# Coronary Arteries at 3.0T: Contrast-enhanced three-dimensional breath-hold MR Angiography

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**Introduction:**

$T_1$ shortening contrast agents have been successfully used in coronary MRA at 1.5T to improve blood signal-to-noise ratio (SNR) and contrast-to-noise ratio (CNR) between blood and surrounding myocardium[1]. In theory, SNR is doubled at 3.0T as compared to 1.5T. However, tissue $T_1$ is prolonged at 3.0T and $T_1$ relaxivity of the contrast agent may change as well. The purpose of this study was to evaluate the feasibility and performance of contrast-enhanced magnetic resonance imaging of coronary arteries at 3.0T using an extravascular, paramagnetic contrast agent.

**Methods:**

Seven healthy volunteers (5 male, 2 female; age range: 26-58; mean: 39) were imaged at a 3.0T Siemens Trio scanner. Two 4-channel phased array coils (one anterior, one posterior) were used as signal receiver. 20 ml of contrast agent (Magnevist, Berlex Laboratories) was injected intravenously using a Medrad power injector for each study at a rate of 1 ml per second.

Both left anterior descending coronary artery (LAD) and right coronary artery (RCA) were imaged using a three-dimensional, cardiac gated, breath-hold, segmented FLASH (Fast Low Angle SHot) sequence. Imaging parameters included: TR/TE = 4.1/1.7 msec, FOV = 237 × 380 $mm^2$, data acquisition matrix size = (124-138) × 512, number of lines/heartbeat = 31-45, slab thickness = 18 mm, number of partitions = 6 (12 after sinc-interpolation), readout bandwidth = 420 Hz/pixel. Flip angle was set to be 15° for pre-contrast imaging and 22° for post-contrast studies.

For contrast-enhanced images, a non-selective inversion pulse was applied to null myocardium signal. Based on computer simulation using Matlab, an inversion-recovery time (TI) of about 280 ms was utilized to optimize CNR between blood and myocardium. To match the data acquisition window with the first pass of contrast agent, a small test bolus (2 ml of contrast agent chased by 15 ml of saline solution) was run to determine the transient time for contrast agent from the injecting vein in the arm to the ascending aorta, where coronary arteries originate.

For each study, both pre-contrast and post-contrast images were acquired. Coronary artery SNR, CNR, length of depicted coronary artery, lumen diameter, and coronary artery sharpness were measured using similar methods as a previous 1.5T study[1]. All data were presented as mean ± standard deviation. Comparisons between different data sets were performed using a paired t-test. P-values ≤ 0.05 were considered significant.

**Results:**

All studies were finished without complications. Example of the left coronary artery and RCA images were shown in Figure 1. With contrast agent injection, vessel delineation was markedly improved as compared to pre-contrast images. All measured results were summarized in Table 1. A 53% increase in SNR and a 305% enhancement in CNR were measured in post-contrast images.

**Conclusions and Discussion:**

Gd-DTPA has been successfully used for contrast enhanced, breath-hold, 3D coronary artery imaging at 3.0T. The existence of contrast agent leads to a marked improvement in the delineation of coronary arteries. The SNR, CNR, depicted coronary artery length and sharpness of blood vessels are consistently enhanced in the contrast agent first pass images, while the lumen diameter is smaller in post-contrast images. Compared to the previous contrast enhanced coronary study at 1.5T using a similar protocol[1], spatial resolution, SNR, and CNR of the current study at 3.0T are all increased. This study shows that contrast enhanced 3D coronary MRA at 3.0T is very promising. Further patient studies are required to evaluate its clinical utility.

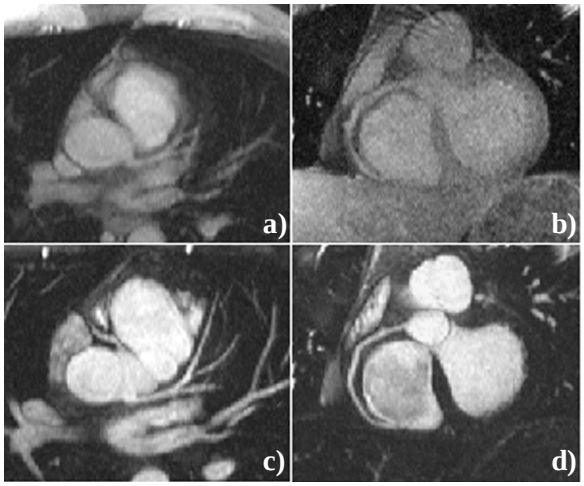


**Figure 1:** MR images from two volunteers demonstrate the improved SNR, CNR, and coronary artery delineation with contrast agent injection.
**a)** pre-contrast image of LAD, **b)** pre-contrast image of RCA, **c)** corresponding post-contrast image of LAD, **d)** corresponding post-contrast image of RCA.

| Characteristic | pre-contrast | post-contrast | p value |
|---|---|---|---|
| SNR | 11.25 ± 2.36 | 17.23 ± 3.01 | < 0.001 |
| CNR | 2.38 ± 0.82 | 9.63 ± 1.85 | < 0.001 |
| length of depiction (mm) | | | |
| LAD | 68.5 ± 9.7 | 85.9 ± 12.4 | 0.003 |
| RCA | 76.7 ± 9.3 | 102.6 ± 14.6 | 0.007 |
| lumen diameter (mm) | | | |
| LAD | 4.4 ± 0.6 | 3.8 ± 0.5 | 0.030 |
| RCA | 3.9 ± 0.8 | 3.4 ± 0.7 | 0.025 |
| Sharpness ($mm^{-1}$) | | | |
| | 0.53 ± 0.14 | 0.65 ± 0.16 | 0.015 |

**Table 1**: Results of measured SNR, CNR, vessel length, lumen diameter, and image sharpness from seven volunteers.
Note the SNR, CNR, depicted length and sharpness of coronary arteries were significantly improved with contrast agent, while measured lumen diameter was smaller in post-contrast images.

**References:** 1. Li D. et al, *Radiology*. 2001; 218:670-678.