Association between Carotid Artery and Thoracic Aorta Plaque Burden in Patients with Neurovascular Symptoms: A 3.0T, Multiple Vascular Beds, Black-Blood Vessel Wall Imaging Study

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Introduction: Atherosclerosis has been shown to be a systemic disease frequently involving multiple vascular beds [1]. Atherosclerotic diseases occurring in carotid arteries and thoracic aorta have been demonstrated to be associated with transient ischemic attack (TIA) and stroke [2-4]. Recently, Mani et al [5] reported that both carotid artery and thoracic aorta showed greater plaque burden in patients with prior major cardiovascular or cerebrovascular events, indicating both vascular beds are frequent targets of atherosclerotic plaque growth in individuals at high risk for developing cardiovascular disease. However, the correlation between carotid artery and thoracic aorta atherosclerosis is unknown. To assess the relation of atherosclerotic disease in these two vascular beds will be helpful for better predicting the disease severity from one vasculature to another.

Purpose: To determine the association between carotid artery and thoracic aorta plaque burden in patients with subacute TIA or stroke by black-blood MR imaging.

Methods: Twenty-six patients (mean age 65 years, 20 males) underwent carotid and thoracic aorta MRI on a Philips Achieva 3.0T scanner within 1 week after TIA or stroke onset. ***Imaging protocol: Carotid MRI:*** Multi-contrast carotid MR protocol (TOF, T1w, T2w, and MP-RAGE) was performed to acquire cross-sectional bilateral carotid artery MR images with a longitudinal coverage extended for 8 slices above and below the bifurcation and a slice thickness of 2 mm. Parameters for the imaging sequences were as follows: 3D TOF: TR/TE 20/4ms, flip angle 20°; T1w: quadruple inversion-recovery (QIR) [6], 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°; field of view (FOV) 14cmx14 cm; acquisition matrix 256x256; in-plane resolution 0.55mmx0.55mm. ***Aorta MRI:*** After carotid MR imaging, a 6-channel cardiac coil and VCG-gated After carotid MR imaging, a 6-channel cardiac coil and VCG-gated DIR TSE T1w sequence was used to acquire cross-sectional images from the aortic arch to descending aorta. Imaging parameters were TR/TE 1 RR/10ms, FOV 14cmx14cm, acquisition matrix 140x140, 40 slices, NEX 2 , 5mm slice thickness. ***Data analysis:*** Bilateral carotid MR images were interpreted by two trained reviewers with consensus blinded to clinical information and aorta images. Aortic measurements were done by a separate trained reviewer blinded to clinical information and carotid MR images. A custom designed software (CASCADE [7], Seattle, WA, USA) was used to outline the lumen, outer wall, and plaque composition boundaries. Lumen area (LA), wall area (WA), total vessel area (TVA), mean and maximum wall thickness (MeanWT, MaxWT), and Normalized wall index (NWI = WA/TVA) were recorded for each location. LA, WA, TVA, MeanWT, MaxWT, and NWI for each axial location of thoracic aorta were measured. The mean value of all the measures for each carotid artery and each segment of thoracic aorta (ascending aorta (AA) and descending aorta (DA)) was calculated respectively.

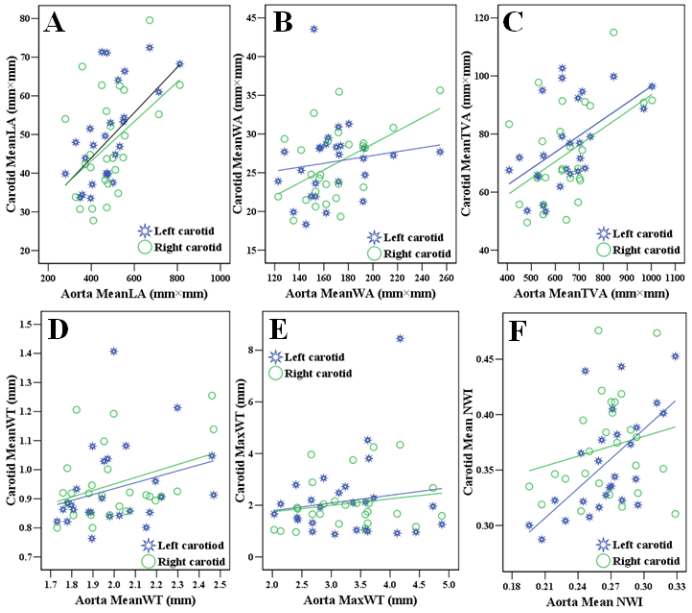

Fig. 1: Correlation of descending aorta with left carotid artery.

