Automated Rectilinear Self-Gated Cardiac Cine Imaging

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Purpose:

Demonstrate the feasibility of self-gated cardiac cine imaging using a conventional rectilinear TrueFISP sequence with online display of the gating signals derived from each channel and user-independent selection of the gating channel. The image quality of these self-gated cine images will be compared with the cine images obtained using ECG and pulse-oximetry gating.

Methods:

The sequence: This technique is a modified retrospectively gated TrueFISP cine sequence that acquires a short second echo after the readout and phase gradients have rewound. Only a slight shift of the slice select gradient is required to form this second echo that is used as the gating signal. The TR increases by 0.61msec but remains short (3.45msec), preserving the advantages of the TrueFISP sequence. The peak amplitude of the second echo varies in proportion to the average signal in the image, which is expected to change in synchrony with the cardiac cycle. A digital ARMA filter is applied to the echo-peak time series for each channel to remove high frequency noise and a peak-detection algorithm determines the trigger positions. The coil element used to generate the self-gating signal is chosen automatically by measuring the standard deviation between trigger times and selecting the channel with the lowest overall trigger variability. A graph containing each channel's filtered gating signal and trigger times is reconstructed online so that the user can verify the choice of gating channel.

Experimental Setup: Short and long axis cine images were obtained from 10 healthy volunteers using self-gating, ECG-gating, and pulse-oximetry gating. Self-gated images were also obtained in one patient with ischemic heart disease. Imaging was performed using a Siemens 1.5T Sonata (Malvern, PA) with an 8-channel body array coil. Breath-held acquisitions were performed using the following parameters: 255mm * 340mm FOV, 150 * 192 matrix, 15 segments, 20 phases, 3.45msec TR, 6 mm slice thickness, and a 1002 Hz/pixel bandwidth. The second echo was designed to acquire eight readout points with a dwell time of 22 us. In each volunteer, cine loops of a mid short axis and two long axis orientations for each gating method were scored by two readers blinded to the gating method using a scale: 1 (poor), 2 (adequate), 3 (good), and 4 (excellent). Left ventricular volume and mass parameters were measured in each volunteer for the self-gating and ECG gating methods using Argus (Siemens, Malvern, PA) to quantitatively evaluate the gating effectiveness. The ECG gated ventricular measurements were assumed to be the 'gold standard'.

Results and Discussion:

An example of the online reconstructed graph containing each channel's filtered gating signal with determined trigger positions is illustrated by Figure #1. High quality self-gated images were obtained in all 10 volunteers and one patient. Figure #2 shows images obtained using the self-gating technique. For both reviewers, a one-way ANOVA test revealed no significant difference between the image quality scores for each gating technique ($p<0.05$ not satisfied). Table #1 contains the average image quality score for each gating method and Table #2 lists the average percent difference for each LV function parameter when self-gating is compared to ECG gating. A shift in the trigger time from one slice to the next was observed in the self-gated cines while ED and ES were manually determined for each slice, this may account for some of the observed error in the quantitative functional parameters.

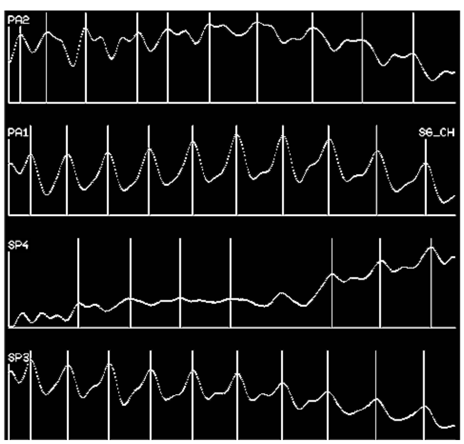

Figure 1: Filtered echo-peak gating signals obtained from different coil elements with the determined trigger positions (vertical lines). Note that the coil element 'PA1' was automatically selected as the gating signal (labeled with SG_CH) since it had the lowest overall trigger variability.

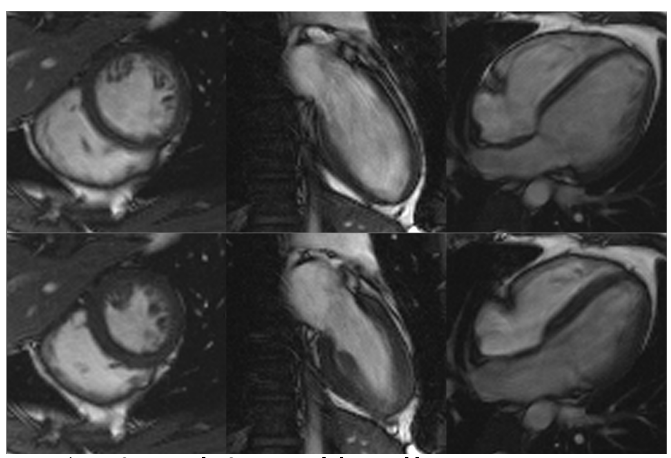

Figure 2: ED and ES images of short and long axis orientations obtained using the self-gating technique.

	Self-Gate	ECG	Pulse
Reviewer 1	3.27 +/- 0.52	3.37 +/- 0.49	3.37 +/- 0.57
Reviewer 2	3.25 +/- 0.75	3.38 +/- 0.67	3.67 +/- 0.66

Table 1: Mean image quality score for each gating method.

	Self-Gating
EF	4.04% +/- 4.95%
Mass	5.29% +/- 2.19%
EDV	6.07% +/- 1.28%
ESV	7.94% +/- 3.32%
SV	6.32% +/- 8.28%

Table 2: Mean percent difference for each LV function parameter when compared to ECG gating.

Conclusion:

Our results suggest that the proposed self-gating method is an effective technique for obtaining cardiac cine images retrospectively. The accurate gating signal, image quality, and convenience of this self-gating technique could make it a possible alternative to ECG-based and pulse-oximetry based gating.

1. Spraggins, *Magnetic Resonance Imaging* 8:6 1990 675-681. 2 Larson et al, *Magnetic Resonance in Medicine* 2004 in press.