Showa Univ J Med Sci **23**(3), 173～179, September 2011

Original

Changes in Atrial Size Following PVI : Comparison of the Right and Left Atria

Sayaka YAMAYA, Yukei HIGASHI, Naoko IKEDA,
Ayaka TANABE, Hideyuki MAEZAWA, Atuo MAEDA,
Hiroyoshi MORI, Daisuke WAKATSUKI, Yoshitaka ISO,
Hisa SHIMOJIMA, Nobuyuki SHIMIZU, Fuyuki ASANO,
Tokutada SATO, Mio EBATO, Hiroshi SUZUKI
and Youichi TAKEYAMA

Abstract : Background : Pulmonary vein isolation (PVI) is expected to cure atrial fibrillation (AF) and to improve atrial remodeling. However, the effects of PVI on the right atrial (RA) size have not been fully examined. We studied the effects of PVI on RA size in comparison that with the effects on LA size.

Method : We studied 17 patients with drug-refractory AF (11 paroxysmal, 6 persistent). Two-dimensional echocardiography was performed at baseline and at follow-up to measure and compare RA and LA size.

Results : Despite a short duration of AF in 7 patients after the PVI, all cases were maintained in sinus rhythm during the follow-up. LA and RA size were both reduced after the PVI compared with baseline measurements (LA $25.5 \pm 2.9\ cm^2$ vs. $23.2 \pm 3.6\ cm^2$, $P < 0.05$, RA $21.2 \pm 2.9\ cm^2$ vs. $18.1 \pm 3.0\ cm^2$, $P < 0.01$). The reduction ratio was more prominent in RA size (14.9%) than in LA size (8.7%) ($P < 0.05$).

Conclusion : Atrial size was reduced following PVI for both the LA and RA, although the rate of reduction was more prominent in the RA.

Key words : atrial fibrillation, pulmonary vein isolation, left atrial size, right atrial size, reverse remodeling

Introduction

Atrial fibrillation (AF) is the most common cardiac arrhythmia. Jais *et al*[1, 2] concluded that premature atrial contractions (PACs) from the pulmonary veins leads to AF and that radiofrequency (RF) ablation of those PACs is effective in preventing AF. Since then, pulmonary vein isolation (PVI) is widely performed as a curative therapy for AF.

When AF occurs frequently or lasts for a long duration, structural remodeling as well as electrical remodeling will occur in the atrial muscle[3]. PVI should restore and maintain

The Cardiovascular Division of Internal Medicine, Showa University Fujigaoka Hospital, 1-30 Fujigaoka, Aoba-ku, Yokohama-City, Kanagawa 227-8501, Japan.

Table 1. Characteristics of the study patients

	Patients (N = 17)
M/F (%)	14 (82.3) / 3 (17.7)
Age (years)	63.9 ± 11.9
Duration of AF (years)	5.3 ± 8.3
Duration of echo after PVI (months)	12.4 ± 3.0
Type of AF	
Paroxysmal (%)	11 (64.7)
Persistent (%)	6 (35.3)
Recurrence (%)	7 (41.2)
PVI first/second (%)	15 (88.2) / 2 (11.8)
Ischemic heart disease (%)	2 (11.8)
Hyper thyroid (%)	0
Hypertension (%)	13 (76.5)
Dyslipidemia (%)	5 (29.4)
Diabetes (%)	4 (23.5)
Chronic heart disease (%)	2 (11.8)
Anti-arrhythmic drugs	
IC (%)	5 (29.4)
IV (%)	8 (47.1)
β-Blocker (%)	5 (29.4)
ACE-I and/or ARB (%)	11 (64.7)
Statin (%)	5 (29.4)

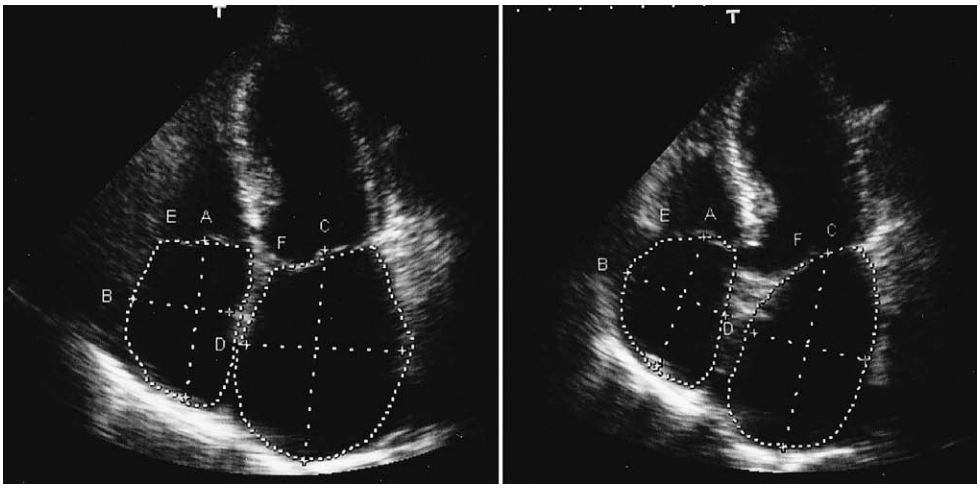
ACE-I, angiotensin-converting enzyme inhibitor ; ARB, angiotensin receptor blocker ; AF, atrial fiblilation.

