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REVIEW

The Clinical Application Value of Susceptibility Weighted Imaging in the Central Nervous System

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ABSTRACT

Susceptibility weighted imaging (SWI) is a relatively new magnetic resonance imaging (MRI) technique that uses the difference in tissue magnetic susceptibility to image, and has unique value compared to traditional magnetic resonance imaging. This article summarizes its application in the central nervous system and provides a reference for imaging diagnosis and clinical treatment.

1. Introduction

Susceptibility weighted imaging (SWI) is a non-invasive magnetic resonance imaging technique that takes advantage of the difference in magnetic properties of different tissues. It is based on a new long echo time, complete flow compensation, and three-dimensional gradient imaging sequence.Compared with the traditional T2* weighted sequence, it has the characteristics of three-dimensionality, high resolution, and high signal-to-noise ratio.The original SWI image is the Magnitude image and the Phase image obtained by scanning the T2* weighted echo sequence. The two can be analyzed separately or processed for image fusion. The Magnitude image contains most of the tissue contrast information, and the Phase image reflects the tissue contrast from the perspective of susceptibility, especially the tissues with large differences in magnetic susceptibility. These two images are obtained at the same time during the scanning process, always appearing in pairs, and the anatomical position corresponding to each pair of images is exactly the same.

SWI is very sensitive to display venous structure, blood metabolites (such as deoxyhemoglobin), iron deposition, calcification, etc. Even without the use of contrast agents, it can clearly show the vascular system and hemorrhagic components, so it is used in cerebrovascular diseases, brain Tumors, brain trauma, neurodegenerative diseases and other central nervous system diseases have high clinical application prospects and value. SWI has now become a key magnetic resonance imaging sequence for the diagnosis of central nervous system diseases, and is an effective supplement to traditional spin echo magnetic resonance imaging sequences. In recent years, quantitative magnetic susceptibility mapping(QSM) that can quantitatively analyze tissue magnetic susceptibility have emerged based on SWI further makes up for the shortcomings of SWI [1]. This article will

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analyze the clinical application value of SWI in the central nervous system from the following points.

2. Cerebrovascular Disease

Biological tissue generates a specific induced magnetic field under the action of an external magnetic field, which depends on the strength of the external magnetic field and the magnetic sensitivity of tissue molecules. Magnetic susceptibility can be measured by the magnetic susceptibility. The degree of magnetization of the reaction material under the action of an external magnetic field is a variable reflecting the organization. The oxygenation and deoxygenation conversion of hemoglobin is the basis of blood oxygen level-dependent imaging. Oxyhemoglobin is diamagnetic, deoxyhemoglobin has 4 unpaired electrons that are paramagnetic, and hemoglobin is a strong paramagnetic substance but has weak magnetic sensitivity, hemosiderin is a paramagnetic substance, deoxyhemoglobin and hemosiderin have strong magnetic sensitivity. Non-heme iron (often in the form of ferritin) is a paramagnetic substance and has a strong magnetic sensitivity effect. The magnetic sensitivity effect of calcification is weaker than that of iron. It is usually diamagnetic. On the SWI corrected phase image, the right-hand magnetic resonance imaging system (United States GE, Philips) showed calcification as a high signal, while the signal in the left-hand MRI system (Siemens, Germany) was opposite. Studies have shown that SWI also has significant advantages in the detection of calcium, and it is the only imaging method that can distinguish bleeding and calcification at the same time [2].

Cerebral microbleeds (CMBs), as a marker of small blood vessel diseases in the brain, is more sensitive than other sequences in displaying microbleeds in the brain, and it is currently the best imaging method for the diagnosis of CMBs[3,4].Studies have shown that the prevalence of CMBs in healthy people is 5%, the prevalence of ischemic stroke patients is 22.9% -43.6%, and the incidence of hemorrhagic stroke patients and mixed stroke patients are respectively As high as 51.8% -82.5% and 41.2% -70.2% [5].Cerebral microhemorrhage is mainly caused by the deposition of hemosiderin and mononuclear macrophages that have swallowed hemosiderin, which leads to local arteriole hyaloid degeneration and amyloid deposition [6]. Therefore, CMBs appear on SWI as clear edges and uniform properties. The diameter is between 2-5mm (the highest is no more than 10mm), and the shape is a round or oval low signal or lack of signal focus, without edema around it [7].

