Multimodal Studies on Cerebral Circulation in Stroke

In the published article [13], it was found that some patients with severe carotid stenosis did not experience discomfort in clinical practice. The reason is that the collateral circulation in the brain replaces the narrowed blood vessels to meet the needs of the body. Meng et al [14] found that people with poor collateral circulation are more likely to have early manifestations of cognitive impairment such as inattention and a decrease in the speed of the brain ‘s processing of information, and with the extension of time, cognitive regional function is impaired. Therefore, it is considered that the status of collateral circulation in patients after stroke can be used as a factor to predict cognitive function. Wang Tiegong et al [15] collected 99 patients who underwent multimodal CT examination during hospitalization, and analyzed the quantitative results of multimodal CT imaging to quantify the cerebral ischemia and collateral circulation status of patients after stroke. The results showed that in clinical practice, when stroke patients underwent multimodal CT scan, the physician quickly learned the intravascular condition, brain tissue perfusion and collateral circulation status of the stroke patients, and further provided more treatment options for clinical treatment of stroke patients. Xing et al [16] observed 152 patients with acute ischemic stroke, and completed brain CTP scan and head and neck CTA scan through multi-slice spiral CT machine to observe the patient ‘s brain perfusion, brain blood vessels and collateral circulation. The results showed that multimodal CT examination could not only directly observe the ischemic site and range of stroke patients, but also had certain clinical significance for the prediction of collateral circulation in stroke patients, which provided certain application value for clinical diagnosis, treatment and prognosis of stroke patients. Zheng et al [17] collected 100 patients with acute ischemic stroke, and used CT plain scan, CTP and CTA to observe the diagnostic value of these three diagnostic methods for stroke. The observation results show that the application of multimodal CT examination can effectively improve the detection rate of stroke patients, and provide a more effective and convenient method for patients with ischemic lesions, ischemic peripheral blood supply and vascular stenosis. It can be used for clinicians to diagnose stroke and guide clinicians to formulate treatment plans for stroke patients and predict the prognosis of stroke patients. Better prevention of cognitive dysfunction in patients. Sun Xueyong et al [18] observed the results of multimodal CT examination in 92 patients with stroke within 24 hours, and found that patients with multimodal CT examination can obtain more comprehensive imaging data of cerebral blood flow circulation, such as ischemic penumbra, core site of infarction and blood vessels in head and neck of stroke patients, which not only improves the speed of detection of stroke patients, but also provides objective basis for clinical diagnosis, cerebral blood flow and further progress of stroke patients. Xu Dabo [19] and other scholars selected 87 patients with acute stroke for one-stop multimodal CT examination. By observing the head and neck CTA, cerebral perfusion related parameters with ischemic penumbra and cerebral perfusion related parameters without ischemic penumbra of 87 patients, the results of head and neck CTA examination showed that the cerebral blood flow and cerebral blood volume of patients with acute cerebral infarction decreased, and the mean transit time and peak time of blood flow were prolonged. It was also found that the mean transit time and peak time of blood flow in the core area of the infarct were significantly higher than those in the ischemic penumbra, while the cerebral blood flow and cerebral blood volume were significantly decreased. Therefore, one-stop multimodal CT examination can quickly and effectively observe the cerebral circulation status of patients, and has high application value in the diagnosis and treatment of clinical stroke. Ruan [20] also found that the application of multimodal CT examination can more effectively, quickly and accurately evaluate the collateral circulation and prognosis of stroke patients. Therefore, it can be seen that multimodal CT examination has guiding significance for detecting the circulation of cerebral blood flow in stroke patients, and further provides relevant basis for patients with cognitive impairment after stroke and can guide the treatment of patients with cognitive impairment.

