Magnetization-Prepared, Free-Breathing, Steady State Free Precession, Cartesian and Radial Coronary MR Angiography

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Abstract

Cartesian spoiled turbo field echo (TFE), cartesian balanced TFE, and radial balanced TFE acquisition strategies were used for high resolution, free breathing, magnetization prepared (T2 preparation pulse, fat saturation pulse) imaging of the right coronary artery in eight healthy volunteers. The balanced TFE sequences profited from shorter acquisition time and improved vessel sharpness, and they visualized smaller vessel diameters. Clinical studies are needed to decide on their ability to detect stenosed vessels.

Introduction

Among the large variety of MR imaging sequences proposed for the visualization of the coronary arteries, free-breathing approaches provide generally increased spatial resolution, higher signal to noise ratio (SNR), and more patient comfort as compared to breath-hold sequences. Steady state free precession (SSFP) sequences [1] have been used for visualization of the coronaries, resulting in higher values for SNR and contrast to noise ratio (CNR) [2,3]. In addition to cartesian sampling schemes, spiral imaging has successfully been applied [4], and alternative schemes such as radial imaging are conceivable.

It was the goal of the present study to combine free-breathing cartesian and radial SSFP sequences with a T2-preparation pulse and a frequency selective saturation pulse for the improved suppression of background signal.

Methods

Eight healthy volunteers (3 women, 5 men, mean age 31.5 years) were examined in a 1.5T Philips Intera I/T Cardiovascular system (Philips Medical Systems, Best, the Netherlands) in supine position, using a five element cardiac synergy receiver coil. A stack covering the right coronary artery was defined using a three point planscan tool on axial balanced TFE survey images. Respiratory motion was prospectively compensated for by gating and tracking according to a rigid body motion model based on data obtained from a two-dimensional respiratory navigator placed on the right hemi-diaphragm. Magnetization preparation was achieved by application of a T2-preparation pulse [5] with a TE of 50 ms, as well as of a frequency selective fat saturation pulse, followed by a spoiler gradient. The imaging parts consisted (in randomized order) of a cartesian spoiled turbo field echo sequence (C-TFE; matrix 384x269, TR=7.6 ms, TE=2.1 ms, α=30°, 10 excitations per heart beat, acquisition duration 246 heartbeats; adapted from [6]), a cartesian balanced TFE sequence (C-bTFE; matrix 272^2, TR=4.7 ms, TE=2.3 ms, α=60°, 15 excitations per heart beat, acquisition duration 177 heart beats), and a radial bTFE sequence (R-bTFE; matrix 272^2, TR=4.7 ms, TE=2.3 ms, α=60°, 15 excitations per heart beat, acquisition duration 183 heart beats). With all sequences, a field of view of 270 mm was covered with a 3D-slab consisting of 10 slices of 3 mm thickness each. Images were reconstructed to 20 slices of 1.5 mm with an inplane matrix of 512^2. Actual acquisition times were in the 6-10 minute range for C-TFE, depending on heart rate and breathing pattern, and ~25% shorter for the balanced approaches.

Resulting images were compared with respect to signal to noise ratio (SNR), contrast to noise ratio (CNR), visible length of the proximal right coronary artery, vessel sharpness [6], and mean vessel diameter. Analysis of variance was performed to test for differences at a significance level of $p<0.05$.

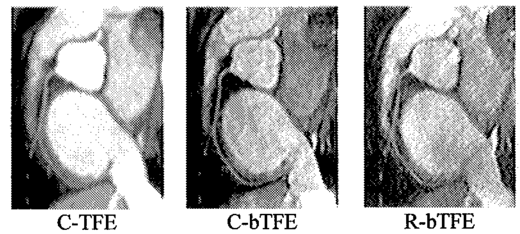

Fig. 1: *Right coronary artery of one volunteer, imaged with three different acquisition strategies.*

Results and Discussion

Imaging was successful in all volunteers. Figure 1 shows example images acquired with the three sequences in the same volunteer. Table 1 summarizes the quantitative findings. Despite nominally lower spatial resolution, sharpness was higher and vessel diameter was lower in both balanced sequences than in the spoiled C-TFE images (differences highly significant). Furthermore, even though CNR values did not differ significantly, combination of higher vessel sharpness and excellent background suppression in the balanced images resulted in an improved perception of coronary anatomy. Since acquisition times of the balanced sequences were approximately 25% shorter, SNR and CNR may be improved by slightly prolonging acquisition times and still remaining at reasonable values. On the other hand, especially the radial balanced version offers the possibility to further shorten acquisition time by angular undersampling [7]. Comparison with x-ray angiography in a clinical study is needed to provide data on the ability to detect stenoses, as well as on the accuracy of vessel length and diameter.

Table 1: *Assessed variables (mean ± standard deviation)*

	C-TFE	**C-bTFE**	**R-bTFE**
SNR	15.0 ± 3.6	14.0 ± 4.0	10.9 ± 2.5
CNR	9.4 ± 2.3	11.5 ± 3.6	9.1 ± 2.5
length [mm]	81.3 ± 13.5	86.8 ± 21.6	76.5 ± 21.8
sharpness [%]	34 ± 5	51 ± 9	59 ± 7
diameter [mm]	2.6 ± 0.5	2.1 ± 0.3	2.1 ± 0.3

Conclusion

Free breathing cartesian and radial balanced turbo field echo sequences in combination with a T2 preparation pulse and a fat saturation pulse generate particularly sharp images of the coronaries and provide excellent background suppression in relatively short acquisition time.

References

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