International Journal of Cardiology 228 (2017) 449–455

Contents lists available at ScienceDirect

International Journal of Cardiology

journal homepage: www.elsevier.com/locate/ijcard

Comparisons of the underlying mechanisms of left atrial remodeling after repeat circumferential pulmonary vein isolation with or without additional left atrial linear ablation in patients with recurrent atrial fibrillation

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ARTICLE INFO

Article history:
Received 1 August 2016
Received in revised form 31 October 2016
Accepted 4 November 2016
Available online 07 November 2016

Keywords:
Atrial fibrillation
2-D strain echocardiography
Speckle-tracking echocardiography
Radiofrequency ablation

ABSTRACT

Background: Radiofrequency catheter ablation (RFCA) is a potentially curative treatment for atrial fibrillation (AF), however, whether or not additional left atrial (LA) linear ablation for recurrent AF adversely affects LA remodeling is unknown.
Methods: Thirty-eight patients experiencing AF recurrence after the 1st circumferential pulmonary vein isolation (CPVI) underwent a repeat RFCA, including 20 and 18 patients receiving a repeat CPVI (group I) or CPVI plus LA linear ablation (group II), respectively. 2-D echocardiography was performed during sinus rhythm within 24 h, at 1-m and 6-m after RFCA. Longitudinal strains and strain rate were measured with speckle-tracking echocardiography. The standard deviation of contraction duration was defined as LA mechanical dispersion.
Results: One and two patients experienced AF recurrence after the 2nd RFCA in group I and II, respectively (P = NS). The 1st CPVI with AF recurrence did not reduce LA size significantly in two groups. After a repeat CPVI, LA diameter but not LA maximal and minimal volume was significantly reduced in group I; additional LA linear ablation significantly decreased LA diameter, maximal and minimal volume in group II. However, there was no significant difference in LA emptying function, global and segmental LA strain and strain rate among the baseline, 1-m and 6-m follow-up in two groups. RFCA did not significantly increase LA mechanical dispersion regardless of the AF ablation strategies.
Conclusions: In patients with recurrent AF, a successful repeat CPVI with or without additional LA linear ablation reduced LA size without significant deleterious effects on LA function and mechanical dispersion.

1. Introduction

Atrial fibrillation (AF) is the most common cardiac arrhythmia that increases the risk of cardiovascular events such as thromboembolic stroke and even mortality [1]. Radiofrequency catheter ablation (RFCA) to create circumferential pulmonary vein isolation (CPVI) and eliminate the triggers of AF is an effective and potentially curative treatment for patients with AF [2–4]. In addition, left atrial (LA) linear ablation at the mitral isthmus and the LA roof has been used to modify the substrate for AF and may improve clinical outcomes [5–8]. However, RFCA by itself produces scarring, which decreases LA size and may also have detrimental effects on LA function [9]. By using multiphase dynamic computed tomography (CT) image reconstruction, Lemola et al. reported that CPVI plus mitral isthmus and LA roof linear ablation can restore sinus rhythm but compromise LA systolic function in patients with paroxysmal AF [10]. In contrast, Verma et al. reported that pulmonary vein (PV) antral isolation causes long-term LA function improvement 6-month after ablation by using echocardiography and cine electro-beam CT [11]. Furthermore, Perea et al. reported that CPVI with extensive LA linear lesions reduces LA volume and preserves or even increases LA ejection fraction in most patients after successful RFCA by using magnetic resonance imaging [12]. The conflicting results with regard to LA function after RFCA may be due to different degrees of myocardial damage according to the RFCA strategy and different AF populations. Since global LA strain correlates with the risk of stroke

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http://dx.doi.org/10.1016/j.ijcard.2016.11.020
0167-5273/

and cardiovascular outcomes in AF patients [13], it is important to clarify whether additional LA linear ablation impairs LA function to potentially increase the post-RFCA thromboembolic risk.

Ultrasound based on two-dimensional imaging such as speckle-tracking imaging (STI) or tissue velocity imaging is a common noninvasive tool to evaluate cardiac function. Speckle-tracking echocardiography (LA strain (LAS) and LA strain rate (LASR)) allows for the quantification of myocardial deformation of the LA during the heart cycle independently of cardiac rotational motion and the tethering effect [14–16]. Higher atrial strain and strain rate predict a greater likelihood of staying in sinus rhythm after electrical cardioversion [14]. In this study, we enrolled patients underwent a 2nd RFCA procedure for recurrent AF after previous CPVI-only procedure, and divided these patients into two groups by whether additional LA linear ablation was performed during the 2nd RFCA to evaluate its effects on LA remodeling.

