3D Visualization of RF ablation scarring using delayed enhanced MRI co-registered with MRA

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Introduction:. Pulmonary vein (PV) isolation by radiofrequency (RF) ablation is an effective method for treatment of atrial fibrillation. In this minimally invasive procedure, fluoroscopic guidance is used to position a catheter against regions of the left atrium near the pulmonary veins. Currently about 15-35 % of patients experience recurrence of arrhythmia after the procedure. The mechanisms for this failure rate are not fully understood; one hypothesis is that incomplete connectivity of scars caused by the RF ablation allows electrical conductivity. We have developed an MR imaging technique for visualization of scar tissue within PV after RF ablation [1], which might provide insight into the relationship between scar morphology and success. Overlaying the MRI scar image onto pulmonary vein MR angiography (MRA) will facilitates this evaluation. We have developed an image fusion technique to image the scar tissue, and overlay the scar image onto anatomical MR angiography (MRA) images for effective visualization.

Methods: Patients with atrial fibrillation were treated with RF-ablation of the PVs, using catheter-guidance from the CARTO system (Biosense Webster, Inc., Diamond Bar, CA). All patients were scanned after PV ablation (average 45 days). Two sets of clinical data were obtained: (1) conventional contrast enhanced MRA of the pulmonary veins, using breath-hold (end-expiratory) non-ECG-gated 3D spoiled gradient imaging during the first pass of 0.2 mmol/kg Gd-DTPA; (2) A T1-weighted delayed enhancement MRI (DE-MRI) technique using 3D navigator-gating (end-expiratory), and an ECG-gated (end-diastolic) using inversion-recovery segmented gradient echo sequence performed 20 minutes after contrast administration. An intensity-based rigid body registration technique was used to co-register DE-MRI with MRA. The registration step was validated by acquiring phantom data. PV-atrial area on the scar DE-MRI was selected, then thresholded at four standard deviations above mean blood signal. Using the transformation calculated from the intensity-based registration, the processed scar images were overlaid onto the MRA to validate the accuracy of registration visually.

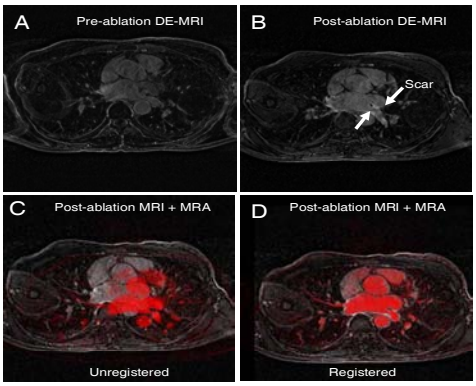

Figure 1. (A) DE-MRI image before PV ablation. (B) DE-MRI image after PV ablation. Scar formation on PV is indicated with arrows. (C) DE-MRI scar image and MRA (red). (D) After fusion.

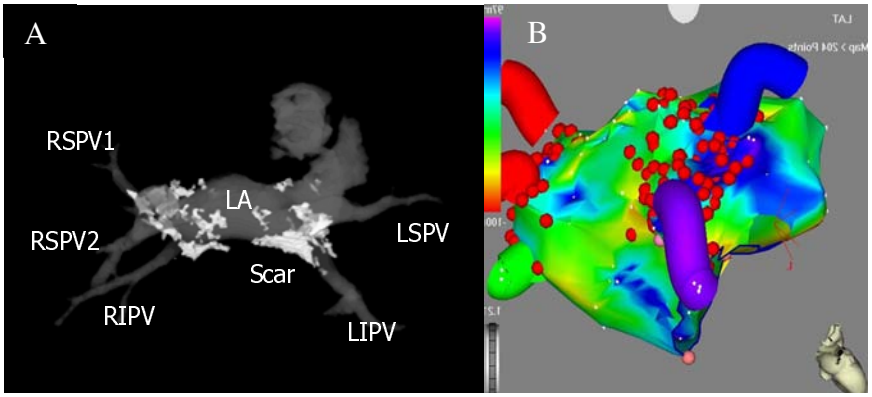

Figure 2. A) Processed scar image (white) was overlaid on PV MRA (gray). Five PV branches (2 right superior, right inferior, left superior and left inferior). B) PV isolation display with electro-anatomic mapping system (CARTRO). PVs (cylinder-like structures) and left atrial surface are mapped. Red points are commanded ablation points.

Results: Intensity-based rigid registration between MRA and DE-MRI images provided qualitatively reasonable fusion (Figure 1). High contrast MRA image was effectively used for anatomical segmentation of pulmonary veins. The processed scar image was overlaid on the PV (Figure 2A), and visually it was clear that the scar surrounded the PV ostia. Electroanatomic mapping from the CARTO system for each patient was obtained for visual comparison (Figure 2B).

Discussion and Conclusion: We have demonstrated an intensity-based rigid body registration technique for 3D visualization of RF ablation scarring in the PVs. It provides 3D visualization of scar extent, which enables evaluation of scar configuration and continuity. In the future, the scar will be compared with intended ablation sites (i.e. Electroanatomical mapping data) acquired during the procedure, as described previously [2]. This registration can be used to evaluate the in vivo accuracy of the electronantomic mapping guidance system. The intensity based rigid image registration of MRA and PV image provided reasonable quality of image fusion between MRA and DE-MRI scar image data, even though MRA was non-ecg-gated.

References: [1] Peters DC et al. ISMRM 2006, 76. [2] Malchano ZJ et al. J Cardiovasc Electrophysiol. 2006 Nov;17(11):1221-9