High-Resolution Coronary Artery MRA at 3 Tesla with Slow Infusion of an Extravascular High Relaxivity Contrast Agent MultiHance

X. Bi[1], J. Carr[1], D. Li[1]

[1]Departments of Radiology and Biomedical Engineering, Northwestern University, Chicago, IL, United States

Introduction Conventional Gadolinium based extracellular contrast agents have been extensively used to improve the depiction of coronary arteries in MRI. Typically, contrast media is rapidly administered to assure adequate T_1-shortening and blood signal enhancement. As a result, the spatial resolution and/or 3D coverage are limited by confining data acquisition within the first-pass of contrast agent (1). Gadobenate dimeglumine (MultiHance; Bracco Imaging, Milan, Italy) is an extravascular contrast agent recently approved for clinical use in the United States. It has a high in vivo R_1 relaxivity (9.7 $(mmol/L)^{-1}.sec^{-1}$) and stays in the blood pool longer because of its weak albumin binding (2), which make it possible to achieve the same T_1-shorting at a lower concentration as compared to conventional gadolinium agents. In this study, we investigated the feasibility of acquiring contrast-enhanced high-resolution coronary artery images at 3 Tesla with slow infusion of MultiHance. The signal enhancing characteristics were also compared to that of a conventional gadolinium chelate – gadopentetate dimeglumine (Magnevist; Schering, Berlin, Germany) on a volunteer using identical imaging protocols.

Methods Six healthy volunteers with written consent were studied on a 3.0T Siemens whole-body scanner (Trio). Volume-targeted high-resolution coronary MRA was acquired before and during contrast agent infusion, respectively, using an ECG-triggered, navigator-gated gradient-echo sequence. Imaging parameters included: 0.9×0.9×0.9 mm^3 voxel size, TR/TE = 3.4/1.5 msec, number of lines per heartbeat = 21, bandwidth = 490 Hz/pixel. The flip angle was 15° and 20° without and with contrast agent, respectively. 16 – 22 slices were collected and interpolated into 32 – 44 slices. For contrast-enhanced scans, a non-selective inversion pulse was played before data readout (inversion recovery time = 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 0.4 ml/sec using a Medrad power injector for a period of about 1.5 min, followed by 20 ml of saline injection at the same rate. To compare the enhancing characteristics of MultiHance to Magnevist, one volunteer was scanned with administration of the two agents, respectively, in two different imaging sessions. Coronary artery images were acquired at 25 seconds, 7 minutes, and 15 minutes after the start of contrast injections. Identical imaging parameters and infusion protocol were applied in the two studies.

The blood signal-to-noise ratio (SNR) and blood-myocardial contrast-to-noise ratio (CNR) were measured from all studies. Comparison between pre- and post-contrast images were conducted using a paired t-test with a two-tailed p-value smaller than 0.05 to be statistically significant.

Results Figure 1 illustrates a set of coronary artery images acquired without and with contrast agent. The right coronary artery and left circumflex coronary artery are clearly depicted with slow infusion of MultiHance and sub-millimeter spatial resolution. The measured results of SNR and CNR are summarized in Figure 2. With an average imaging time of 5.46 ±0.66 minutes per scan, the CNR is improved by 65.6% (pre-contrast / post-contrast: 9.3 ±2.8 / 15.4 ±3.2, p-value = 0.003) with contrast agent injection. Slight increase of SNR is observed post-contrast but the difference is not significant (pre-contrast / post-contrast: 22.0 ±1.8 / 23.9 ±3.0, p = 0.3). SNRs and CNRs acquired at various time points after MultiHance and Magnevist injections are shown in Figure 3. Similar SNR and CNR were observed at the first time point (25 seconds). However, the drop of the SNR and CNR as delay time increases is slower with MultiHance. As shown in the same figure, coronary arteries are still well delineated with data acquisition started at seven minutes after the MultiHance injection.

