Small left atrial volume before ablation is a predictor of tachycardia-induced cardiomyopathy with atrial fibrillation

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Abstract

Abstract Introduction: Tachycardia-induced cardiomyopathy (TCM) is a reversible cause of heart failure (HF) with impaired left ventricle (LV) function. However, the diagnosis is difficult before treatment or control of the arrhythmia for the first time. Methods: In this retrospective observational study, we observed 32 patients with paroxysmal or persistent atrial fibrillation (AF) who had impaired LV function without structural heart disease and who underwent catheter ablation. We defined impaired LV function as LV ejection fraction (LVEF) <50%. After ablation, the LVEF became <60% (Group 1; n = 11) or 60% (Group 2; n = 21). We compared the differences in baseline characteristics between the two groups. The patients in Group1 had no ischemic disease. A receiver operating curve (ROC) with area under the curve (AUC) was used to evaluate the prediction efficiency. Results: There were significant differences in left atrial (LA) volume (LAV) and LAV adjusted by body surface area (LAVI) measured by computed tomography ($p < 0.05$ for both). The AUCs were 0.810 and 0.823, respectively. The points at which sensitivity and specificity were maximum were 147 ml and 79. Small LAV and LAVI were predictors of LVEF improvement. Conclusion: Small LAV measured by computed tomography (CT) before ablation may be useful for diagnosis of TCM with AF.

1 Introduction

Tachycardia-induced cardiomyopathy (TCM) is a reversible cause of heart failure with impaired left ventricle (LV) function. Atrial fibrillation (AF) is the most common cause.1 We cannot always observe echocardiographic data in typical TCM at the first occurrence: LV ejection fraction (LVEF) is <30%, LV end-diastolic diameter is <65 mm, and LV end-systolic diameter is <50 mm. The diagnosis is determined by a recovery of LV function within 3 months after treatment or control of the arrhythmia.2 In other words, we cannot determine the diagnosis for at least 3 months after arrhythmia control. Moreover, the diagnosis is determined by excluding other causes of cardiomyopathy, especially idiopathic dilated cardiomyopathy (DCM). Cardiac magnetic resonance (CMR) imaging has been useful for excluding other causes.3 However, it is an unusual method and is difficult for patients with impaired renal function.

Thus, the purpose of this study was to clarify the characteristics of TCM before AF ablation. These should help establish early and optimal examinations, such as transesophageal echocardiography or enhanced computed tomography (CT), and treatments, such as AF ablation or cardioversion.

2 Methods

2.1 Study population

This was a single-center, retrospective analysis of patients with AF who had impaired LV function (LVEF <50%) and who underwent catheter ablation for the AF. We excluded patients receiving hemodialysis or who had structural heart disease and suspicion of other cardiomyopathies by echocardiography. After control of the AF, the patients were divided into two groups based on whether the LVEF was <60% (Group 1) or

60% (Group 2) more than 3 months after ablation. We compared the baseline characteristics between the two groups.

2.2 Echocardiographic data

Echocardiography was performed using various devices (Vivid E95, GE Healthcare Japan Corp.; APLIO Artida, APLIO I900, and APLIO 300, Canon Medical Systems Corp.; and iE, Philips Japan, Ltd.). LVEF and left atrial (LA) volume (LAV) were measured by the modified Simpson's method and by the prolate-ellipsoid method, respectively. If the patient had a recurrence after ablation, echocardiography was performed >3 months after the arrhythmia resolved.

2.3 CT data

We performed CT before ablation. The LAV determined by CT (LAV-CT) was constructed by Ziostation2 Version 2.9.7.1 (Ziosoft, Inc). The LA appendage and pulmonary veins were removed from the LAV-CT by a manual procedure. Division of the LAV by the body surface area resulted in the LAV index of CT (LAVI-CT).

2.4 Ablation procedure

Patients received intravenous heparin with a target minimum activated clotting time of 300 seconds. AF ablation was performed using a cryoballoon (Arctic Front Advance; Medtronic, Inc) for pulmonary vein isolation (PVI) and a 3-dimentional electroanatomic mapping system (EnSite Precision; Abbott, Inc) in all patients. If the PVI was incomplete, complete PVI was performed with an irrigated radiofrequency (RF) catheter (FlexAbility; Abbott, Inc). Cavotricuspid isthmus line ablation was completed with the RF catheter.

2.5 Post-ablation follow-up

A 12-lead electrocardiogram (ECG) was performed at every visit; 24-hour Holter monitoring and echocardiography were performed according to the physician's judgment. If patients had a cardiac implantable electronic device (CIED), AF was monitored. Biopsy and CMR were not performed.