sinus rhythm, and it is thought to result in improved atrial function or an atrial volume reduction[4–10]. However, these previous studies were mainly focused on the left atrium (LA), and the changes in the right atrium (RA) following PVI have not been fully evaluated[9, 10]. This study therefore examined the changes in both LA and RA size following PVI and compared the effect of the PVI on both atria.

Methods

Study patients

Seventeen patients (14 men ; age 63.9 ± 11.9 years, range 37–77 years) with drug-refractory non-valvular paroxysmal (PAF ; n = 11) or persistent (PER-AF ; n = 6) AF were studied. Table 1 details the patient characteristics. The average AF history was 5.3 ± 8.3 years, with cases of hypertension the most prevalent (76.5%). Selected patients were taking prescribed oral medications, including angiotensin receptor blocker (ARB)/angiotensin-converting enzyme inhibitor (ACE-I) agents and statins, and these regimens were not changed during the follow-up. The anti-arrhythmic drugs were not stopped at the time of the PVI procedure, and were only discontinued at the follow-up visit if no AF recurrence was observed.



A) before PVI B) After PVI (12-month follow-up)

Fig. 1. The measurement of the atrial areas
The left panel shows the 4 chamber echocardiographic image before the PVI and the right panel shows the 4 chamber echocardiographic image after the PVI (12-month follow-up). Both atrial sizes were reduced after the PVI.

AF recurrence was defined as AF lasting for more than 30 sec recorded on a Holter ECG, mobile ECG, or 12-lead ECG in the clinic. The classification of AF was based on the ACC/AHA/ESC guidelines[11].

Echocardiography

Transthoracic echocardiography was performed in all patients at baseline and at 12 months after the PVI. They were done by two skilled sonographers and one doctor. We acquired several recordings from each view and performed measurements on the best images. All measurements were acquired in sinus rhythm. The apical long axis view was used to measure both atrial sizes by a tracing method as indicated in Fig. 1, with images obtained at the end diastolic phase of the cardiac cycle. The left ventricular ejection fraction (LVEF) was measured using a biplane Modified Simpson method.

Catheter ablation procedure

All patients provided written informed consent to undertake the PVI, which was performed under electro-anatomical mapping (Carto ; Biosense-Webster, Diamond Bar, CA). Two circular mapping catheters (Lasso ; Biosense-Webster) and a 4-mm or 8-mm tip ablation catheter (Navistar ; Biosense-Webster) were introduced into the LA by the Brockenbrough technique REF. The left- and right-sided PVs were each encircled with RF lesions 0.5-1.0 cm from the ostia. The end point of the ablation procedure was defined as the electrical disconnection of all 4 PVs from the LA. No additional ablation lines or CAFE

ablation was added in these study cases. Patients who underwent an RA isthmus ablation were excluded from this study.

Statistical analysis

The continuous variables are reported as mean ± SD and categorical variables as proportions. Student's *t*-test was used to evaluate changes in the echocardiographic parameters. All *P* values were two-sided, and a *P* value of less than 0.05 was considered to indicate statistical significance. Although the number of cases examined was small, the data exhibited a normal distribution.

Results

Disconnection of all 4 PVs was achieved by the ablation procedure in all patients. During the follow up, AF recurrence was documented in 7 patients (41.2%), comprising 5 with PER-AF and 2 with PAF. The recurrence occurred within 3 months after the PVI in both groups. No cases went into chronic AF during follow-up.

The echocardiographic findings at baseline and after the PVI are detailed in Table 2. Both LA and RA sizes were reduced after the PVI compared to baseline values (LA : $25.4 \pm 2.9\ cm^2$ vs. 23.2 ± 3.6 ; RA : $21.2 \pm 2.9\ cm^2$ vs. 18.1 ± 3.0). Table 2 indicates the degree of atrial size reduction in all cases, and shows a greater reduction in RA than LA size (14.9% vs. 8.7%, $P < 0.05$). Considering the variability in the examinations and reduction rate in all cases, we then examined whether atrial size was reduced by at least 10% more than the sizes at baseline ; size reduction after the PVI was 10% or greater in 13/17 (76%) cases in the RA, and 8/17 cases (47%) in the LA. The LVEF did not significantly change after the PVI compared to baseline (data not shown). With respect to AF type, the atrial size was significantly reduced in PAF cases, but not in the PER-AF cases (Table 3). Finally, a reduction in atrial size was observed only in cases with no AF recurrence (Table 3).

