Biomedical Research 2017; 28 (21): 9265-9268

ISSN 0970-938X
www.biomedres.info

Application of susceptibility weighted imaging in the diagnosis of hemorrhagic transformation of acute massive cerebral infarction and assessment of collateral circulation re-formation.

Hai-Yan Yan*, Hong-Yan Xi, Hong-Mei Wang, Feng-Chun Zhang, Duan-Hua Cao

Department of Neurology, Harrison International Peace Hospital, Hengshui, PR China

Abstract

Objective: Application of Susceptibility Weighted Imaging (SWI) in diagnosis of Hemorrhagic Transformation (HT) of acute Massive Cerebral Infarction (MCI) and assessment of collateral circulation re-formation.

Methods: 50 patients with MCI in internal carotid artery system were included. Magnetic Resonance Imaging (MRI) scans of T1WI (T1 Weighted Image), T2WI (T2 Weighted Image), DWI (Diffusion Weighted Image), MRA (Magnetic Resonance Angiography) and SWI sequences were performed on patients. WI and routine MR (Magnetic Resonance) sequence images obtained before and after treatment were statistically analyzed to detect HT of MCI and reveal differences in collateral circulation re-formation in ischemic regions before and after treatment.

Results: (1) HT was detected in 18 patients (36%) in SWI scans including 14 cases (28%) of HI (Hemorrhagic Infarction) and four cases (8%) of PH (parenchymal hemorrhage). 11 cases (22%) of hemorrhagic transformation was detected in routine MR sequence scans, in which seven cases (14%) were HI and four cases (8%) were PH. The difference between groups was statistically significant (P<0.05). In SWI scans, 106 post-infarction hemorrhagic lesions were detected, with 100% detection rate. In routine MR sequence scans, only 26 hemorrhagic lesions were detected, with a detection rate of 32.51%. Mainly micro hemorrhagic lesions were missing. Difference between groups was statistically significant (P<0.05); (2) SWI sequence images provide a good display of microvessels in cerebral infarct region. Microvessels in patients in acute phase were found to reduce or disappear, while microvessels surrounding infarct area in patients in recovery phase were found to increase; occurrence rate was 66%. MRA scans were able to find 82% of responsible blood vessels of cerebral infarction.

Conclusion: SWI sequence scans are more sensitive than routine MRI sequence scans in revealing HT of acute MCI. MRA combined with SWI can effectively detect responsible blood vessels of cerebral infarction and monitor collateral circulation re-formation in infarct area.

Keywords: Susceptibility weighted imaging (SWI), Cerebral infarction with haemorrhage, Massive cerebral infarction (MCI), Collateral circulation, Criminal vessel.

Accepted on September 06, 2017

Introduction

In recent years, the incidence of cerebrovascular diseases has continuously increased, which has become one of the diseases that seriously endanger the health of the elderly and Massive Cerebral Infarction (MCI) has been found to have a much higher disability and lethality rate. Studies have shown that the incidence of secondary hemorrhage after Hemorrhagic Infarction (HI) was approximately 30%. Furthermore, the incidence of HI after MCI was much higher, in which severe HT patients had a mortality of up to 80% [1,2]. Therefore, accurate and timely detection of bleeding in lesions and timely adjustment of treatment plans is of great significance to the prognosis of patients. At the same time, whether collateral circulation is effectively established after MCI is an important index of prognosis. Determining how to rapidly and effectively monitor collateral circulation re-formation in the infarct area is difficult, which has become a hot topic in the treatment of MCI.

Susceptibility Weighted Imaging (SWI) is a magnetic resonance imaging technology that has recently been used in clinical practice. It produces an image contrast using magnetic sensitivity differences between different tissues. Furthermore, it has high sensitivity to bleeding, vein and iron deposition; and can clearly display intracranial microbleeds and venous structures [3]. In recent years, SWI has been gradually applied in the diagnosis and treatment of cerebrovascular disease [1-5]. In this study, 50 cerebral infarction patients with relatively large infarct areas in the internal carotid artery system received inpatient treatment in our hospital from January 2012 to January 2014. Then, these patients were enrolled for comparative analysis through routine MRI and SWI sequence scans. Our aim is to evaluate the clinical significance of SWI in the detection of HT of cerebral infarction, and assess collateral circulation re-formation.

Materials and Methods

General materials

From January 2012 to January 2014, a total of 50 patients in our hospital, who were confirmed to develop acute MCI in the internal carotid artery system by clinical and imaging diagnosis, were enrolled as research objects. The main clinical manifestations were: unconsciousness, hemiplegia, hemianopsia, hemihypesthesia, aphasia, etc.