5. The Application of Multimodal Imaging in Post-stroke Care.

Today, the living environment is getting better and better, and the incidence of stroke is also rising. For stroke patients, our clinicians should achieve early detection, early diagnosis, and early treatment. These principles are only crucial for stroke

patients. Early intervention helps to improve the quality of life of stroke patients, and also helps to prevent the further development of the patient's condition as soon as possible. Some foreign researchers [21,22] have found in the high-resolution MRI of stroke patients, which has the significance of in-depth study for some specific regional markers. In the study of these specific marked areas, it was found that these marked areas can provide information such as cognition and behavior assessment, which can be used to predict the recovery of functional areas such as cognitive function in stroke patients. At present, there are still many deficiencies in multimodal analysis. Huang Weijian et al [23] proposed several new methods such as: network structure CLCI-Net, dimension fusion U-shaped network and unsupervised two-dimensional convolutional neural network registration framework to improve the current deficiencies of multimodal analysis and multimodal registration of brain images. The multimodal MRI images of 235 stroke patients were collected, including T1, FLAIR, AD and DWI sequences. The study found that the three new methods proposed by Huang Weijian et al. can promote the fusion of multimodal information and obtain multimodal complementary information of the same tissue. It provides a more appropriate method for the analysis of clinical multimodal information. Ye [24] combined MRI multimodal imaging technology with CTA examination of cerebral vessels, and observed 102 patients with suspected ischemic stroke. It was found that MRI multimodal imaging technology just made up for the shortcomings of CTA technology insensitivity to small blood vessels. The combined application can be used to understand the cerebrovascular situation of stroke patients at a glance and has certain clinical significance. Shang Huijuan [25] analyzed the multimodal magnetic resonance imaging of 60 patients with ischemic stroke to observe the risk of rebleeding in ischemic stroke. The results showed that multimodal magnetic resonance imaging could effectively detect the rate of rebleeding in patients with high stroke; Similarly, Tian Jing [26], Zhou Hong [27], Shang Huijuan and other scholars found that the use of multimodal MRI imaging can effectively and accurately find the micro-bleeding area of stroke patients. If we can optimize the multimodal MRI imaging technology again in clinical practice, it can provide strong support for clinical prevention and intervention of cerebral hemorrhage in stroke patients. Jiang Yu et al [28] found that one-stop multi-modal plain MR dynamic imaging can quickly and effectively diagnose the ischemic penumbra area of patients with acute stroke, further evaluate the condition of stroke patients, and provide a basis for clinical treatment. Xie Fuyou [29] and other scholars have discussed the predictive value of one-stop multimodal CT for hemorrhagic transformation after mechanical thrombectomy in patients with acute ischemic stroke (AIS). As an emerging endovascular treatment, mechanical thrombectomy has the advantages of long treatment time window, rapid opening and high vascular opening rate, which provides a new treatment for patients with acute ischemic stroke in the case of ineffective intravenous thrombolysis or contraindications of intravenous thrombolysis. By establishing Logistic regression model, ROC curve and decision curve, it was found that one-stop multimodal CT had certain predictive value for hemorrhagic transformation after mechanical thrombectomy in AIS patients, providing reference for clinical practice. Yin Tong [30] and other scholars used conventional ultrasound (CUS), shear wave elastography (SWE) and superb microvascular imaging (SMI) to observe the ultrasound parameters of carotid plaques in patients with acute stroke. The differences of multimodal ultrasound characteristics between the observation group and the control group were compared. Logistic regression was used to analyze the independent influencing factors of poor prognosis in patients with acute stroke. ROC curve analysis of clinical data, single ultrasound examination technology, multimodal ultrasound, multimodal ultrasound combined with clinical data has certain value in the prognosis of patients with acute stroke.

6. Summary

In summary, with the progress of society, imaging technology is becoming more and more advanced, and there are more and more means for stroke diagnosis. However, the differences in the value of these means also have their own advantages in stroke diagnosis. From the above clinical studies, it can be seen that multimodal analysis has certain clinical value in the formulation of treatment plans and prognosis development of stroke patients. However, the development of multimodal assessment of stroke still needs further study. Therefore, it is hoped that our clinicians will pay more attention to multimodal assessment in the evaluation of stroke patients in the future, and hope to achieve further development in the near future.

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