Feasibility of Contrast Enhanced Time-resolved Whole-heart (4D) Coronary MR Angiography in Humans

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Introduction

The advantages of CT for imaging the coronary arteries are its high spatial resolution, robustness and short examination time. This examination does not need careful planning because of the brute-force nature of the acquisition: Imaging of the entire cardiac volume at multiple time points during the cardiac cycle. The examiner is sure to be able to reconstruct at least one volume data set within the cardiac rest period; retrospective reconstruction and optimization of the R-wave delay is possible. It was the aim of the study presented here to test, if such an approach does work with MR imaging as well. By using a T1-relaxation enhancing blood pool contrast medium in combination with multiphase spoiled gradient echo imaging for T_1 contrast preparation it should be possible to overcome flow related problems of non contrast enhanced 4D scanning techniques, e.g. whole-heart bSSFP 4D acquisition [1].

Materials and methods

All experiments were performed at 1.5 T on a clinical MR system (Magnetom Sonata, Siemens, Erlangen, Germany). Within the scope of a phase II clinical trial, an iron oxide based blood pool contrast medium (VSOP-C184, Ferropharm, Teltow, Germany) was administered in a randomized way at doses of 0.030, 0.045 or 0.060 mmol Fe/kg. Time resolved whole-heart coronary MRA was performed during free breathing using navigator gating and rigid body motion correction to reduce respiratory artefacts. A fat suppressed 3D spoiled gradient echo readout was used with a TE of 1.5 ms (asymmetric echo), 320 Hz per pixel bandwidth, 17 acquired lines per phase and heart beat with an excitation flip angle of 22 degree. Images with a spatial resolution of 1.1 x 1.3 x 1.5 mm were measured and interpolated to 1.1x1.1x1.25 mm. An inter-phase TR of 110 ms was achieved, the number of phases was adjusted to fit into the individual R-R interval of the subject.

Results and discussion

4D coronary MR angiography using a T1-relaxation enhancing blood pool contrast medium is feasible but comes at the expense of contrast compared to the IR-prepared single phase approach. A typical scan using the moderate spatial resolution as we did took about 15-20 minutes, dependent on the acceptance rate. Images from a 4D data set are presented in figure 1. When compared to an inversion recovery prepared single-phase study, simulation shows that the contrast-to-noise ratio at the highest dose is about 40% lower in a 4D acquisition, because myocardium is not perfectly suppressed and blood magnetization cannot fully relax. This translates into almost double scan time to achieve equal CNR. For lower dosages this ratio is even worse. However, planning of the examination is extremely simplified since no time is needed for determination of a trigger delay. Coronary arteries might be assessable in more than one cardiac phase, leading to an improved diagnostic accuracy. Functional cardiac parameters like ejection fraction or wall motion determined from the 4D scan provide additional information.

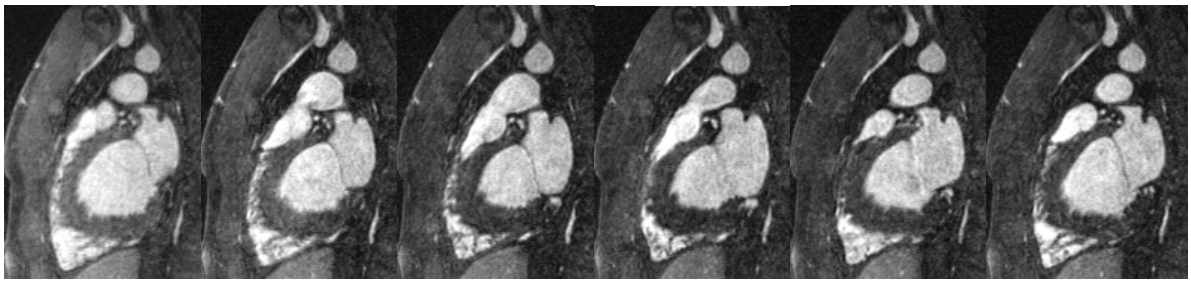

Figure 1: 4D coronary MR angiography in a 28-year old patient who received 0.06 mmol Fe/kg VSOP-C184 as blood pool contrast medium. A sagittalreformation from the 4D data set is shown in 6 phases during the cardiac cycle. Phase 3 and 6 in peak systole and late diastole are least effected by motion blurring.

References

[1] Börnert P et al., Proc. ISMRM 2006, #2153