Clinical recurrence and electrical pulmonary vein reconnections after second-generation cryoballoon ablation

Shinsuke Miyazaki, MD,* Hiroshi Taniguchi, MD,* Hitoshi Hachiya, MD,* Hiroaki Nakamura, MD,* Takamitsu Takagi, MD,* Kenzo Hirao, MD,† Yoshito Iesaka, MD, FHRS*

From the *Cardiovascular Center, Tsuchiura Kyodo Hospital, Tsuchiura, Ibaraki, Japan and †Heart Rhythm Center, Tokyo Medical and Dental University, Tokyo, Japan.*

BACKGROUND Electrical reconnections after pulmonary vein isolation (PVI) are less common after second-generation cryoballoon than radiofrequency ablation.

OBJECTIVE The purpose of this study was to investigate the incidence and characteristics of pulmonary vein (PV) reconnections after second-generation cryoballoon ablation in patients with and those without clinical recurrences.

METHODS Forty patients with paroxysmal atrial fibrillation undergoing second procedures after cryoballoon ablation were enrolled. Twenty-five patients experienced clinical recurrences, and the remaining 15 did not.

RESULTS All 158 PVs were reevaluated a median [25th, 75th percentiles] of 6.0 [4.0–9.0] months after the initial procedure. In total, reconnections were detected in 39 PVs (24.7%) among 25 patients (62.5%). Reconnected PVs included 6 left superior (LS) (15.8%), 7 left inferior (LI) (18.4%), 5 right superior (RS) (12.5%), 20 right inferior (RI) (50.0%), and 1 left common (LC) (50.0%) PV. Reconnected PV potential conduction delays were a median of 112 [76–130], 103 [82–133], 84 [66–96], 68 [49–73], and 204 ms in the LS, LI, RS, RI, and LC PV, respectively. There was no significant difference between those with and those without clinical recurrences with regard to clinical characteristics, procedural results, incidence of reconnections (25/98 vs 14/60, $P = .758$), and PV conduction delays in each PV. The most common gap location was the RI PV bottom in both groups. Among 5 patients with reconnections of arrhythmogenic PVs (with atrial fibrillation initiation), 2 experienced clinical recurrences, whereas 3 did not. Non-PV foci (with atrial fibrillation initiation) were identified in a second procedures in 10 of 25 patients with clinical recurrences.

CONCLUSION The incidence and characteristics of PV reconnections after second-generation cryoballoon ablation were similar between patients with and those without clinical recurrences. The results should be considered when discussing the optimal dose of cryoballoon applications.

KEYWORDS Pulmonary vein reconnection; Cryoballoon; Pulmonary vein isolation; Durability

(Heart Rhythm 2016;13:1852–1857)

Introduction

Pulmonary vein isolation (PVI) is currently the mainstay acute procedural endpoint in the catheter ablation of paroxysmal atrial fibrillation (AF), and pulmonary vein (PV) reconnections have been considered the main mechanism of recurrent AF.[1,2] Although several ablation strategies and technologies have been proposed to improve the durability of an electrical PVI to improve the success rate, resumption of conduction is still a common observation during repeat procedures in patients with clinical recurrences.[2] Recently, the second-generation cryoballoon (CB) has been introduced into clinical use and is highly effective in terms of procedural efficacy,[3–5] presumably because of the higher durability of PVI compared to radiofrequency (RF) point-by-point ablation.[6] Although a few studies have evaluated the incidence and characteristics of PV reconnections after point-by-point RF ablation in patients with and those without clinical recurrences,[7–9] those after CB ablation have not been examined. The purpose of this study was to investigate the incidence and characteristics of electrical PV reconnections after second-generation CB ablation in patients with and those without clinical recurrences to investigate the implication of electrical PV reconnections on clinical recurrence.

Methods

Study population

Among 51 consecutive patients who underwent a second-generation CB ablation (Arctic Front Advance, Medtronic, Minneapolis, MN) for paroxysmal AF with a single big-balloon 3-minute freeze technique between July 2014 and December 2014, 41 patients (80.4%) were free from

Address reprint requests and correspondence: Dr. Shinsuke Miyazaki, Cardiology Division, Cardiovascular Center, Tsuchiura Kyodo Hospital. 11-7 Manabeshin-machi, Tsuchiura, Ibaraki 300-0053, Japan. E-mail address: mshinsuke@k3.dion.ne.jp.

1547-5271/$-see front matter http://dx.doi.org/10.1016/j.hrthm.2016.05.025

recurrent arrhythmias after a 3-month blanking period. Among these patients, 15 (36.6%) were prospectively enrolled for repeat procedures, whereas the remaining 26 refused consent. Among 135 consecutive patients who underwent the same procedure between July 2014 and August 2015, 25 who underwent repeat ablation for recurrent arrhythmias were analyzed for a comparison. AF was classified according to the latest guidelines.[2] All patients gave written informed consent. The study protocol was approved by the hospital's institutional review board, and the study complied with the principles of the Declaration of Helsinki.

