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Long duration of radiofrequency energy delivery is an independent predictor of clinical recurrence after catheter ablation of atrial fibrillation: Over 500 cases experience

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ABSTRACT

Background: Although radiofrequency catheter ablation (RFCA) for atrial fibrillation (AF) is an effective rhythm control strategy, there is a substantial amount of recurrence. We explored the predictors of AF recurrence after RFCA with consistent ablation strategy.
Methods and results: This study included 575 patients (77% male, 56 ± 11 years old) with AF (65.7% paroxysmal AF [PAF], 34.3% persistent AF [PeAF]) who underwent RFCA. We evaluated the clinical, serological, and electrophysiological parameters thereof. Results: 1. During 15 ± 7 months of follow-up, patients who experienced AF recurrence (21.8%) were older (58 ± 10 vs. 55 ± 11 years old, $p = 0.019$) and more likely to have PeAF (50.4% vs. 29.4%, $p < 0.001$) and greater LA volume (137.3 ± 49.1 vs. 116.6 ± 37.9 mL, $p < 0.001$). 2. In patients with clinical recurrence after RFCA, both ablation time (110.1 ± 43.8 vs. 92.3 ± 30.1 min, $p < 0.001$) and procedure time (222.7 ± 79.6 vs. 205.8 ± 58.8 min, $p < 0.001$) were prolonged, and the early recurrence rate within 3 months of the procedure was higher (63.0% vs. 26.4%, $p < 0.001$) than those without clinical recurrence. 3. In logistic regression analysis, LA volume (OR 1.008, CI 1.001–1.014), ablation time (per quartile, OR 1.380, CI 1.031–1.847), and early recurrence (OR 3.858, CI 2.420–6.150) were independent risk factors for recurrence of AF after RFCA.
Conclusion: In this single center consistent study of over 500 cases of AF ablation, patients with AF recurrence had a larger atrium, longer ablation time, and a higher chance of early recurrence than those remained in sinus rhythm. Inadvertent, long duration of ablation was an independent predictor of worse clinical outcomes after catheter ablation of AF.

1. Introduction

Although radiofrequency catheter ablation (RFCA) of AF is an effective rhythm control strategy [1], there is a substantial recurrence rate therewith [1–3]. Therefore, the development of clinical and electrophysiological predictors of recurrence after AF ablation may reduce the number of unnecessary invasive procedures, the risk of complications, or medical cost, and improve clinical outcomes in the selected patients. Knowledge of these predictors would also contribute to the understanding of AF pathophysiology. Although previous reports have suggested various predictors, such as left atrial (LA) size [4], serologic markers [5], and early recurrence of AF [6], there is no consensus on ablation strategy and how much of a duration of RF energy delivery is an appropriate ablation. Electrical isolation of pulmonary veins (PV) is known to be the corner stone of catheter ablation of AF [1,7]. However, it is not sufficient in patients with significant atrial remodeling, and various kinds of ablation techniques have been proposed to improve the clinical outcome thereof [8–10]. However, excess atrial tissue damage by RF energy may potentially induce collateral damage [11] or can be pro-arrhythmic [12] in some circumstances. Therefore, we investigated whether certain parameters, including ablation time, predict AF recurrence after RFCA. The purpose of this study was to compare the following data of patients who experienced AF recurrence after RFCA with those that retained sinus rhythm: clinical parameters, LA imaging analyses, serological biomarkers, and electrophysiological parameters.

2. Methods

2.1. Study population

The study protocol was approved by the Institutional Review Board of Yonsei University Health System. All patients provided written informed consent. The study included 575 consecutive patients with AF (77% males, 56 ± 11 years old) who underwent RFCA between Mar 2009 and June 2011. Among them, 65.7% of patients had paroxysmal AF (PAF) and 34.3% had persistent AF (PeAF). A mean of 1.9 ± 1.3 antiarrhythmic drugs were proven to be ineffective in treating the patients' AF. The study's exclusion criteria were as follows: 1) permanent AF refractory to electrical cardioversion; 2) LA size > 55 mm as measured by echocardiogram; 3) AF with rheumatic valvular disease; 4) associated structural heart disease other than left ventricular

