Multimodality imaging to guide cardiac interventional procedures

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Effect of radiofrequency catheter ablation for atrial fibrillation on left atrial cavity size

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ABSTRACT

Left atrial (LA) remodeling is associated with atrial fibrillation (AF). Radiofrequency catheter ablation offers a good treatment option for AF, with reasonable long-term results. The purpose of the current study was to assess whether LA reverse remodeling occurs after successful catheter ablation. Fifty-seven consecutive patients (45 men, age 53 ± 8 years) with symptomatic drug-refractory AF were treated with radiofrequency catheter ablation. Patients were divided in 2 groups based on recurrence of AF on Holter monitoring and 12-lead ECG at 6 weeks and 3 months follow-up (SR-group: no recurrence; AF-group: recurrence of AF). At baseline and 3 months follow-up, 2-dimensional echocardiography was performed to assess LA size and dimensions. Furthermore, LA volumes were measured at end-systole (LAESV) and end-diastole (LAEDV). After 3 months 39 of 57 patients (68%) maintained sinus rhythm. At 3 months follow-up, LA anteroposterior diameter showed a significant reduction in the SR-group (4.5 ± 0.3 cm vs. 4.2 ± 0.2 cm, $p<0.01$), whereas a further increase was observed in the AF-group (4.5 ± 0.3 cm vs. 4.8 ± 0.3 cm, $p<0.05$). Furthermore, LAESV and LAEDV decreased significantly in the SR-group from baseline to follow-up (LAESV 59 ± 12 ml vs. 50 ± 11 ml, $p<0.01$; LAEDV 37 ± 9 ml vs. 31 ± 7 ml, $p<0.01$), whereas a tendency towards an increase in LA volumes was observed in the AF-group. In conclusion, this study demonstrates that LA reverse remodeling occurs after successful radiofrequency catheter ablation for AF.

INTRODUCTION

Radiofrequency catheter ablation offers a curative treatment modality for patients with drug-refractory atrial fibrillation (AF) (1). Anatomical based electrical isolation of pulmonary veins has proven to be a safe method with reasonable long-term results (2). However, the effect of radiofrequency catheter ablation on left atrial (LA) size has not been evaluated extensively. Accordingly, the purpose of the current study was to assess whether LA reverse remodeling occurs after successful radiofrequency catheter ablation for AF.

METHODS

The study population consisted of 57 consecutive patients (45 men, age 53 ± 8 years) with symptomatic drug-refractory AF, who were referred for radiofrequency catheter ablation. AF was present for 6 ± 5 years and was paroxysmal in 35 (61%), persistent in 18 (32%) and permanent in 4 (7%). In 17 patients ablation of atrial flutter was performed previously.

Radiofrequency ablation

The ablation procedure was aimed at electrical isolation of all pulmonary veins from the LA. With the use of phased-array intracardiac echocardiography an intracardiac thrombus was excluded and a transseptal puncture was guided. Endocardial mapping was performed with a 4 mm quadripolar mapping/ablation catheter (7F Thermocool, Biosense Webster, California, USA), using a 3-dimensional electroanatomical mapping system (CARTO^{TM}, Biosense Webster). A 6F diagnostic catheter placed in the right atrium served as a temporal reference.

Radiofrequency current was applied outside the ostia of all pulmonary veins, using the ablation catheter with a 4 mm open loop irrigated tip. Additional lines were targeted between the mitral annulus and the left inferior pulmonary vein (mitral isthmus line) and between the ostia of the left and right superior pulmonary veins (roof line). The following power and temperature settings were used: irrigation rate 20 mL/min, maximum temperature 50°C, maximum radiofrequency energy 30 W. At each point, radiofrequency current was applied until a voltage <0.1 mV was achieved, with a maximum of 60 seconds per point. The procedure was considered successful when pulmonary vein isolation was confirmed by recording entrance block during sinus rhythm or pacing in the coronary sinus. All patients received heparin intravenously (activated clotting time > 300 sec) to avoid thrombo-embolic complications.

Follow-up

After the ablation procedure rhythm was continuously monitored until discharge. Patients received heparin intravenously until INR was adequate with oral anticoagulants. Transthoracic

2-dimensional echocardiography was performed within 24 hours after the ablation procedure to detect pericardial effusion.

Follow-up was scheduled at 6 weeks and 3 months after the ablation procedure. Follow-up at 6 weeks consisted of an outpatient clinic visit with a 12-lead surface ECG. At 3 months follow-up, 24-hour Holter monitoring, a 12-lead surface ECG, and a standard 2-dimensional echocardiogram were performed. During the 3 months follow-up all medication, including anti-arrhythmic drugs, was continued in all patients. Patients were divided into 2 groups based on their rhythm during follow-up. Group 1 maintained sinus rhythm during the 3 months follow-up (SR-group) whereas group 2 had recurrence of AF during follow-up (AF-group).