2. Methods

2.1. Patient population

We retrospectively evaluated 300 consecutive AF patients (233 paroxysmal) who received RFCA between April 2008 and April 2015 at our institution. In the paroxysmal AF group, 61 (26%) patients had recurrence of AF after 1st RFCA, including 39 and 22 patients receiving CPVI or CPVI plus LA linear ablation, respectively. In these 61 patients, 50 patients (35 receiving CPVI and 15 receiving CPVI plus LA linear ablation during 1st RFCA) underwent a 2nd RFCA. In the persistent AF group, 33 out of 67 (49%) patients had recurrence of AF after 1st RFCA. In these 33 patients, 24 patients (3 receiving CPVI and 21 receiving CPVI plus LA linear ablation during 1st RFCA) underwent a 2nd RFCA. To clarify whether the additional LA linear ablation during the 2nd RFCA procedure adversely effects LA remodeling, we only selected patients who underwent "CPVI-only" procedure during the 1st RFCA and received repeat CPVI (group I) or CPVI plus LA linear ablation (group II) for a 2nd RFCA, and then compared the LA remodeling parameters of the same patient between two procedures among baseline and different follow-up periods. Therefore, there were 38 patients enrolled in this study, including 35 paroxysmal AF patients (20 received repeat CPVI only and 15 received repeat CPVI + LA linear ablation for the 2nd procedure) and 3 persistent AF patients (all received additional LA linear ablation during the 2nd procedure). The Institutional Review Board of Chang Gung Memorial Hospital approved the study protocol. Patients with significant valvular disease or prior valve surgery were excluded.

2.2. Percutaneous radiofrequency catheter ablation

All patients received the procedure under general anesthesia with 1–2% isoflurane. RFCA was performed using a 3-D electroanatomical mapping system (CARTO, Biosense Webster, Diamond Bar, CA, USA) to support the creation and validation of ablation lesions. The integration of previously acquired CT helped to optimize 3-D reconstruction and understanding of the LA anatomy.

A bolus dose of intravenous heparin (5000 units) was administered, and the activated coagulation time was kept at >300 s using extra doses of heparin during the procedure. A double transseptal procedure was performed to access the LA. A 3.5-mm open-tip irrigated CARTO catheter and a circular catheter (Lasso, Biosense Webster) were introduced percutaneously through the right femoral vein. Radiofrequency energy was continuously delivered with a power of 20–35 W and irrigating rate of 17 mL/min, and a maximum temperature of 42 °C to circumferentially encircle the ipsilateral superior and inferior PVs. The end point was the absence or dissociation of a local electrogram inside the entire surrounding region together with exit block by pacing within the pulmonary vein ostia in the first RFCA procedure. During the 2nd RFCA procedure, the goals were re-isolation of the PVs, and then identification of non-PV triggers. Additional ablation lines along the mitral isthmus and LA roof were performed according to the operator's criteria and depending on the type of AF. In patients with documented reentrant LA tachycardia, an induction protocol was used. Activation maps were constructed to localize the circuits of the tachycardia and guide the ablation.

2.3. Echocardiography, speckle-tracking imaging and tissue velocity imaging

The patients received transthoracic echocardiography within 24 h after RFCA (baseline), at the 1-m and 6-m follow-up visits. All patients were in sinus rhythm during echocardiography. Baseline 2-D echocardiographic examinations were performed using a commercially available ultrasound scanner (Vivid 7 or 9, General Electric Medical Health, Waukesha, WI, USA) with a 2.5-MHz phased-array transducer. Standard echocardiographic views including apical four- and two-chamber views were obtained in 2-D and color tissue Doppler imaging (TDI) modes. Mitral inflow velocity was recorded by standard pulse-wave Doppler at the tips of the mitral valve leaflets in an apical four-chamber view. LA and left ventricular (LV) measurements were obtained according to the guidelines of the American Society of Echocardiography [17]. The LA diameter, volume [18], and emptying fraction were also assessed according to previously published methods [19,20].

STI of the LA obtained in apical four- and two-chamber views with a frame rate between 60 and 100 frames/s was recorded and stored digitally for offline analysis of LAS and LASR (EchoPac PC, GE Vingmed, Horton, Norway). 2-D strain images derived from STI in the apical four- and two-chamber views were analyzed by a single experienced investigator. The operator manually adjusted segments that were not tracked. LAS determined regional changes in length, and was expressed as a positive value for lengthening or as a negative value for shortening. Peak positive systolic LAS during ventricular systole (SI) and LASR during ventricular systole (S-sr), early diastole (E-sr) and late diastole (A-sr) were assessed at four segments (excluding the LA roof) from apical four- and two-chamber views (named the basSeptal, midSeptal, midLateral, basLateral, basInferior, midInferior, midAnterior and basAnterior segments) [21], and were averaged to acquire global LAS and LASR values. The duration of contraction was measured as the time from the peak of the P wave to maximum LA shortening by LAS. The standard deviation of contraction duration in eight segments was defined as LA mechanical dispersion [22].

2.4. Reproducibility of measurements

Ten patients were randomly selected to determine the reproducibility of the measurements of global LAS and LASR by two independent physicians for inter-observer variability and by the same observer on two separate occasions for intra-observer variability. Repeat measurement was made at the same cardiac cycle of the same image for each patient to avoid the inherent variability caused by different cycle lengths. Variability was determined by paired *t* test and the difference between the 2 sets of measurements divided by the mean of the measurements, expressed by P value and a percentage.

2.5. Clinical follow-up

Patients were seen at 1, 3, 6 and 12 months and then at 6-month interval regularly after the ablation procedures and whenever required due to the symptoms. Serial ECGs or Holter 24-hour ECG were recorded after the ablation procedure and when the patients had symptoms of palpitation. The procedure was considered successful if the patients had no symptoms and no atrial tachyarrhythmias lasting >30 s during follow-up.