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Original Article

Visualizing radiofrequency lesions using delayed-enhancement magnetic resonance imaging in patients with atrial fibrillation: A modification of the method used by the University of Utah group

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ABSTRACT

Background: Atrial tissue fibrosis has previously been identified using delayed-enhancement MRI (DE-MRI) in patients with atrial fibrillation (AF). Although the clinical importance of DE-MRI is well recognized, the visualization of atrial fibrosis and radiofrequency (RF) lesions has still not been achieved in Japan, primarily because of the differences in contrast agents, volume-rendering tools, and technical experience. The objective of this study was to visualize RF lesions by using commercially available tools.
Methods: DE-MRI was performed in 15 patients who had undergone AF ablation (age, 59 ± 4 years, left atrium diameter, 40 ± 2 mm). Specific parameters for MR scanning obtained from previous reports were modified.
Results: Of the 15 images, the images of three patients were uninterpretable owing to low image quality. RF lesions could be visualized in 8 (67%) of the 12 patients.
Conclusions: In the current study, we successfully demonstrated that RF lesions could be visualized in Japanese patients using DE-MRI, although only commercially available tools were used.

1. Introduction

Delayed-enhancement magnetic resonance imaging (DE-MRI) is an established method for characterizing cardiac tissue in various disease processes [1]. Recently, DE-MRI has emerged as an effective method for noninvasively assessing and quantifying the extent of left atrium (LA) structural remodeling [2], which has been reported to be independent of the type of atrial fibrillation (AF) and associated comorbidities. Moreover, selecting appropriate treatment candidates based on the quality and quantity of atrial fibrosis detected using DE-MRI has shown to improve the procedural outcome and prevent unnecessary interventions [3]. Furthermore, a multicenter trial has also demonstrated that atrial fibrosis, as estimated by DE-MRI, is independently associated with the likelihood of recurrent arrhythmias [4]. We recognize the use and importance of DE-MRI for visualizing atrial fibrosis [3]. However, neither atrial fibrosis nor radiofrequency (RF) lesions can be visualized using DE-MRI in Japan, mainly due to the differences in contrast agents, volume-rendering tools and technical experience. Therefore, the objective of the current study was to visualize RF lesions and tissue fibrosis in the left atrium (LA) of Japanese patients who underwent AF ablation using commercially available tools for DE-MRI. In addition, we also investigated the clinical differences between the successful and unsuccessful MRI acquisitions groups.

2. Material and methods

2.1. Patient selection

The study was conducted in consecutive 15 patients who had undergone AF ablation. DE-MRI scans were uninterpretable in

Abbreviations: DE-MRI, delayed-enhancement magnetic resonance imaging; AF, atrial fibrillation; RF, radiofrequency

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3 patients because the imaging was performed too early after the injection ($n=1$) and owing to insufficient respiratory gating ($n=2$). Therefore, the remaining 12 patients were enrolled in this study and were subsequently divided into two groups according to the quality of the acquired MRI (the adequate DE-MRI and the inadequate DE-MRI groups). The study was approved by the local institutional review board (Date: 11.19.2013; Approval number: 20), and written informed consent was obtained from all the patients.

2.2. DE-MRI acquisition

All the patients underwent contrast-enhanced MR imaging using a 1.5-T MR system (Intera Achieva; Philips Medical Systems) equipped with a 32-channel cardiac coil. The scanning technique and parameters for the DE-MRI have been previously reported [5–8]. The DE-MRI of the left atrium (LA) with pulmonary veins (PVs) was acquired using a 3D inversion recovery, respiration navigated, electrocardiogram-gated, T1-FFE sequence in the transverse plane 15 min after the injection of 0.1 mmol/kg gadolinium (Magnevist; Bayer HealthCare). Typical scan parameters were: repetition time (TR)/echo time (TE)=4.7/1.5, voxel size=$1.25 \times 1.26 \times 2.60$ mm^3 (reconstructed to $0.63 \times 0.63 \times 1.30$ mm^3), flip angle=15, inversion time (TI)=280–330 ms, SENSE with a reduction factor of 2, and 70 reference lines. The TI value was identified from the myocardial TI_{null} using a Look-Locker. The T1 of the LA wall was similar to the myocardial T1 [5]. Data acquisition was limited to 15% of the cardiac cycle. During the MRI, in sinus rhythm (SR) cases, data acquisition was performed during the mid-diastolic phase of the left ventricle. Furthermore, in AF cases, the trigger delay of the cardiac synchronization was set to the shortest value. Saturation bands were placed in the phase-encoding (right–left) line to minimize back-folding from the arms. Fat saturation was applied to suppress any fat signals. The typical scan time for the DE-MRI study was 7–12 min depending on the heart rate (HR) and respiration pattern of each patient; we attempted to maintain the HR at <70 bpm using metoprolol 20 or 40 mg.

