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Radiofrequency ablation of left atrial flutter mediated with double potentials in a seemingly normally structured heart

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ABSTRACT

Background: Left atrial flutter (left AFL) is common in patients who undergo atrial fibrillation ablation and cardiac surgery; however, few reports describe left AFL in detail in a seemingly normally structured heart, and the mechanisms of the occurrence of such arrhythmia are still not clear. We describe left AFL in patients without prior cardiac surgery or catheter ablation and discuss the electrophysiological characteristics that may explain the preferential generation and perpetuation of such tachycardia.

Methods and results: Eleven patients with left AFL, who had no history of cardiac surgery or interventions, underwent electrophysiological studies and 3-dimensional electroanatomic mapping studies. Echocardiography revealed a relatively mild dilation of the left atrium, mild to moderate mitral regurgitation, and a normal left ventricular ejection fraction. The electroanatomic mapping during tachycardia showed a "reentrant" activation pattern in all patients. The mean tachycardia cycle length was 266 ± 17 ms. A single-loop reentrant circuit was identified in 7 patients. A counterclockwise left atrial flutter evolved around the mitral valve annulus in 6 patients. The tachycardia rotated around the left atrial anterior wall in 1 patient. Four patients exhibited a double-loop reentrant circuit with a "figure of 8" pattern reentry. Double potentials as the critical isthmus of the circuit were identified in the left atrial anterior wall near the mitral annulus which displayed a low-voltage area matched with the left atrium–aorta contiguity. The conduction velocity was significantly slower in the double-potential recording area than in the lateral mitral annulus (0.36 ± 0.03 m/s vs 0.74 ± 0.12 m/s; $P < 0.05$). Successful ablation around the double-potential recording site caused an interruption of the tachycardia, and remained free of recurrence during a 12-month follow-up in all patients.

Conclusion: Left AFL in patients without a history of surgery or ablation is rarely observed in clinical practice. The successful site of ablation was within the anterior wall near the mitral annulus showing the double potentials as the critical part of the reentrant circuit. This suggests that perhaps a double potential-targeted ablation may be effective for these patients.

1. Introduction

Atrial flutter (AFL) is a common rhythm disorder that persists by complex reentrant impulse propagation within the atria. A variety of reentrant circuits of AFL has been described in the left atrium (LA) after atriotomy or catheter ablation of atrial fibrillation (AF) [1], because of the regions of blocked or slowed conduction in the atrial surgical incisions or gaps in an isolation line. However, atrial tachycardia in patients without any prior atriotomy or catheter ablation had been reported recently, but still rarely. The nature of the atrial substrate of such an arrhythmia is still not well characterized, with some being explained as spontaneous scar-related AFL. The potential arrhythmogenic substrates and unique electroanatomical properties within the LA may be linked to these rare left AFL. The aim of this study was to characterize the electrophysiological characteristics that may explain the preferential generation and perpetuation of this special left AFL, in patients with a seemingly normally structured heart.

2. Material and methods

2.1. Patients

This study included a total of 11 patients with a seemingly normally structured heart who underwent electrophysiological study (EPS) and radiofrequency (RF) ablation during ongoing AFL. There were 5 males and 6 females, aged from 50 to 66 years. These patients had no history of cardiac surgery or cardiac interventions, and were without concomitant heart disease, hypertension, diabetes mellitus, thyroid disease or chronic obstructive pulmonary disease. All patients underwent an initial evaluation that included physical examination, and electrocardiogram (ECG), chest radiography and echocardiogram tests. The patients were refractory to more than two antiarrhythmic drugs (β blocker, verapamil, amiodarone, ibutilide, and propafenone). Antiarrhythmic drugs were discontinued for 5 half-lives prior to the electrophysiological study with the exception of amiodarone, which was discontinued at least 4 weeks before the procedure. A transesophageal

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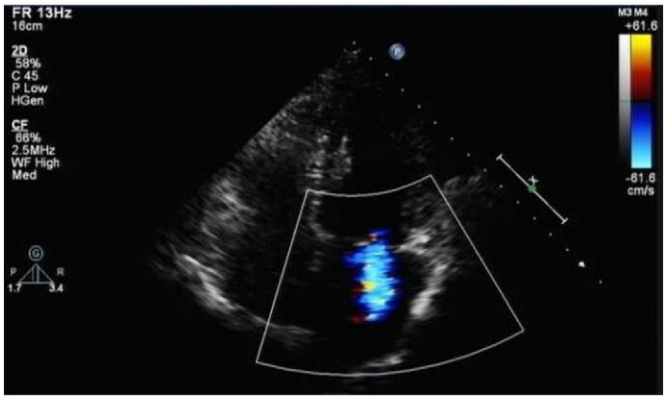

Fig. 1. Typical 2D transthoracic echo image of patient #3 with moderate mitral regurgitation (MR).

echocardiogram on the day of the procedure confirmed the absence of an atrial thrombus. The informed consent was obtained before the procedure.

