

Carotid Atherosclerotic Score--A New Method to Identify High Risk Carotid Plaques Based on Multi-Contrast MRI: Validation and Preliminary Results from Patients

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Introduction:

Recent studies indicate that knowledge of the topography of individual carotid plaque components in relation to the fibrous cap and the lumen is critical to identify the “vulnerable”, high-risk plaque¹. Multi-contrast MRI technique of the carotid has been shown to be able to characterize plaque components and determine luminal surface condition². The new challenge is to transform the information about vessel lumen narrowing, tissue components, and luminal surface condition obtained from analyzing MRI of atherosclerosis into a format appropriate for clinical settings. Our goals are 1) to design an MRI-based Carotid Atherosclerosis Scoring (CAS) system to assign scores based on the topography of plaque components and the status of the fibrous cap, 2) to validate these scores by comparing MRI to histology, and 3) to summarize these quantitative entries into a risk score that can be used clinically for risk assessment. An important feature of the CAS is its emphasis of plaque tissues in the juxtaluminal layer including fibrous cap.

Methods:

This study was approved by the institutional review boards of both our hospitals. Patients (n=34) scheduled for a carotid endarterectomy were imaged with a 1.5T-scanner using TOF-/T1-/PD-/T2- and contrast-enhanced T1-weighted images. The presence (yes/no) and the location (deep vs. superficial) (Figure 1) of hemorrhage, necrotic core (including intraplaque hemorrhage), and calcification, and the status (ruptured or intact) of the fibrous cap (FC) were evaluated by histology and by MRI. The wall is divided into 3 equal parts based on the distance from the outer wall to luminal surface. The partition adjacent to the lumen is labeled as the “superficial” location and the other two partitions are labeled as the “deep” location (Figure1). A score was assigned to each component, “0” when it was absent, “1” when the component was located deep within the plaque and “2” when the component was located close to the luminal surface. The score was multiplied with empirical weighting factors for the components (hemorrhage=1; necrotic core=0.75; calcification=0.5) and the following scores were generated: Score A = (hemorrhage score × 1) + (necrotic core × 0.75) + (calcification × 0.5); Score B = Score A × cap status (“x1” if FC intact or “x2” if FC ruptured). To assess this correlation to clinical status, the CAS score was calculated by MRI in 32 asymptomatic and 40 recently symptomatic patients. Pearson correlation was used to assess MRI and histology results and the paired t-test was used to compare the scores of symptomatic and asymptomatic patients.

Results:

There was a strong correlation between MRI and histology for CAS Score A (r=0.84; p<.001) and CAS Score B (r=0.86; p<.001). Symptomatic patients had a significantly higher Score A (3.8 vs. 3.1; p=.003) and Score B (6.2 vs. 3.8; p<.001) compared to asymptomatic patients (Figure 1, 2).

Conclusions:

The proposed MRI-based CAS system for describing the presence and topography of key carotid plaque components in relation to the FC status and luminal surface is highly correlated to histological findings. Furthermore, higher scores were significantly associated with the presence of recent ipsilateral TIA, stroke or amaurosis fugax. This score better defines the status of atherosclerosis and its impact on vessel lumen and is better associated with patient’s neurological symptoms than examining lumen narrowing alone.

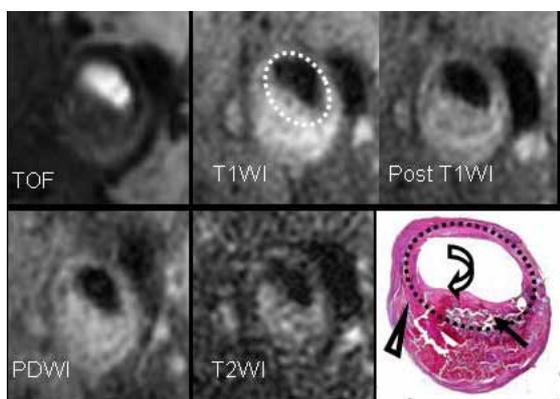


Figure1: In this location of the common carotid, there were “deep” calcium (empty arrow head), “superficial” necrotic core (arrow) and hemorrhage (curved arrow). The fibrous cap was ruptured. Therefore, Score A=4 and Score B=8.

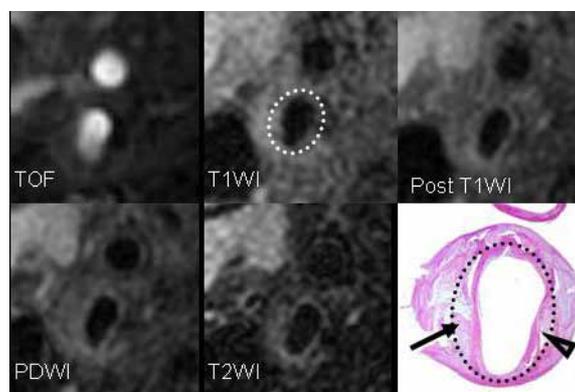


Figure2: In this location of internal carotid, there were “superficial” necrotic core (arrow) and calcium (empty arrow head), but “no” hemorrhage. The fibrous cap was intact. Therefore, Score A=2.5 and Score B=2.5.

References:

1. Virmani R, et al. J Interv Cardiol 2003; 16: 267-72.
2. Yuan C, et al. J. Magn. Reson. Imaging 2004; 19: 710-7