Inclusion criteria: All the diagnostic criteria of MCI in the internal carotid artery system are in line with the revised diagnostic criteria for cerebral infarction established during the Fourth National Cerebrovascular Diseases Conference in China in 1995, and cerebral hemorrhage was excluded by CT. CT scans of the brain at 24 h after the onset revealed a large area of cerebral infarct, which belonged to MCI of the anterior circulation (according to the Adamas standard: infarct area>3 cm^2 and the main blood supply area of large blood vessels in two or more anatomical sites were affected).

Exclusion criteria: Patients with claustrophobia syndrome, with metal inside body, and combined with pressure disease and severe heart disease of the respiratory system, as well as patients who could not cooperate during MRI tests, were excluded from this study.

Age: Twenty-eight male patients aged 56.0-78.0 y old, with an average age of 68.5 ± 2.5 y old. Twenty-two female patients aged 50.0-70.0 y old, with an average age of 65.5 ± 3.0 y old.

This study was conducted in accordance with the declaration of Helsinki. This study was conducted with approval from the Ethics Committee of our hospital.

Written informed consent was obtained from all participants.

Research methods

MRI scans of T1WI, T2WI, DWI, MRA and SWI sequences were performed on the 50 selected patients. SWI and routine MR sequence images obtained before and after treatment were statistically analyzed to detect the HI of cerebral infarction and reveal the difference in collateral circulation reformation in ischemic regions before and after treatment.

Instrument and parameters

The Siemens AVANGO 1.5T superconducting MRI machine was used in this study. Scanning parameters: T1WI: TR 550 ms, TE 8.4 ms, Turbo Spin Echo (TSE); T2WI: TR 4500 ms, TE 88 ms, 6 mm slice thickness, 1.8 mm gap, 250 × 250 matrix; SWI: TR 49 ms, TE 40 ms, 2.0 mm slice thickness, 15 degrees anti-rotation angle, 0.4 mm gap, 250 × 250 matrix.

Evaluation criteria

(1) The criterion for judging internal bleeding in SWI images are as follows. The signals are different from the patch and ribbon-shaped hypointense signals that belong to the vein and the normal sequence. Distinction between bleeding and calcification [4-6]: hypointense signals on SWI images, and hyperintense signals on the SWI phase image indicate calcification; hypointense signals on both SWI and phase images suggest slight bleeding. (2) The criterion for judging vein blood vessels on SWI: The linear hypointense signal shadow, which is located at or close to the lesion, is displayed in continuous layers. (3) Type of bleeding: According to the most widely used classification criteria (classification criteria of the European Cooperative Acute Stroke Study), HT is classified into Hemorrhagic Infarction (HI) and parenchymal hemorrhage (PH); and HI and PH are further divided into two subtypes, respectively. Type HI1 shows spot-shaped micro bleedings in the infarct area, while type HI2 shows fusion flake bleedings in the infarct area. Hematoma of type PH1 is<30% of the infarct area and has no mass effect, while hematoma of type PH2 is>30% of the infarct area and has a marked mass effect or bleeding beyond the infarct lesion.

Statistical processing

Data was processed using statistical software SPSS 13.0. Normal distribution measurement data were expressed as x ± SD, and t-test was used for two-group comparisons. Technical data were expressed as a percentage, and X^2 test was used for group comparison.

Results

Comparison of results of two different diagnostic methods for HT

SWI examination revealed 18 cases of HT, accounting for 36% of the total cases. Among these cases, 14 (28%) cases were type HI; in which 10 (20%) cases were type HI1 and four (8%) cases were type HI2. Furthermore, four (8%) cases were type PH, in which three (6%) cases were type PH1 and one case (2%) was type PH2. The difference between groups was statistically significant (P<0.05, Table 1). It was suggested that microbleedings accounted for the highest proportion of the manifestations of MCI, and that the SWI sequence scan was the most sensitive to microbleeding.

Comparison of hemorrhagic lesion numbers detected by SWI and routine MR sequence scans

In SWI scans, 106 post-infarction hemorrhagic lesions were detected in 50 patients, with a detection rate of 100%. In routine MR sequence scans, only 26 hemorrhagic lesions were detected, with a detection rate of 32.51% and mainly micro hemorrhagic lesions were missing. The difference between groups was statistically significant (X^2=21.045, P<0.05). The detection rate of hemorrhagic lesions in cerebral infarction lesions by SWI sequence scans, especially the detection rate of micro hemorrhage, was significantly better than routine MRI sequence scans.

