Sequential biatrial linear defragmentation approach for persistent atrial fibrillation

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BACKGROUND The strategy for catheter ablation of persistent atrial fibrillation (AF) and the procedural end point remain controversial.

OBJECTIVE To evaluate the feasibility of a sequential defragmentation approach.

METHODS One hundred thirty-five patients (aged 62.4±9 years; 76 long-standing persistent AF) underwent first ablation procedure for persistent AF. With an end point of AF termination, the ablation procedure was performed sequentially in the following order: pulmonary vein antrum isolation, linear defragmentation of complex fractionated electrograms at left atrial (LA) roof, bottom, septum, inferior LA, base of LA appendage, anterior LA, right atrial septum, crista terminalis, and base of right atrial appendage. Ensuing atrial tachycardias (ATs) were mapped and ablated.

RESULTS AF termination was achieved in 69 (51%) patients (59 in the left atrium and 10 in the right atrium). The total procedure and fluoroscopic times were 145.4±36.1 and 35.1±14.3 minutes, respectively. At median 19.0 months, 105 (78%) patients demonstrated recurrent atrial tachyarrhythmia necessitating repeat ablation procedure(s). With mean 1.7±0.7 procedures per patient, 100 (74%) patients were free from atrial tachyarrhythmia at median 15.0-month follow-up. Among 73 mappable ATs, 49 were macroreentrant ATs. On multivariate Cox regression analysis, greater LA diameter (hazard ratio 1.10; 95% confidence interval 1.04–1.17; $P = .0004$) and non-AF termination (hazard ratio 1.50; 95% confidence interval 1.01–2.36; $P = .036$) were independent predictors of AF recurrence after single and multiple ablation procedures, respectively.

CONCLUSIONS Pulmonary vein antrum isolation followed by biatrial substrate modification in a predetermined order of linear ablation of specific anatomical regions with predilection for complex fractionated atrial electrograms is a feasible alternative persistent AF ablation strategy.

KEYWORDS Catheter ablation; Atrial fibrillation; Persistent atrial fibrillation

ABBREVIATIONS **AF** = atrial fibrillation; **AT** = atrial tachycardia; **BNP** = brain natriuretic peptide; **CFAE** = complex fractionated atrial electrogram; **CS** = coronary sinus; **CTI** = cavotricuspid isthmus; **ECG** = electrocardiogram; **LA** = left atrial; **LV** = left ventricular; **PV** = pulmonary vein; **PVAI** = pulmonary vein antrum isolation; **RA** = right atrial

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Introduction

Catheter ablation is an established therapy for paroxysmal atrial fibrillation (AF),[1–3] and pulmonary vein antrum isolation (PVAI) has become a widely accepted strategy.[3–5] While the ablation strategy for persistent AF and the procedural end point remain controversial, various ablation strategies such as those targeting complex fractionated atrial electrograms (CFAEs),[6] linear lesions,[7–9] and their combinations[10–13] have been proposed. This prospective clinical study was designed to evaluate the feasibility of a new sequential biatrial linear defragmentation approach in the ablation of persistent AF and to determine its electrophysiological and clinical outcomes.

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Methods

The study comprised 135 consecutive patients undergoing catheter ablation for persistent AF (Table 1) between January 2010 and March 2011 at our institution. AF was defined as persistent (sustained beyond 7 days or lasting less than 7 days but necessitating cardioversion) or long-standing persistent (continuous AF of greater than 1-year duration) according to the HRS/EHRA/ECAS 2012 Consensus Statement on Catheter and Surgical Ablation of AF.[14] All patients were in AF spontaneously at the beginning of the procedure and had provided written informed consent before the procedure.

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Table 1 Clinical characteristics

N	135
Age (y)	62.4±9.0
Sex: Male	115 (85.2%)
Hypertension	69 (51.1%)
Structural heart disease	12 (8.9%)
Cardiomyopathy	6 (4.5%)
Valvular disease	4 (3.0%)
Coronary disease	2 (1.5%)
Type of AF	
Persistent	59 (43.7%)
Long-standing persistent	76 (56.3%)
AF duration (mo)	48 (19–96)
AF lasting duration (mo)	24 (6–54)
LA diameter (mm)	47.2±4.9
LV ejection fraction (%)	60.6±9.9
$CHADS_2$	1.1±1.1
CHA_2DS_2-VAS_C	1.7±1.3

AF = atrial fibrillation; LA = left atrium; LV = left ventricular. Data represent mean ± SD or number (percentage).

