Whole-Heart Coronary MR Angiography for the Detection of Coronary Artery Stenosis in Patients with Coronary Calcification: Preliminary Comparison to 64-slice CT Angiography

X. Liu[1], X. Bi[2], N. Leloudas[1], A. Hitchell[1], A. Kino[1], C. Francois[1], D. Li[3], and J. C. Carr[1]

[1]Department of Radiology, Northwestern University, Chicago, Illinois, United States, [2]Siemens Medical Solutions, Chicago, Illinois, United States, [3]Radiology, Biomedical Engineering, Northwestern University, Chicago, Illinois, United States

Introduction: State-of-the-art 64-slice multidetector CT has shown high accuracy for the detection of significant coronary stenosis [1]. However, its ability to visualize calcified coronary lumen is usually compromised by blooming artifact from high density calcification[2]. Coronary MRA (CMRA), on the other hand, does not suffer from such bright imaging artifacts and can potentially depict the lumen of calcified coronary arteries.

The purpose of this work is to evaluate the feasibility of using high spatial-resolution whole-heart CMRA[3] for the detection of coronary stenosis in patients particularly with coronary calcification. Coronary CT angiography (CTA) was performed on the same patients for comparison.

Methods: Five patients with suspected coronary artery disease underwent both coronary CTA (Sensation Cardiac 64, Siemens, Erlangen, Germany) and whole-heart CMRA study (Avanto, Siemens, Erlangen, Germany), respectively. Oral β-blocker was given to subject if the heart rate was higher than 70 bpm. CMRA was performed on a 1.5 Tesla clinical scanner. An ECG-triggered, fat-saturated, T2-prepared, segmented 3D steady-state free precession sequence was employed for free-breathing whole-heart CMRA. Imaging parameters are as follows: TR/TE 3.7/1.7 ms, flip angle 90º, lines per heartbeat 25 ~ 30, readout bandwidth 870 Hz/pixel, voxel size 0.9 x 0.9 x 1.3 mm^3 ~ 1.3 x 1.3 x1.3 mm^3. The image quality was assessed in 15 coronary segments (according to the AHA classification of coronary artery segment anatomy) using a 4-point grading scale (poor, fair, good, and excellent). Coronary stenosis was evaluated by two experienced radiologists in consensus. Coronary calcification was graded as mild (CS < 100), moderate (CS 100 ~ 400), and extensive (CS > 400) based on the coronary calcium scoring calculated by volume score approach[4] .

Results: CTA images showed normal coronary arteries without calcification in four patients. For the remaining subject, multiple calcifications were found in all three main coronary vessels, as shown in Figure a and Figure c. For non-calcified coronary arteries, no difference was observed between the CTA and CMRA in the LM, proximal and middle segments of RCA, LAD, and LCX. For the distal segments of all three coronary vessels, the image quality from CTA was superior to that from CMRA. CMRA failed to visualize seven minor branches that were depicted on CTA in the four patients.

The calcium score of the RCA, LM, LAD, and LCX was 101 (1 lesion), 65 (1 lesion), 410 (3 lesions), and 121 (6 lesions), respectively, for the patient with coronary calcification. CTA was able to assess the luminal narrowing caused by mild calcification in the LM and LCX, but it failed to depict the luminal narrowing in the proximal RCA and LAD with larger and extensive calcification (CS of single lesion > 100). On the other hand, CMRA clearly depicted the coronary lumen with no significant stenosis including the calcified sites in the LM, LCX, and RCA (Figure b). In addition, CMRA showed the irregular coronary lumen in the proximal LAD without overlapping from calcification and detected a significant stenosis (>50%) in the middle LAD (Figure b and Figure d).

Discussion: Due to repetitive plaque rupture and healing, diffuse calcification is typically associated with severe luminal narrowing [5]. Thus, high-resolution whole-heart CMRA is very helpful to accurately detect the significant coronary stenosis in patient with severe calcification. However, more patient studies are needed to evaluate the accuracy of the whole-heart CMRA for the detection of significant coronary stenosis in patients with severe calcification using conventional angiography as a golden standard. In addition, the relation between calcification and the degree of luminal narrowing should be further investigated.

Conclusions: This preliminary study demonstrated that whole-heart CMRA with high resolution has advantage for the depiction of coronary lumen and the detection of significant stenosis in patients with severe calcification.

References: 1. Raff GL, et al. J Am Coll Cardiol 2005; 46: 552-557 2. Ong TK, et al. Am Heart J 2006; 151: 1323.e1-1323.e6 3. Sakuma H, et al. Radiology 2005; 237: 316-321 4. Mühlenbruch G, et al. Invest Radiol 2005; 40: 695-699 5. Burke AP, et al. Herz 2001; 26: 239-244

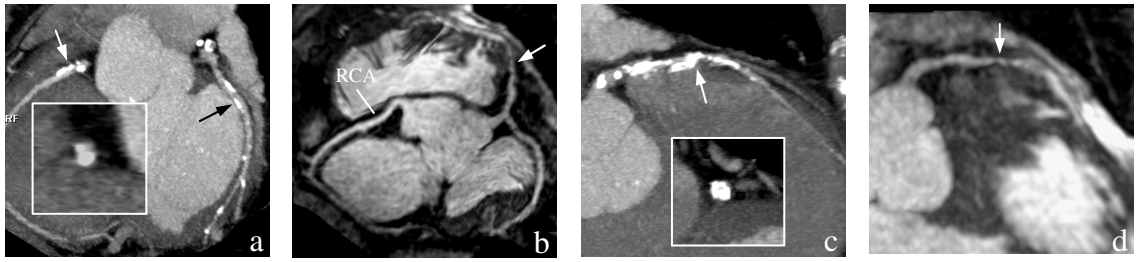

Figure: CTA **(a, c)** and MRA **(b, d)** images from a patient with calcified coronary arteries. **a):** CTA showed multiple calcification nodus in the proximal RCA (white arrow) and LCX (black arrow), it was difficult to evaluate the luminal narrowing in the proximal RCA on the cross sectional multiple planner reformat image (white box); **b):** Reformatted whole-heart CMRA demonstrated no significant stenosis at the calcified site in RCA and LCX but a significant stenosis (>50%) caused by the diffuse calcification in the proximal LAD (arrow); **c):** CTA demonstrated diffuse calcification in the proximal LAD (arrow). It neither depicted the coronary lumen nor assessed the stenosis on the cross sectional MPR image (white box) due to the overlapping and blooming artifact of calcification; **d):** Maximum intensity projection image of whole-heart CMRA demonstrated the irregular lumen with a significant stenosis in the proximal LAD (arrow).