2.2. Electrophysiological study

All patients underwent EPS under local anesthesia. The catheters were introduced through the subclavian and femoral veins: (1) A 6-French quadripolar deflectable catheter was placed in the right ventricle apex. (2) A 6-French decapolar deflectable catheter was positioned within the coronary sinus (CS) for endocardial recording. (3) A transseptal puncture was performed under fluoroscopic guidance, and an 8-French externally saline irrigated Coolpath ablation catheter (NaviStar ThermoCool, Biosense Webster) was advanced across the inter-atrial septum and was positioned in the LA for atrial mapping, pacing, and ablation. Intravenous heparin was administered to maintain an activated clotting time of ≥300 s after the transseptal puncture. If a sinus rhythm was present at baseline, AFL was induced using burst pacing, with isoproterenol when necessary (the induced AFL was identical to the clinical arrhythmia). Entrainment pacing was used to confirm the reentrant circuit of the arrhythmia. A post-pacing interval (PPI)–tachycardia cycle length (TCL) <20 milliseconds (ms) indicated that a particular pacing site was likely involved in the tachycardia circuit [2]. Surface ECG and intracardiac electrograms were continuously recorded on the electrophysiology workstation (Cardiolab, GE, Freiburg, Germany). Intracardiac signals were filtered at a bandpass of 30–500 Hz.

2.3. Three-dimensional mapping

Electroanatomic mapping (EAM) was available in all patients using a 3-dimensional (3-D) electroanatomical mapping system (CARTO, Biosense Webster). Before the LA was approached, right atrial flutter was excluded. We created the entire left atrial 3D geometry during tachycardia with sufficient mapping points to identify the underlying mechanism. A stable signal from the distal CS was used as the timing reference for local activation. All activation times were defined off the reference and average conduction velocity (CV) was calculated. A reentrant circuit was defined as a continuous sequence of atrial activation with the earliest activation adjacent to the latest activation, and a range of activation times ≥90% of the TCL.

During activation mapping, a bipolar voltage map was constructed simultaneously. The voltage of the bipolar atrial potential recorded at each site was also displayed in color (lowest, red; greatest, purple). The low-voltage zone was defined by the presence of a bipolar voltage ≤0.3 mV.

2.4. Assessment of double potentials and conduction

Double potentials (DPs) were defined as those with 2 discrete deflections separated by an isoelectric interval [3].

Using a CARTO isochronal map, the CV can be quantitatively estimated by using the distance between 2 points on the electroanatomical activation map and the difference between their activation times. Normal CV ranges lie between 0.60 and 1.15 m/s, whereas values below 0.40 m/s definitively identify areas of slow conduction [4,5].

2.5. Catheter ablation

After identification of the presumed reentrant circuit, RF energy was delivered through a Cordis-Stockert generator (Biosense Webster) during irrigation at a rate of 17 ml/min via the Cool Flow pump (Biosense Webster). The RF power output was limited to 30 W, with a target temperature of maximal 45 °C. The RF delivery was applied for 30–60 s at each site. Procedure success was defined as termination and noninducibility of the AFL.

2.6. Statistical analysis

Continuous variables are expressed as mean ± standard deviation or median with range, and are compared using the Student unpaired *t* test. A P value <0.05 was considered statistically significant.

3. Results

3.1. Patient characteristics

The atypical AFL was persistent or paroxysmal in all patients with a 12-lead ECG showing 2:1 or 3:1 atrioventricular (AV) conduction. The median duration of symptoms was 8.7 ± 6.4 months (11.5 ± 3.8 months for paroxysmal patients and 1.5 ± 1.0 months for persistent patients). Physical examination and chest radiography showed no evidence of structural heart disease. Echocardiography revealed a relatively mild dilation of the LA (40.1 ± 3.1 mm), a normal left ventricular ejection fraction (60 ± 2%) and structurally normal cardiac valves. The mitral regurgitation (MR) was assessed semi-quantitatively as follows: 0 (no regurgitation), 1 (trace), 2 (mild), 3 (moderate), and 4 (severe). Mild to moderate MR was present in all patients (Fig. 1). The mean LA volume measured by the CARTO system was 134 ± 15 ml (Table 1).

3.2. Analysis of surface ECG patterns

All patients had a documented ECG showing AFL with a longer mean cycle length (TCL of 250 ms to 300 ms). An ECG pattern of atypical flutter was observed, associated with positive F waves in both V1 and the inferior leads (II, III, and avF). Lead I showed low amplitude negative or was flat. A distinct isoelectric interval between the surface F waves was observed, and F waves showed low amplitude or were flat in 9 of 11 patients. A distal-to-proximal CS activation during the tachycardia was indicative of the LA origin in the 11 patients.

Table 1
Patient clinical characteristics.

1	Gender (F/M)	Age (years)	LA diameter (mm)	LVEF (%)	MR	LAV (ml)	CL (ms)	Circuit
1	M	52	37	62	2	117	250	Single loop
2	F	50	38	61	2	129	264	Double loop
3	M	59	40	60	3	135	268	Single loop
4	M	54	37	62	2	126	254	Single loop
5	F	57	47	57	3	166	300	Double loop
6	M	61	39	61	3	133	256	Single loop
7	M	66	43	59	3	156	296	Double loop
8	F	54	40	61	3	132	250	Single loop
9	F	53	39	60	2	130	266	Single loop
10	F	58	43	58	3	145	270	Double loop
11	F	57	38	59	2	119	258	Single loop

LA = left atrium; LVEF = left ventricular ejection fraction; LAV = LA volume calculated by the CARTO system; MR = mitral regurgitation graded semi-quantitatively as follows: 0 (no regurgitation), 1 (trace), 2 (mild), 3 (moderate), and 4 (severe).