

Correlation of MR image features and hemorrhagic transformation in acute cerebral infarction: a multi-modal study

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Introduction

Hemorrhagic transformation (HT) of acute cerebral infarction [1-3] is a secondary hemorrhage following a cerebral vascular occlusion or hemodynamic disorders of brain tissue in ischemia, hypoxia and necrosis. Early prediction of HT is very difficult due to the rapid development and the complexities of the pathophysiology of the disease. Advanced neuroimaging techniques, including SWI, DWI, MRA, ASL, played a central role in the clinical studies on the frequency, predictor and characterization of HT. Most of the studies, however, employed only one of these techniques and may not fully reveal or define the characteristics of HT. In this communication, we report a multimodal MRI approach to studying the HT in acute cerebral infarction. Our fundamental hypotheses are that each modality of the MRI techniques may provide complimentary information about HT and by applying multimodal MRI techniques in a synergetic way, we would be able obtain a stereoscopic or holographic picture of the HT and, thereby, improve the prediction of HT in the cerebral infarction.

Methods and Materials

Subjects: 87 patients (male: 49; age: 39-79yr: mean 67.29±14.25) were enrolled from the neurological wards of Tianjin Union Medical Center. The protocol was approved by the IRB and written informed consents were obtained from all participants prior to the participation of the study.

MRI scans: All MRI scans were performed on a PHILIPS Achieva 1.5T scanner. Each patient was scanned twice. The first scan was carried out within 2 days after the onset of the symptoms and the follow-up scan was on the third day after the onset or when the patient's condition worsened. All patients completed the following scans: T1 weighted- and T2 weighted MRIs (T₁WI and T₂WI), diffusion weighted imaging, 3D time of flight (TOF) MRA and susceptibility weighted imaging (SWI). As an example, the pulse sequence parameters for SWI are as follows: 3D T1-FFE, TR=24ms, TE=34ms, flip angle=10°, a slice thickness of 1mm, field of view =22cm×18cm, acquisition matrix=168×137. Total scan time: 16.5min.

Image processing: raw images of DWI, SWI and MRA were processed on an EWS 2.6 work station. SWI was analyzed using a 3D MIP toolkit and MRA was analyzed using MIP and VR toolkits.

Image variables (independent) and clinical variables (dependent): The former includes: site, size, number and morphology of the infarction; cerebral microbleeds, infarct relative apparent diffusion coefficient (rADC), the intralesional venous anomalies in SWI images, the intracranial arterial stenosis, follow-up HT. The latter entails: time between onset and HT, frequency of HT, rADC of HT lesions, type of HT (hemorrhagic or parenchymal).

Statistical analysis: SPSS 17 was used for both the univariate and multivariate analysis. T-test, χ^2 test and Kruskal-wallis' sum of rank test were used for measurement data, count data and classification, respectively. When $P \leq 0.05$ was found in the univariate analysis, the variable was assumed to be related to HT and was incorporated into multivariate analysis, which was done by Logistic regression.

Results and Discussions

Statistical analysis: Univariate analysis identified that area of infarction (AI), rADC, increased abnormal veins (AV) and CMBs are associated to HT. Logistic regression analysis reveals that rADC, increased abnormal veins and CMBs are independent risk factors of HT (Table 1).

Correlations of imaging factors and HT: (1) Area of Infarction. Large area infarction was observed in 57 patients (65.6%), among which 16 developed HT (28.1%); Small area infarction was observed in 15 patients (17.2%), among which 1 developed HT (6.7%); Lacunar infarction was observed in 15 patients (17.2%), among which no HT occurred. The univariate analysis showed that large area of cerebral infarction was one of the risk factors of HT ($P < 0.021$). Multivariate analysis does not show significant correlation between area of infarction and HT, but we speculate that this warrants further investigation in the future. (2) rADC. The rADC values were approximately 0.4 and 0.5 for the HT and the non HT groups, respectively. The univariate analysis showed that rADC was a risk factor for HT ($P = 0.023$); Multivariate analysis showed that the rADC value independently associated with HT ($P < 0.05$). Due to the small sample size of this study, caution should be exercised regarding to a conclusion. Further research and analysis with a larger sample size are necessary. (3) CMBs. Microhemorrhages was observed in 16 patients, among which 12 developed HT (75%). Multivariate analysis showed that Microhemorrhages was an independent risk factor for HT ($P < 0.05$)^[4]. (4) Abnormal Veins. Increased thickening of veins within the lesions were observed in 20 cases, among which 5 developed HT, giving the incidence rate of HT was 25%; Multivariate analysis showed that abnormal vein is an independent risk factor of HT ($P < 0.001$).

Conclusion

We have demonstrated the usefulness of multimodal MRI techniques in the study of HT in acute cerebral infarction and identified the correlations between image features and the clinical outcomes of patients.

References [1] Choi KH, Park MS, Kim JT, et al. European Journal of neurology, 2011, 9: 1468-1331. [2] Sakamoto Y, Kimura K, Iguchi Y. Cerebrovascular Diseases, 2011, 32: 327-333. [3] Kablau M, Kreisel SH, Sauer T. Cerebrovascular Disease, 2011, 32: 334-341. [4] McKinney AM, Sarakiya B, Gustafson C, et al. AJNR Am J Neuroradiol. 2012, 12: 1-8.

Table 1. Logistic regression analysis of factors

Factors	B	S.E.	Wald	P	95%CI
AI	-1.566	1.186	1.743	.187	.020_2.136
rADC	-9.494	4.656	4.158	.041*	.000_.692
CMBs	-2.506	1.015	6.095	.014*	.011_.597
AV	-2.724	.926	8.661	.003*	.011_.403