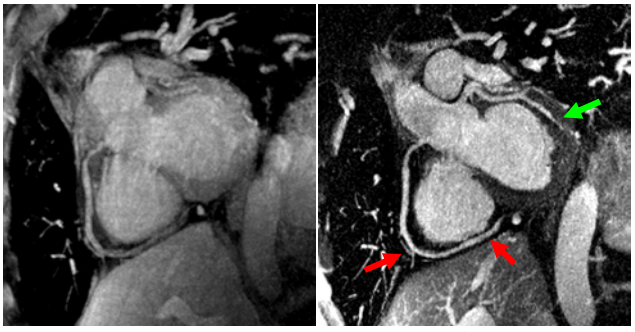

Figure 1. Coronary artery images (0.9×0.9×0.9 mm^3) acquired from a 192-lb volunteer without (left image) and with (right image) contrast media. With slow infusion of MultiHance, the right coronary artery (red arrows) and left circumflex coronary artery (green arrow) are well depicted, particularly at the distal portions.

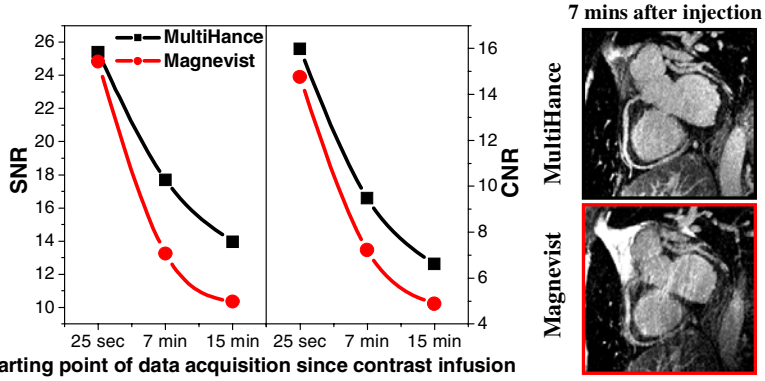

Figure 3. SNR and CNR of coronary artery images acquired at different time points after contrast agent infusions. Note that MultiHance shows slower drop of SNR and CNR than Magnevist. Coronary arteries (right images) are well depicted in MultiHance-enhanced image (top image) even 7 minutes after contrast infusion.

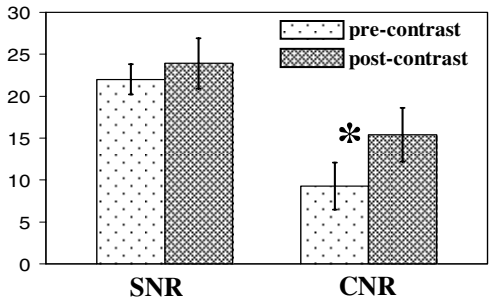

Figure 2. SNR and CNR measured from six volunteers. Note the significantly improved blood-myocardial CNR (* p = 0.003) with slow infusion of MultiHance.

Discussion Although blood pool agents can provide high relaxivity and long time window for contrast enhancement in coronary artery imaging, they have not been approved for clinical use up to date. This study shows that high resolution coronary MRA at 3 Tesla with slow infusion of clinically approved extravascular agent MultiHance is feasible. Compared to SSFP sequence, conventional gradient-echo sequences are less sensitive to the increased field inhomogeneity at 3 Tesla. In addition, energy deposition is small due to low flip angles used with conventional gradient echo sequences. Combined with slow infusion of MultiHance, the gradient-echo sequence can potentially be a robust technique for high-resolution coronary MRA at 3 Tesla under free breathing. The prolonged time of signal enhancement allowed by MultiHance potentially allows for contrast-enhanced whole-heart coronary MRA at 3 Tesla.

References

1. Bi X. et. al. JMRI 21: 133 – 139, 2005. 2. Knopp MV. et. al. Radiology 230: 55 – 64, 2004.