Delayed Enhancement MRI Detects RF Ablation pattern in the Left Atrium and Pulmonary Vein Ostia

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Introduction: Pulmonary vein isolation as a treatment for atrial fibrillation has been widely adopted, but there is no method that permits visualization of the ablated tissue, which could potentially discern if failures are due to ablation techniques. Delayed enhancement cardiovascular magnetic resonance (DE-CMR) has previously been shown to identify scar among patients with myocardial infarction (1,2). We developed a higher spatial resolution DE-CMR technique to detect scar/ablated tissue in the left atrium and pulmonary veins (PV).

Methods: The left atria of 15 patients pre-ablation and 18 patients at least 30 days post-ablation were studied with a high resolution 3D DE-CMR imaging method. Bi-directional PV isolation was performed with an 8mm non-irrigated tip ablation catheter and a circumferential catheter placed at each PV ostium to confirm PV entrance and exit block. All imaging was performed on a 1.5 T Philips MR scanner (Gyroscan ACS-NT, Philips Medical Systems, Best, NL). MR scan parameters were (3): a 3D inversion recovery gradient echo sequence for T1-weighting, 1 RR interval between inversions, TR/TE/θ= 4.3ms/2.1ms/15º, 30 x 30 x 12.5 cm field of view, full echo, 110 Hz/pixel receiver bandwidth, matrix 224 x 224 x 23-32 Nz, TI set to null tissue, 1.3 x 1.3 x 5 mm spatial resolution reconstructed to 0.6 x 0.6 x 2.5 mm resolution, ECG-gating (~150 ms end-diastolic window), centric acquisition, navigator-gating with 5-7 mm window[15] (no tracking). Saturation bands were placed in the phase-encoding direction to minimize aliasing from the arms; fat-saturation was used to suppress signals from fat. The phase-encoding direction was chosen to be in the right-left direction to reduce motion ghosting. Imaging occurred 20 minutes post 0.2 mmol/kg gadolinium contrast injection. SNR of blood and left atrial wall and CNR (PV ostial wall vs. blood pool) were measured for all PV ostia for all studies. Wall thickness was measured adjacent to the right superior PV (see asterisk, Fig. 1C) in a blinded fashion, and a reformatted image was made of the left inferior PV (as shown in Fig. 1D) to investigate the circumferential ablation pattern. A blinded experienced electrophysiologist read each study to determine whether or not left atrial hyperenhancement was present, the circumferential extent for each reformat, and image quality on a scale of 0-2 (0=poor, 2=good).

Results: Figure 1 shows an MR angiogram and DE-CMR images in a patient scanned pre and post ablation, in the same patient. The scar (C,D) is evident on the wall of the left atrium. The blinded reader identified hyperenhancement in 100% of good quality post-ablation studies, and 0% of pre-ablation studies. Average image quality was score was 1.5. In 11/16 post-ablation studies, a partial to complete circumferential hyperenhancement pattern was identified for the left inferior pulmonary vein, and its extent was 76±20% of the circumference. The average blood pool SNR was 12 for both pre and post-ablation studies (p=NS). The average PV ostial wall SNR was 15 and 22 ($p<0.05$), for patients before and after ablation, respectively. The average PV ostial wall CNR was 10.5 and 3.3 for walls with and without scar. An inverse linear relationship between hyperenhancement thickness and the time interval from ablation was identified ($R^2=0.71$, $p<0.05$; scar thickness = -0.02mm/day +4 mm) measured in scar adjacent to the right superior PV ostium.

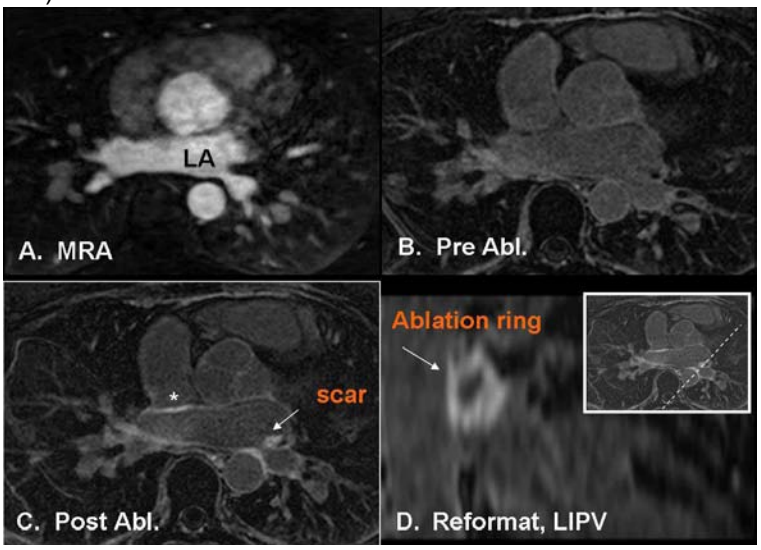

Figure 1: Matched slices are shown from (A) MR Angiogram, (B) DE-CMR pre-ablation, (C) DE-CMR post-ablation, and (D) the cross-sectional view of the left inferior pulmonary vein post-ablation, showing the complete circumferential ablation (arrow) (all images from the same patient). Scar is observed as bright signal in (C, D), and is absent in (B). * in (C) indicates position where scar thickness was measured.

Discussion and Conclusion: The detection of scar resulting from PV ablation treatment is possible, and allows for visualization of the ablation pattern. These patterns may be related to recurrence/non-recurrence of atrial fibrillation in follow-up. The measurement of decreasing scar thickness with scar age agrees with other reports of scar thinning in the myocardium (4). The clinical utility of this method and its role in identifying treatment success and failure are being studied.

References: 1) Simonetti OP et al, *Radiology*. 2001;218:215-231. 2) RJ Kim et al., NEJM 2000:343:1445-53. 3) M Stuber et al., JMRI, 1999;10:790-9. (4) RJ Kim et al., *Circulation* 1999;100:1992-2002.