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Original article

Relationship between CHA2DS2-VASc score and atrial electromechanical function in patients with paroxysmal atrial fibrillation: A pilot study

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ABSTRACT

Background: CHA2DS2-VASc score is the most widely preferred method for prediction of stroke risk in patients with atrial fibrillation. We hypothesized that CHA2DS2-VASc score may represent atrial remodeling status, and therefore echocardiographic evaluation of left atrial electromechanical remodeling can be used to identify patients with high risk.

Methods: A total of 65 patients who had documented diagnosis of paroxysmal atrial fibrillation (PAF) were divided into three risk groups according to the CHA2DS2-VASc score: patients with low risk (score = 0, group 1), with moderate risk (score = 1, group 2), and with high risk score (score ≥2, group 3). We compared groups according to atrial electromechanical intervals and left atrium mechanical functions.

Results: Atrial electromechanical intervals including inter-atrial and intra-atrial electromechanical delay were not different between groups. However, parameters reflecting atrial mechanical functions including LA phasic volumes (V_{max}, V_{min} and V_p) were significantly higher in groups 2 and 3 compared with group 1. Likewise, LA passive emptying volume (LATEV) in the groups 2 and 3 was significantly higher than low-risk group (14.12 ± 8.13 ml/m^2, 22.36 ± 8.78 ml/m^2, 22.89 ± 7.23 ml/m^2, p: 0.031). Univariate analysis demonstrated that V_{max}, V_{min} and V_p were significantly correlated with CHA2DS2-VASc score ($r = 0.428$, $r = 0.456$, $r = 0.451$ and $p < 0.001$). Also, LATEV ($r = 0.397$, $p = 0.016$) and LA active emptying volume (LAAEV) ($r = 0.281$, $p = 0.023$) were positively correlated with CHA2DS2-VASc score. In the ROC analysis, $V_{min} \geq 11$ ml/m^2 has the highest predictive value for CHA2DS2-VASc score ≥2 (88% sensitivity and 89% specificity; ROC area 0.88, $p < 0.001$, CI [0.76–0.99]).

Conclusion: Echocardiographic evaluation of left atrial electromechanical function might represent a useful method to identify patients with high risk.

Introduction

Atrial fibrillation (AF) is the most common cardiac rhythm disturbance, occurring in up to 10% of the population older than 80 years [1]. AF is a major risk factor for thromboembolic events with an incidence of 7.4% per year [2]. The stroke risk is comparable in patients with paroxysmal AF (PAF) to those with permanent AF [3]. Risk stratification is essential to determine thromboembolism risk and to identify patients eligible for anticoagulation. Numerous risk stratification models have been proposed to predict stroke risk in patients with non-valvular AF. Among them, CHA2DS2-VASc score is the most widely preferred method in clinical practice. It is based on clinical risk factors such as congestive heart failure, hypertension, age >65–75 years, diabetes mellitus, vascular disease, female sex, previous history of stroke or transient ischemic attack (TIA) [4,5]. The association between the individual risk

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factors in CHA2DS2-VASc score and atrial electromechanical, and functional remodeling have been proposed [6]. Electrical and structural remodeling of the left atrium maintain AF and may be responsible for the progression of incidental and paroxysmal AF to persistent and permanent AF [7]. Persistent AF has been proposed as a risk factor for unsuccessful AF ablation outcomes [8]. The process of atrial remodeling includes atrial enlargement, low atrial contractile reserve, and prolonged atrial conduction time [9]. Also, as a consequence of atrial electromechanical remodeling, atrial myocardial fibrosis, blood stasis and hypercoagulability ensues which may lead to thrombus formation [10–12]. Thus, CHA2DS2-VASc score may reflect deleterious effects of the clinical risk factors on the left atrium resulting with left atrial electromechanical remodeling.

Conventional and tissue Doppler echocardiography is a non-invasive and simple method in the assessment of left atrial electromechanical function [13]. The aim of the present study is to evaluate the association between LA electromechanical function and the CHA2DS2-VASc score, and also to define some basic echocardiographic parameters associated with higher CHA2DS2-VASc risk score in patients with PAF.

