Improved Method for Retrograde Gating for Cardiac Magnetic Resonance Imaging

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Introduction: In conventional retrospective gating cardiac image reconstruction, data acquisition is carried out continuously, with the segmented k-space acquisitions updated at trigger detections. The acquired data are then typically interpolated onto equivalent equally spaced intervals, generally by simply linearly scaling the data to fit into the average cycle (Fig. 1b). However, in the presence of significant R-R variation (common in heart disease), which largely reflects differences in the duration of diastasis (Fig. 1a), the usual linear time scaling used in conventional retrospective gating method can result in temporal blurring and degradation of the image quality. In this work, we propose a 'retrograde gating' method, which allows for retrospectively including the late diastolic events preceding each QRS detection in a fixed relation with the interval following it (including systole and early diastolic filling) (Fig. 1c). Thus, only the events of diastasis are interpolated in the cardiac cycle reconstruction.

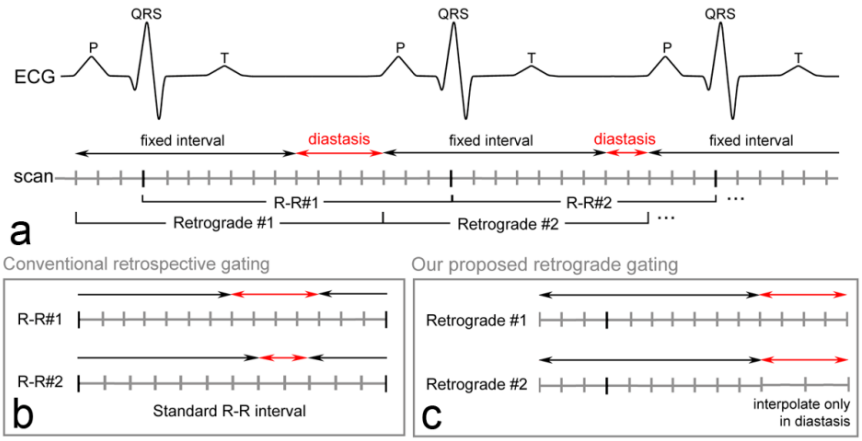

Figure 1. (a) ECG signal with R-R variation. (b) Conventional retrospective gating. (c) Our proposed Retrograde gating.

Method: Conventional cardiac cine long-axis retrospective MR imaging with ECG-gating was performed in 4 patients (55 ± 23 years old; mean R-R = 878 ms (507 - 2020 ms)) with arrhythmia, using a 1.5T MR scanner (Avanto, Siemens). The raw data from the scans were reconstructed into 25 cardiac phases, using both the conventional retrospective gating and the proposed retrograde gating reconstruction methods. For the retrograde gating method, a fixed interval of 450 - 500 ms (300 - 400 ms for early systole and 50 - 150 ms for late diastole) was used, depending on the R-R. Linear interpolation was used for the rest of the interval. For 6 representative pairs of reconstructed image sets, each of the 25 frames was scored by an expert radiologist in a blinded manner, using a 6-point Likert-type scale (0, none; 1, mild; 3, moderate; 5, severe) for image blurring and artifacts. The scores for the 25 frames for each cine image set were summed.

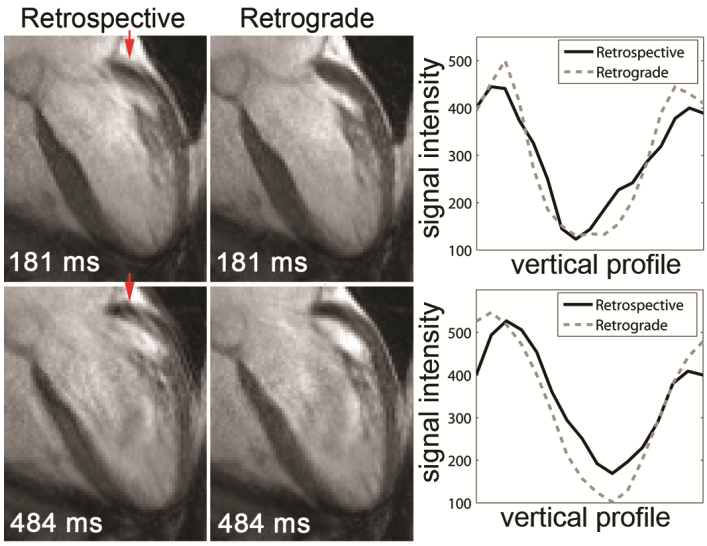

Figure 2. Representative cine images (R-R mean 756 and range 517-935) reconstructed using (left) retrospective and (middle) retrograde gating methods; (right) corresponding vertical intensity profiles at the position indicated by red arrows.

Results: Figure 2 shows representative images reconstructed using the retrospective and retrograde gating methods at trigger times of 181 ms and 484 ms, and corresponding vertical intensity profiles of the basal lateral wall. The edges are seen to be defined more clearly with the retrograde gating method. The averages of the summed scores for 6 image sets for the retrospective and retrograde gating methods were: (blurriness) 52 ± 18 and 42 ± 15, and (artifacts) 40 ± 18 and 34 ± 15, respectively.

Discussion: This method permits acquiring higher quality gated cardiac images of the whole cardiac cycle in patients with arrhythmias, compared with conventional retrospective reconstruction that uniformly interpolates data onto an average R-R interval. While likely to be clinically useful for MR imaging, this approach is also potentially useful for other kinds of medical imaging that use cardiac gating.

References: [1] C. McCollough and R. Morin, Radiol Clin N Am, 1994; [2] J. Bishop, et al., MRM, 2006.