Feasibility of integrating high spatial-resolution, 3D whole-heart viability imaging and coronary MRA at 3 Tesla

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Introduction: A major advantage of cardiac MRI is the potential to obtain a comprehensive 3-dimensional examination of the severity of coronary arterial disease and associated myocardial viability in the same setting (1). Current breath-hold 2D delayed-enhancement cardiac MR (DE-CMR) has relatively poor spatial resolution in the through-plane direction and requires multiple breath-holds to cover the entire left ventricle. 3D isotropic coverage of the heart for DE-CMR would enable re-formatting cardiac views in arbitrary orientations and accurate image registration with coronary MRA. In this study, 3D coronary MRA and DE-CMR were integrated into the same imaging session. High spatial resolution and whole-heart coverage were achieved for both scans using a navigator-gated, segmented gradient-echo sequence at 3.0 Tesla. The potential of a combined approach to both these aspects could provide a powerful tool in the assessment of ischemic heart disease with the improved 3D spatial resolution providing additional quantitative and characterization information. The feasibility of such an approach was evaluated in volunteer studies.

Method: Five volunteers without known heart disease were studied on a 3.0 Tesla Siemens whole-body scanner (Trio, Siemens, Erlangen, Germany). High-resolution whole-heart coronary MRA was first acquired during slow infusion of clinical contrast agent (Magnevist; Schering, Berlin, Germany) (2). An ECG-triggered, navigator-gated gradient-echo sequence was used for data acquisition. Imaging parameters included: 1.3 × 1.3 × 2.3 mm^3 voxel size (interpolated to 0.65 × 0.65 × 1.15 mm^3), TR/TE = 3.0/1.2 msec, number of lines per heartbeat = 47, bandwidth = 600 Hz/pixel and the flip angle was 20°. 56 slices were sequentially acquired and interpolated into 112 slices. A nonselective inversion pulse was applied before data readout to null the myocardium signal. The inversion recovery time (TI) for coronary MRA was 200 msec. Data acquisition started 25 seconds after the initiation of contrast infusion. Contrast agent (0.2 mmol/kg body weight) was intravenously administered at the rate of 0.3 ml/sec using a Medrad power injector, immediately followed by 20 ml of saline injected at the same rate.

DE-CMR for infarction imaging was performed 10 – 15 minutes after the contrast agent administration. Imaging parameters (spatial resolution and slab coverage) are identical to those used for coronary MRA except that the TI was increased to 300 – 320 msec. For comparison, reference standard 2D segmented, breath-hold gradient-echo sequence and phase-sensitive inversion-recovery infarction imaging was performed in the 4-chamber, 2-chamber and multiple short-axis views (3). Imaging parameters for 2D imaging included: 1.9 × 1.9 × 8.0 mm^3 voxel size, TI = 300 msec, TR/TE = 8.4/3.4 msec, bandwidth = 140 Hz/pixel.

Whole-heart coronary artery images were reformatted using the CoronaViz software (Siemens, Erlangen, Germany) to project multi-branch vessels with their surroundings onto a single image (4).

Results: Whole-heart coronary artery images were successfully acquired from all volunteers. The average imaging time for one whole-heart scan (coronary artery imaging or viability imaging) was 4.5 ± 1.1 minutes. Myocardial infarction was observed in one of the volunteers. Coronary artery images and viability images from this subject are shown in Figure 1. Severe stenosis is clearly depicted in the proximal portion of the right coronary artery. Narrowing is also noticeable in the proximal section of the left anterior descending coronary artery, as indicated by the arrows in Fig. 1(a). Severe infarction is detected in the anterior wall of the left ventricle using the whole-heart viability imaging. The depicted areas of infarction are in good agreement with those acquired with the 2D images. No hyperenhancement of the myocardium and areas of coronary stenosis were observed in the other volunteers.

Discussion: The study demonstrates that it is feasible to integrate whole-heart coronary MRA and viability imaging within 20 minutes at 3.0 Tesla. Improved SNR at 3.0 Tesla warrants higher spatial resolution than conventional viability imaging at 1.5 Tesla. In addition, whole-heart coverage facilitates the 3D reformation as well as precise quantification of the damaged tissue. Coronary MRA yields information of the diseased vessels and can potentially supplement the information acquired from viability imaging.

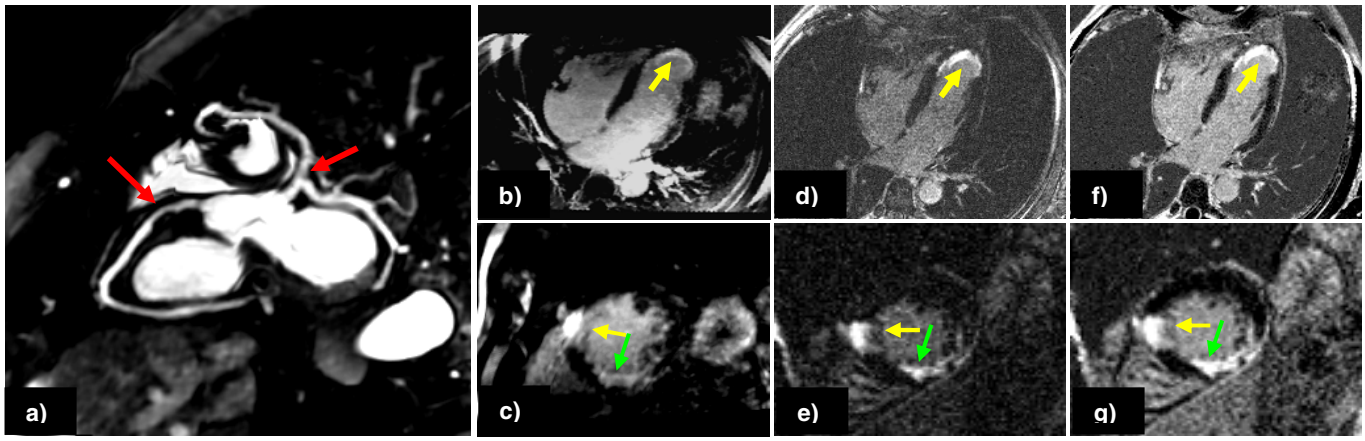

Figure 1. Reformatted whole-heart coronary artery image **(a)** and viability images **(b, c)** acquired from a volunteer (male, 45 years old, 192 lbs). Note the stenosis in the proximal section of the right and left anterior descending coronary arteries (red arrows). 3D viability images revealed hyperenhancement in the inferior region consistent with the right coronary artery stenosis (green arrow) and an anteroseptal/apical regions consistent with a left anterior descending artery stenosis (yellow arrow). Corresponding 2D viability images from the same subject both without **(d, e)** and with **(f, g)** PSIR confirmed the same areas of infarction. Note the spatial resolution (1.3 × 1.3 × 2.3 mm^3) in 3D images (b, c) is much higher than that from the 2D acquisition (images d – g: 1.9 × 1.9 × 8.0 mm^3).

References:

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