Methods

A total of 65 patients who had documented diagnosis of PAF were enrolled in this study. The diagnosis was based on sustained AF attack which persists more than 1 h and lasts spontaneously for 7 days on the 12-lead electrocardiography (ECG). Patients with permanent AF, rheumatic valvular heart disease, history of prior AF ablation, under the treatment of Class 1 and 3 antiarrhythmic drugs and recurrent PAF episodes documented during 4 weeks after the last PAF were excluded from the study. The patients were divided into three groups according to the CHA2DS2-VASc score: group 1 with low-risk score (score = 0), group 2 with moderate risk (score = 1), and group 3 with high-risk score (score $\geq$2). We compared groups by atrial electromechanical interval and left atrium mechanical function. The study was approved by The Ethical Committee of Sakarya University School of Medicine.

Standard echocardiographic evaluation

Echocardiographic measurements were obtained at 4 weeks after the PAF attack. Standard echocardiographic examinations were performed in all patients using a Philips IE33 xMatrix cardiac ultrasound system with multifrequency transducers (Andover, MA, USA). All measurements were recorded as average of three cardiac cycles according to the standards of American Society of Echocardiography. Left ventricle ejection fraction (LVEF) was calculated by Simpson's method [14]. Left ventricle end-diastolic and end-systolic dimensions were measured in the parasternal long-axis view. Left ventricle mass was assessed according to the Devereux method [15].

Atrial electromechanical interval

Atrial electromechanical interval was evaluated by pulsed tissue Doppler (TDI) echocardiography with a 2–4 MHz probe. On the apical-four-chamber view, the pulsed TDI cursor was positioned parallel to the annular motion. Spectral pulsed-wave Doppler signal filters were adjusted until a Nyquist limit of 15–20 cm/s, and using the minimal optimal gain to obtain the best signal-to-noise ratio. The monitor sweep speed was set to 50–100 mm/s to optimize the spectral display of myocardial velocities.

In the apical-four-chamber view, the velocities were subsequently recorded at the level of the left ventricle lateral mitral annulus, septal mitral annulus, and right ventricle tricuspid annulus. Velocity pattern was presented by a positive myocardial systolic wave (Sm) and two negative diastolic waves: early (Em) and atrial (Am). Atrial electromechanical interval (PA) was measured as the time from the beginning of P wave on the surface ECG to peak of the Am wave velocity. PA interval was obtained from the lateral mitral annulus (PA lateral), septal mitral annulus (PA septal), and tricuspid annulus (PA tricuspid). The difference between PA lateral and PA tricuspid (PA lateral − PA tricuspid) was defined as inter-atrial electromechanical delay, and the difference between PA septum and PA tricuspid (PA septum − Pa tricuspid) as intra-atrial electromechanical delay.

Left atrial mechanical function

The most useful method in the assessment of left atrium (LA) function is based on the measurement of LA phasic volumes. LA phasic volumes were measured by the modified biplane Simpson's method in four- and two-chamber apical views. Maximum volume (V_{max}) was measured at end-systole just before the opening of the mitral valve, minimal volume (V_{min}) at end-diastole just before mitral valve closure, and the volume just before the atrial systole was measured at the beginning of the P wave on the ECG (V_p). The following three parameters, reflecting the phasic function of the LA, were calculated from the volumes: LA passive emptying volume (LAPEV) = $V_{max} - V_p$, LA active emptying volume (LAAEV) = $V_p - V_{min}$, LA total emptying volume (LATEV) = $V_{max} - V_{min}$, LA passive emptying fraction (LAPEF) = $(V_{max} - V_p)/V_{max} \times 100$, LA active emptying fraction (LAAEF) = $(V_p - V_{min})/V_p \times 100$, and LA expansion index (LAEI) = $(V_{max} - V_{min})/V_{min} \times 100$.

Statistical analysis

Categorical variables are shown as counts (n) and percentages (%) and continuous data were presented as the mean $\pm$ standard deviation. Chi-square test was used to compare the categorical variables. Kruskal–Wallis H test was used to compare the continuous data among low-, moderate- and high-risk groups according to CHA2DS2-VASc score (for pairwise comparisons Bonferroni adjusted Mann–Whitney U test was used). Spearman's correlation coefficients were used to determine the correlations between CHA2DS2-VASc score and echocardiographic parameters.

Receiver operating characteristic (ROC) curve analysis was performed to define thresholds for echocardiographic parameters for predicting high CHA2DS2-VASc score with corresponding specificity and sensitivity. Two-sided p values of $<$0.05 were considered statistically significant. Analyses were performed using statistical software (IBM SPSS Statistics 20, SPSS Inc., An IBM Corp., Armonk, NY).