Mapping and ablation protocol

All antiarrhythmic drugs were discontinued for at least 5 half-lives before the procedure. Preprocedural cardiac enhanced computed tomography was performed to evaluate cardiac anatomy. Surface ECG and bipolar intracardiac electrograms were continuously monitored and stored on a computer-based digital recording system (LabSystem PRO, Bard Electrophysiology, Lowell, MA). Bipolar electrograms were filtered from 30 to 500 Hz. A 7Fr 20-pole 3-site mapping catheter (BeeAT, Japan-Life-Line, Tokyo, Japan) was inserted through the right jugular vein for pacing, recording, and internal cardioversion.

The procedure was performed with patients under moderate sedation obtained with dexmedetomidine. Heparin 100 IU per kilogram body weight was administered immediately after venous access was obtained, and heparinized saline was additionally infused to maintain the activated clotting time at 250–350 seconds. A single transseptal puncture was performed using an RF needle (Baylis Medical Inc, Montreal, Quebec, Canada) and an 8-Fr long sheath (SL0, AF Division, SJM, Minneapolis, MN). The transseptal sheath was exchanged over a guidewire for a 15-Fr steerable sheath (Flexcath Advance, Medtronic). A spiral mapping catheter (Achieve, Medtronic) was used to advance the 28-mm second-generation CB into the PV for support and to map the PV potentials. After verification of complete sealing at the PV ostium using contrast medium, a freeze cycle of 180 seconds was applied. No additional applications were performed after the isolation. A 23-mm CB was not used in any cases. In order to avoid bilateral phrenic nerve injury,[10] all CB applications were applied under monitoring of ipsilateral diaphragmatic compound motor action potentials during phrenic nerve pacing.[11] The procedural endpoint was defined as an electrical PVI verified by a 20-mm circular mapping catheter (Lasso, Biosense Webster, Diamond Bar, CA), and was verified 20 minutes after the isolation. In addition, an adenosine triphosphate test was performed, and all dormant PV conduction was eliminated. Additional touch-up freezes with an 8-mm-tip conventional cryocatheter (Freezor MAX, Medtronic) were performed for 2 minutes for each application.

Second procedure

During the second procedure, at first, an electrical PVI was evaluated with a 20-mm circular mapping catheter (same as in the initial procedure). In reconnected PVs, the delay of the PV potential during sinus rhythm, which was defined as the time interval from the onset of the sinus P wave to the earliest potential recorded by any of the circular mapping catheter electrodes, was measured. Then, in cases with PV reconnections, PVI was achieved by a minimal focal RF ablation where the earliest PV potential was recorded. Subsequently, a pacing protocol was undertaken during an isoproterenol infusion and adenosine triphosphate injection to identify non-PV triggers. Cardioversion of sustained AF was undertaken. If an arrhythmogenic superior vena cava (SVC) was identified, an electrical SVC isolation was performed.

Follow-Up

No antiarrhythmic drugs were prescribed after the procedure. The patients underwent continuous, in-hospital ECG monitoring for 2–4 days after the procedure. The first outpatient clinic visit was 3 weeks after the procedure. Subsequent follow-up visits consisted of a clinical interview, ECGs, and 24-hour Holter monitoring every 3 months. To avoid missing asymptomatic recurrences, a 14-day consecutive monitoring was added using an external loop recorder (Spider Flash, Sorin, France)[12] at our cardiology clinic. Recurrence was defined as any atrial tachyarrhythmias lasting longer than 30 seconds, and a 3-month blanking period was applied according to the latest guidelines. Procedural success was defined as freedom from any recurrence without administration of any antiarrhythmic drugs.

Statistical analysis

Continuous data are expressed as mean ± SD for normally distributed variables or as median [25th, 75th percentiles] for non-normally distributed variables, and were compared using a Student t test or Mann–Whitney U test, respectively. Categorical variables were compared using the χ^2 test. $P < .05$ was considered significant.

Results

Patient characteristics and procedural results

Patient characteristics and procedural results are summarized in Tables 1 and 2. Of a total of 40 patients, 158 PVs, including 2 left common pulmonary veins PVs (LCPVs), were identified. Overall, 151 of 158 PVs (95.6%) were isolated successfully using exclusively a 28-mm CB. The mean number of CB applications resulting in PVI was 1.1 ± 0.6, 1.2 ± 0.5, 1.1 ± 0.3, 1.8 ± 1.2, and 3.0 ± 1.4 for the left superior pulmonary vein (LSPV), left inferior pulmonary vein (LIPV), right superior pulmonary vein (RSPV), right inferior pulmonary vein (RIPV), and LCPV, respectively. Real-time recordings of the PV potentials was possible on the spiral Achieve catheter during the cryoapplications in a total of 82 PVs (51.9%), including 26 LSPVs, 19 LIPVs, 21 RSPVs, and 16 RIPVs. Touch-up lesions were created in the remaining 7 PVs (4.4%) with a cryocatheter, and all were RIPVs. In total, all 158 PVs were successfully isolated by cryothermal ablation. Except for 6 patients with