Discussion

The occurrence and perpetuation of AF cause electrical and structuring remodeling of heart atria, and restoring and maintaining sinus rhythm are expected to improve remodeling[3]. Reduced LA size after PVI for AF was found in some studies[4–10]; however, few reports have assessed changes in RA size[9, 10].

The present study examined and compared the changes in both RA and LA size following PVI. Although both atria showed reduced size following the PVI, the RA size was more reduced than the LA size, which is consistent with other reports despite the small patient number in our study[9, 10].

Verma *et al*[8] reported that PVI improved LA systolic function and reduced LA size using echocardiography and computed tomography[8], with no mention of RA function. In

Table 2. Results of parameter at baseline and after PVI

	The change of LA area after PVI			The change of RA area after PVI				
Patients	Pre ABL (cm^2)	Post ABL (cm^2)	Decrease rate (%)	Pre ABL (cm^2)	Post ABL (cm^2)	Decrease rate (%)	AF type	Recurrence
A	23	22	4.3	22	18	18.2	PAF	+
B	20	15	25.0	16	13	18.8	PER-AF	+
c	26	20	23.1	21	17	19.0	PER-AF	+
d	25	22	12.0	19	19	0	PAF	−
e	26	19	26.9	23	16	30.4	PAF	−
f	20	22	−10	18	17	5.6	PAF	−
g	26	26	0	21	18	14.3	PAF	−
h	23	24	−4.3	21	21	0	PER-AF	−
i	29	22	24.3	16	13	18.7	PAF	−
j	27	30	−11.1	21	17	19.0	PER-AF	+
k	25	25	0	25	22	12.0	PAF	+
l	28	25	10.7	24	20	16.7	PER-AF	+
m	28	28	0	25	24	4.0	PER-AF	+
n	26	24	7.6	19	16	15.7	PAF	−
o	24	23	4.1	22	18	18.2	PAF	−
p	31	27	12.9	26	22	15.4	PAF	−
q	26	20	23.1	21	16	23.8	PAF	−
Average	25.4 ± 2.9	23.2 ± 3.6	8.7 ± 12.4*	21.2 ± 2.9	18.1 ± 3.0	14.9 ± 8.1*		
Above 10% reduction after PVI			8/17 (47%)		13/17 (76%)*		*$P < 0.05$	

Table 2 shows the results of the parameters before and after the PVI. Both the left and right atrial areas were significantly reduced after the PVI. A reduction in the LA area of greater than 10% before the PVI was observed in 8/17 cases, whereas a decrease in the RA area of greater than 10% was observed in 13/17 cases ($P < 0.05$).

Table 3. The change in the atrial size of AF type and AF recurrence

Variable	PAF (n = 11)	PAR-AF (n = 6)
LA area (cm^2)	25.5 ± 2.9 → 22.9 ± 2.4*	25.3 ± 3.2 → 23.7 ± 5.5
RA area (cm^2)	21.1 ± 3.0 → 17.7 ± 2.6*	21.3 ± 3.1 → 18.7 ± 3.8
Left ventricular EF (%)	64.3 ± 10.9 → 66.0 ± 11.0	56.3 ± 15.7 → 60.3 ± 13.0

Variable	Non-recurrence group (n = 10)	Recurrence group (n = 7)
LA area (cm^2)	25.6 ± 3.0 → 22.9 ± 2.5*	25.3 ± 2.9 → 25.6 ± 5.1
RA area (cm^2)	20.6 ± 2.8 → 17.6 ± 2.6*	22.0 ± 3.2 → 18.7 ± 3.6
Left ventricular EF (%)	64.6 ± 11.0 → 66.3 ± 11.5	57.0 ± 15.0 → 61.5 ± 12.5

*$P < 0.05$

Table 3 shows the change in the atrial size of AF type (PAF vs. PER-AF) and AF recurrence (non-recurrence vs. recurrence), the atrial size was reduced in PAF cases, but the reduction was insignificant in the PER-AF cases. Concerning AF recurrences, a reduction in the atrial size was observed in the non-recurrence cases, but not in the recurrence cases. LV-EF did not change between the two groups.

contrast, Wylie *et al*[10] found no improvement in LA function following PVI. Using magnetic resonance imaging, these authors found that PVI caused the LA volume to decrease by 15%, while LA-EF decreased by 14%. The RA volume decreased by 13% and the RA-EF increased by 5% after the PVI. They suggested an association between the degree of LA-EF decrease and the LA scar volume. It is speculated that the LA size was reduced due to the AF episodes ceasing, but the RA may reduce more than the LA because it does not receive ablation procedure.