Results

The study population included 28 men and 37 women with the mean age of 55 $\pm$ 12 years. Among this population, 4 patients had previous history of stroke, 42 had hypertension, 6 had diabetes mellitus, 6 had coronary artery or the other vascular disease, and 3 had congestive heart failure. The baseline clinical characteristics such as age, sex, hypertension, vascular disease, and previous history of stroke were different in the groups (Table 1).

Atrial electromechanical interval

The mean PA lateral, PA septum, and PA tricuspid intervals were 69.61 $\pm$ 12.93 ms, 54.58 $\pm$ 12.56 ms, and 39.2 $\pm$ 9.59 ms, respectively. Regarding the echocardiographic parameters, PA lateral (68.67 $\pm$ 11.79 ms, 68.94 $\pm$ 12.78 ms, 71.25 $\pm$ 13.72 ms, p = 0.787), PA septal (53.67 $\pm$ 14.03 ms, 53.75 $\pm$ 11.18 ms, 56.48 $\pm$ 14.38 ms,

Table 1
Comparisons of the patient characteristics and echocardiographic parameters among CHA2DS2-VASc risk groups.

	Low risk (*n* = 9)	Moderate risk (*n* = 36)	High risk (*n* = 20)	*p*
Age	40 ± 14	54 ± 13	66 ± 9[a,b]	**<0.001**
Hypertension	0	23 (63.9%)	19 (95%)[a,b]	**<0.001**
Heart failure	0	1 (2.8%)	2 (10%)	0.363
Diabetes mellitus	0	2 (5.6%)	4 (20%)	0.119
Stroke	0	0	4 (20%)[a]	**0.008**
Vascular disease	0	1 (2.8%)	5 (25%)[a]	**0.013**
Gender (female)	0	24 (66.7%)	13 (65%)[a,b]	**0.001**
CHA2DS2-VASc score				
0	9 (100)	0	0	
1	0	36 (100%)	0	
2	0	0	13 (65%)	–
3	0	0	3 (15%)	
4	0	0	3 (15%)	
5	0	0	1 (5%)	
PA lateral (ms)	68.67 ± 11.79	68.94 ± 12.78	71.25 ± 13.72	0.787
PA septal (ms)	53.67 ± 14.03	53.75 ± 11.18	56.48 ± 14.38	0.516
PA tricuspid (ms)	40.67 ± 11.04	38.89 ± 7.63	39.13 ± 12.49	0.955
Inter-atrial electromechanical delay (ms)	28.03 ± 9.43	29.64 ± 11.12	31.72 ± 9.13	0.653
Intra-atrial electromechanical delay (ms)	13.05 ± 6.16	14.86 ± 8.77	17.41 ± 15.75	0.912
V_{max} (ml/m^2)	23.44 ± 10.89	39.69 ± 13.65[a]	42.9 ± 12.83[a]	**0.002**
V_{min} (ml/m^2)	9.42 ± 3.53	17.61 ± 7.25[a]	19.65 ± 7.43[a]	**0.001**
V_p (ml/m^2)	14.17 ± 6.41	26.48 ± 9.77[a]	30.35 ± 11.92[a]	**0.001**
LA passive volume (ml/m^2)	9.11 ± 5.45	13.69 ± 7.83	12.58 ± 4.89	0.202
LA active volume (ml/m^2)	6.18 ± 3.85	8.93 ± 4.53	10.42 ± 5.35	0.118
LA total volume (ml/m^2)	14.12 ± 8.13	22.36 ± 8.78[a]	22.89 ± 7.23[a]	**0.031**
LA passive emptying fraction	0.36 ± 0.11	0.33 ± 0.12	0.29 ± 0.10	0.280
LA active emptying fraction	0.31 ± 0.13	0.33 ± 0.12	0.34 ± 0.9	0.888
LA expansion index	1.71 ± 0.54	1.40 ± 0.62	1.27 ± 0.47	0.104
LA anterior–posterior diameter (mm)	35.1 ± 3.0	35.6 ± 2.8	35.6 ± 2.4	0.857

Data were shown as mean ± standard deviation and *n* (%). Two-sided *p* values of <0.05 were considered statistically significant and indicated in bold.
PA: time interval from the onset of the P wave to the peak of the Am wave; V_{max}: maximal left atrial volume; V_{min}: minimal left atrial volume; V_p: left atrial volume at the beginning of atrial systole; LA: left atrium.
[a] There was statistically significant difference from low-risk group.
[b] There was statistically significant difference from moderate-risk group.