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hypertrophy; and 5) prior AF ablation. Three-dimensional (3D) spiral computerized tomography (CT) scans (64 Channel, Light Speed Volume CT, Philips, Brilliance 63, Netherlands) were performed to visually define pulmonary vein (PV) anatomy. The presence of an LA thrombus was excluded by trans-esophageal echocardiography. All antiarrhythmic drugs were discontinued for a period corresponding to at least five half-lives. In total, 127 patients (22.1%) were taking amiodarone, which was discontinued for at least four weeks prior to the procedure. Anticoagulation therapy was maintained before catheter ablation.

2.2. Electrophysiologic mapping

Intracardiac electrograms were recorded using the Prucka CardioLab™ electrophysiology system (General Electric Health Care System Inc., Milwaukee, WI, USA), and catheter ablation was performed in all patients using 3-D electroanatomical mapping (St. Jude Medical Inc., Minnetonka, MN, USA) merged with 3-D spiral CT. If the initial rhythm was sinus, we generated an LA 3-D electroanatomical voltage map by obtaining contact bipolar electrograms from 350 to 400 points on the LA endocardium during atrial pacing. The bipolar electrograms were filtered from 32 to 300 Hz. Color-coded voltage maps were generated by recording bipolar electrograms and measuring peak-to-peak voltage during high right atrial pacing with a cycle length of 500 ms as previously described [13–15]. In patients whose AF persisted after linear ablation, we generated complex fractionated atrial electrogram (CFAE) cycle length (CL) maps by generating contact bipolar AF electrograms for durations of >6 s at 150–200 sites throughout the LA. The CFAE-CL was calculated by averaging the peak-to-peak intervals of recordings of bipolar electrograms and color coded on a 3D-CT merged LA electro-anatomical map [13–15]. We measured effective refractory periods (ERP) at the high right atrium, low right atrium, proximal coronary sinus, and distal coronary sinus by S1–S2 methods, and calculated mean ERP in patients who remained in sinus rhythm during S1–S2 pacing.

2.3. Radiofrequency (RF) catheter ablation

We used an open irrigated-tip catheter (Celsius, Johnson & Johnson Inc.; Diamond Bar, CA, USA; irrigation flow rate 20 to 30 mL/min; 30 W; 47 °C) to deliver RF energy for ablation (Stockert generator, Biosense Webster Inc.; Diamond Bar, CA, USA). We generally performed RFCA in sinus rhythm after electrical cardioversion. However, if sinus rhythm could not be maintained due to immediate recurrence of AF, RFCA was done during AF. All patients initially underwent circumferential PV isolation (CPVI) and bi-directional block of the cavo-tricuspid isthmus (CTI). For the patients with PAF, we added a roof line, posterior inferior line (posterior box lesion), anterior line [10], and CFAE ablation guided by 3D-CFAE-CL map [16] sequentially in a stepwise approach (Fig. 1), until termination of AF. In patients with PeAF, we conducted CPVI, CTI block, roof line, and posterior inferior line as a routine lesion set in all patients (Fig. 1). If AF was sustained, we generated an anterior line and CFAE ablation guided by 3D-CFAE-CL map in a stepwise approach until the termination of AF. If AF persisted beyond the aforementioned ablation protocols for PAF or PeAF, we stopped the procedure after internal cardioversion. The end point of our procedure was at the point of no immediate recurrence of AF after cardioversion with isoproterenol infusion (5–20 μg/min). If there were non-PV foci under isoproterenol, we ablated them all.

