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POSTER PRESENTATION

Comparison of noninvasive three dimensional delayed enhancement MRI of left atrial scar with invasive voltage map by using robust 4D point-to-point registration in patients with atrial fibrillation

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Background

Left Atrial scar imaging using delayed enhancement MRI (DE-MRI) has been proposed as a promising tool to guide ablation strategies in patients with atrial fibrillation (AF). Studies have shown that the scar areas detected by DE-MRI correlate with the low voltage areas on the co-registered electroanatomic voltage map based on surface matching. However, such matching methods did not consider the misalignment of the scar areas: a point-to-point comparison between DE-MRI and voltage map remains problematic. In this study, we proposed a robust 4D (3D of geometry and 1D of scar degree) registration algorithm for the point-to-point comparison of DE-MRI and voltage map. Based on the registered images, we hypothesized that by utilizing complex image information extracted from DE-MRI, we were able to predict the low voltage areas in the co-registered voltage maps.

Methods

Eleven patients scheduled for ablation for paroxysmal AF were recruited and imaged on a 1.5 T Avanto scanner. DE-MRI was acquired 10 minutes after contrast injection using a 3D inversion-recovery-prepared, respiration-navigated, ECG gated, fast spoiled gradient recalled sequence with fat saturation. Typical acquisition parameters included: TR 500-700 ms, TE 1.34 ms, in-plane resolution 1.1 × 1.1 mm, slice thickness 1.5 mm, FOV 350 mm, and flip angle 10°. At the time of ablation, a detailed pre-ablation bipolar voltage map of the left atrium was created using an electroanatomic mapping system (CARTO; Biosense Webster).

See Figure 1 (A-C;E-G). We adapted a 4D coherent point drift matching framework, which is robust for large deformation and topological variation. Signal intensity in DE-MRI and voltage map were converted to a dimension of scar degree, in which the conversions were iteratively estimated by linear regression and an expectation-maximization strategy. On the point-to-point registered DE-MRI image, a complex intensity profile and the blood pool statistics at each point were extracted. A principal component denoised multivariate regression was performed to estimate the voltage map from DE-MRI. The performance of voltage estimation was measured by linear correlation, and the detection of low voltage area was evaluated using sensitivity, specificity and the area under the ROC curve (AUC).

Results

See Figure 1 (D,G,H). From the 11 patients, a total of 86854 voltage points were studied. The estimated voltage map by DE-MRI was significantly correlated with the electroanatomic mapping results ($r = 0.51$, $p = 0$). DE-MRI detected low voltage areas (< 0.6 mV) with a sensitivity of 54%, a specificity of 83% and an AUC of 75%; DE-MRI detected very low voltage areas (< 0.1 mV) with

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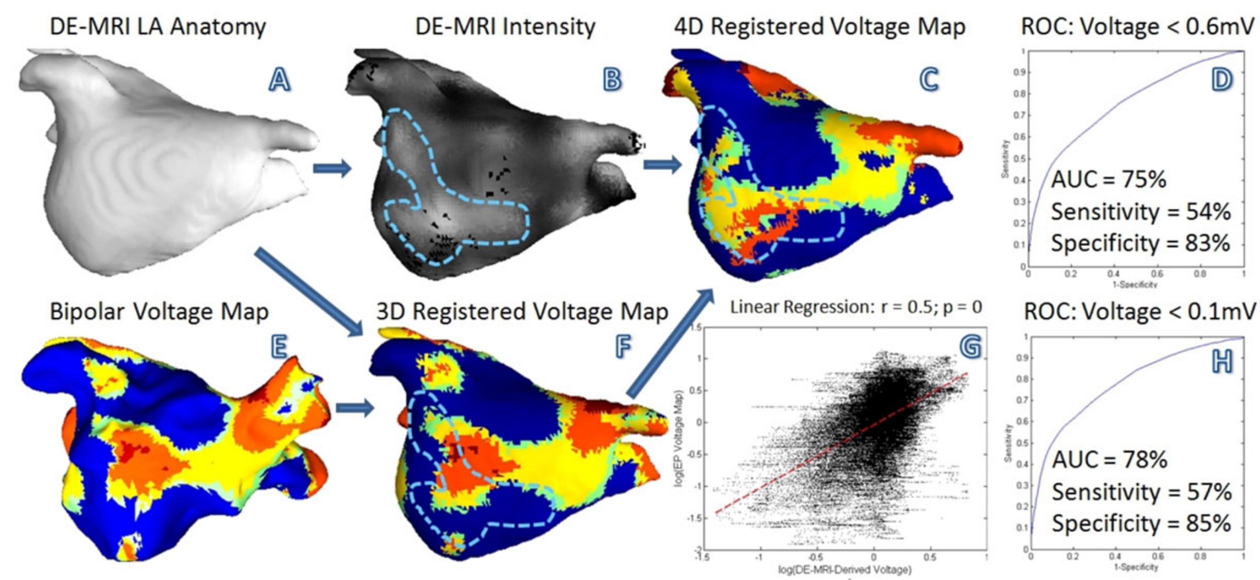

Figure 1 (A-C;E-G): The flowchart of the 4D point-to-point registration framework. Note that the high-intensity patch inside the dotted line on the DE-MRI intensity model coincided well with the low voltage area on the 4D registered voltage map, but not on the 3D one. (G): the linear regression results of DE-MRI-derived voltage map and electroanatomic mapping. (D,H): the ROC curves of the DE-MRI-derived voltage map for the detection of low voltage areas of <0.6 mV and <0.1 mV, respectively.

a sensitivity of 57%, a specificity of 85% and an AUC of 78%.

Conclusions

Low voltage areas can be identified by DE-MRI using our novel 4D point-to-point registration framework and a more comprehensive analysis of the DE-MRI intensity profile. Such approach may be potentially applicable to clinical ablation guidance but needs further investigation.

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