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Original Article

Magnetic resonance imaging of the left atrial appendage post pulmonary vein isolation: Implications for percutaneous left atrial appendage occlusion

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ABSTRACT

Background: There is increasing interest in performing left atrial appendage (LAA) occlusion at the time of atrial fibrillation (AF) ablation procedures. However, to date there has been no description of the acute changes to the LAA immediately following pulmonary vein (PV) isolation and additional left atrium (LA) substrate modification. This study assessed changes in the size and tissue characteristics of the LAA ostium in patients undergoing PV isolation.
Methods: This series included 8 patients who underwent cardiovascular magnetic resonance evaluation of the LA with delayed enhancement magnetic resonance imaging and contrast enhanced 3-D magnetic resonance angiography pre-, within 48 h of, and 3 months post ablation. Two independent cardiac radiologists evaluated the ostial LAA diameters and area at each time point in addition to the presence of gadolinium enhancement.
Results: Compared to pre-ablation values, the respective median differences in oblique diameters and LAA area were +1.8 mm, +1.7 mm, and +0.6 cm^2 immediately post ablation (all NS) and −2.7 mm, −2.3 mm, and −0.5 cm^2 at 3 months (all NS). No delayed enhancement was detected in the LAA post ablation.
Conclusion: No significant change to LAA diameter, area, or tissue characteristics was noted after PV isolation. While these findings suggest the safety and feasibility of concomitant PV isolation and LAA device occlusion, the variability in the degree and direction of change of the LAA measurements highlights the need for further study.

1. Introduction

Atrial fibrillation (AF) is a common condition that is associated with a 5-fold increased risk of stroke [1]. While oral anticoagulants have traditionally been utilized for stroke reduction in AF patients, their use has been suboptimal because of concerns over bleeding [2]. Catheter ablation [3–5] and left atrial appendage (LAA) occlusion [6] may reduce stroke risk without the need for oral anticoagulation. The mechanism of the former is related to sinus rhythm maintenance, whereas the latter acts through exclusion of the LAA, which is the dominant site of thrombus formation in patients with non-valvular AF [7,8]. As the long-term freedom from AF associated with catheter ablation procedures is not ideal [9], an appealing solution for stroke reduction would be the placement of an LAA occlusion device at the time of an AF ablation procedure. Such a combined approach may result in very low rates of stroke, potentially similar to those reported in patients undergoing surgical MAZE procedures with LAA ligation [10,11], as well

Abbreviations: AF, atrial fibrillation; LAA, left atrial appendage; RF, radiofrequency; LA, left atrium; CMR, cardiovascular magnetic resonance imaging; PV, pulmonary vein; CE-3D MRA, contrast enhanced 3-dimensional magnetic resonance angiography; DE-MRI, delayed enhancement magnetic resonance imaging; TR, repetition time; TE, echo time; NEX, number of excitations; FOV, field of view; IR, inversion recovery

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as minimize the need for a repeat invasive procedure requiring transseptal catheterization.

To date, one small series evaluating the feasibility of LAA occlusion at the time of catheter ablation comprising pulmonary vein (PV) isolation has been published [12,13]. In addition, we know of two clinical trials currently under way that are evaluating the merits of this combined strategy (LAALA-AF Registry [14] and LAA Occlusion after catheter ablation of AF (Clinical Trials.gov identifier number: NCT01695824) [15]). However, despite the enthusiasm among electrophysiologists for simultaneous PV isolation and LAA occlusion, it is unknown whether PV isolation triggers morphologic changes of the LAA that may affect the ability to safely perform concomitant LAA occlusion. That is, radiofrequency (RF) ablation in the region of the left PV may alter the size, shape, and tissue characteristics of the LAA ostium. Knowledge of any such changes would be important as it may affect the approach to and safety of percutaneous LAA occlusion at the time of an ablation procedure, thereby influencing future clinical studies in this field. In this pilot study, we address this knowledge gap by reporting on changes in the size and tissue characteristics of the LAA os in patients undergoing PV isolation and additional left atrium (LA) substrate modification as assessed using gadolinium-enhanced cardiovascular magnetic resonance imaging (CMR).

2. Material and methods

Patients who underwent a first-ever RF catheter ablation procedure for AF and were evaluated by CMR pre-, up to 48 h after, and 3 months post procedure were included in this study. Consent for participation was obtained from each patient. Ethics approval was obtained from the Sunnybrook Health Sciences Center Research Ethics Board (Study Number: 357-2006; Initial Approval Date: September 18th 2006; Study Closure Date: October 2013).

