Association of Coronary Calcification and Carotid Artery Morphology: a High Resolution Magnetic Resonance Imaging Study

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Introduction:

Atherosclerosis has been shown a systematic disease which often involves multiple arterial vascular beds such as coronary, carotid, and peripheral arteries. Arterial luminal narrowing because of atherosclerotic plaque deposition or thrombosis will consequently result in acute ischemic events, including myocardial infarction, ischemic stroke, limb ischemia, and even sudden cardiac death. Etiologically, atherosclerosis occurred in different arterial vascular beds may have the similar risk factors [1]. Atherosclerosis occurred in one arterial circulation may be a predictor to the other arterial territory. Recently, a number of studies demonstrated a significant correlation between coronary and carotid atherosclerosis [2~5]. However, the association of coronary calcification and carotid artery morphology as measured by magnetic resonance imaging (MRI) is unknown. This study sought to evaluate the association between coronary calcification and carotid artery morphology.

Materials and Methods:

Study population: Forty-eight subjects (mean age 59 years, 35 males) who underwent coronary computed tomography (CT) angiography because of the suspect of coronary artery disease were recruited in this study. **Coronary artery calcium score (CACS) data acquisition:** A pre-contrast low-dose CT scan was performed for all the subjects to measure the coronary artery calcium score (CACS) before CT angiography examination at a Dual Source CT scanner (SIEMENS Dual Source CT, German). The parameters of CT scan for CACS are following: 120KV, 80mAs/rot, pitch 0.2~2.0, rotation time 0.33s, slice thickness 3.0mm. CACS was computed using commercial software (Syngo MultiModality Workplace). **Carotid MR imaging:** All the subjects obtained bilateral carotid arteries MR imaging within one week after coronary CT scans. MR scans were performed using 3.0T MR scanner (GE Signa, General Electric Healthcare, USA) and phased-array carotid surface coil. A standardized carotid multi-sequence protocol [6] was used to acquire four different contrast-weighted images (T1-weighted [T1W], proton density weighted [PDW], T2-weighted [T2W], and time of flight [TOF]). Parameters for the imaging sequences were as follows: T1W: quadruple inversion-recovery (QIR) [7], black-blood, 2D fast spin-echo, TR/TE 800/8.8ms; PDW and T2W: double echo, TR=3000 ms, TE 13.1ms for PDW and 56.9 ms for T2W; and 3D TOF: TR/TE 29/2.1ms, flip angle 20°. All images were obtained with a field of view of 14 cm and matrix size 256 × 256 for an in-plane acquisition resolution of 0.55 × 0.55 mm^2. Axial images of the bilateral carotid arteries were acquired with a 2 mm slice thickness over a longitudinal coverage of 32 mm. **Carotid MR image review:** All carotid MR images were interpreted by two trained reviewers via consensus opinion blinded to clinical information and coronary CT results. For MR image review, image analysis software (CASCADE [8]) was used to draw the lumen and outer wall boundaries. The carotid morphological measurements, including minimum lumen area (LA), mean/maximum wall area (MWA/MaxWA), total vessel area (TVA) and mean/maximum wall thickness (MWT/MaxWT), were recorded for each axial location. Normalized wall index (NWI) was calculated (NWI = wall area/[lumen area + wall area]) as well. **Data analysis:** The minimum LA, MWA/MaxWA, MWT/MaxWT, and mean/maximum NWI were evaluated for each artery. The more severe value for each measurement in bilateral carotid arteries was selected as the corresponding subject's morphological measurement. All the subjects were divided into two groups: high-CACS group with CACS >400, and low-CACS group with CACS <400. The carotid morphological measurements between two groups were compared using an Independent-Samples t test. The association of CACS and carotid morphological measurements was analyzed using Pearson's correlation analysis. A P-value < 0.05 was considered statistically significant.