Results: The mean NWI was 0.36 ± 0.05 for left carotid artery and 0.37 ± 0.05 for right arotid artery, respectively. There was no significant difference between left carotid and right carotid artery NWI (P = 0.225). Compared to ascending aorta (NWI = 0.19 ± 0.02), descending aorta (NWI = 0.27 ± 0.03) showed significantly larger mean NWI (P <0.001). In addition, compared to aorta, both sides of carotid arteries showed significantly larger mean NWI (P <0.001). There were significant correlations of carotid artery MeanLA (Fig. 1A) and MeanTVA (Fig. 1C) with that of descending aorta (table 1). Similarly, carotid artery MeanLA and MeanTVA were significantly correlated with that of ascending aorta (Table 1). In addition, descending aorta mean NWI was associated with that of left carotid artery (Table 1, Fig. 1F and Fig. 2). For measurement of MeanWA, a significant correlation was found between descending aorta and right carotid artery (Table 1 and Fig. 1B). There was no significant correlation between ascending aorta plaque burden measurements, including WA, MeanWT, maxWT and NWI, and that of carotid artery (Table 1).

Table 1: Correlation between carotid artery and thoracic aorta plaque burden measurements.

	Pearson's r (P value)					
	Mean LA (Left /right)	Mean WA (Left/right)	Mean TVA (left/right)	MeanWT (left/right)	MaxWT (left/right)	Mean NWI (left/right)
DA	0.627/0.458 (**0.001/0.019**)	0.142/0.498 (0.488/**0.010**)	0.528/0.482 (**0.006/0.013**)	0.294/0.368 (0.145/0.064)	0.146/0.195 (0.475/0.341)	0.610/0.208 (**0.001**/0.309)
AA	0.537/0.427 (**0.012/0.054**)	0.081/0.216 (0.726/0.347)	0.530/0.444 (**0.013/0.044**)	-0.215/-0.007 (0.346/0.976)	-0.208/0.118 (0.366/0.611)	0.102/0.088 (0.658/0.704)

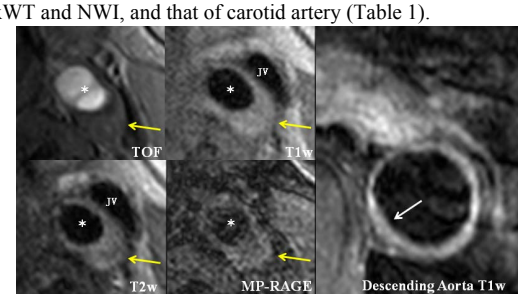

Fig. 2: Eccentric atherosclerotic plaques (yellow arrow) can be found at the bifurcation of left carotid artery (star) and descending aorta (white arrow) in a 70 year old male patient. JV represents jugular vein.

Discussion and conclusions: The correlations of lumen and total vessel areas between thoracic aorta and carotid artery in this study indicate that the vessel size of these two vasculatures may be correlated intrinsically. Thus the NWI index measure is important to compare carotid and aortic plaque burden by normalizing for corresponding sizes. Using the normalized plaque burden measure, we found that descending aorta plaque burden, as measured by NWI, was significantly associated with that of left carotid artery. The association to only the left carotid may be due to small sample size or difference in flow between left and right carotids as previous studies have suggested [8]. Our findings suggest that carotid artery plaque burden may be an effective indicator of atherosclerotic disease in descending thoracic aorta, or vice versa. We would expect to see the plaque compositional correlations in these two vascular beds with larger sample size in future studies.

Reference:

[1] Ross R. N Engl J Med. 1999;340:115-126.

[2] Takaya N. Stroke. 2006;37:818-823.

[3] Amarenco P. N Engl J Med. 1994: 331:1474-1479.

[4] Bitar R. Am J Roentgenol. 2006;187:228-34.

[5] Mani V. J Cardiovasc Magn Reson. 2009:24;11(1):10.

[6] Yarnykh V et al. MRM. 2002;48:899-905.

[7] Kerwin W et al. Top MRI. 2007;18:371-8.

[8] Bogren et al. J Magn Reson Imaging. 1994;4(1):37-42.