3. Brain Tumors

Conventional MRI examination sequence is difficult for the preoperative grading diagnosis of brain tumors, and the use of SWI to evaluate the angiogenesis and intratumor hemorrhage within the tumor is an effective supplement to the conventional MRI examination.In addition to distinguishing bleeding and calcification in brain tumors, SWI can clearly show the neovascular structure in the tumor and the blood oxygen status inside the tumor, which is of great significance for the staging and grading of the tumor [8]. At the same time, SWI is proposed to be used To evaluate the effects and differences of different anti-vascular gene drugs, as well as the diagnosis of curative effects after radiotherapy and chemotherapy, the progression of tumors can be studied longitudinally.Studies have shown that high-grade tumors generally have rapid growth and a large number of new pathological blood vessels and are prone to bleeding and necrosis; on the contrary, low-grade tumors often appear calcification due to slow growth and malnutrition [9].Grading and scoring using intratumoral susceptibility signalintensity (ITSS) is considered to be related to its pathological grading and is an important basis for distinguishing benign and malignant tumors [10].

4. Brain Injury

Diffuse axonal injuries (DAI) is the most common type of brain trauma. It is caused by the shear force formed during the acceleration or deceleration of the head. Its common occurrence areas include the junction of the gray matter of the brain, The pressure part of the corpus callosum, the basal segment area and the dorsal side of the brain stem, etc., can detect punctate microhemorrhages in the deep white matter that cannot be displayed by CT or conventional MRI sequences.A study specifically for patients with mild traumatic brain injury compared the results of CT and SWI. The conclusion showed that the detection rate of SWI was as high as 97.83%, especially for brain contusion and laceration [11]. The detection rate was significantly higher than that of CT.It is more sensitive to traumatic brain injury and can accurately assess the patient's prognosis.

5. Central Nervous System Degenerative Disease

Central nervous system degenerative disease is a chronic progressive neurodegenerative disease. Studies have shown that the increase of iron in the brain is related to the increase of age [12]. The abnormal iron metabolism is a significant feature of central nervous system degenerative diseases, including Parkinson's disease (PD), Alzheimer's disease (AD) and multiple sclerosis (MS), etc. SWI can accurately analyze the distribution range and amount of iron

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deposits in the brain. The detection provides a safe, simple and non-invasive inspection method, and is clearer than conventional sequences. The etiology of PD is due to abnormal iron metabolism resulting in increased iron deposits in the substantia nigra and striatum, leading to progressive loss of dopaminergic neurons, resulting in increased muscle tone, resting tremor, retardation of movement, postural balance disorders, and a series of clinical symptom. Studies have shown that [13] possible signal changes related to iron deposition on SWI can accurately distinguish PD from various other forms of Parkinson's disease. At the same time, the FA value of the substantia nigra and the size of the substantia nigra compact zone are helpful for the early diagnosis of PD. By measuring the signal intensity of related brain nuclei and calculating the phase value, it can evaluate brain iron deposition, which is the treatment and treatment of PD patients. Provide help for the subsequent effect evaluation. For AD, studies have shown that [14] the vast majority of AD patients are transformed from mild cognitive impairment (MCI). SWI can not only intervene in the conversion process from MCI to AD, but also monitor iron deposition during the conversion process. In order to guide clinical diagnosis and treatment in the early stage of dementia.

SWI is a relatively new imaging method, which has great development prospects in the diagnosis and treatment of central nervous system diseases. However, SWI still has some shortcomings. For example, SWI has a long scanning time and requires a long inspection site. The time limit is temporarily not suitable for tissues and organs with greater mobility. At the same time, parts with extremely large differences in magnetic susceptibility (air-tissue plane) such as the level of the skull base and sinuses will cause heavier artifacts and have "magnification effects", which affect the observation and evaluation of lesions. These challenges require further research and improvement by technicians and scientific researchers. It is believed that with the development and progress of science and technology, SWI's diagnosis of diseases will become deeper and deeper, and it will no longer be limited to the central nervous system.

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