2.3. 3D visualization of RF lesions and atrial fibrosis

The method for 3D visualization of the lesions using DE-MRI was as follows: first, source images were transferred to a workstation (AZE Virtual Place; AZE, Tokyo, Japan); second, segmentation was performed with AZE Virtual Place, and the LA was further segmented semi-manually by contouring the endocardial and epicardial borders of the atrium, including the PVs (Fig. 1); third, a voxel-intensity histogram analysis of the LA wall measured the intensities (>1SD) of the Des, and the degree of intensity was categorized into a color-coded scale (green: 1SD–2SD: yellow: 2SD–3SD; red: >4SD) [2]; and finally, 3D reconstruction of the LA and PVs with the DEs was achieved automatically.

2.4. Statistics

Data were tested using the Kolmogorov–Smirnov test and are presented as mean $\pm$ standard deviation for normally distributed variables. The medians and quartiles are given for non-normally distributed variables. Categorical variables are expressed as number and percentage of patients. Continuous variables were analyzed using Student's t test. Categorical variables were analyzed using Fisher's exact test. A value of $p<0.05$ was considered statistically significant. All the statistical analyses were performed with SPSS, Release 11.0 software (SPSS, Chicago, IL, USA).

3. Results

3.1. Patient characteristics

The patient characteristics are displayed in Table 1. The primary AF type was paroxysmal AF in most patients (9/12 [75%]). Moreover, the mean left atrial diameter and the mean left atrial appendage (LAA) flow were 40 ± 2 mm and 63 ± 25 cm/s, respectively.

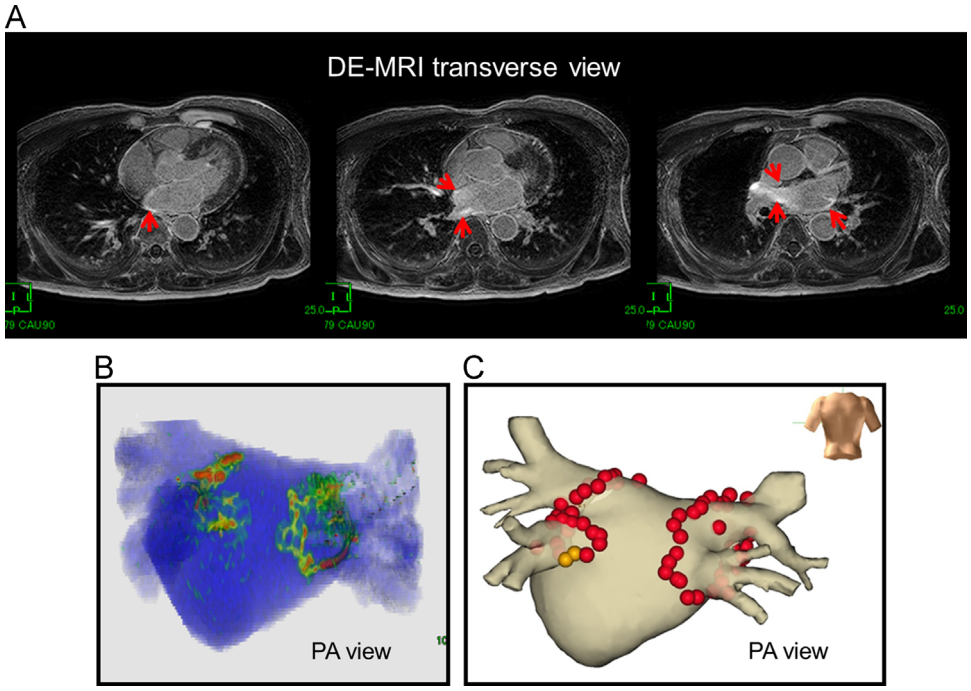

Fig. 1. Adequate 3D visualization of an RF lesion in a patient without AF recurrence. (A) The LA wall slice 3 months after AF ablation observed using DE-MRI. The red arrows show delayed enhancement. (B) 3D visualization of RF lesions. (C) AF ablation using the NavX system. The red and brown 3D tags indicate ablation points. The patient has been free of any AF recurrence for 12 months after a single AF ablation, without using any anti-arrhythmic drug.