

# Plaque Burden Measurement by Black-blood MR Imaging Technique in Intracranial and Extracranial Carotid Arteries in Acute Stroke Patients

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**Introduction:** Concurrent atherosclerosis of the intracranial and extracranial cerebrovascular system is common in Asians [1-3]. Atherosclerotic diseases occurring in carotid arteries and intracranial arteries have been demonstrated to be associated transient ischemic attack (TIA) and stroke [4-6]. Recently, Black-blood magnetic resonance imaging (MRI) has been increasingly applied for assessment of the carotid artery and intracranial vessel wall [7-8]. However, measure of plaque burden in intracranial and extracranial carotid arteries at the same individual by black-blood MRI and its association have not been determined. To investigate these correlations will be helpful for better understanding the heterogeneity of disease progression in these two vascular territories and potentially improving the predictive value for cerebrovascular events.

**Purpose:** To measure the plaque burden of both intracranial and extracranial carotid arteries by black-blood MRI and determine the plaque burden correlation of these two vascular beds in patients with acute stroke.

**Methods:** Thirty-one patients (27 men; mean age 64 years) with acute anterior circulation stroke determined by MRI underwent intracranial and carotid artery MR vessel wall imaging on a Philips Achieva 3.0T scanner within 1 week after stroke onset. **Imaging protocol:** *MCA imaging protocol:* a single contrast weighting of Black-blood T2w was performed for vessel wall imaging of M1 segment of bilateral MCAs with coverage of 16 mm (8 slices). The imaging parameters were as follows: T2w: Multi-slice Double IR (MDIR), TR/TE 4000/50ms; field of view (FOV) 14cmx14 cm; acquisition matrix 256x256; in-plane resolution 0.55mmx0.55mm; slice thickness 2mm. *Carotid imaging protocol:* a multi-contrast carotid protocol was used to acquire axial images for bilateral carotid arteries (centered the carotid bifurcation) with a longitudinal coverage of 32 mm. The imaging parameters were as follows: 3D TOF: TR/TE 20/4ms, flip angle 20°; T1w: quadruple inversion-recovery (QIR) [9], black-blood, 2D TSE, TR/TE 800/10ms; T2w: Multi-slice Double IR (MDIR), TR/TE 4000/50ms; MP-RAGE: IR TFE, TR/TE 13.4ms, flip angle 15°; FOV 14cm x 14cm; acquisition matrix 256x256; in-plane resolution 0.55mmx0.55mm. **Image interpretation:** Bilateral carotid MR images were interpreted by two trained reviewer with consensus blinded to clinical information and MCA images. A custom designed software (CASCADE [10], Seattle, WA, USA) was used to outline the lumen and outer wall boundaries. The Lumen area (LA), wall area (WA), total vessel area (TVA), and Normalized wall index (NWI = WA/TVA) were measured for each location. The LA, WA, TVA, and NWI of M1 segment of MCAs were measured by an experienced radiologist blinded to clinical information and carotid MR images. The mean value of LA, WA, and NWI for each carotid artery and each M1 segment of MCA were calculated respectively. The image quality for each image was evaluated using 4-point scale: 1, poor; 2, marginal; 3, good; 4, excellent. The ipsilateral carotid artery and M1 segment of MCA with image quality >1 were paired for statistic analysis. The correlation between carotid artery and MCAs plaque burden measurements was analyzed.

**Results:** In total, 21 paired carotids and M1 segments of MCA were included in final analysis. The mean LA and WA of carotid arteries were  $45.6 \pm 13.5$ mm and  $28.6 \pm 11.2$ mm, respectively. For M1 segment of MCA, the mean LA and WA of carotid arteries were  $5.7 \pm 2.6$ mm and  $9.3 \pm 3.1$ mm respectively. Correlation analysis revealed that carotid mean NWI was significantly correlated with the mean NWI ( $r=0.501$ ,  $P=0.001$ , Fig. 1 and 2). There was no significant correlation between carotid and MCA LA ( $r=0.341$ ,  $P=0.078$ ) and WA ( $r=0.271$ ,  $P=0.186$ ).

**Discussion and conclusions:** The black-blood technique provided the opportunities to acquire the vessel wall images for both extracranial and intracranial artery arteries. Anatomically, the vessel size in these two vascular territories is dramatically different. Therefore, using NWI to measure the plaque burden is advocated by many investigators due to its characteristic of normalizing the vessel size. In this study, we found a significant correlation of plaque burden as measured by NWI between carotid artery and M1 segment of MCAs. This finding further compels the evidence that atherosclerosis is a systemic disease frequently involving multiple vascular beds. In addition, our results also suggest that the plaque burden measurement in these two vascular beds may be an effective indicator for acute ischemic stroke. Furthermore, in this study, only one contrast weighting (T2w) was used for MCA vessel wall imaging which may limit the evaluation of lumen and outer wall boundaries, and the imaging was performed in two scanning sections. Future directions of our studies will focus on building a Neurovascular Coil which may enable acquire the vessel wall images for the whole carotid artery tree including extracranial and intracranial circulations as the same scanning section. And we would also optimize the intracranial artery imaging protocol using multi-contrast sequences and new blood suppression technique such as the improved motion-sensitized driven-equilibrium (iMSDE) [11].

## Reference:

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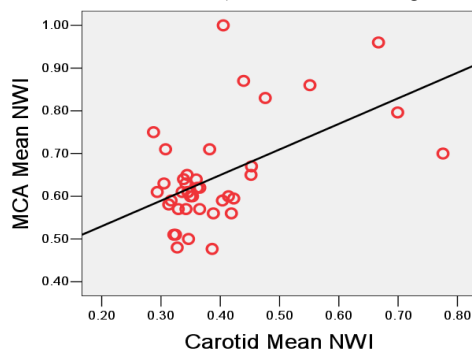


Fig. 1: Correlation of mean NWI between carotid arteries and M1 segment of MCAs.

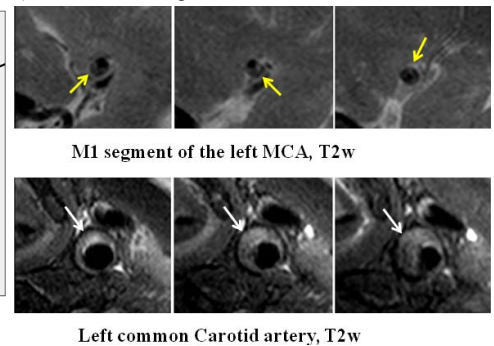


Fig. 2: The first and second rows represent the continuous left MCA cross-sectional T2w images and the left carotid artery T2w images respectively, where an eccentric lesion (yellow arrow for MCA and white arrow for carotid artery) can be found.