Table 1. *Comparison of results of the two different diagnostic methods for hemorrhagic transformation ((n) %).*

Group	N	Hemorrhagic transformation	HI type	HI1 type	HI2 type	PH type	PH1	PH2
SWI group	50	18 (36)	14 (28)	10 (20)	4 (8)	4 (8)	3 (6)	1 (2)
MRI conventional sequence group	50	11 (22)	7 (14)	3 (6)	4 (8)	4 (8)	3 (6)	1 (2)
χ^2		10.21	9.987	11.024	0.145	0.145	0.124	0.941
P		<0.05	<0.05	<0.05	>0.05	>0.05	>0.05	>0.05

The monitoring of collateral circulation formation after cerebral infarction by different sequence scans

Routine MRI sequence scans on 50 patients could not display microvascular information. However, SWI sequence scans revealed that the number of microvessels in the infarct area in the acute phase was significantly reduced or disappeared compared with the non-infarct area. Among these, SWI sequence images of 29 patients in the acute phase revealed a significant reduction in the number of microvessels in the infarct area, while in the recovery phase, the number of microvessels in 21 of these 29 cases increased. SWI sequences scans in the acute phase for the other 21 patients revealed that microvessels in the infarct area completely disappeared; however, in the recovery period, microvessels in 12 of the 21 cases re-appeared. The occurrence rate of increase in the number of microvessels in the infarct area was 66%. The increase in microvessels mainly concentrated in the surrounding area of the infarct area, suggesting the re-formation of cortical vessel collateral circulation.

Detection of responsible blood vessels of anterior circulation MCI

Responsible blood vessels could be detected in the early stage by MRA scans. Clues include the stenosis or occlusion of the internal carotid artery, stenosis or occlusion of the middle cerebral artery, and stenosis or occlusion of branches of the middle cerebral artery. Among them, 14 cases of stenosis or occlusion of the internal carotid artery, 16 cases of stenosis or occlusion of middle cerebral artery and 11 cases of stenosis or occlusion of the middle cerebral artery branches were found and the detection rate was 82%.

Discussion

This study revealed that SWI can sensitively display substances of different magnetic susceptibility such as bleeding or deoxidized compositions in blood, and has many imaging advantages such as 3D acquisition and high resolution [5-8]. Hemoglobin in erythrocytes in bleeding lesions is mainly deoxygenated hemoglobin, which is a paramagnetic substance; and under SWI scans, clear hypointense signals were shown. Therefore, SWI scans are of high sensitivity to cerebral microbleeds [9-12]. Data from this study revealed that SWI detected 18 patients with HT (36%), in which 14 cases were type HI (28%) and four cases were type PH (8%). Furthermore, only 11 cases of HT (22%) were detected in the routine MR sequence scans, in which seven cases were HI (14%) and four cases were PH (8%). In SWI scans, 106 post-infarction hemorrhagic lesions were detected, with a detection rate of 100%. In routine MR sequence scans, only 26 hemorrhagic lesions were detected, with a detection rate of 32.51% and mainly micro hemorrhagic lesions were missing. The difference between groups was statistically significant (P<0.05). This suggests that micro bleedings accounted for the largest proportion in HT of MCI and compared with MRI sequence scans, SWI sequence scans had a significantly higher detection rate of micro hemorrhagic lesions in cerebral infarction lesions.

In SWI imaging, venous blood shows a clear signal loss and venous structures are clearly displayed. Thus, SWI imaging is known as the MRI imaging of the vein. The number of veins revealed by SWI images reflects the regional cerebral metabolic rate of oxygen and regional cerebral blood flow speed and provides more information on the formation of collateral circulation [13-17]. However, the application of SWI in the detection of collateral circulation re-formations after cerebral infarction has been seldom reported. In the data of this study, the number of microvessels in the acute phase revealed by SWI images significantly decreased or disappeared compared with the contralateral non-infarct area. During the recovery period, the number of micro vessels in the infarct area increased, and the increase in microvessels mainly concentrated in the surrounding areas of the infarct area. The early detection rate of responsible blood vessels (stenosis vessels) by MRA sequence was 82%. All the above suggests that SWI images can display changes in microvessels in the cerebral infarct area through changes in the number of veins. Thus, researchers can evaluate cerebral collateral circulation re-formation through observing collateral vessels. MRA combined with SWI can effectively detect responsible blood vessels of cerebral infarction and monitor collateral circulation reformation in infarct area [18-24].

In summary, SWI scan can sensitively display HT of acute MCI, especially micro bleedings and is capable of monitoring collateral circulation reformation in the infarct area. It has a high guiding value for making treatment plans for MCI, as well as in the evaluation of prognosis.