Concerning the atrial size change and AF type or AF recurrence, most of the non-recurrence cases (9/11) were PAF patients, while most cases of recurrence (5/6) occurred among the among the PER-AF cases. Our findings may indicate only the effects of AF recurrence.

Limitations

Our study consisted of a small number of cases, so that we were not able to closely examine the association between the atrial size changes and the basic disease, kinds of medications, AF recurrence, and type of AF. Further examination using a large number of cases needs to be carried out to clarify the effects of these factors on the atrial size. This should include changes in atrial function, that is, the amplitude of the atrial kick or atrial ejection fraction. Further examination is also needed using 3D echocardiography, because of the limitations with 2D imaging for accurately detecting changes in atrial volume.

Conclusion

This study demonstrated size reduction in both left and right atria following PVI, with the RA size more prone to reduction than the LA size.

References

1) Jaïs P, Haïssaguerre M, Shah DC, Chouairi S, Gencel L, Hocini M and Clémenty J : A focal source of atrial fibrillation treated by discrete radiofrequency ablation. *Circulation* **95** : 572–576 (1997)
2) Jaïs P, Weerasooriya R, Shah DC, Hocini M, Macle L, Choi KJ, Scavee C, Haïssaguerre M and Clémenty J : Ablation therapy for atrial fibrillation (AF): past, present and future. *Cardiovasc Res* **54** : 337–346 (2005)
3) Nattel S : Therapeutic implication of atrial fibrillation mechanisms : can mechanic insights be used to improve AF management? *Cardiovasc Res* **54** : 347–360 (2002)
4) Tops LF, Bax JJ, Zeppenfeld K, Jongbloed MR, van der Wall EE and Schalij MJ : Effect of radiofrequency catheter ablation for atrial fibrillation on left atrial cavity size. *Am J Cardiol* **97** : 1220–1222 (2006)
5) Reant P, Lafitte S, Jaïs P, Serri K, Weerasooriya R, Hocini M, Pillois X, Clementy J, Haïssaguerre M and Roudaut R : Reverse remodelling of the left cardiac chambers after catheter ablation after 1 year in series of patients with isolated atrial fibrillation. *Circulation* **112** : 2896–2903 (2005)
6) Lutomsky BA, Rostock T, Koops A, Steven D, Müllerleile K, Servatius H, Drewitz I, Ueberschär D, Plagemann T, Ventura R, Meinertz T and Willems S : Catheter ablation of paroxysmal atrial fibrillilation improves cardiac function : a prospective study on the impact of atrial fibrillation ablation on left ventricular function assessed by magnetic resonance imaging. *Europace* **10** : 593–599 (2008)
7) Beukema WP, Elvan A, Sie HT, Misier AR and Wellens HJ : Successful radiofrequency ablation in patient with

previous atrial fibrillation result in a significant decrease in left atrial size. *Circulation* **112** : 2089-2095 (2005)
8) Verma A, Kilicaslan F, Adams JR, Hao S, Beheiry S, Minor S, Ozduran V, Claude Elayi S, Martin DO, Schweikert RA, Saliba W, Thomas JD, Garcia M, Klein A and Natale A : Extensive ablation during pulmonary vein antrum has no adverse impact on left atrial function : an echographic and cine computed tomography analysis. *J Cardiovascular Electrophysiol* **17** : 741-756 (2006)
9) Müller H, Noble S, Keller PF, Sigaud P, Gentil P, Lerch R, Shah D and Burri H : Bilateral anatomical reverse remodeling after radiofrequency catheter ablation for atrial fibrillation : evidence from real-time three-dimensional echocardiography. *Europace* **10** : 1073-1078 (2008)
10) Wylie JV Jr, Peters DC, Essebag V, Manning WJ, Josephson ME and Hauser TH : Left atrial function and scar after catheter ablation of atrial fibrillation. *Heart Rhythm* **5** : 656-662 (2008)
11) Fuster V, Rydén LE, Asinger RW, Cannom DS, Crijns HJ, Frye RL, Halperin JL, Kay GN, Klein WW, Lévy S, McNamara RL, Prystowsky EN, Wann LS, Wyse DG, American College of Cardiology, American Heart Association, European Society of Cardiology and North American Society of Pacing and Electrophysiology : ACC/AHA/ESC Guidelines for the management of patient with atrial fibrillation. A report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines and the European Society of Cardiology Committee for Practice Guidelines and Policy Conferences (Committee to dcvelop guidelines for the management of patients with atrial fibrillation) developed in collaboration with the North American Society of Pacing and Electrophysiology. *Eur Heart J* **22** : 1852-1923 (2001)

[Received May 30, 2011 : Accepted June 23, 2011]