Journal of the American College of Cardiology
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Published by Elsevier Inc.

Vol. 55, No. 10, 2010
ISSN 0735-1097/10/$36.00
doi:10.1016/j.jacc.2009.09.060

Disparate Evolution of Right and Left Atrial Rate During Ablation of Long-Lasting Persistent Atrial Fibrillation

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Objectives The purpose of this study was to assess whether additional ablation in the right atrium (RA) improves termination rate in long-lasting persistent atrial fibrillation (PsAF).

Background Prolongation of atrial fibrillation (AF) cycle length (CL) measured from the left atrial appendage predicts favorable outcome during catheter ablation of PsAF. However, in some patients, despite prolongation of AF CL in the left atrium (LA) with ablation, AF persists. We hypothesized that this persistence is due to RA drivers, and that these patients may benefit from RA ablation.

Methods In all, 148 consecutive patients undergoing catheter ablation of PsAF (duration 25 ± 32 months) were studied. AF CL was monitored in both atria during stepwise ablation commencing in the LA. Ablation was performed in the RA when all LA sources in AF had been ablated and an RA-LA gradient existed. The procedural end point was AF termination.

Results Two distinct patterns of AF CL change emerged during LA ablation. In 104 patients (70%), there was parallel increase of AF CL in LA and RA culminating in AF termination (baseline: LA 153 ms [range 140 to 170 ms], RA 155 ms [range 143 to 171 ms]; after ablation: LA 181 ms [range 170 to 200 ms], RA 186 ms [range 175 to 202 ms]). In 24 patients (19%), RA AF CL did not prolong, creating a right-to-left frequency gradient (baseline: LA 142 ms [range 143 to 153 ms], RA 145 ms [range 139 to 162 ms]; after ablation: LA 177 ms [range 165 to 185 ms], RA 152 ms [range 147 to 175 ms]). These patients had a longer AF history (23 months vs. 12 months, $p = 0.001$), and larger RA diameter (42 mm vs. 39 mm, $p = 0.005$), and RA ablation terminated AF in 55%. In the remaining 20 patients, biatrial ablation failed to terminate AF.

Conclusions A divergent pattern of AF CL prolongation after LA ablation resulted in a right-to-left gradient, demonstrating that the right atrium is driving AF in ≈20% of PsAF. (J Am Coll Cardiol 2010;55:1007–16) © 2010 by the American College of Cardiology Foundation

Left atrium (LA) tissue is often necessary to ablate in addition to pulmonary vein isolation (PVI) to achieve optimal results in patients with long-lasting persistent atrial fibrillation (PsAF) (1–12). During ablation, prolongation of atrial fibrillation (AF) cycle length (CL) occurs in the left atrium with its magnitude predicting procedural termination of AF. However, the need for right atrium (RA) ablation has not yet been clearly established in studies using surgery or catheter ablation (13), with some studies showing no utility of RA ablation and other studies showing benefit (14). As a result, it is unclear whether it is possible to identify a subset of patients who may benefit from additional RA ablation for long-lasting PsAF.

We hypothesized that failure to terminate AF after LA ablation is due to RA drivers, and these patients may benefit from additional RA ablation. Furthermore, we evaluated the

From the Hôpital Cardiologique du Haut-Lévêque, Bordeaux-Pessac, and Université Victor Segalen, Bordeaux, France. Dr. Hocini has received speaker honoraria from Biosense Webster. Dr. Nault is supported by a St. Jude Medical grant. Dr. Narayan is a member of the Speakers' Bureau and has fellowship funding from St. Jude Medical, Boston Scientific, and Medtronic, and has received consulting fees from Biosense Webster. Dr. Jaïs has received speaker honoraria from St. Jude Medical. Dr. Miyazaki has received fellowship support from St. Jude Medical. Dr. Haïssaguerre has received speaker honoraria from Biosense Webster. Hakan Oral, MD, served as Guest Editor for this article.

Manuscript received May 25, 2009; revised manuscript received September 11, 2009, accepted September 15, 2009.

JACC Vol. 55, No. 10, 2010
March 9, 2010:1007–16

Abbreviations and Acronyms

AF = atrial fibrillation
AT = atrial tachycardia
CL = cycle length
CS = coronary sinus
LA = left atrium
LAA = left atrial appendage
PsAF = persistent atrial fibrillation
PV = pulmonary vein
PVI = pulmonary vein isolation
RA = right atrium
RF = radiofrequency
RAA = right atrial appendage
SR = sinus rhythm
SVC = superior vena cava

clinical and procedural factors predictive of the need for RA ablation, the extent of ablation required, its impact on AF termination, and long-term clinical outcome.

