ECG and Navigator-Free 4D Whole-Heart Coronary MRA: Preliminary Comparisons with Conventional Protocols

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Introduction: Cardiac and respiratory motion artifacts are major challenges to whole-heart coronary MRA. The conventional motion suppression strategies often involve prospectively gating the acquisition based on motion surrogates, such as ECG and navigator, which complicate the scan setup procedure and prolong the scan time significantly due to low scan efficiency. To address these limitations, an ECG and navigator-free 4D whole-heart coronary MRA technique was recently proposed, providing both cardiac function and coronary visualization from a single measurement [1]. In this work, we evaluate the 4D technique by benchmarking it against conventional cine and coronary MRA protocols.

Methods: The proposed technique used a Gd-BOPTA enhanced, ungated spoiled GRE sequence with 3DPR trajectory achieving whole-heart coverage, (1.0 mm)^3 spatial resolution, and fixed 10-min scan time. During the offline reconstruction, data were binned into respective cardiac and respiratory phases based on motion information extracted from the multi-channel self-gating projections using PCA, and respiratory motion was corrected using an image-based approach [2]. Then, the LV function parameters were calculated from a 16-phase 4D reconstruction, from which the cardiac quiescent period was also identified to reconstruct a higher quality coronary image. The measured LV ESV, EDV and EF were validated on nine healthy subjects by comparing with a 2D multi-slice breath-hold cine protocol [3]. The quality of coronary visualization, evaluated in terms of apparent SNR/CNR and vessel sharpness, were compared on three healthy subjects with two contrast-enhanced coronary MRA protocols with prospective ECG gating: 3DPR with respiratory motion correction [4] and Cartesian trajectory with navigator gating [5].

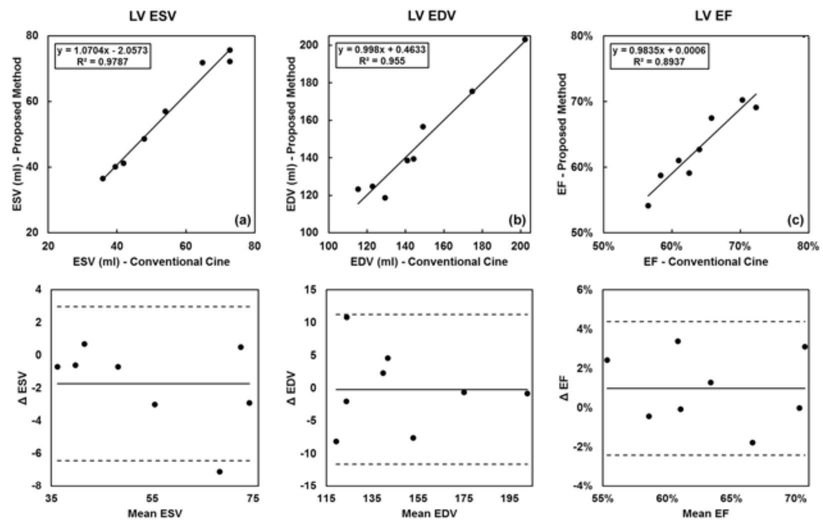

Fig. 1 Comparison of a: LVESV, b: LVEDV and c: LVEF from both conventional cine and the proposed 4D technique. Good correlation and agreement were found between the two methods.

Results: Shown in Fig. 1, the LV function parameters showed excellent correlation and agreement (one subject excluded due to poor ECG). No statistically significant differences were found (ESV: P=0.10, EDV: P=0.94, EF: P=0.17). For the proposed, ECG+3DPR and Cartesian protocol, the mean scan times were 10.0±0.0, 6.4±1.1 and 15.7±5.3 min, respectively; the mean coronary sharpness were 0.35±0.08, 0.36±0.10 and 0.41±0.06 mm^{-1}, respectively; the mean aSNR were 12.4±3.8, 12.8±1.1 and 12.9±2.5, respectively, and the mean aCNR were 4.5±1.5, 6.8±0.3, and 10.2±3.0, respectively. Example images are shown in Fig. 2 for two subjects.

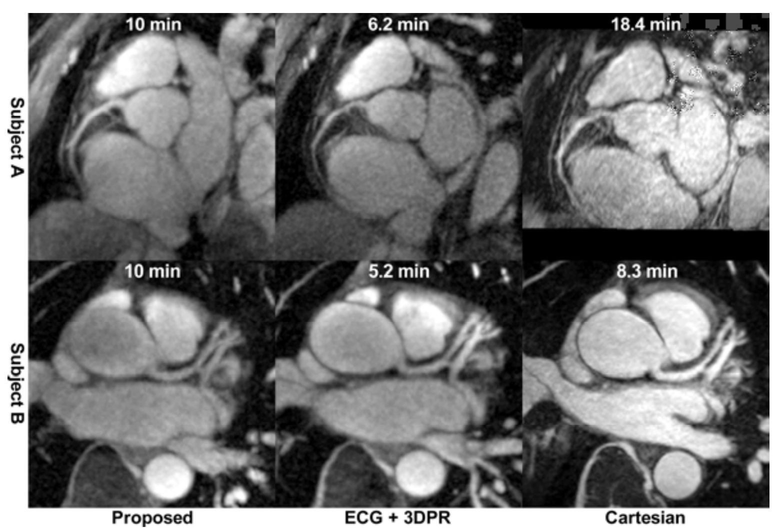

Fig. 2 Example images from the three coronary MRA techniques of two subjects. Also shown is the scan time for each image.

Discussion and Conclusion: In this preliminary validation on healthy volunteers, the proposed 4D technique yielded cardiac function parameters in agreement with the conventional 2D cine protocol, and coronary visualization quality comparable with conventional ECG-gated coronary MRA protocols. Future efforts will be focused on more systematic validation on both healthy and CAD patient population, as well as further optimization of the 4D acquisition and reconstruction framework.

References: [1] Pang et al MRM 2014, [2] Pang et al MRM 2013, [3] Simonetti et al Radiology 2001, [4] Pang et al ISMRM 2014, [5] Bi et al MRM 2007