Echocardiography

Two-dimensional echocardiography was performed 2 days before the ablation procedure, and at 3 months follow-up. Two-dimensional images were recorded with patients in the left lateral decubitus position using a commercially available system (Vingmed system Seven, General Electric-Vingmed, Milwaukee, Wisconsin, USA). Images were obtained using a 3.5-MHz transducer at a depth of 16 cm in the parasternal and apical views (standard long-axis and 2- and 4-chamber images). Standard 2-dimensional images and color Doppler data triggered to the QRS complex were saved in cine loop format.

LA measurements were performed off-line using commercial software (Echopac 6.1, General Electric-Vingmed). LA anteroposterior diameter was measured at end-systole on the M-mode image obtained from the parasternal long-axis view (3). Short- and long-axis of the LA were measured on apical 4-chamber views at end-systole. Furthermore, LA volumes were measured on apical 2- and 4-chamber views using the biplane Simpson's rule (4,5). Measurements on LA volumes were acquired from 3 consecutive beats, and subsequently averaged. Left atrial end-systolic volume (LAESV) was defined as the largest LA volume in ventricular systole; left atrial end-diastolic volume (LAEDV) was defined as the smallest possible LA volume in ventricular diastole (5). Inter- and intraobserver agreement for the assessment of LA volumes were 92% and 95%, respectively.

Statistical analysis

Data are expressed as mean ± SD or number (%), as appropriate. Continuous variables were compared using the nonparametric Mann-Whitney U test for unpaired variables or the nonparametric Wilcoxon signed-ranks test for paired variables. The chi-square test was used to test categorical variables. All statistical tests were performed using SPSS 12.0 software for Windows. A p-value <0.05 was considered significant.

RESULTS

A total number of 57 patients were treated with radiofrequency catheter ablation for AF. Immediate success of the procedure was achieved in all patients. In 3 patients (5%) mild pericardial effusion (<1.0 cm) was observed within 24 hours after the ablation procedure, without hemodynamic consequences. No acute complications were observed. Complete rhythm and echocardiography follow-up data was available in all patients.

After 3 months follow-up, 39 of 57 patients (68%) maintained sinus rhythm. The study population was divided in 2 groups (with maintained sinus rhythm or relapsed AF). Baseline characteristics of the 2 groups are listed in Table 1. There were no significant differences in baseline characteristics between the AF-group and the SR-group. Only the proportion of patients with non-paroxysmal AF at baseline was higher in the AF-group as compared to the SR-group (72% versus 23%, p<0.05).

Table 1. Clinical characteristics of patients with maintenance of sinus rhythm (SR-group) and recurrence of atrial fibrillation (AF-group)

Variable	SR-group (n=39)	AF-group (n=18)
Age (years)	53 ± 9	54 ± 8
Men/Women	32/7	13/5
Body surface area (m^2)	2.07 ± 0.16	2.07 ± 0.17
Non-paroxysmal AF	9 (23%)	13 (72%)*
Duration AF (years)	7 ± 5	5 ± 4
Number of anti-arrhythmic drugs per patient	3.5 ± 1.8	4.0 ± 1.5
Left ventricular ejection fraction (%)	55 ± 9	54 ± 6
Valvular disease	4 (10%)	2 (11%)
Hypertension	13 (33%)	4 (22%)
Coronary artery disease	2 (5%)	2 (11%)

* p <0.05 SR-group vs AF-group.

Left atrial dimensions and volumes

The LA dimensions (anteroposterior diameter, short- and long-axis) and volumes at baseline and 3 months follow-up are listed in Table 2. Baseline echocardiographic parameters were

Table 2. Left atrial dimensions and volumes at baseline and 3 months follow-up

Variable	SR-group (n=39)	AF-group (n=18)
Baseline		
LA anteroposterior diameter (cm)	4.5 ± 0.3	4.5 ± 0.3
LA short axis (cm)	4.5 ± 0.3	4.6 ± 0.2
LA long axis (cm)	5.1 ± 0.3	5.2 ± 0.4
LAEDV (ml)	59 ± 12	63 ± 7
LAESV (ml)	37 ± 9	43 ± 7*
3 months follow-up		
LA anteroposterior diameter (cm)	4.2 ± 0.2†	4.8 ± 0.3*‡
LA short axis (cm)	4.2 ± 0.3†	4.8 ± 0.3*‡
LA long axis (cm)	4.6 ± 0.4†	5.3 ± 0.3*
LAEDV (ml)	50 ± 11†	68 ± 8*
LAESV (ml)	31 ± 7†	47 ± 7*

*p <0.05 SR-group vs AF-group; †p<0.01 baseline vs 3 months follow-up; ‡p<0.05 baseline vs 3 months follow-up.

similar in both groups, except that the LAEDV was significantly smaller in the SR-group as compared to the AF-group (37 ± 9 ml vs. 43 ± 7 ml, p<0.05).

