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MAGNITEC RESONANCE IMAGING IN CEREBROVASCULAR DISEASE

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Annotation

Cerebrovascular disease is currently one of the foremost diseases in the world with respect to incidence, disability, and fatality rates. The most common type of cerebrovascular disease is ischemic, accounting for 75–90% of all cases. Ischemic cerebrovascular disease has a complicated etiology and complex pathological mechanisms. It generally results from ischemic and hypoxic brain tissue caused by intracranial vessel wall lesions, alterations in blood components, or changes in hemodynamics, leading to brain dysfunction, or even the necrosis and softening of brain tissue. Clinically, this manifests as transient ischemic attacks, reversible ischemic neurological deficits, or cerebral infarctions, subsequently leading to corresponding neurological signs and symptoms. Although most cases of ischemic cerebrovascular disease are non-fatal, the resulting disability rate is very high; therefore, this disease has remained a major research topic in the field of medicine worldwide.

Key words: MRI, DWI, cerebral infarct, DTI, PWI, ischemic cerebrovascular disease.

The rapid development of neuroimaging, in particular, the ability of functional imaging techniques to not only display morphological changes but also provide information on cerebral blood flow, metabolism, and other aspects, has played a crucial and even decisive role in the early diagnosis and appropriate treatment of ischemic cerebrovascular disease.

During the pathophysiological process of cerebrovascular disease, cellular and histological damage is preceded by changes in cerebral hemodynamics, which is constantly in a state of dynamic flux. Therefore, these changes in cerebral hemodynamics and the associated changes in brain function are of critical importance to research on the early signs, diagnosis, and pathogenic mechanisms of

cerebrovascular disease. Functional MRI (fMRI) techniques include diffusion-weighted imaging (DWI), diffusion kurtosis imaging (DKI), diffusion tensor imaging (DTI), perfusion-weighted imaging (PWI), arterial spin labeling (ASL), magnetic resonance spectroscopy (MRS), and blood-oxygen-level dependent (BOLD) imaging. These techniques can display focal cerebral ischemia at a very early stage, track the course of white matter fibers, reflect the perfusion status of brain tissues, display tissue metabolic and biochemical changes, determine the location of brain functional areas, and reveal whole-brain functional connectivity and functional networks.

DWI involves the detection of the diffusion movement of water molecules in human tissues. By measuring the signal intensities before and after the application of diffusion-sensitivity gradient magnetic fields, we can calculate the tissue diffusion coeffcient, known as the apparent diffusion coeffcient (ADC), and therefore quantify the diffusion rate of water molecules in tissues. DWI is primarily utilized in the diagnosis of acute and hyperacute cerebral infarction. Due to the occurrence of cytotoxic edema in the early stages of cerebral ischemia, the intracellular water content increases, causing increased cellular swelling and decreased extracellular space, in turn decreasing the diffusion rate of water molecules in the area of infarction. Therefore, at 30 min after the onset of cerebral ischemia, abnormal hyperintensities can be observed in DWI, appearing as hypointensities on the ADC map. ADC values can be used to monitor lesion growth and progression, with areas of cerebral infarction showing a significant reduction in ADC values during the acute stage, followed by the pseudo-normalization or even elevation of ADC values in the late subacute and chronic stages. DWI enables the accurate delineation of the extent and degree of cerebral infarction, the prediction of disease severity, and the dynamic evaluation of therapeutic efficacy. In conventional T2-weighted imaging (T2WI), cerebral infarcts appear as homogeneous hyperintensities, which does not allow for the distinction between old and new lesions; whereas in DWI, acute lesions appear as hyperintensities and chronic lesions as hypointensities, which are easily differentiated. Furthermore, DWI can also improve the detection rate of small ischemic lesions, especially small subtentorial lesions that are easily missed in conventional computed tomography (CT) and MRI sequences. DKI is an extension

of DWI. Traditional DWI is based on the normal distribution of diffusion in water molecules, whereas DKI shows the non-normally distributed diffusion of water molecules in tissues. Therefore, DKI is able to provide a more accurate delineation of changes in tissue microstructures and allows for the early evaluation of the extent of any cerebral infarct. Additionally, DKI can simultaneously obtain both DKI and DWI parameters, which primarily include mean kurtosis (MK), mean diffusivity (MD), and ADC values. The size of the MK depends on the complexity of the tissue structures rather than their spatial direction, and can therefore more accurately display the extent of cerebral infarcts and their associated internal microstructural changes. MD is the mean ADC value of the three orthogonal directions and is primarily used to measure the diffusion rate of water molecules, in turn reflecting cellular size and integrity. Compared to ADC, MD provides a more comprehensive refection of the rate of diffusion movement. In acute cerebral ischemia, MD reflects the extent of cytotoxic edema in tissues, while MK is more sensitive to the disintegration of cytoskeletal structures and mitochondrial swelling. Therefore, regions with mismatched MK and MD abnormalities represent the ischemic penumbra, whereas matched regions represent the area of infarction and severe cell damage. DKI is more accurate than DWI in the diagnosis of early cerebral infarction, and the comparative analysis between the two may have significant implications in both determining the ischemic penumbra and improving patient prognosis. Furthermore, DKI can also facilitate the more in-depth analysis of pathological mechanisms at the microscopic level, which can provide useful information for more targeted clinical treatments. Although research on the utilization of DKI in ischemic stroke is currently in its infancy, DKI is ideal for widespread clinical use due to its minimal hardware requirements and short scan time; relevant research will provide new ideas for the diagnosis and treatment of cerebral infarctions.

All in all, nowadays many new examination methods are being discovered in modern medicine. This, in turn, creates the possibility of accurate and rapid diagnosis of diseases that are difficult to diagnose. We have discussed the operation of the DWI method of MR and its advantages.

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