Cardiac Gating Calibration by the MR Septal Scout

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Target Audience: This work benefits those who are interested in high spatial-resolution cardiac MRI.
Purpose: The long-axis motion of the inter-ventricular septum (IVS) as determined by tissue Doppler echocardiography may be used to identify the timing of ventricular diastasis relative to the electrocardiogram signal [1]. In this work, we present a new MRI technique, the Septal Scout, for measuring IVS velocity at high temporal resolution (<10ms). We demonstrate that, compared with a typical cine-SSFP [2], the Septal Scout produces more accurate quiescent gating windows that in turn yield sharper coronary MRA images.
Methods: 9 healthy volunteers were scanned on a GE Optima 450w 1.5T MR system using a 32-channel cardiac phased-array coil. A 30-phase cine-MRI was acquired in the 4-chamber view during a 16-heartbeat breath hold and used to identify the start and end times of the diastasis window (W_{cine}).

The Septal Scout is a 1D projection SSFP readout (5-mm slice thickness; 10-ms TR) along the IVS, prescribed from the 4-chamber view of the heart, and acquired for 5 seconds at the beginning and end of a 20-second breath hold. Image intensities at a "depth of field" selected to encompass the basal IVS are processed to produce a septal displacement function, and its derivative reveals the typical S, E, and A waves of ventricular dynamics from which the diastasis period for each heartbeat is identified (see FIG. 1). The intersection of diastases across all heartbeats produces the multi-heartbeat diastasis period as determined by the Septal Scout (W_{sep}).

Non-contrast-enhanced MRA was performed twice for each volunteer: once gated to W_{cine} and once gated to W_{sep}. An oblique 4-cm slab was prescribed near the base of the heart, which typically covered: (1) a group of large (ø~2.5 to 5mm) vessel segments including the LM, proximal/mid RCA, and proximal LAD/LCx arteries; and (2) a group of small (ø~1.0 to 2.5mm) vessel segments including the distal RCA, proximal marginal and diagonal branches, and proximal conus and sino-atrial nodal arteries. The MRA acquisition parameters were as follows: 3D fat-suppressed SSFP; TR = 3.9 ms; TE = 1.9 ms; FOV = 35 x 35 x 4 cm; resolution = 1.5 x 1.5 x 2.0 mm.

Vessel sharpness was assessed subjectively by two experienced observers on a 5-level scale, and quantitatively by full width half maximum (FWHM) measurements. The Wilcoxon signed-rank test was used to assess the statistical significance of median differences in sharpness scores. Scores are reported in the format: median [interquartile range].
Results and Discussion: Vessel segments were sharper when imaged during the Septal Scout gating windows for both the large and small diameter groups (large ø: FWHM in mm of 3.6 [0.7] vs. 4.1 [0.6], p=0.03; small ø: FWHM of 2.1 [0.2] vs. 2.4 [0.2], p=0.03). Subjective assessment of sharpness also improved for the Septal Scout-gated scans (observer 1 large ø: 2.8 [0.9] vs. 1.9 [1.2], p=0.008; observer 1 small ø: 2.4 [0.8] vs. 1.7 [0.8], p=0.016; observer 2 large ø: 3.3 [0.9] vs. 2.5 [1.0], p=0.008; observer 2 small ø: 3.0 [1.1] vs. 2.0 [1.0], p=0.016). Sample images and the corresponding gating windows are shown in FIG. 2 and FIG. 3.

The use of Septal Scout-determined gating windows led to a significant increase in vessel sharpness. The Septal Scout may determine gating windows that are robust across the heart-rate variability within a 20-second breath hold.

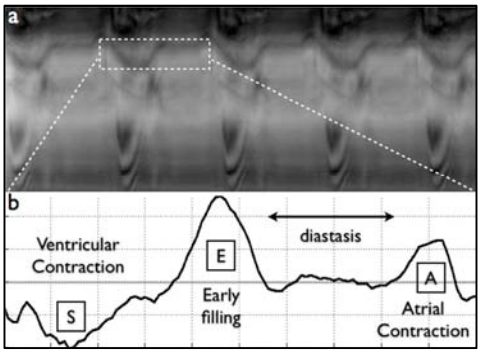

FIG. 1: (a) Sample Septal Scout data - 1D (vertical) displacement projections; (b) data from dotted box processed as velocity to show characteristic ventricular dynamic phases.

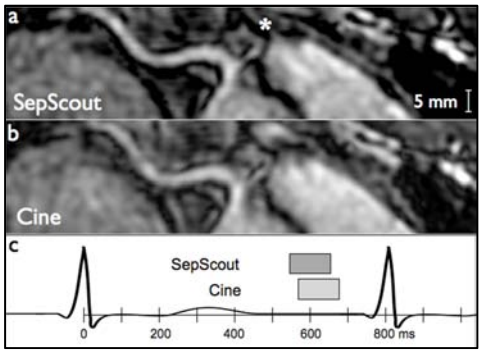

FIG. 2: Image of a proximal RCA segment with a conus branch (*) acquired during (a) W_{sep}; (b) W_{cine}. (c) Timing diagram illustrating gating windows of the two techniques.

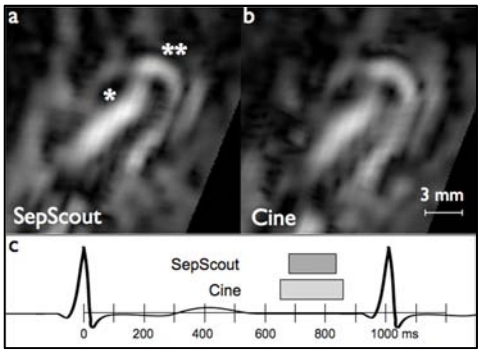

FIG. 3: Image of a conus artery (**) branching off of the proximal RCA (*) acquired during (a) W_{sep}; and (b) W_{cine}. (c) Timing diagram illustrating gating windows of the two techniques.

Conclusion: We have successfully applied the MR Septal Scout technique to find more accurate cardiac gating windows than those obtained by cine-MRI. This led to sharper coronary MRA images.
References: [1] Liu et al. *Med. Phys.*, 2012 [2] Jahnke et al. *JCMR*, 2005