Electrophysiological study

All antiarrhythmic medications were discontinued at least 5 half-lives before ablation. All patients were anticoagulated with warfarin for at least 1 month before the procedure (target INR2–3), and therapeutic anticoagulation was maintained with intravenous heparin after warfarin discontinuation 3 days before the intervention. Transesophageal echocardiography was performed within 24 hours preprocedurally to exclude left atrial (LA) thrombus. Warfarin was readministered on the day of the procedure and effective anticoagulation maintained with heparin until the INR was greater than 2. An enhanced cardiac computer tomography was performed for the evaluation of relevant cardiac anatomy before the procedure in all patients.

The surface electrocardiogram (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 7-F, 20-pole or 14-pole two-site mapping catheter (Irvine Biomedical Inc, Irvin, CA) was inserted through the right jugular vein and positioned in the coronary sinus (CS) for pacing, recording, and internal cardioversion. The electrophysiological study was performed under mild sedation with pentazocine and hydroxyzine pamoate.

Catheter ablation protocol

After 1 transseptal puncture, 2 long sheaths (SL0, SJM, Minneapolis, MN) were introduced into both superior PVs. Pulmonary venography during ventricular pacing and contrast esophagography were performed to obtain the relative locations of the pulmonary vein (PV) ostia vis-à-vis esophagus. A 100 IU/kg body weight of heparin was administered after the transseptal puncture, and heparinized saline was additionally infused to maintain the activated clotting time at 300–350 seconds. Ipsilateral PVs were circumferentially ablated under the guidance of a 3-dimensional (3D) mapping system (CARTO3, Biosense Webster, Diamond Bar, CA) with the double-lasso technique.[2,3,5] During AF, PVAI was defined as abolition of all PV potentials within the continuous circumferential lesions.[15] After the restoration of sinus rhythm, bidirectional conduction block between LA and PVs was confirmed by the pacing technique. Radiofrequency current was delivered point by point for 30 seconds with 3.5-mm externally irrigated-tip ablation catheter (Thermocool, Biosense Webster) with power up to 35 W, target temperature $\leq 38^{\circ}$C, and irrigation rate 30 mL/min. The power was limited to 20 W on the posterior wall within 1 cm from the esophagus on fluoroscopy. The substrate modification, when AF persisted after PVAI, was performed sequentially in a predetermined (fixed) order of ablation (Figure 1). Linear point-by-point lesions guided by the 3D mapping system in the regions with predilection for CAFE were undertaken sequentially in the following order: LA roof and bottom—lines connecting PV circumferential lesions; LA septum—from high septum on the right circumferential line to fossa ovalis; inferior LA along the CS (from 6 to 3 o'clock); base of the LA appendage; LA anterior wall; right atrial (RA) septum from RA superior vena cava junction to fossa ovalis; crista terminalis; and base of the RA appendage. All lesions were deployed to draw a continuous line of ablation even if there were areas without CFAE in between the sites displaying CFAE. Regarding the base of the appendage and the LA anterior wall, we targeted CFAEs. The end point of the substrate ablation was termination of AF and restoration of sinus rhythm by ablation (Figure 2). If AF continued after this step, the patients underwent internal electrical cardioversion. No antiarrhythmic drugs were given during the procedure. Termination of AF was defined as conversion of AF to sinus rhythm directly or via 1 or more intermediate atrial tachycardias (ATs). If AF was converted to an AT, it was mapped and ablated by using activation 3D mapping and entrainment maneuvers.[16] When a critical isthmus of the macroreentrant circuit was identified, the lesions were deployed to achieve complete bidirectional conduction block.[7,8,17,18] After restoration of sinus rhythm, a cavotricuspid isthmus (CTI) line was created with an end point of bidirectional conduction block in all patients. The total procedure time was defined from the start of vascular access until the removal of all sheaths.

Repeat procedure

In patients with recurrence of atrial tachyarrhythmias, PVAI was evaluated first. In the presence of conduction recovery, reisolation of the PVs was performed. Patients with recurrent AF underwent a repeat stepwise ablation with the same strategy as in the initial procedure. If a stable AT was present, its mechanism was deduced using 3D activation and entrainment mapping.

Other parameters

All patients underwent transthoracic echocardiogram before the procedure and during the follow-up period. LA parasternal diameter and left ventricular (LV) function (Simpson)