Feasibility of Whole-Heart Coronary MRA on 3 Tesla Using Ultrashort-TR SSFP VIPR

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Introduction:

Coronary magnetic resonance angiography (MRA) has been performed on 3.0T to generate higher SNR compared to 1.5T. In addition, high blood-to-myocardium contrast could be achieved using the SSFP technique [1]. However, SSFP is highly sensitive to field inhomogeneities. In particular, signal nulls occur every 1/TR in resonance frequency, producing "banding" artifacts in images. With VIPR (Vastly Undersampled Imaging with Projections) imaging, non-selective RF pulses are used, which will allow ultrashort TR, increasing the bandwidth in which the signal remains uniform. In addition, whole-heart MRA with isotropic resolution could be achieved with VIPR. 3D isotropic coverage of the heart would enable reformatting the images to visualize coronary arteries from arbitrary orientations. The purpose of the work was to evaluate the feasibility of whole-heart coronary MRA on 3.0T using SSFP and verify that ultrashort TR with VIPR allows good coronary MRA image quality with SSFP.

Method:

Four healthy volunteers were studied on a 3.0 Tesla Siemens whole-body scanner (Trio, Siemens, Erlangen, Germany) during free breathing. An ECG-triggered, navigator-gated SSFP VIPR sequence was used for data acquisition. 4 coils with 3 channels each were employed. The imaging parameters were: TR/TE = 3.0 ms/1.5 ms, bandwidth/pixel was 868 Hz, basic matrix = 288*288*288, resolution = 1.3*1.3*1.3 mm^3.15360~16720 projections (undersampling factor 5~6), 512 readout points per projection were collected. With the SAR limitation, a flip angle of 50~60 degree was used.

T2 preparation has proven useful for improving contrast in coronary imaging [2]. At 3.0T, however, increased B_1 and B_0 inhomogeneities pose significant challenges to uniform T2 preparation of the magnetization across the imaged volume. Thus, adiabatic T2 preparation scheme was used with a T2-prep time of 40 ms [3]. SPIR (Spectral Presaturation Inversion Recovery) was used to suppress the fat signal.

Visual assessment from two objective observers are given to reconstruction images, scoring based on a 4-point scale, (1 = poor (non-assessable), 2 = fair (mild to moderate artifacts), 3 = good (minimum to mild artifacts), 4 = excellent (minimum or no artifacts. The length of visualization was also measured.

Results:

The acquisition time of whole-heart MRA ranged between 9 to 13 min. Both left and right coronary arteries from four volunteers were successfully visualized. Figure 1 is a multiplanar reformatted (MPR) image delineating LAD, RCA, and LCX. Excellent contrast between blood and myocardium is observed and no banding artifacts are present. Average image quality scores were 3.10 with a standard deviation of 0.41. Mean lengths and standard deviations of each coronary artery are shown in Fig. 2.

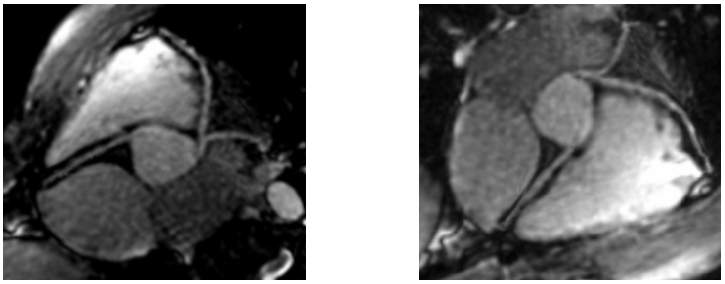

Figure 1. MPR images acquired with ultrashort-TR SSFP VIPR from two volunteers. Note the good delineation of both the left and right coronary arteries.

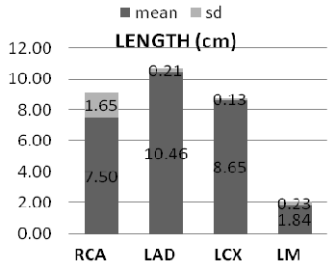

Fig.2. Quantitative analysis of coronary arteries. Black columns represent mean scores, grey columns show standard deviations (SD).

Discussion and conclusion:

SSFP has been the method of choice for coronary MRA on 1.5T. However, image quality with SSFP is highly variable on 3.0T due to increased B_0 inhomogeneity. Image artifacts are related to TR. With non-slab-selective excitation for VIPR, TR could be decreased to 3.0 ms as compared to 4.0 ms usually required for slab-selective SSFP. As a result, no apparent image artifacts were observed in the region of interest and excellent delineation of coronary arteries were obtained in our volunteer studies. Another advantage of VIPR imaging is isotropic high resolution. Future work should further reduce TR by asymmetric sampling along the readout direction, making this method more robust. Moreover, parallel imaging method should be employed to reduce imaging time and potential artifacts related to cardiac and respiratory motion.

References:

[1] Bi X, et al. JMRI 2005;22:206-212

[2] Shea SM, et al. JMRI 2002;15:597-602

[3] Nezafat R, et al. MRM 2006;55:858-864