Methods

Study population. This study population consisted of 148 consecutive patients (119 males, age 58 ± 10 years) with symptomatic long-lasting PsAF referred for catheter ablation. Baseline characteristics are presented in Table 1.

Electrophysiologic study. All patients provided written informed consent. Antiarrhythmics agents were discontinued ≥5 half-lives before ablation, with the exception of amiodarone. Before the procedure, patients were receiving oral anticoagulant agents targeting an international normalized ratio of 2 to 3 for at least 1 month, and transesophageal echocardiography was performed within 5 days to exclude atrial thrombus. A transthoracic echocardiogram was performed within 1 week preceding the procedure. The RA and LA longitudinal and transverse diameters were measured in the apical view at end-systole from the tip of the mitral or tricuspid valve to the posterior wall of the LA or RA, and the LA parasternal diameter in the parasternal long-axis view at end-systole from the trailing edge of the posterior aortic wall to the leading edge of the posterior LA.

Surface electrocardiogram and bipolar endocardial electrograms were monitored continuously and stored on a computer-based digital amplifier/recorder system (Labsystem Pro, Bard Electrophysiology, C. R. Bard Inc., Lowell, Massachusetts). Intracardiac electrograms were filtered from 30 to 500 Hz.

The following catheters were introduced through the right femoral vein for the electrophysiological study: 1) a steerable quadripolar or decapolar catheter (Xtrem, formerly ELA Medical LLC, Plymouth, Minnesota), 5-mm electrode spacing, was positioned within either the coronary sinus (CS) with the proximal electrode positioned at 4 to 5 o'clock along the mitral annulus or the left atrial appendage (LAA) or the lateral RA; 2) a 10-pole circumferential catheter was used for mapping the pulmonary veins (Lasso, Biosense-Webster, Diamond Bar, California), and was introduced after transseptal access through a long sheath (SLO, St. Jude Medical, Sylmar, California) perfused continuously with heparinized D5W; after PVI, this catheter was placed in either the LAA or RAA; and 3) an irrigated-tip radiofrequency (RF) ablation catheter with a distal 3.5-mm tip (Thermocool, Biosense-Webster). For RA ablation, the ablation catheter was introduced through the long sheath. After transseptal puncture, a single bolus of heparin, 50 IU/kg, was administered.

Study protocol. The procedural end point was termination of AF to either an intermediate atrial tachycardia (AT) or directly to sinus rhythm (SR) by RF application during the index procedure. After restoration of SR, PVI was rechecked and conduction across any of the linear lesions performed (15,16). Additional RF applications were performed to achieve PVI and linear block. No attempt at reinduction was made. Duration of RF in the RA was limited to 25 min, as LA ablation of fractionated activity is

Table 1 Baseline Characteristics

	LA Termination (n = 104)	RA Termination (n = 24)	Nontermination (n = 20)	p Value
Age, yrs	58 ± 10	60 ± 11	58 ± 11	0.72
Males	79%	83%	80%	0.89
AF duration	12 (6–20)*†	23 (12–48)*	35 (12–72)†	<0.001*†
Hypertension	27%	23%	28%	0.92
SHD	41%	46%	50%	0.74
Emboli	5%	5%	12%	0.56
Heart failure	19%	8%	26%	0.76
No AAD	2.5 (2–3)	3 (1–3)	3 (2–3)	0.75
LVEDD	53 (48–57)	52 (48–61)	54 (50–60)	0.33
LVESD	36 (30–41)	35 (28–44)	39 (34–44)	0.45
LVEF	56 ± 13	59 ± 12	55 ± 14	0.49
LA parasternal	48 ± 8*	48 ± 7*†	57 ± 9*†	<0.001*†
LA longitudinal	61 ± 7*	61 ± 7*†	67 ± 9†	0.01*†
LA transversal	45 (42–50)*	43 (40–47)*†	51 (45–57)†	0.009*†
RA longitudinal	54 (49–58)*	56 (52–61)	58 (53–66)*	0.02*
RA transversal	39 ± 7*	42 ± 7	45 ± 8*	0.005*

Values are mean ± SD, %, or n (range). Data compared using analysis of variance (ANOVA) for means, ANOVA on ranks for medians, and chi-square test for categorical data. *Statistically significant p values ≤0.05. †Statistically significant difference between marked variables.

AAD = antiarrhythmic drug; AF = atrial fibrillation; LA = left atrium; LVEDD = left ventricular end-diastolic diameter; LVEF = left ventricular ejection fraction; LVESD = left ventricular end-systolic diameter; RA = right atrium; SHD = structural heart disease.