Results: CACS showed strong correlation with MWA (r= 0.632, p<0.001) and MaxWA (r=0.622, p<0.001), moderate correlation with MWT (r=0.479, p=0.001) and MaxWT (r=0.540, p<0.001) (Figure 1A, 1B), weak correlation with maximum NWI (r=0.308, p=0.033), and marginal weak correlation with mean NWI (r=0.266, p=0.068). There was no significant correlation between CACS and minimum LA (r=0.047, p=0.749). Both wall area (MWA/maxWA) and wall thickness (MWT/MaxWT) in high-CACS group were larger than that of low-CACS group (p<0.05, Table 1).

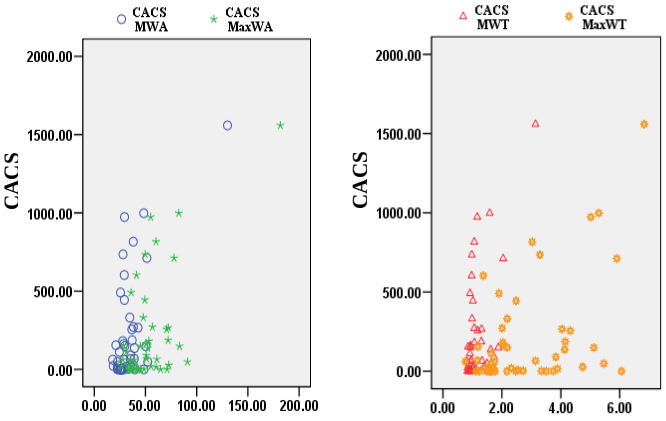

Figure. 1A Figure. 1B

Figure. 1 showed the correlation of CACS with carotid wall area (A) and wall thickness (B).

Table 1 Comparison of carotid morphology in high-CACS and low-CACS groups

Carotid morphology	High-CACS†	Low-CACS†	P
Minimum LA (mm^2)	23.6±15.7	21.5±10.0	0.623
MWA (mm^2)	45.5±33.0	31.2±8.5	0.018*
MaxWA (mm^2)	70.4±44.5	49.2±16.1	0.018*
MWT (mm)	1.4±0.7	1.1±0.3	0.035*
MaxWT (mm)	3.9±1.9	2.7±1.3	0.028*
Mean NWI	0.4±0.1	0.4±0.1	0.307
Maximum NWI	0.6±0.2	0.5±0.1	0.231

Notes: †Mean±SD; * P<0.05 (Independent-Samples t test).

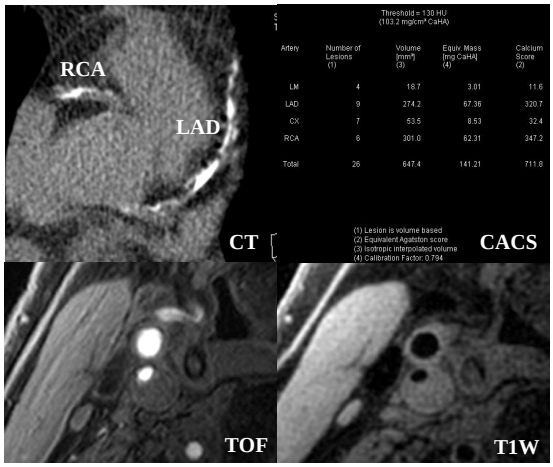

Figure. 2 An example showed high CACS (CACS=711.8) on coronary artery CT images and larger WA and WT on the right internal carotid artery MR images in the same patient.

Conclusion: This study showed a significant correlation between coronary calcium score detected by CT and carotid morphological measurements by MRI, which indicates that patients with high coronary calcium score may have big plaque burden in carotid arteries. Coronary calcium score as a marker of coronary disease is potentially capable of predicting carotid atherosclerosis. Based on the promising findings of this study, in the future, the correlation between carotid atherosclerotic plaque features on MRI and coronary disease on CT angiography needs to be investigated, and the potential ability of carotid MRI to predict coronary disease also needs to be evaluated.

References:

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