PROSPECTIVE RESPIRATORY MOTION CORRECTION WITH AN IMAGE BASED NAVIGATOR

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Introduction: Respiratory motion remains the major impediment in a small but substantial amount of patients undergoing coronary magnetic resonance angiography (CMRA). Motion correction in CMRA is typically performed with a diaphragmatic 1D navigator (1Dnav) assuming a constant linear relationship between diaphragm and the heart. Respiratory gating is often performed in conjunction with motion correction to allow for increased gating windows while maintaining image quality. Motion correction, however, relies on a linear relationship between the diaphragm and the heart, which often is only fulfilled for small end-expiratory gating windows and thus may lead to an increased scan time. Extending the navigator image to 2D or 3D allows for direct, and possibly more accurate, measurement of cardiac motion, which could enable the use of larger gating windows and shorter scan time, without compromising image quality. In this work a novel 2D navigator (2Dnav) is proposed, which prospectively corrects for translational motion in foot-head and left-right direction.

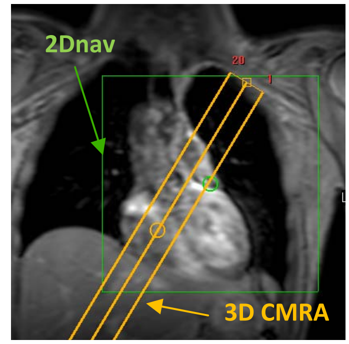

Figure 1. Planning of 2Dnav and 3D CMRA sequence.

Materials and Methods: The 2D navigator was implemented as a balanced steady-state free precession (bSSFP) sequence with Cartesian sampling with high-low profile order. The 2Dnav was typically planned in the coronal plane and centered on the left ventricular free wall, as shown in Figure 1. The imaging parameters of the 2Dnav included α = 30°, TR/TE = 2.6/0.9 ms, FOV = 200 × 250 mm, slice thickness = 20 mm resulting in 2 mm resolution in read-out and 5 mm in phase encoding direction. A 2D Inverse Fast Fourier Transform and image registration algorithm was implemented on the spectrometer to allow prospective motion correction. The image registration was a template matching algorithm which uses a normalized cross correlation as similarity measure. The data flow, including 2Dnav acquisition, reconstruction, image registration and position update of the 3D volume, is shown in Figure 2. The 2Dnav acquisition time including post processing was approximately 90 ms. The proposed 2Dnav approach was compared to a diaphragmatic 1Dnav with a tracking factor of 0.6. Datasets were acquired with a gating window of 10 mm diaphragmatic motion and without any respiratory gating for both the 1D and 2Dnav. CMRA datasets were acquired in 8 healthy subjects and the acquired images were visually scored (1-4) by a blinded expert with 4 being excellent.

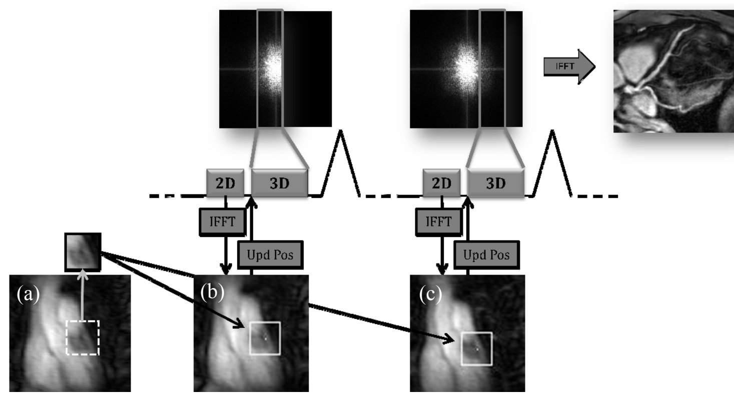

Figure 2. 3D segmented k-space CMRA sequence using 2Dnav for prospective motion correction. A template is extracted from reference image (a) and used to calculate 2D motion in the shots (b) and (c). This information is used to update the position of the 3D image before each acquisition.

Results: Visual assessment always preferred the 2Dnav over the 1Dnav for no gating (Figure 3) while there was no significant difference for a gating window of 10mm. Figure 4 shows example images of the acquired whole heart data.

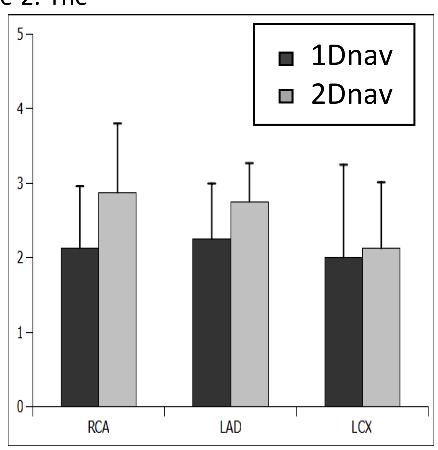

Figure 3. Visual score for 8 healthy subjects from CMRA acquired without respiratory gating.

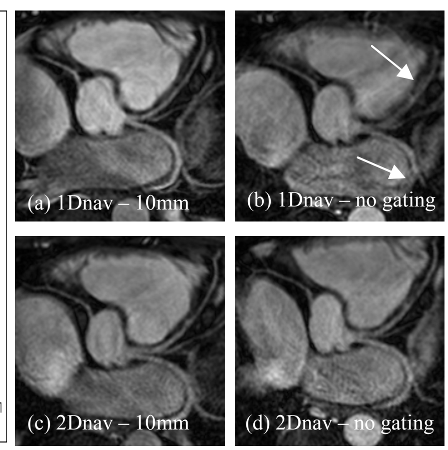

Figure 4. Representative images of one volunteer acquired with 1Dnav (a,b) and 2Dnav (c,d). For the 2Dnav there is little visible difference between 10mm gating (c) and no gating (d), while the LAD and LCX are blurred (arrows) for the 1Dnav with no gating (b).

Discussion: Here we report a novel image based motion compensation technique for CMRA and demonstrate improved coronary artery delineation using the 2Dnav if no respiratory gating window is used. For smaller gating windows (10mm) there was no significant difference in image quality between the 1D and 2Dnav.