

## The composition of acute MCA thrombus is heterogeneous: a comparison of MR susceptibility image and CTA

M. Zhu<sup>1</sup>, M. Hiroki<sup>1</sup>, H. Ay<sup>1</sup>, A. B. Singhal<sup>2</sup>, N. M. Menezes<sup>1</sup>, C. J. Lopez<sup>1</sup>, C. Melinosky<sup>1</sup>, A. G. Sorensen<sup>1</sup>

<sup>1</sup>Martinos Center for Biomedical Imaging, Dept. of Radiology, Massachusetts General Hospital, Charlestown, MA, United States, <sup>2</sup>Dept. of Neurology, Massachusetts General Hospital, Charlestown, MA, United States

Susceptibility sign (SS) of middle cerebral artery (MCA) on MR susceptibility images (SI) in acute stroke patients is reported to be a direct sign of intra-arterial thrombus resulting from a high concentration of paramagnetic deoxyhemoglobin in red thrombus. While SS has been shown to have high specificity and sensitivity for thrombus in the stem and major branches of the MCA, false negative cases are also reported, probably due to white thrombi predominantly composed of platelets aggregates. SS correlates with MR angiography and perfusion imaging in the location of thrombi. The presence of SS on SI is associated with arterial occlusion on MR angiography and compromised tissue perfusion on perfusion-weighted imaging. It is, however, not known that the size of SS represents the actual size of thrombus in acute stroke patients. CT angiography (CTA) study shows the site of MCA occlusion as a segment of filling defect. It is not sensitive to the thrombus composition. In this study, we hypothesize that the combined evaluation of SS and CTA may provide information about thrombus composition in acute stroke patients.

### Material and Method

Consecutive patients were identified from a database that listed all stroke admissions between 2002 and 2005. Inclusion criteria include: 1, the presence of CTA and SI that were performed within 12 hours after onset of symptoms. 2, the absence of any thrombolytic therapy administered between CTA and SI study. 3, the presence of MCA occlusion on CTA. The size of SS and MCA filling defect were measured on pixel-by-pixel basis by a commercially available imaging processing software Alice. If filling defect is > 20% larger than SI, a complex thrombus was diagnosed; indicating a significant part of the embolus is consisting of diamagnetic material. Otherwise was considered as a red thrombus. The presumed source of clot and time between symptom onset and CT and MR studies were correlated with the vascular sign.

### Results

A Total of 30 patients with 31 M1 or M2 occlusions were included in this study. The size of occlusion on CTA ranged from 4 to 38 mm, (mean 16mm). The SS was found in 27 (87%) of 31 occlusions (size: 4-32mm, mean 14mm) and no SS in 4 (13%). SI and CTA were not always identical in thrombus size (Fig 1,2). Red thrombus was found in 61% (19/31) while 39% (12/31) had complex thrombus. The patients with complex thrombus had a significantly shorter time to CTA (2.38 vs 5 hours,  $p < 0.01$ ) whereas there was a trend towards significance in time to SI (5.8 vs 7.3 hours,  $p = 0.11$ ). The SS with complex thrombus was significantly smaller than that with red thrombus (7 vs 17mm,  $p < 0.01$ ). The size of CTA occlusion of complex thrombi had no significant differences with that of red thrombi. There were no significant differences in patient age, gender, and the possible etiology (cardioembolic vs Large vessel disease) between patients with red and complex thrombi.

### Conclusion and discussion

Our results suggest that the composition of MCA thrombus is heterogeneous in acute stroke. The thrombi size on CTA and SI didn't match in our patients' group, especially in those with a relatively shorter symptoms onset time. SI underestimates the thrombus size in 39% of them; probably implying the thrombus composition may vary in term of magnetization property. MCA thrombi may not always consist of red blood clot which is rich in paramagnetic deoxyhemoglobin. Platelet-rich white or lipid containing thrombi may account for smaller SS. Diamagnetic oxyhemoglobin-rich thrombus is also a potential explanation of a small SS as we found a SS of a complex thrombus became larger on follow-up SI and correspond with initial CTA findings (Fig 2). Comparison of CTA and SI may provide information about thrombus composition in acute stroke patients.

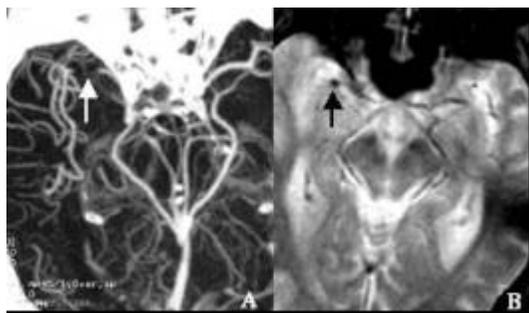


Fig1. Right MCA occlusion. CTA at 1.68 hours after symptom onset (A) shows a MCA stem occlusion (arrow). SI at 9.9 hours (B) shows a small susceptibility sign in area of MCA stem (arrow) that may suggest a large part of the embolus is diamagnetic.

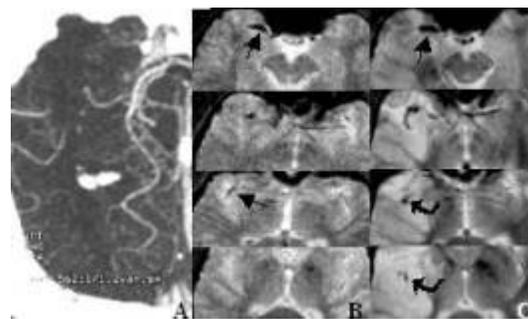


Fig2. Right MCA occlusion. M1 and M2 are absent on CTA at 2.5 hours after symptom (A). SI at 2.75 hrs (B) shows the SS at MCA stem and proximal of M2 (arrows). Follow-up SI at day 3 (C) shows a larger SS corresponding to the initial CTA. The SS growth probably suggests diamagnetic oxyhemoglobin in acute thrombus transfers into paramagnetic deoxyhemoglobin and showed on follow-up SI (curve arrow).