References

1. Guo DJ, Chen WJ, Wu W. Diagnostic value of magnetic susceptibility weighted imaging in cerebral infarction. J Third Military Med Univ 2010; 32: 176-179.
2. Zhang L, Qi JP, Zhu WZ. The value of magnetic susceptibility imaging in the diagnosis of cerebral hemorrhage. Radiol Pract 2009; 24: 19-22.
3. Lu J, Li YH, Li YD. The clinical value of antiplatelet therapy for patients with hemorrhage after thrombolysis based on susceptibility-weighted imaging: a prospective pilot study. Eur J Radiol 2012; 81: 4094-4098.
4. Gao YJ, Wang J. Progress in clinical application of magnetic susceptibility weighted imaging. Med Rev 2013; 19: 1289-1293.
5. Li N, Wang WT, Sati P. Quantitative assessment of susceptibility-weighted imaging processing methods. J Magn Reson Imaging 2014; 40: 1463-1473.
6. Greer DM, Koroshetz WJ, Cullen S. Magnetic resonance imaging improves detection of intracerebral hemorrhage over computed tomography after intra-arterial thrombolysis. Stroke 2004; 35: 491-495.
7. Zhou Z, Zhao X, Chen M. Micro magnetic sensitive weighted imaging for intracerebral hemorrhage. Zhonghua Yi Xue Za Zhi 2014; 94: 1661-1663.
8. Goos JD, van der Flier WM, Knol DL. Clinical relevance of improved microbleed detection by susceptibility-weight demagnetic resonance imaging. Stroke 2011; 42: 1894-1900.
9. Liu F, Cao XX. Diagnostic value of susceptibility weighted imaging in the diagnosis of occult hemorrhage in the brain. China Modern Doctor 2012; 50: 80-81.
10. Schelhorn J, Gramsch C, Deuschl C. Intracracranial hemorrhage detection over time using susceptibility-weighted magnetic resonance imaging. Acta Radiol 2015; 56: 1501-1507.
11. Yu L, Liang XX. The clinical application of MR susceptibility weighted imaging in cerebral vascular diseases. Modern Med Health 2013; 29: 908-909
12. Kou Z, Ye Y, Haacke EM. Evaluating the role of reduced oxygen saturation and vascular damage in traumatic brain injury using magnetic resonance perfusion-weighted imaging and susceptibility-weighted imaging and mapping. Top Magn Reson Imaging 2015; 24: 253-265.
13. Di Ieva A, Lam T, Alcaide-Leon P. Magnetic resonance susceptibility weighted imaging in neurosurgery: current applications and future perspectives. J Neurosurg 2015; 123: 1463-1475.
14. Krishnan AS, Lansley JA, Jäger HR. New vistas in clinical practice: susceptibility-weighted imaging. Quant Imaging Med Surg 2015; 5: 448-452.
15. Chaudhry US, De Bruin DE, Policeni BA. Susceptibility-weighted MR imaging: a better technique in the detection of capillary telangiectasia compared with T2* gradient-echo. AJNR Am J Neuroradiol 2014; 35: 2302-2305.
16. El-Koussy M, Schroth G, Gralla J. Susceptibility-weighted MR imaging for diagnosis of capillary telangiectasia of the brain. AJNR Am J Neuroradiol 2012; 33: 715-720.
17. Pendharkar HS, Thomas B, Gupta AK. Susceptibility-weighted imaging in capillary telangiectasia. Neurol India 2010; 58: 618-619.
18. Yoshida Y, Terae S, Kudo K. Capillary telangiectasia of the brain stem diagnosed by susceptibility-weighted imaging. J Comput Assist Tomogr 2006; 30: 980-982.
19. Lee RR, Becher MW, Benson ML. Brain capillary telangiectasia: MR imaging appearance and clinicohistopathologic findings. Radiol 1997; 205: 797-805.
20. Idbaih A, Boukobza M, Crassard I. MRI of clot in cerebral venous thrombosishigh diagnostic value of susceptibility-weighted images. Stroke 2006; 37: 99l-995
21. Quan GM, Yuan T, Liu HJ. Hemorrhagic transformation and MRI evaluation after acute cerebral infarction. Radiol Foreign Med Sci 2006; 29: 311-314.
22. Verma RK, Wagner F, Weisstanner C. Venous pattern of polymicrogyria detected by susceptibility weighted imaging (SWI). Acta Radiol Open 2015; 4: 2058460115617353.
23. Gelal F, Karakaş L, Sarsilmaz A. Capillary telangiectasia of the brain: imaging with various magnetic resonance techniques. JBR-BTR 2014; 97: 233-238.
24. Weisstanner C, Gratz PP, Schroth G. Thrombus imaging in acute stroke: correlation of thrombus length on susceptibility-weighted imaging with endovascular reperfusion success. Eur Radiol 2014; 24: 1735-1741.

*Correspondence to

Hai-Yan Yan

Department of Neurology

Harrison International Peace Hospital

Hengshui

PR China