At 3 months follow-up, the LA anteroposterior diameter had decreased significantly in the SR-group (baseline 4.5 ± 0.3 cm vs. follow-up 4.2 ± 0.2 cm, p<0.01). In contrast, in the AF-group, the LA anteroposterior diameter increased significantly from 4.5 ± 0.3 cm to 4.8 ± 0.3 cm (p<0.05) (Figure 1). In addition, at 3 months follow-up LAESV and LAEDV had decreased

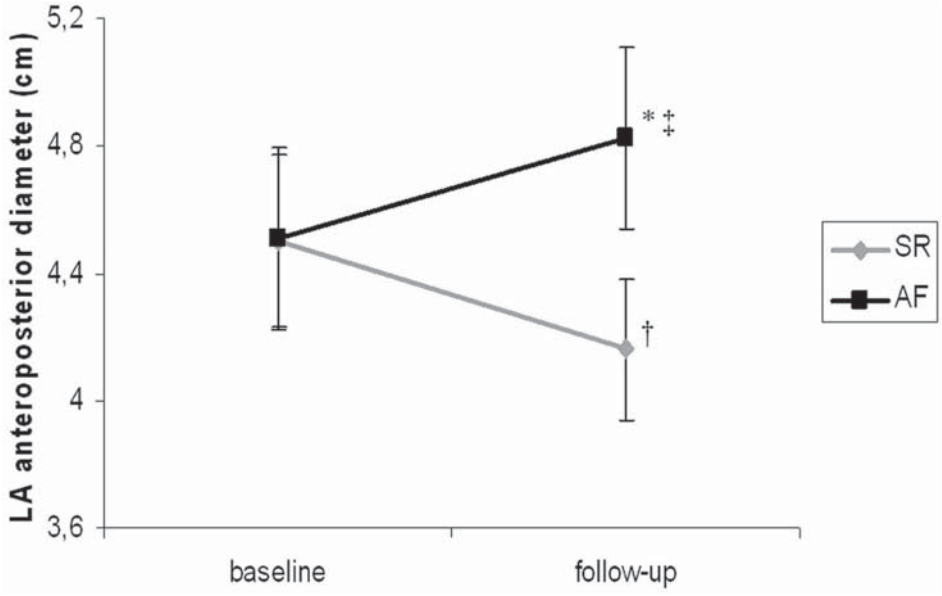

Figure 1. Left atrial anteroposterior diameter at baseline and 3 months follow-up in the SR-group and the AF-group. * p <0.05 SR-group vs. AF-group; † p<0.01 baseline vs. 3 months follow-up; ‡ p<0.05 baseline vs. 3 months follow-up.

significantly in the SR-group in comparison to baseline measurements (Table 2). In contrast, in the AF-group, LAESV and LAEDV showed a tendency to increase, although the differences were not significantly different (Table 2). As a consequence, at 3 months follow-up all LA dimensions and volumes were significantly larger in the AF-group as compared to the SR-group (Table 2).

DISCUSSION

The findings in current study demonstrate that reverse remodeling of the LA occurs after successful radiofrequency catheter ablation for AF. In patients who maintained sinus rhythm, LA dimensions showed a significant decrease at 3 months follow-up. In contrast, in patients with recurrence of AF during follow-up, an increase in LA dimensions was observed. Furthermore, LA volumes decreased significantly in the SR-group, whereas a tendency towards a further increase in LA volumes was observed in the AF-group.

In the current study, LA dimensions and volumes were measured using standard 2-dimensional echocardiography to determine LA size at baseline and 3 months follow-up. A significant decrease in LA anteroposterior diameter was observed in the SR-group. Although M-mode is used commonly in clinical practice to measure LA dimension, it may not be sufficient to determine true LA size (6). Since M-mode represents only 1 dimension of the LA, it may underestimate LA size. Therefore, short- and long-axis of the LA were also evaluated on the apical 4- and 2-chamber images. The short- and long-axis measurements confirmed the findings observed on M-mode echocardiography (LA anteroposterior diameter). A significant decrease was observed in patients who maintained sinus rhythm, and an increase in LA dimensions was observed in patients with recurrence of AF.

LA enlargement may result in an asymmetrical geometry of the LA. Therefore, optimal assessment of LA size should include LA volume measurements (6). In the current study the biplane Simpson's rule (4,5) was used to assess LAEDV and LAESV. Several reports have demonstrated that this method is an accurate technique for assessment of LA volumes using echocardiography (6,7). Furthermore, this method has been validated against CT (4) and MRI techniques (8) in previous studies. Using the biplane Simpson's rule, a significant decrease in LA volumes was demonstrated in the SR-group at 3 months follow-up, whereas a tendency towards an increase in LA volumes was noted in the AF-group.

CONCLUSIONS

In conclusion, LA cavity size decreases in patients who maintain sinus rhythm after radiofrequency catheter ablation, whereas LA size increases in patients with recurrence of AF.

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