Respiratory Navigator with Adaptive Acceptance Gating Window Size and Fixed Scan Time for Coronary MRI

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Introduction: Correcting respiratory motion is a challenging task in coronary MRI. Commonly, a pencil-beam right hemi-diaphragm (RHD) navigator is used with a constant 5-7mm gating window (GW) [1]. Data following the navigator signal is only used in image reconstruction if the navigator signal is within the GW otherwise it is reacquired. This usually results in 30%-70% gating efficiency which prolongs the scan. A longer acquisition may results in significant variations in gating efficiency, especially toward the end of scan which can lead in significant drift and incomplete scan [2]. In this study, we evaluated a method where gating efficiency is set to a constant value $\alpha$, i.e. fixed scan time, by adaptively and temporally varying the GW throughout the scan.

Methods: To gate and track the respiratory motion in coronary MRI, there is a training phase before imaging for monitoring RHD, and computing the location of GW. In this phase, GW is conventionally determined as the maximum position of the RHD minus 25% of the GW’s size. In the proposed method, during the training phase the histogram of RHD’s positions is calculated from the acquired positions of the RHD (Fig.1). The upper position of GW, $Y$, is set at the maximum position of the RHD. The lower position of GW, $X$, is placed where the gating efficiency (i.e., the area under histogram between $X$ and $Y$) is $\alpha\%$. During the scan, by measuring more RHD positions, the lower position of GW is continuously updated to keep the gating efficiency fixed at $\alpha\%$. To examine the image quality of the proposed technique, 10 healthy subjects (3 males, 25 ± 12 years) were recruited. Coronary MRI of right coronary artery (RCA) was acquired using following parameters: 3D ECG triggered SSFP sequence imaged at rest period of RCA, TE/TR/\(\alpha\) = 2.8ms/5.6ms/90°, FOV= 270×270×30 mm$^3$, 1×1×3 mm$^3$, size of GW =100 mm, i.e. efficiency of 100%, and 10 dynamics. Retrospectively, two sets of images were reconstructed. Initially, a 5mm GW was used to retrospectively gate the respiratory motion, and reconstruct the images. Also, the proposed adaptive GW algorithm was used for retrospectively gating the respiratory motion, and reconstructing the images with 50% gating efficiency. Reconstructed images were qualitatively scored based on a 4-point scale (1: poor and 4: excellent) [3]. Vessel sharpness was also calculated. All measurements are given as mean±std. T-test and Wilcoxon-test were used for comparing quantitative and qualitative measures of two methods, respectively.

Results and Discussions: Fig. 2 shows variation of GWs for different subjects. There were differences in size of GWs between the fixed (50%) efficiency and fixed (5mm) GW for some subjects. Fig.3 displays variation of gating efficiencies for 10 subjects. As expected, the fixed GW has larger variance in gating efficiency rates compared to those of the fixed efficiency. Fig.4 displays example reformatted images of the reconstructed RCA images. Table 1 shows the vessel sharpness and score for both methods. There was no significant difference in the vessel sharpness ($p=0.4$), or in the visual grading ($p=0.4$).

Conclusions: In this retrospective study, we evaluated an adaptive navigator gating technique for correcting respiratory motion in a predictable time (in contrast to fixed GW approach) without compromising the quality of reconstructed images.

Acknowledgements: Authors acknowledge grant support from NSERC-PDF-357920-08, NIH R01EB008743-01A2.