2.1. Ablation procedure

Catheter ablation was performed with either a manual or robotic (Stereotaxis Niobe Remote Magnetic Navigation System, St. Louis, USA) approach using an irrigated RF ablation catheter and a 3D-electroanatomic mapping system. Fluoroscopy and the created 3D-electroanatomic maps were used to guide catheter manipulation and ablation in the region of the PVs. Ablation was typically performed along the venous side of the ridge when ablating the anterior aspect of the left PV (Fig. 1). Irrigated RF ablation was typically performed for 30 s at each site with a maximum power of 40 W and temperature of 48°. The goal of pulmonary venous ablation was the elimination of high frequency local electrograms with subsequent PV isolation. Additional LA substrate modification was performed at the operator's discretion. No patients underwent electrical isolation of the LAA, LA substrate modification in the region of the LAA, or ablation within the distal coronary sinus or ligament of Marshall. Recurrence of any atrial arrhythmia during follow-up was determined using intermittent Holter, Loop, and electrocardiography monitoring.

2.2. Magnetic resonance imaging data acquisition

All images were acquired on a 1.5 T Twinspeed Signa magnetic resonance (MR) scanner (GE Healthcare, Inc., Milwaukee, Wisconsin). In all patients, a contrast-enhanced 3D MR angiography (CE-3D MRA) data set was acquired in the coronal orientation following a 13 cc gadolinium chelate injection (Gadobutrol, Bayer Healthcare, Berlin, Germany). To measure the delay time, a test bolus repeating a single axial 2D spoiled gradient echo (2D FSPGR) slice was used after a 1 cc contrast injection. Representative imaging parameters for the 2D FSPGR were as follows: repetition time (TR)/echo time (TE) = 13/min, flip angle = 90°, sampling matrix = 128 × 128 pixels, number of excitations (NEX) = 1, field of view (FOV) = 38 mm, and slice thickness = 10 mm/0 gap. The parameters for the CE-3D MRA sequence were as follows: TR/TE = 3.8/1.3 ms, flip angle = 45°, sampling matrix = 320 × 160 pixels, NEX = 1, FOV = 380 mm, 34 locations/slab, slice thickness = 5 mm, and a breath hold time of 20 s. This sequence was acquired twice after a single contrast injection. The inversion recovery (IR)-prepared delayed enhancement MRI (DE-MRI) was obtained in a sagittal oblique plane approximately 20 min after contrast injection. Imaging parameters were as follows: free-breathing navigator gating, TR/TE = 5.1/1.6 ms, flip angle = 25°, sampling matrix = 256 × 256 pixels, FOV = 350 mm, and slice thickness = 3.4 mm. An inversion time was selected using a Cine-IR pulse sequence prior to the delayed enhancement scan.

2.3. Image analysis

Images were analyzed using commercially available software (Aquarius, Intuition v4.4.8, TeraRecon, Inc., Foster City, California). Two experienced cardiac radiologists independently created multiplanar reformatted images using the double oblique technique (Fig. 2). The “full-width at half maximum” technique of image contrast and brightness adjustment was applied to ensure measurement consistency and reproducibility [16]. The os of the LAA was defined as the site of reflection of this structure with the adjacent LA [17]. Measurements of the LAA ostial diameter were obtained in 2 orthogonal views (D1, D2) (Fig. 2). The area of the LAA at the os was determined by manual planimetry of the LAA os. To minimize bias, each radiologist was blinded to the timing of imaging relative to the ablation procedure.

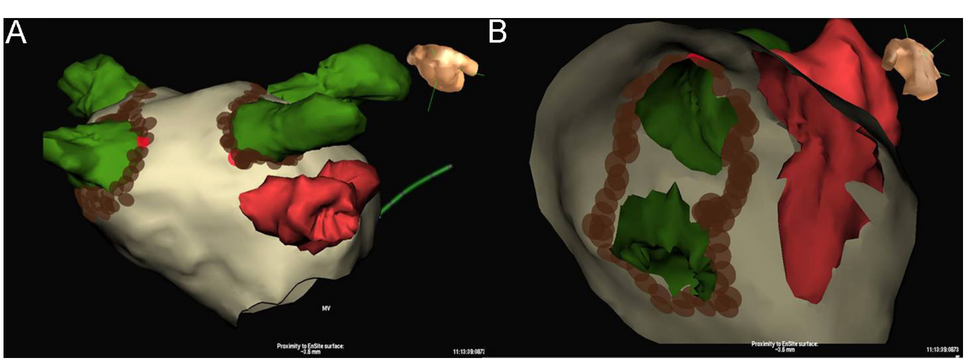

Fig. 1. Ablation along the venous side of the left Pulmonary vein – left atrial appendage (PV-LAA) ridge. 3D electroanatomic map reconstruction of the LA and LAA with the NavX (St. Jude Medical, Minneapolis, USA) electroanatomic mapping system. Panel A: Anterior–posterior top-down view showing the relationship between the left PVs (green), the LAA (red), and the sites where ablation lesions are placed (brown dots). Panel B: Sagittal clipping plane showing the relationship between the left PVs (green), the LAA (red), and the sites where ablation lesions are placed (brown dots).