Defining and Categorizing Microbleeds (MB) in Neurodegenerative Disease using SWI

M. Ayaz[1,2], E. M. Haacke[1,2], A. S. Boikov[1], W. M. Kirsch[3], and D. Kido[3]

[1]The MRI Institute for BioMedical Research, Detroit, Michigan, United States, [2]Department of Radiology and BioMedical Engineering, Wayne State University, Detroit, Michigan, United States, [3]Neurosurgery Center for Research, Loma Linda University, Loma Linda, California, United States

Introduction: The role of microbleeds (MB) in aging is gaining more and more attention (1). Most of these studies include a large number of subjects and often discuss the roles of cerebral amyloid angiopathy (CAA), intracranial hemorrhage (ICH) and signal hyperintensites (2,3). However, these studies are cross sectional snapshots of a variety of ages and conditions rather than longitudinal investigations. The purpose of the current study is to use Susceptibility Weighted Imaging (SWI) (1) to follow a set of 6 subjects from a total of 78 mild cognitively impaired subjects who developed progressive dementia and to find and categorize the types of MB that occur in this subset of subjects. SWI is very sensitive to the presence of hemosiderin even at the arteriole level. No previous study clearly defines when to call a signal loss a microbleed (especially when it involves MB as small as a few pixels) nor has anyone categorized the types of MB that appear in the images (mostly because SWI is such a new technique from a clinical perspective and because it reveals MB characteristics not yet seen in other methods).

Methods: A series of 106 patients, 28 controls and 78 mild cognitively impaired (MCI) patients, were evaluated in a longitudinal study of aging (informed consent was obtained in all cases). All subjects were scanned at least on an annual basis over a period of 4 years. Apart from conventional imaging methods (T1 and T2), SWI was also done. SWI acquisition parameters were: in-plane resolution 0.5mm x 1.0mm; TH = 2mm, FOV = 256mm x 256mm; Nx = 512; Ny = 256; Nz = 48; TE = 40 ms; TR = 57 ms; and FA = 20 degrees. The phase images were high-pass (HP) filtered and SWI magnitude images were created. The images were reviewed for the presence of MB. All original magnitude images, SWI filtered phase images and the contrast-enhanced SWI magnitude images were used in the data review process. Local minimum intensity projections (mIPs) over 5 slices were used to ensure that a MB was not connected to a major vessel but rather was isolated from the macro-vasculature. Images from different time points were put side by side for a careful comparison and detection of any new MB that developed over time. MB (*Identification Guidelines*): (1) A MB will not appear in more than 3 slices. Several slices above and below the slice of interest should be evaluated for any kind of connection to vessels. (2) Not every black dot in the image is MB. A signal loss can be caused from a vessel perpendicular to the image plane. To help discriminate between this case and an isolated signal loss or putative MB, it is common practice to mIP over 3 to 5 slices centered on the slice of interest. According to current literature, MB are smaller than 5mm, therefore anything observed in more than 3 slices (representing a 6mm thick section) will not be counted as a MB. Also, the bifurcation of a vessel can create a MB effect and this can be seen with the mIP approach.

Results: Based on location and appearance we categorized at least four types of MB. 1) a MB that appears adjacent to a vessel (Fig. 1a); 2) a MB attached to the end of a vessel (Fig. 1b); 3) an isolated MB with no vessel connection (Fig. 1c) that remains constant in time and 4) a MB that increases in size over time as shown in (Fig. 1b) white arrow. We often observe the development of these lesions over time for the progressive dementia subjects. On occasion, type 1 lesions may not be counted initially, but if they continue to expand over time and the surrounding tissue does not change, then these will be counted as lesions in a longitudinal study. Figure 2 shows stepwise development of type 1 MB where the first scan doesn't show any sign of MB and the second and third show one MB while the fourth scan even shows a new microbleed along with the existing one.

Discussion and Conclusion: A four year longitudinal study of patients progressing from MCI to PCI (Progressive Cognitive Impaired) has made it possible for us to follow increases in MB over time and to categorize them thanks to the changing signal appearance from scan to scan. When MB are evaluated longitudinally, it is possible to characterize them into four types as discussed above. A careful analysis in this way may make it possible to better understand the progression of the disease and the occurrence of stroke.

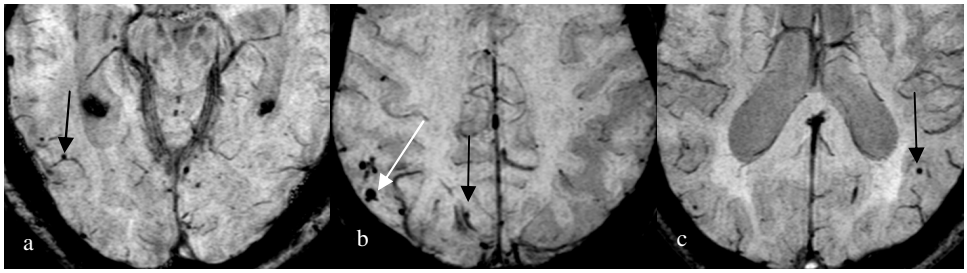

Figure 1: Four different categories of microbleeds

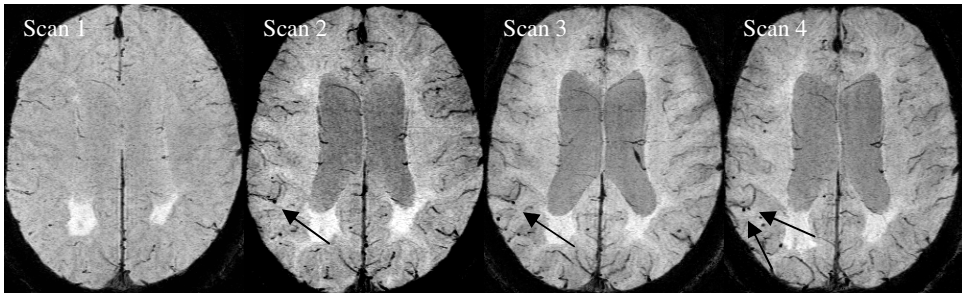

Figure 2: Stepwise development of microbleed in different scans of the same subject. First and last scans are two year and two month apart.

References: 1) D.A. Walker et al, Routine Use of Gradient-Echo MRI to screen for Cerebral Amyloid Angiopathy in Elderly Patients. AJR : 182, June 2004. 2) M.W. Vernooij et al, Cerebral microbleeds on brain MRI in the general elderly population: prevalence and relation to small vessesl disease. Proc. Intl. Soc. Mag. Reson. Med. 15 (2007). 3) H-C Koennecke, Cerebral microbleeds on MRI: Prevalence, associations and potential clinical implications. Neurology 2006; 66; 165. 4) EM Haacke et al, Susceptibility Weighted Imaging. Magn. Reson. Med. 52: 612 (2004).

Acknowledgment: This project is supported by NIH Iron Metabolism Alteration in Alzheimer's Disease RO1 AGZ0948