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Meeting abstract

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2140 Time-resolved contrast-enhanced whole-heart coronary MRA using 3DPR

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Introduction

In contrast-enhanced coronary MR angiography (CMRA), the transit time of the contrast agent is dependent on both the injection scheme and the blood circulation of the individual subject. Therefore, for the conventional protocol with Cartesian reconstruction, a bolus prescan and additional assessment are usually necessary to synchronize centre-k-space acquisition with the period of the highest blood signal. This work aimed to investigate the feasibility of time-resolved contrast-enhanced CMRA using 3DPR which eliminates the tedious planning task and enables automatic selection of the optimal time frame.

Methods

A new sequence was developed by implementing 3DPR in a segmented FLASH sequence with navigator gating (NAV). Studies were conducted on 4 healthy volunteers using a 1.5 T Siemens Avanto system. Gd-BOPTA (0.2 mmol/kg) was slowly infused using a Medrad power injector at a rate of 0.3 ml/sec[1]. Sequence parameters included: 175 × 175 × 175 mm^3 FOV, 160 readout points; 1.1 × 1.1 × 1.1 mm^3 isotropic spatial resolution; 8600 projections/measurement; 43 lines/segment; 20° flip angle; TR/TE = 3.3/1.75 ms; TI = 200 ms. The scan time for one measurement during free-breathing is approximately 6 minutes. Data acquisition was started immediately after contrast injection and was repeated within 10 minutes to approximately cover contrast agent kinetics. As shown in Fig. 1, tornado filtering, including all outer-k-space (Kmax) samples but only center-k-space (Kmin) samples within a small temporal aperture (860 projections) for image reconstruction, was used to increase temporal resolution[2]. Sliding window was used to reconstruct images at different time points. GRAPPA was used to reduce undersampling streaking artifacts.

The center-k-space sample repeatedly measured in each k-space line was used to automatically determine the optimal time frame. First, the signal intensity variation as a function of the heartbeat number was derived by summing all the centre k-space samples acquired in each heartbeat and then low-pass filtered to eliminate modulations of respiratory and cardiac motion. Only signals acquired by the coil closest to the heart were used for the above calculation. Due to background suppression using inversion-recovery pulses, this signal intensity variation is correlated with the change of cardiac-blood-signal enhancement during the scan, which approximates coronary-blood-signal enhancement with slow contrast agent infusion. Next, by sliding the Kmax and Kmin apertures in temporal direction, signal integration over the two apertures were calculated in different aperture positions and the positions corresponding to the peak integration values were used to design the optimal tornado filter, based on which the optimal time frame was reconstructed.

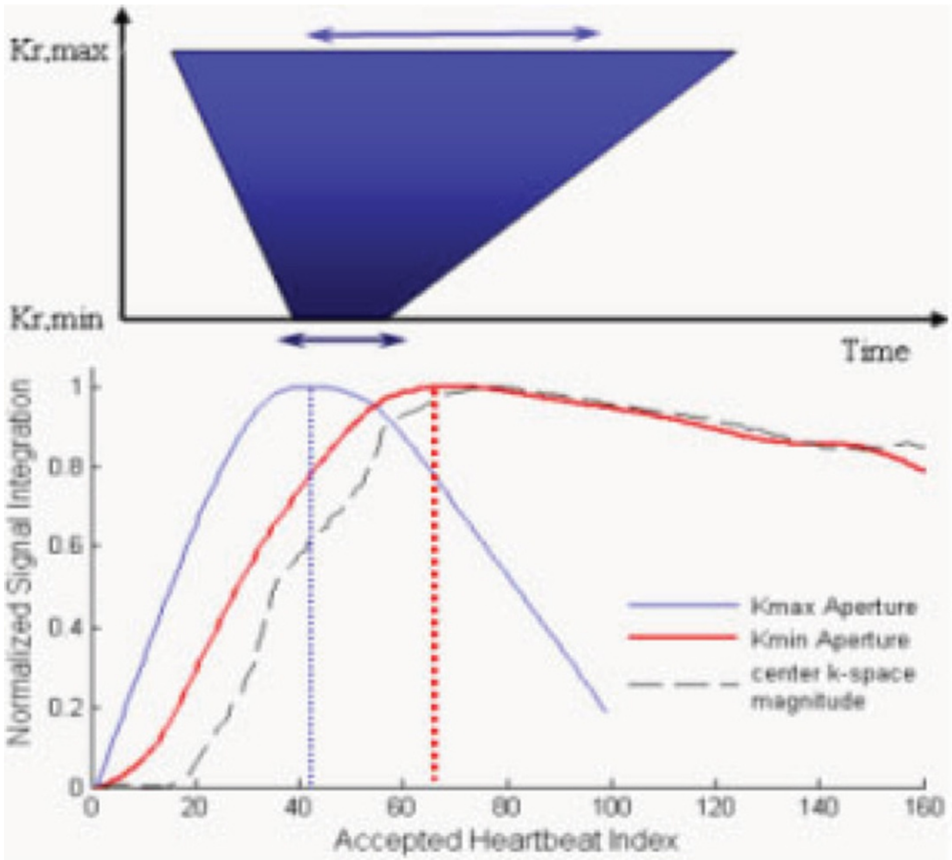

Figure 1
Upper; temporal tornado filter. Lower; selection of the optimal Kmax and Kmin aperture postions based on blood signal change.

Results

Fig. 1 shows the signal intensity curve in the NAV-accepted heartbeats during the scan. The signal intensity increases as the contrast agent accumulates in the heart, reaches the peak at the 75th heartbeat (~160 seconds) and then declines as the contrast agent flushes out. The signal integration varies with different aperture selections. The maximum signal integration values were achieved at the 44th and 68th hearbeats for Kmax and Kmin apertures, respectively, and were used to design the optimal tornado filter. A transverse slice covering the root of RCA were reconstructed at the optimal and two early and two late time points (Fig. 2). Clearly, the image at the optimal time point exhibits the highest blood signal and best coronary artery delineation. The right-most image shows the same slice at the optimal time point reconstructed using GRAPPA (acceleration factor = 3). Compared to the original image, streaking artifacts were significantly suppressed.

Discussions

The proposed technique enables time-resolved CMRA capturing the contrast kinetics in the heart. The repeatedly measured center-k-space sample can be exploited to track cardiac-blood-signal enhancement during the scan. The optimal tornado filter providing best contrast-enhancing effects can be automatically determined and used for reconstructing images for diagnosis.

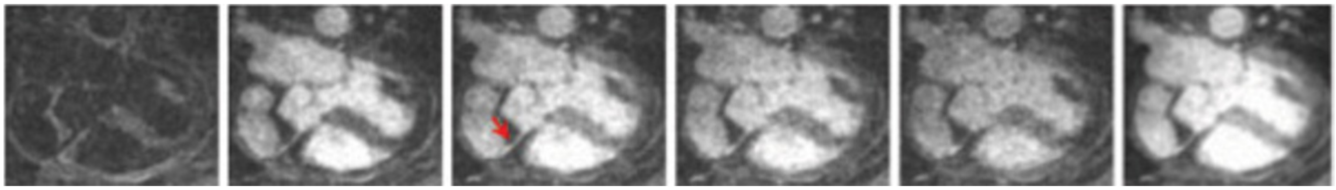

Figure 2
From left to right 1st–5th: time frame 1, 34, 68 (optimal), 108 and 137 respectively; 6th: the optimal frame with GRAPPA Arrow: RCA root.

References

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