Delayed Enhancement MR Coronary Vessel Wall Imaging in Patients with Suspected Coronary Artery Disease

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Introduction:

Atherosclerosis is a systemic inflammatory disease that affects large and medium sized vessels including the coronary arteries. X-ray coronary angiography is the gold standard for the detection of lumen encroaching coronary lesions but fails to identify the underlying plaque itself. During recent years, multi detector CT and MRI have emerged as the most promising non-invasive imaging techniques for coronary plaque visualization and characterization. Native MR coronary vessel wall imaging has been shown to allow assessment of coronary wall thickness[1,2] but requires high spatial resolution and accurate motion correction. Contrast enhanced MRI may be an alternative and has been found to be useful for the evaluation of carotid[3-5] and aortic[6] plaque. Contrast uptake was associated with neovascularization[3] and was most prominent in fibrous[4,5] plaque components. Recent studies of giant cell arteritis[7] and Takayasu's[8] disease also suggest early contrast uptake in the setting of acute inflammation. From a technical point of view, CE-MRI reduces the imaging task to the detection of the presence or absence of contrast uptake, thereby lowering the requirements on spatial resolution and motion compensation, which is especially beneficial for coronary plaque imaging.

Purpose:

We sought to investigate the relationship between conventional coronary angiography and delayed enhancement (~60-90 minutes) coronary vessel wall imaging (DE-MRI)[9,10] in patients with suspected CAD. The delayed enhancement approach was used to minimize signal from blood and surrounding tissues.

Methods:

Twelve patients (64±13 years) that had undergone invasive coronary angiography were examined. Nine (75%) patients had angiographically confirmed coronary artery stenoses. All subjects were imaged in supine position using a 1.5T Phillips ACS-NT scanner equipped with a cardiac coil and a cardiac software package (R11). Approximately 30 minutes prior to MR scanning, 0.2mmol/kg Gd-DTPA (Magnevist) was administered. Coronary MRA of the left and right coronary artery was performed using a magnetization prepared (T2prep, fatsat) 3D SSFP technique. Imaging parameters included spatial resolution=1.25x1.25x3mm, TR/TE=5.4ms/2.7ms, flip angle=110º, and slices=20. Motion compensation was performed using ECG triggering and navigator gating and correction. Data were acquired using a patient specific mid-diastolic trigger delay. For determination of the inversion delay, a Look Locker sequence was performed. Subsequently (~60min. post Gd injection), DE-MRI of the left and right coronary vessel wall was performed using a T1 weighted 3D inversion recovery fast gradient echo technique. Imaging parameters were identical to the coronary MRA sequence, except for: TR/TE=6.1/1.9ms, flip angle=30 º and inversion time ~280ms. For MR image analysis, the three major coronary vessels were subdivided into a total of 8 segments. The intensity of contrast enhancement within the vessel wall was assessed for each segment according to a semi-quantitative score (0=no, 1=mild, 2=moderate, 3=severe) by consensus reading and compared with the corresponding invasive angiogram. Image quality was assessed on a scale from 1-4 with 1 being very good.

Results:

Image quality was good for both MRA (2.0±0.4) and DE-MRI (1.7±0.8) and contrast enhancement was primarily diffuse (Figure 1) and correlated well with the presence of luminal irregularities or >20% stenoses (Figure 2) as defined by x-ray angiography. Together, 92 coronary artery segments in 12 patients were evaluated (1 segment not evaluated due to stent, 3 segments not available). MR contrast enhancement within the coronary vessel wall was significantly more often found in patients with CAD than in those with a normal x-ray angiogram (5.4±1.7 vs. 2.0±0 segments, p=0.008) (Figure 2a). The enhancement score correlated with the severity of CAD (r=0.65). Based on the segmental analysis, 85% of stenotic segments showed contrast enhancement within the coronary artery wall. However, the incidence of coronary contrast enhancement was also high in segments with only minimal wall irregularities (72%) and even in segments without detectable abnormalities (34%) by coronary angiography (Figure 2b).

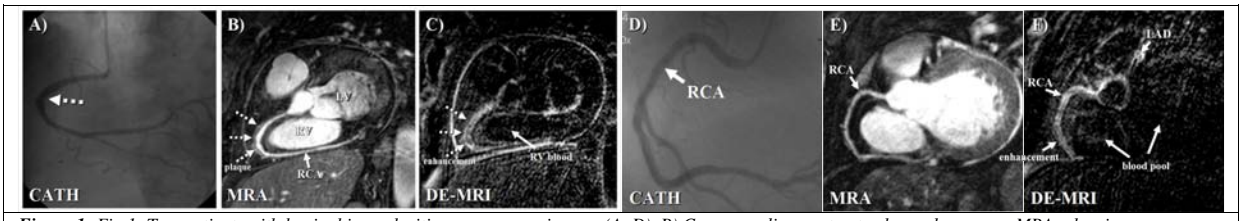

Figure 1: *Fig 1: Two patients with luminal irregularities on x-ray angiogram (A, D). B) Corresponding contrast enhanced coronary MRAs showing an irregular lumen (B, E). In (B), an iso-intense layer suggestive for outward remodeling can be observed. C, E) Delayed enhancement (~60minutes post Gd) vessel wall images demonstrate contrast uptake in the proximal and mid RCA suggestive for diffuse atherosclerosis.*

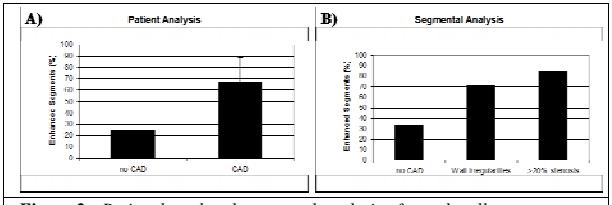

Figure 2: *Patient based and segmental analysis of vessel wall enhancement. In patients with CAD, contrast uptake was observed in ~68% of the evaluated segments while in patients with no angiographically detectable CAD, ~25% were enhanced. Segment based analysis demonstrates enhancement in 72% of the segments with wall irregularities and in 85% of stenotic segments by x-ray angiography.*

Conclusions:

Delayed enhancement imaging is a promising technique for the non-invasive visualization of the coronary vessel wall. The good correlation of coronary vessel wall delayed enhancement with clinically evident CAD suggests that contrast uptake may be associated with an increased distribution volume in the altered vessel wall, which may be related to angiogenesis or collagen deposition both signs of chronic inflammation. Coronary vessel wall imaging by DE-MRI thus may provide an estimation of coronary plaque burden and may allow detection of subclinical CAD. Further studies are now warranted to better understand the underlying pathophysiology of these observations.

References:

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