2.6 Statistical analysis

Continuous data were described as median and interquartile range and categorical data as numbers and percentages. The Mann–Whitney U test and Fisher exact test were used to compare differences across groups. All tests were 2 sided, and a p value < 0.05 was considered to indicate statistical significance. A receiver operating characteristics (ROC) curve was calculated to identify the optimal cutoff point where sensitivity and specificity would be maximal for the prediction of improved LVEF. The area under the curve (AUC) and its 95% confidence interval were calculated as measures of the accuracy of the data. Statistical analysis was performed using IBM SPSS Advanced Statistics 24 (IBM, Inc). We could not perform multivariable analysis because of the small amount of data.

3 Results

3.1 characteristics of 2 groups at base line and factors for improving LVEF

A total of 32 patients (eight in Group1 and 24 in Group 2) were included in this study. One patient in Group 1 and seven patients in Group 2 had AF controlled by cardioversion and/or medications before ablation. In Group 1, one patient had a CIED before ablation and two patients had it after ablation. LAVI, LAV-CT and LAVI-CT were significantly smaller in Group 2 than in Group 1. Small LAV-CT and LVAI-CT were predictors for improving LVEF. All other characteristics were not significantly different between the groups (Table 1). The AUCs of the LAV-CT and LAVI-CT were 0.810 and 0.823, respectively (Figure 1), and the cutoff values were 147 ml and 79 ml/m^2, respectively. The AUCs of the LA diameter (LAD) and LAV of echocardiography were 0.691 and 0.714, the cutoff values were 45.8 mm and 66.6 ml.

3.2 Characteristics of 2 groups after ablation

Post-ablation echocardiography data were not significantly different between the groups except for the LAD. Recurrence of arrhythmia was not significantly different between the groups (Table 2).

4 Discussion

4.1 Major finding

All patients with HF should have ablation for AF,4 but the risk of the procedure's complications prevents this. We recognize some characteristics of TCM before ablation, and we are willing to recommend patients with possible TCM have ablation.

Small LV dimensions, younger age, and male sex may help to differentiate TCM from DCM.2,5,6 These parameters in this study were not significantly different between the two groups. LAV-CT was significantly different, whereas the difference in the LAV determined by echocardiography was close to significant ($p = 0.0519$). Patients with DCM have LV dilatation as well as LA dilatation.7 Echocardiography is noninvasive and easy. Small LV dimension, like LA dimension measured by echocardiography (LA diameter <45.8 mm and LAV <66.6 ml, which were the optimal cutoff values), may be helpful for the diagnosis of TCM.

4.2 Variety in Group 1

Patients in Group 1 were classified into two groups. In Group A, their LVEF improved a little. In group B, their LVEF remained the same or decreased. Group A was composed of the following patients: (1) those whose LVEF had been improving, (2) those with overlapping DCM and TCM,1 and (3) those with recurrence of AF. Group B was composed of just DCM or other cardiomyopathies. We should have followed Group 1 longer.

4.3 Limitations

This study has several limitations. It was a single-center study and included a small number of patients. LAV-CT was measured by hand and it might not be exact. Some tests, such as echocardiography, were performed according to individual judgment.

5 Conclusion

LAV-CT <147 mL was a predictor for improving LVEF significantly. Small LAV before ablation may be a predictor for TCM with AF and may be helpful for its diagnosis.

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Conflict of interests

The authors declare that there are no conflicts of interests.

