Clinical Application of Whole-heart Coronary MRA using "Paddle-wheel" Balanced SSFP

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Introduction: Self-navigated "paddle-wheel" balanced SSFP has an advantage to reduce image acquisition time of whole-heart coronary MRA (WH-CMRA) because it enables to use all dataset by correcting motion. We applied this technique to clinical cases and evaluated the image quality improvement by motion correction and the detectability of coronary artery stenosis.

Methods: The pulse sequence was implemented on a 1.5T clinical scanner (GE Signa Excite TwinSpeed, ver11-12). The eight-channel cardiac coil was used for a receiver. A total of 30 patients suspected coronary artery disease or cardiomyopathy were enrolled in this study. WH-CMRA followed routine cardiac MR studies including cine, and delayed enhancement in 25 patients. In 5 patients, WH-CMRA was performed after cine studies without the administration of Gd-DTPA. The sequence was used with the following parameters: 224 of readout points, 300 of projections, 64 of slices, TR/TE of 4.0/2.0 msec, FOV of 30-35 cm, reconstruction matrices of 256x256. Readout length per trigger was 256 msec and imaging time was 300 heart-beats. A subject specific trigger delay time was determined based on the period during the motion of the right coronary artery was minimized on the cine images (30 phase/ cardiac cycle). The image dataset was transferred to a workstation and respiratory motion was corrected using linear shift along read-out and slice directions. 1) The subjective image quality for three segments (proximal, middle, and distal) of RCA, LCA and LCX on 4-point-scale was determined on reconstructed transverse images before and after motion correction, independently (4=excellent ... 1=poor). 2) WH-CMRA after motion correction was interpreted to detect significant stenosis without patient information. In 20 patients, the results of WH-CMRA were compared with conventional coronary angiography (CAG) performed within one month of MR imaging study based on the major coronary arteries. The stenosis of 75 % and over was considered to be significant on CAG as gold standard. We calculated sensitivity, specificity, accuracy, positive and negative prediction values (PPV/NPV) for the detection of significant stenosis in the major coronary arteries.

Results: All patients accomplished WH-CMRA in approximately 5 minutes. The averaged image quality scores before the motion correction were 2.14, 1.75 and 1.51 for RCA, LAD and LCX, respectively. The scores improved to 3.11, 2.23 and 1.81 after the motion correction (Table, $P<.001$; paired t-test). A total of 60 arteries were assessed with significant stenoses of 16 arteries detected on CAG. The sensitivity, specificity, accuracy were 70%, 96% and 92%, respectively. PPV and NPV were calculated as 78% and 94%. In distal portions of LAD and LCX, it was difficult to evaluate the presence of lesions.

Discussions and Conclusion: Paddle-wheel balanced SSFP has an advantage in shortening exam time to 5 minutes. The motion correction was effective to improve the image quality of coronary arteries. In total of RCA, proximal and mid portion of LAD and LCX, the image quality was acceptable for the detection of stenosis; however, it was difficult to evaluate coronary arteries in distal portion of LAD and LCX. The sensitivity and PPV were not satisfactory in this study. In the current implementation, only linear shift correction is applied. Image quality would be improved if image deformation is corrected in the future implementations.

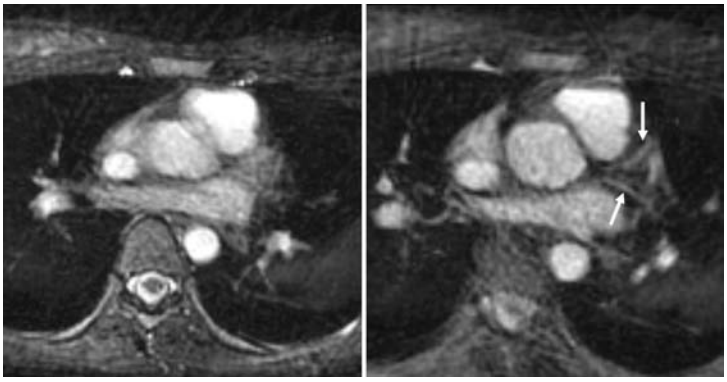

Figure: Image Quality Improvement after Motion Correction

Score	Before Correction	After Correction
4	2	68
3	56	66
2	99	49
1	113	87

Table : Number of Arteries Classified by Imaging Score

Image quality score improved after motion correction ($P<.001$).

References: Oshio K, Proc.ISMRM.13(2005), 707.
Okuda S et al., Proc.ISMRM.14(2006), 369.