A Joint Prospective-Retrospective Respiratory Navigator for Contrast Enhanced Whole-Heart Coronary MRI

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Introduction: Over past decades, several respiratory motion compensation techniques have been studied [1]. Prospective navigator (NAV) is the most commonly used technique to monitor respiratory motion. NAV results in an increase in acquisition time (2-3×) to allow for re-sampling of motion-corrupted k-space lines. Compressed-sensing (CS) for motion compensation has been previously demonstrated in feasibility studies [2, 3].In this study, we sought to evaluate a joint prospective-retrospective NAV to reduce image acquisition time in coronary MRI by estimating the motion-corrupted data. Experiments using prospective non-rigid respiratory motion phantom and *in vivo* coronary MRI were used to investigate this approach.

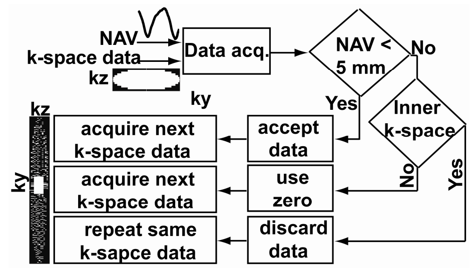

Fig.1: *Schematic diagram of proposed joint retrospective-prospective NAV for CosMo.*

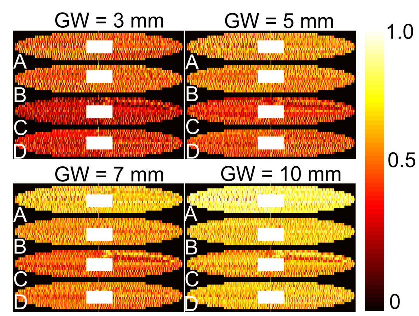

Fig.2: *Color probability map of generated undersampled k-space for 4 subjects (A, B, C, D) with different GW (3, 5, 7, 10 mm).*

Material and Method: Fig. 1 shows the schematic of proposed compressed sensing for motion correction (CosMo) algorithm. The k-space data is divided into two regions of inner and outer k-space. Inner k-space is first fully acquired at the beginning of a scan within the predefined 5mm, gating window (GW) similar to the prospective navigator acquisition. GW is then increased to accept outer k-space data, and keep the scan acquisition time constant. Subsequently, only the k-space lines acquired within the GW are selected for reconstruction. This collection results in a k-space with fully and randomly sampled inner and outer data, respectively. To retrospectively investigate the randomness of the generated under-sampled k-space data and quality of the reconstructed images using CosMo, 9 healthy subjects (3 males, 25 ± 12years) were imaged using Philips 1.5T MR scanner. Coronary MRI was acquired to image right coronary artery with following parameters: FOV=270×270×30mm^3; 1×1×3mm^3 spatial resolution; TE/TR/α = 2.6/5.3/90°; and 10 averages. To investigate the under-sampling pattern generated by NAV, a probability map was generated from k-space lines acquired for four different GWs. Reconstructed CosMo and NAV gated images were scored by an expert reader, blinded to imaging technique(1-Poor, 4-Excellent). Normalized vessel sharpness was calculated using Soap-Bubble [4]. Wilcoxon and t-test were used for comparing the image scores and vessel sharpness, respectively. To perform prospective CosMo data acquisition, a whole heart coronary sequence was modified for acquiring the k-space lines using the methodology described in Fig.1 on the scanner. Initially, in a non-rigid MR compatible motion phantom, images were acquired by programming the phantom to simulate the respiratory motion derived from a patient. In an *in-vivo* study, contrast-enhanced whole heart coronary MRI was acquired after a bolus infusion of 0.2 mmol/kg of Gd-BOPTA [5]. Imaging parameters for both phantom and in vivo were: 3D axial ECG triggered SSFP sequence, TR/TE/α = 4.3/2.2/90°; FOV = 300×300×120 mm^3; 1.4×1.4×1.3 mm^3; GW=5mm for inner k-space data (k_y×k_z of 37×26 for phantom, and 31×7 for *in vivo*); and no gating for outer region.

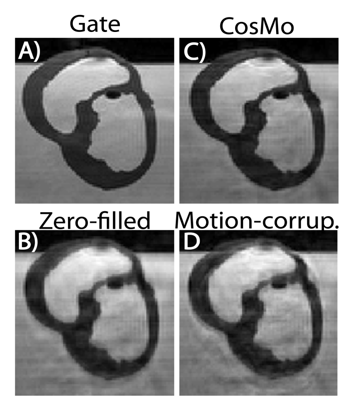

Fig.3 *Phantom images: A) NAV gated; B) Zero-filled; C) CosMo; and D) Semi-motion corrupted.*

Results and Discussion: Fig.2 shows the generated color probability map for 4 subjects with different GW sizes (3, 5, 7, and 10), which shows variability of the respiratory-generated undersampling pattern for different subjects and GWs. Image scores and vessel sharpness for retrospectively reconstructed images by CosMo and respiratory gating, (2.8±0.4, 2.8±0.7, p=1) and (0.52±0.08, 0.49±0.09, p=0.44) were similar. Fig.3 displays the phantom images using CosMo (using 51% of k-space data), compared to the prospectively respiratory gated, zero-filled, and semi-motion corrupted images. Fig.4 demonstrates the CosMo (using 61% of data k-space) reformatted images from a contrast-enhanced whole-heart coronary MR of a healthy adult subject. **Conclusions**: CosMo acquisition results in randomly sampled k-space data that can be estimated in reconstruction using CS without reacquiring the motion-corrupted data.

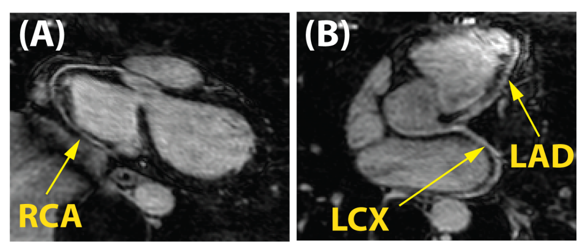

Fig.4: *Reformatted right (A) and left (B) coronary arteries from contrast enhanced whole heart MRI with CosMo.*

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References:[1]Scott,Radiology,2009;[2]Barral,ISMRM,2009;[3]Moghari,ISMRM,2010;[4]Etienne,MRM, 2002;[5]Hu,MRM,2010;