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Figure 1

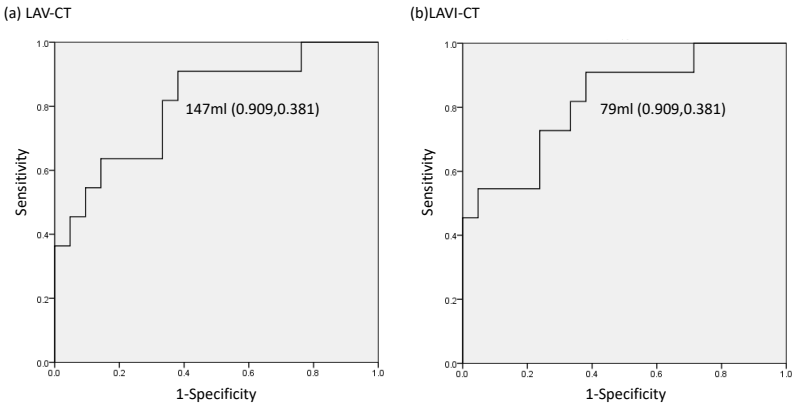

Table 1. Characteristics at base line

	Group 1	Group 2	p value
	n=11	n=21	
Age - median(IQR) yr	63(60-71)	58(50-67)	0.142
Male - no. (%)	8(72.7)	16(76.2)	1
Body mass index - median(IQR)	25.1(22.8-26.5)	24.7(22.3-28.0)	1
Body surface area - median(IQR)	1.70(1.58-1.81)	1.81(1.71-1.91)	0.168
New York Heart Association class- no. (%)			
Ⅰ	4(36.4)	8(38.1)	
Ⅱ	5(45.5)	5(23.8)	
Ⅲ	2(18.2)	8(38.1)	
Ⅳ	0(0)	0(0)	
Type of atrial fibrillation - no. (%)			
Paroxysmal	2(18.2)	0(0)	
Persistent	7(63.6)	18(85.7)	
Long standing persistent	2(18.2)	3(14.3)	
CHADS2	2(1.5-2.5)	2(1-2)	0.932
CHA2DS2-VASc	3(2-4)	2(2-3)	0.683
echocardiographic parameters - median(IQR)			
LAD - mm	47.1(42.3-51.9)	44.5(37.5-45.6)	0.0843
LAV - ml	76.5(70.7-93.9)	68.1(54.0-76.8)	0.0519
LAVI - ml/m^2	46.1(41.7-52.5)	31.9(29.6-43.6)	0.0173
LVEF - %	35.7(24.0-42.4)	38.4(28.9-43.0)	0.766
LV end-diastolic diameter - mm	53.6(53.2-60.9)	49.9(47.5-57.4)	0.19
LV end-systolic diameter - mm	45.6(43.2-52.6)	40.7(34.4-47.6)	0.165
computed tomographic parameters - median(IQR)			
LAV - ml	165(154-194)	141(118-158)	0.00483
LAVI - ml/m^2	101(88-117)	75(63-88)	0.00232
Period from CT to ablation - d	11(8-13)	13(10-15)	0.187
NT-proBNP - median (IQR) pg/ml	715(522-1716)	819(586-1323)	0.755
Hb - median (IQR) g/dl	14(13.5-15.1)	14.7(14.2-16.2)	0.197
eGFR - median (IQR) ml/min/1.73m^2	60(56-70)	66(58-77)	0.475
Hypertension - no. (%)	7(63.6)	15(71.4)	0.703
Diabetes - no. (%)	2(18.2)	3(14.3)	1
Chronic renal disease - no. (%)	1(9.1)	2(9.5)	1
Dyslipidemia - no. (%)	4(36.4)	7(33.3)	1
Sleep apnea syndrome - no. (%)	2(18.2)	1(4.8)	0.2661
Alcohol consumption - no. (%)	7(63.6)	13(61.9)	1
Current smoker - no. (%)	1(9.1)	6(28.6)	0.3741
Beta-blocker use - no. (%)	9(81.8)	20(95.2)	0.266
ARB or ACE inhibitor use - no. (%)	7(63.6)	8(38.1)	0.2662
MRA use - no. (%)	8(72.7)	13(61.9)	0.7026
Loup diuretic use - no. (%)	10(90.9)	12(57.1)	0.1058
Amiodarone use - no. (%)	2(18.2)	4(19)	1
Bepridil use - no. (%)	2(18.2)	5(23.8)	1
Digitalis use - no. (%)	0(0)	1(4.8)	1
CIED - no. (%)	2(18.2)	0(0)	0.111

Abbreviations: IQR, interquartile range; LAD, left atrial diameter; LAV, left atrial volume; LAVI, left atrial volume index; LVEF, left ventricular ejection fraction; LV, left ventricular; CT, computed tomography; ARB, angiotensin Ⅱ receptor blocker; ACE, angiotensin converting enzyme; MRA, mineralocorticoid receptor antagonist; CIED, cardiac implantable electronic device

Table 2. Characteristics after ablation

	Group 1 n=11	Group 2 n=21	p value
echocardiographic parameters – median (IQR)			
follow-up period of echocardiography	199(165-223)	276(115-402)	0.968
LAD - mm	41.3(37.5-43.7)	37.6(33.2-43.2)	0.275
LAV - ml	58.0(55.5-66.5)	45.9(37.8-51.8)	0.0099
LAVI - ml/m^2	32.9(29.0-42.2)	23.9(20.8-27.5)	0.0073
LVEF - %	48.8(38.0-54.4)	64.1(61.8-66.9)	0.0000323
LV end-diastolic diameter - mm	53.5(49.8-57.5)	47.4(42.9-50.2)	0.0012
LV end-systolic diameter - mm	37.9(37.1-47.5)	30.9(28.1-33.7)	0.000304
NT-proBNP - median (IQR) pg/ml	337(72-1242)	99(51-134)	0.275
Recurrence of Arrhythmia - no.(%)	2(18.2)	7(33.3)	0.441
Period from ablation to recurrence - median (IQR)	635	176(105-397)	0.667

Abbreviations: IQR, interquartile range; LAD, left atrial diameter; LAV, left atrial volume; LAVI, left atrial volume index; LVEF, left ventricular ejection fraction; LV, left ventricular