Multi-sequence coronary vessel wall MRI at 1.5 T: a feasibility study

S. C. Gerretsen[1], M. E. Kooi[1], R. M. Botnar[2], J. M. van Engelshoven[1], T. Leiner[1]

[1]Radiology, Maastricht University Hospital, Maastricht, Netherlands, [2]Cardiac MR Center, Beth Israel Deaconess Medical Center & Harvard Medical School, Boston, MA, United States

Introduction:

MRI is a promising, non-invasive technique for atherosclerotic plaque imaging and characterization of plaque components in the carotid arteries and the aorta (1,2). Several researchers have demonstrated the feasibility of atherosclerotic plaque detection using black-blood MRI in human coronary arteries (3,4). However, for plaque characterization multi-sequence MRI is desirable. Characterization of atherosclerotic plaques in coronary arteries remains challenging due to cardiac and respiratory motion. The aim of this study was to investigate the feasibility of in vivo multi-sequence coronary vessel wall MRI at 1.5 T in patients with angiographically proven coronary artery disease.

Materials and methods:

Fifteen subjects (three healthy volunteers and twelve patients, age: 24-77 yrs) were included. All patients had angiographically proven coronary artery disease. Healthy volunteers were included for sequence design and optimization. All imaging was done on a 1.5 T clinical MR scanner (Intera, R 9.1, Philips Medical Systems, Best, The Netherlands) using vector ECG gating and a commercially available 5-element phased array SENSE cardiac coil. Prior to vessel wall imaging, bright blood steady state free precession (balanced TFE) imaging of the coronary lumen was performed for localization of stenoses. Subsequently, T2 weighted TSE and T1 weighted TSE coronary vessel wall sequences were obtained in stenotic vessel segments, with the scan plane positioned perpendicular to the coronary artery. Both sequences were preceded by a double inversion recovery (DIR) prepulse for blood signal suppression. Scan parameters are listed in Table 1. All data were acquired during free-breathing using navigator gating and subject specific middiastolic trigger delays and acquisition windows. To assess the feasibility of multi-sequence coronary vessel wall imaging, a range of different values between 2.5 and 5.0 mm for partition thickness were assessed.

sequence	TR (heart beats)	TE (ms)	Echo train length	FOV (mm)	Matrix	slices	Slice thickness (mm)	Spatial resolution (mm^3)	Nominal Scanduration (@ 60 bpm)
T2w TSE	2	50	12	270x270	352x352	1	5.0	0.77*0.77*5.00	3:56 min
T1w TSE	1	14	8	270x270	352x352	1	5.0	0.77*0.77*5.00	2:58 min

Table 1. Present scan parameters of the T1w and T2w vessel wall sequences.

Results:

Bright blood MRI reliably located coronary artery stenoses in comparison to intra-arterial digital subtraction angiography (IA-DSA) (Figure 1). Ten subjects (three volunteers and seven patients) underwent coronary artery vessel wall imaging. As expected, vessel wall visualisation was difficult in normal subjects due to the small size of the vessel wall. Not all vessel wall sequences were performed in all patients due to claustrophobia and long scan durations. Long scan durations of sometimes more than 10 minutes were caused by low respiratory navigator efficiency and cardiac arrhythmias. Slice thicknesses below 5 mm yielded poor results in terms of signal-to-noise ratio (SNR) and coronary vessel wall detection in patients. In four patients with moderate to severe coronary stenosis, the vessel wall was visualized. The coronary vessel wall exhibited bright signal intensity on T1 and T2 weighted images (Figure 2).

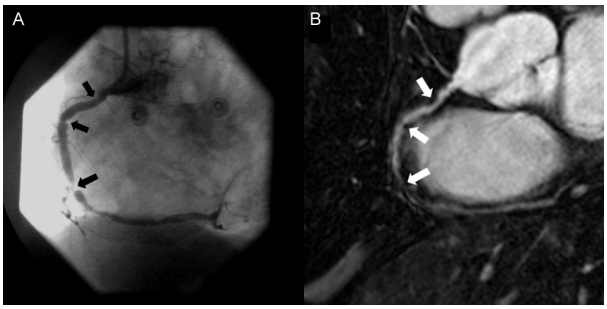

Figure 1. Note the similarity between A) IA-DSA and B) MRI of right coronary artery in a patient with coronary artery disease

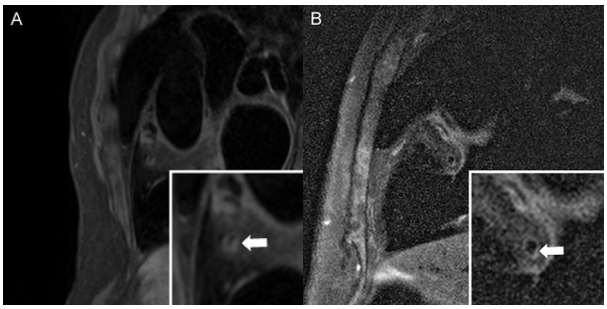

Figure 2. A) T1w TSE of RCA B) T2w TSE of LCA in two patients with coronary artery disease

Conclusion:

In this work we demonstrated the feasibility of multi-sequence MRI of the coronary arteries, but further optimization of MRI sequences in terms of scan duration, navigator efficiency and spatial resolution is necessary. A potentially useful adjunct to conventional non-enhanced multi-sequence imaging might be the use of contrast-enhanced sensitive sequences (5). In addition, comparison with an independent standard of reference such as intravascular ultrasonography is necessary to confirm MRI findings. In patients with 2.5 mm slices the coronary vessel wall was poorly visualized due to insufficient SNR. Therefore, a slice thickness of 5 mm is recommended.

References:

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