2.4. Post-ablation follow-up

Patients were asked to visit the outpatient clinic at 1, 3, 6, 9, and 12 months after RFCA and then every 6 months thereafter for follow-up. Electrocardiography (ECG) was performed at each visit or anytime the patient reported palpitations. A Holter ECG (24 h or 48 h) and/or event recorder was evaluated at 3, 6, and 12 months after RFCA. We defined recurrence of AF as any episode of AF or atrial tachycardia of at least 30 s in duration [17]. If any ECG documented an AF episode within the three-month blanking period during follow-up, the patient was diagnosed with an

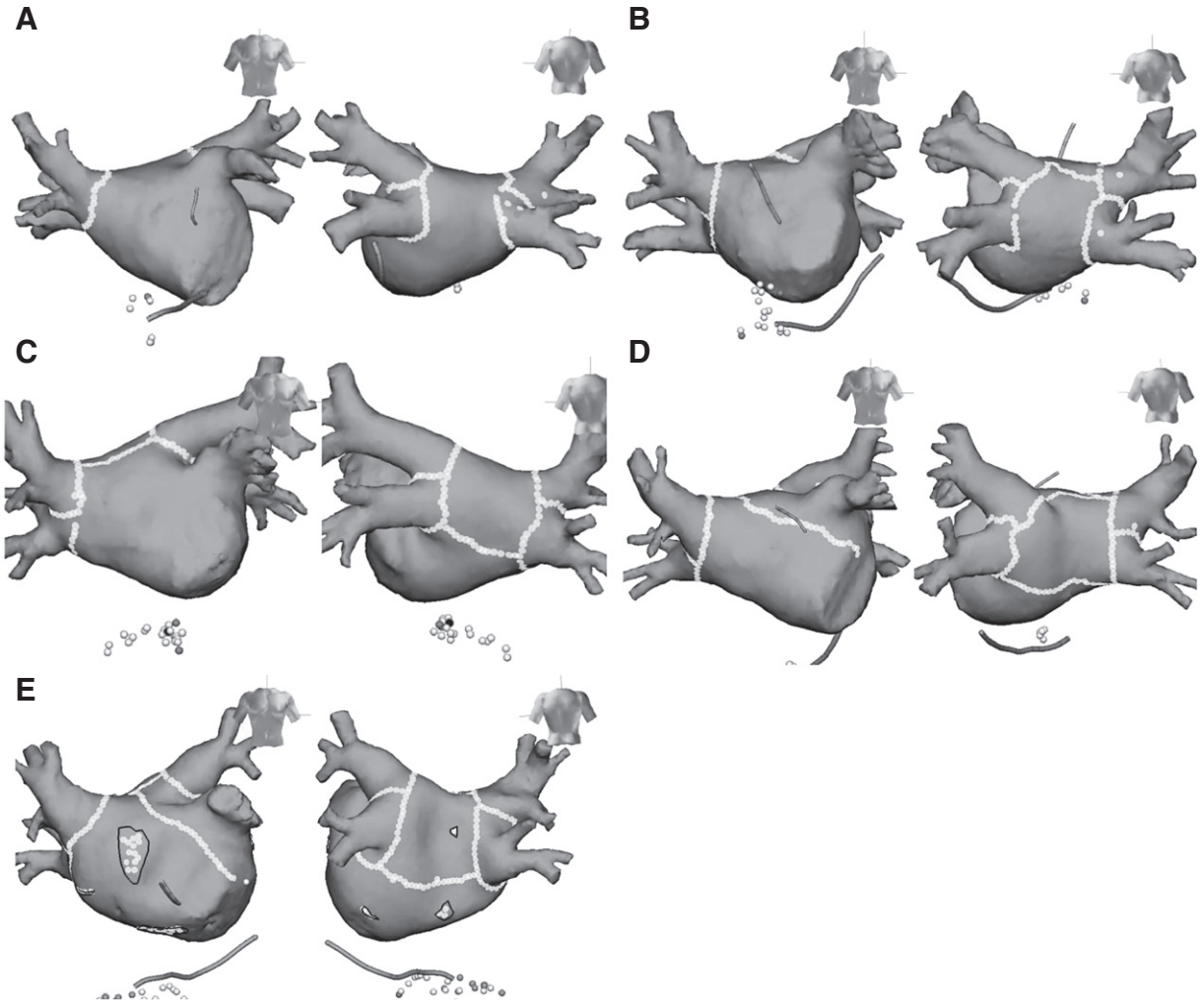

Fig. 1. Ablation protocol with stepwise approach. A. CPVI, B. Roof line, C. Posterior box lesion, D. Anterior line, E. CFAE ablation.