Intracerebral Microbleed Assessment by Using Quantitative Susceptibility Mapping

Meng-Chi Hsieh[1,2], Jyh-Horng Chen[1,2], and Hon-Man Liu[3]

[1]*Institute of Biomedical Electronic and Bioinformatics, National Taiwan University, Taipei, Taiwan,* [2]*Interdisciplinary MRI/MRS Lab, Department of Electrical Engineering, National Taiwan University, Taipei, Taiwan,* [3]*Department of Medical Imaging, National Taiwan University Hospital and College of Medicine, Taipei, Taiwan*

Introduction Cerebral microbleed, mostly caused by hypertension and cerebral amyloid angiopathy, is a commonly disease in elderly people. In addition, the intracerebral hemorrhage might lead to heavy headache, sickness and even hemiparesis, according to the amount in microbleed [1]. Recently, quantitative susceptibility mapping (QSM) has been developed to quantify the subtle changes of the magnetic susceptibility in-vivo. Although QSM is potentially useful to clinical applications, its capability to reveal the severity of microbleed has not been fully demonstrated. Therefore, the purpose of this study was to assess the susceptibility change of cerebral microbleed using QSM technique.

Materials and Methods Six adult volunteers were recruited (mean = 53.7, SD = 6.5, M = 3, F = 3) to perform brain imaging on a 3T MR scanner (Siemens Trio, Germany). A 3-dimensional (3D) gradient-echo sequence with 1st flow compensation was employed with 75% partial Fourier acceleration to obtain the T2*-weighted images. The sequence parameters were as follows: FOV = 23×20.8×17.6 cm^3, matrix size = 256×232×160, TR/ TE = 27/ 20 ms, FA = 15°, BW = 120 Hz/pix and the total acquisition time was approximately 14 minutes. Image reconstruction and QSM calculation of the whole brain dataset were performed using in-house program written in MATLAB (MathWorks, MA, USA). QSM calculation was implemented by the following steps. Firstly, the wrapped phase was unwrapped with a path-based phase unwrapper [2]. Secondly, the effective SHARP (Sophisticated Harmonic Artifact Reduction for Phase data) method was applied to remove homogenous background field and the dipole fitting method was employed to minimize the residual field around the brain [3, 4]. Finally, an optimized total variation regularization algorithm was used to accurately estimate the susceptibility map [5]. Here, the BET tool in FSL (Oxford, UK) was used on the magnitude data to create a mask and the total computation time of this framework was approximately 30 minutes for each subject.

Results Fig. 1 shows the T2*-weighted images (A, B), internal field maps (C, D) and estimated susceptibility maps (E, F) of a single subject. The regions of microbleeds are indicated by white arrows and a hypointensity in T2*-weighted image can be clearly observed. Fig. 2 shows the intensity profiles across the microbleeding regions. Fig. 2A shows the intensity profile along the red dotted line in fig. 1E. The susceptibility of microbleeding region is approximately 0.5 ppm and the susceptibility profiles of other iron-rich structures are also identified, such as putamen (PU) and globus pallidus (GP). Fig. 2B shows the intensity profile along the microbleeding regions in different slice (blue dotted line in fig. 1F), The susceptibility of microbleeding region is approximately 2.3 ppm. In order to summarize total amount of microbleeds of each patient, the total susceptibility of microbleeds (greater than 0.1 ppm) was summed as shown in Table 1 according to the flowing equation: $m = \sum \chi \cdot \Delta v$, where m denotes the total susceptibility of mircrobleeds and v is the voxel size [1].

Conclusions In summary, a framework of QSM calculation was implemented to assess the intrinsic susceptibility of cerebral microbleed in this study. Our results suggest that QSM could be a potentially useful imaging marker to identify the microbleeding regions in patients and provide their quantitative susceptibility values. Additionally, QSM is also capable of identifying the neuroanatomy in several iron-rich sub-cortical structures, such as PU and GP.

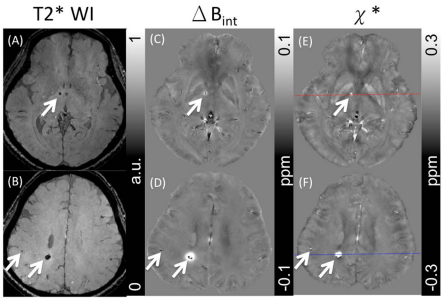

Fig 1. Axial T2-weighted images (A, B), internal field maps (C, D) and estimated susceptibility maps (E, F). The microbleeding regions are indicated by white arrows and two different imaging slices are shown here.*

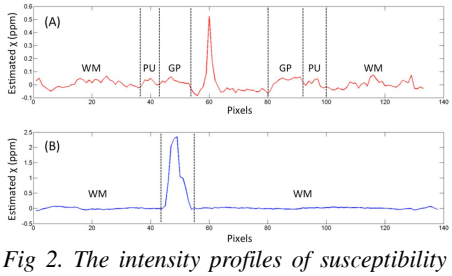

Fig 2. The intensity profiles of susceptibility along two different microbleeding regions. (A) The intensity profile along the red dotted line in fig. 1E and (B) The intensity profile along the blue dotted line in fig. 1F.

Patient No.	Total Susceptibility of Microbleeds in Patient (ppm×mL)
1	30.89
2	28.98
3	21
4	18.7
5	11.36
6	7.27

Table 1. Total estimated susceptibility of microbleeds in patient.

References [1] T. Liu et al., *Radiology*, 2012; [2] H. Abdul-Rahman et al., *Applied Optics*, 2007; [3] F. Schweser et al., *NeuroImage*, 2011; [4] T. Liu et al., *NMR in Biomedicine*, 2011; [5] M.-C. Hsieh et al., *ISMRM*, 2012.