Application of DE-MRI to assess the LA myocardium composition in AF patients

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Background. The pathophysiology of atrial fibrillation (AF) is characterized by diffuse left atrial (LA) fibrosis and a reduction in endocardial voltage. Currently, the extent and location of abnormal electrical remodeling in the wall of the atria cannot be assessed without invasive techniques. This study investigated the utility of delayed enhancement MRI (DE-MRI) in detecting electrically abnormal tissue prior to radiofrequency ablation.

Methods. Thirty one patients presenting for pulmonary vein antrum isolation (PVAI) for AF underwent 3D DE-MRI of the left atrium prior to PVAI. All patients underwent MRI studies on a 1.5 Tesla Avanto clinical scanner (Siemens Medical Solutions, Erlangen, Germany) using a TIM phased-array receiver coil. Delayed enhancement MRI (DE-MRI) was acquired approximately 15 minutes after contrast agent injection (dose = 0.1 mmol per kilogram of body weight [Multihance, Braco Diagnostic Inc., Princeton, NJ]) using 3D inversion-recovery-prepared, respiration navigated, ECG-gated, gradient echo pulse sequence with fat saturation. Typical acquisition parameters were: free-breathing using navigator-gating, a transverse imaging volume with voxel size = 1.25x1.25x2.5 mm, repetition time/echo time = 6.3/2.3 ms, inversion time (TI) = 230 – 270 ms, parallel imaging using GRAPPA technique with R = 2 and 32 reference lines. ECG gating was used to acquire a subset of phase encoding views during diastolic phase of the LA cardiac cycle. Typical scan time for the DE-MRI study was 5-9 minutes depending on subject respiration and heart rate. DE-MRI images were manually segmented to isolate the LA and custom software was implemented to detect regions of fibrosis by quantifying delayed enhancement. DE-MRI models were compared to voltage maps acquired prior to PVAI. Patients then underwent PVAI and were assessed for recurrence.

Results. DE-MRI demonstrated some enhancement in all patients. A clear relationship between enhancement on DE-MRI and low voltage maps was seen in all patients (Figure). Following visualization and analysis, 17 patients were classified as having minimal enhancement (enhancement of left atrial volume = 8.0% ± 5.5%), 10 as moderate (enhancement = 19.0% ± 6.2%), and 4 as extensive (enhancement = 58.8% ± 18.5%). No patients with minimal LVA suffered AF recurrence, 2 (20%) of the moderate and 3 (75%) of the patients with extensive enhancement suffered AF recurrence ($p < 0.01$).

Conclusions. DE-MRI provides a non-invasive means of assessing the myocardial tissue remodeling in patients suffering from atrial fibrillation. Extent of enhancement as identified by DE-MRI may have important implications in the treatment of these patient and shows promise to predict responders to the PVAI procedure.

Figure. MRI (A), 3 dimensional MRI maximum intensity projection (MIP) volume model (B), MRI – Color Model (C) and electroanatomic map (D) acquired during invasive EP study for one patient. Posterior view shown. There is a strong relationship between region and the extent of low voltage tissue on both MRI (b,c) and the EA map (D). A similar relationship was noted for all other patients in the study.