Optimization of extravascular contrast injection parameters to prolong data acquisition window for coronary MRA at 3T

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Introduction

A major requirement of coronary artery imaging is high spatial resolution, high signal-to-noise ratio (SNR), and blood-myocardial contrast-to-noise ratio (CNR) to estimate the degree of luminal stenosis. Steady-state free precession (SSFP) techniques are gaining acceptance for coronary MRA at 1.5T, but SSFP is compromised at 3T due to higher local B0 inhomogeneities. Gradient-echo approaches (e.g. FLASH) may be better suited for coronary imaging at 3T. To alleviate saturation effects with FLASH, T_1-shortening agents can be used to increase SNR and blood-myocardial CNR (1). A limitation of the FDA approved contrast agents is that they are extravascular in nature and leak into the myocardium, thus reducing the effect of the contrast agent after first pass. This is an impediment to high-resolution imaging, which takes longer imaging times than a first pass breathold. However, there is a plateau phase after the injection of even an extravascular contrast agent, when the blood T1 time remains relatively short up to several minutes after injection, and can potentially be used for high-resolution imaging. The goal in this study was to assess the time window that is available for contrast-enhanced imaging after the injection of an extravascular contrast agent, and evaluate what factors affect this time window.

Materials and Methods

A 3D breath-hold, fat suppressed, ECG triggered, segmented FLASH sequence with non-selective inversion recovery (IR) preparation was used to acquire the images (3 T, MAGNETOM TRIO, Siemens). Three healthy volunteers were examined and the resulting images were evaluated in terms of SNR and CNR. A total dose of the contrast agent (Magnevist, Berlex) of 40 ml was split into two injections of 20 ml each (injection rate: 1 ml/s). Breath-hold images were acquired during first pass of the first injection, and 2 min., 4 min., and 6 min., following injection 1. After these images were acquired, the second injection dose was administered and again images were acquired during first pass, and 2 min., 4 min., 6 min., 8 min. and 10 min. after injection. The following imaging parameters were used: TR/TE/TI = 3.5 ms/1.4 ms/250 ms, flip angle = 20°, readout bandwidth = 400 Hz/pixel, field-of-view (FOV) = 180 mm × 300 mm, matrix size = 124 × 256, slice thickness = 3 mm interpolated to 1.5 mm, number of partitions = 16, parallel acquisition factor = 2. The coronary artery SNR and CNR were measured for each dataset.

Results

Contrast-enhanced IR-prepared FLASH imaging gives high blood SNR and blood-myocardial CNR, as shown in Fig. 1. Uniform background suppression was achieved by using an adiabatic IR-preparation at 3T. The SNR and CNR at the different time points in the study, and their changes at those time points with respect to SNR and CNR acquired during the first pass scan for injection 1 (reference) are shown in Figure 2 and Table 1. Relatively high SNR and CNR were acquired during the first-pass scan of injection 1, but the SNR and CNR rapidly reduced after injection 1. SNR and CNR observed during the first-pass scan of injection 2 were similar to that during first-pass of injection 1, but the enhancement was found to last much longer after injection 2 than after injection 1. Images acquired even 10 min. after injection 2 show relatively high SNR and CNR.

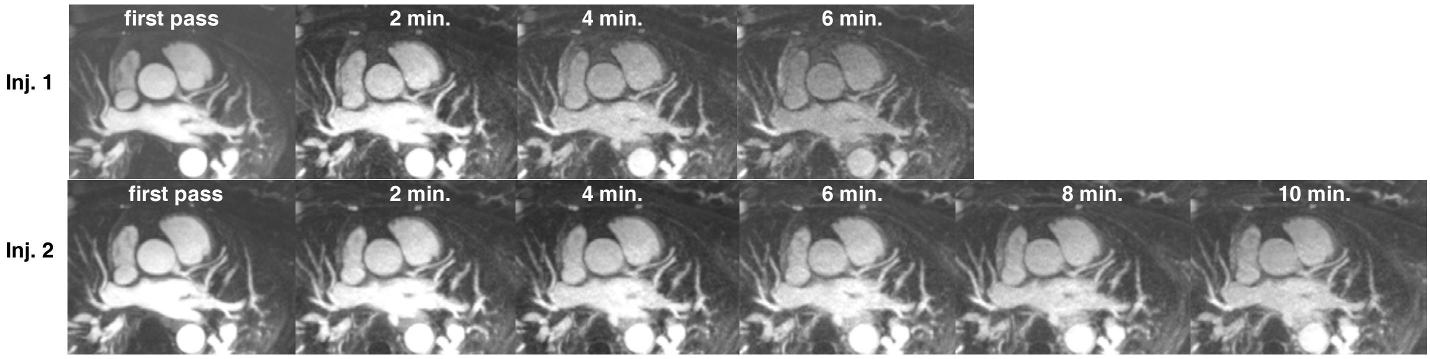

Figure 1. IR-FLASH images of the LAD during and after injections 1 and 2. The times after injection are indicated on the images. Comparing images 6 min. after post-contrast, the SNR and CNR are much higher in the image after the second injection than after the first injection. Note the SNR and CNR enhancement up to 10 min. after the second injection, lasting much longer than after single dose.

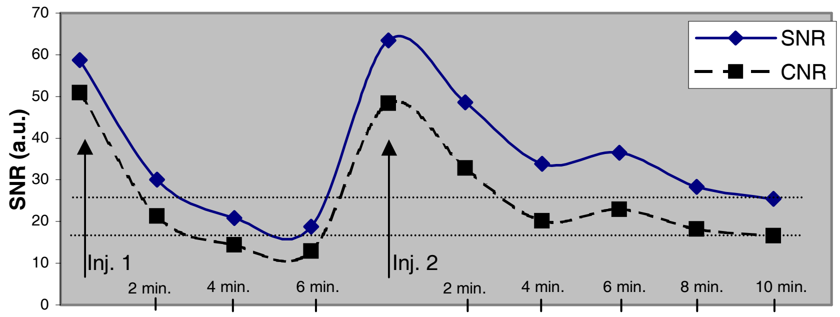

Figure 2. SNR and CNR as a function of time after injections 1 and 2. Note that even 10 min. after injection 2, the SNR and CNR are only slightly lower than the corresponding values after 2 min. post injection 1.

% change	SNR	CNR
First inj.	reference	reference
2 min.	-48.8%	-58.3%
4 min.	-64.5%	-72.4%
6 min.	-68.2%	-75.2%
Second inj.	+0.08%	-4.5%
2 min.	-17.2%	-35.5%
4 min.	-35.2%	-46.3%
6 min.	-37.8%	-54.8%
8 min.	-51.8%	-64.3%
10 min.	-56.8%	-67.4%

Table 1. Comparison of SNR and CNR during and after the contrast injections, with respect to the SNR and CNR during first pass of injection 1.

Discussion

Results show that the blood SNR and blood-myocardial CNR remain relatively high for at least 10 min. post contrast injection when a total of double dose of an extravascular contrast agent is used. For one single dose injection, the first pass SNR is high, but drops off rapidly in the first 4 min. After another single dose injection (total of double dose), the drop in SNR is slower. Even 10 min. after the second injection, the drop in SNR is 57%, which corresponds to a similar drop in SNR only 2 min. after the first injection. In conclusion, contrast-enhancement with a double dose of contrast injection can last at least 10 min. after the injection, and may potentially allow longer imaging times while maintaining high SNR and CNR at 3T. The effect of varying injection rates remains to be studied.

References

1. Yang CW. et al., Invest Radiol. 2006 Aug;41(8):639-44