$p = 0.516$) and PA tricuspid (40.67 ± 11.04 ms, 38.89 ± 7.63 ms, 39.13 ± 12.49 ms, $p = 0.955$) intervals were similar in low-, moderate- and high-risk groups. Likewise, inter-atrial (28.03 ± 9.43 ms, 29.64 ± 11.12 ms, 31.72 ± 9.13 ms, $p = 0.653$) and intra-atrial electromechanical delay (13.05 ± 6.16 ms, 14.86 ± 8.77 ms, 17.41 ± 15.75 ms, $p = 0.912$) were not different between groups (Table 1).

Left atrial mechanical function

The mean anterior–posterior diameters of the left atrium were similar between groups (35.1 ± 3.0 mm in group 1, 35.6 ± 2.8 mm in group 2, and 35.6 ± 2.4 mm in group 3). There was no statistical difference between the mean LA diameters and CHA2DS2-VASc score levels ($p = 0.857$). The mean volumes of left atrium (V_{max}, V_{min}, V_p, and V_{total}) were 36.42 ± 13.01 ml/m^2, 17.10 ± 6.79 ml/m^2, 25.96 ± 9.96 ml/m^2, and 21.38 ± 8.21 ml/m^2, respectively. The LA volumes (V_{max}, V_{min}, and V_p) were significantly higher in groups 2 and 3 as compared to group 1. Likewise, LATEV in groups 2 and 3 were significantly higher than that of low-risk group (corresponding LATEV for groups 1, 2 and 3 were 14.12 ± 8.13 ml/m^2, 22.36 ± 8.78 ml/m^2, and 22.89 ± 7.23 ml/m^2, respectively; $p = 0.031$). Nevermore, other LA mechanical function parameters including LAPEV, LAAEV, LAPEF, LAAEF, and LAEI were subsequently similar between each group (Table 1).

The correlation of atrial electromechanical parameters and CHA2DS2-VASc score

Univariate regression analysis was used to determine correlation between left atrial electromechanical functions and CHA2DS2-VASc score. Univariate analysis demonstrated that V_{max}, V_{min} and V_p were significantly correlated with CHA2DS2-VASc score ($r = 0.428$, $r = 0.456$, $r = 0.451$ and $p < 0.001$ for V_{max}, V_{min} and V_p, respectively). Also, LATEV and LAAEV were positively correlated with higher CHA2DS2-VASc score ($r = 0.397$, $p = 0.016$ and $r = 0.281$, $p = 0.023$ for LATEV and LAAEV, respectively). However, there was no association between atrial electromechanical interval parameters and CHA2DS2-VASc score levels (Table 2).

The valuable echocardiographic parameters for predicting high CHA2DS2-VASc score

The receiver-operator characteristic (ROC) was used to test the diagnostic value of various echocardiographic parameters of atrial

Table 2
Correlations between CHA2DS2-VASc scores and echocardiographic parameters.

	CHA2DS2-VASc risk score	
	r	*p*
PA lateral (ms)	0.110	0.385
PA septal (ms)	0.151	0.230
PA tricuspid (ms)	−0.094	0.456
Inter-atrial electromechanical delay (ms)	0.228	0.068
Intra-atrial electromechanical delay (ms)	0.075	0.550
V_{max} (ml/m^2)	0.428	**<0.001**
V_{min} (ml/m^2)	0.456	**<0.001**
V_p (ml/m^2)	0.451	**<0.001**
LA passive volume (ml/m^2)	0.161	0.200
LA active volume (ml/m^2)	0.281	**0.023**
LA total volume (ml/m^2)	0.297	**0.016**
LA passive fraction	−0.206	0.100
LA active fraction	0.069	0.587
LA expansion index	−0.238	0.056

r: Spearman's correlation coefficient.
PA: time interval from the onset of the P wave to the peak of the Am wave; LA: left atrium; V_{max}: maximal left atrial volume; V_{min}: minimal left atrial volume; V_p: left atrial volume at the beginning of atrial systole. Two-sided p values of <0.05 were considered statistically significant and indicated in bold.

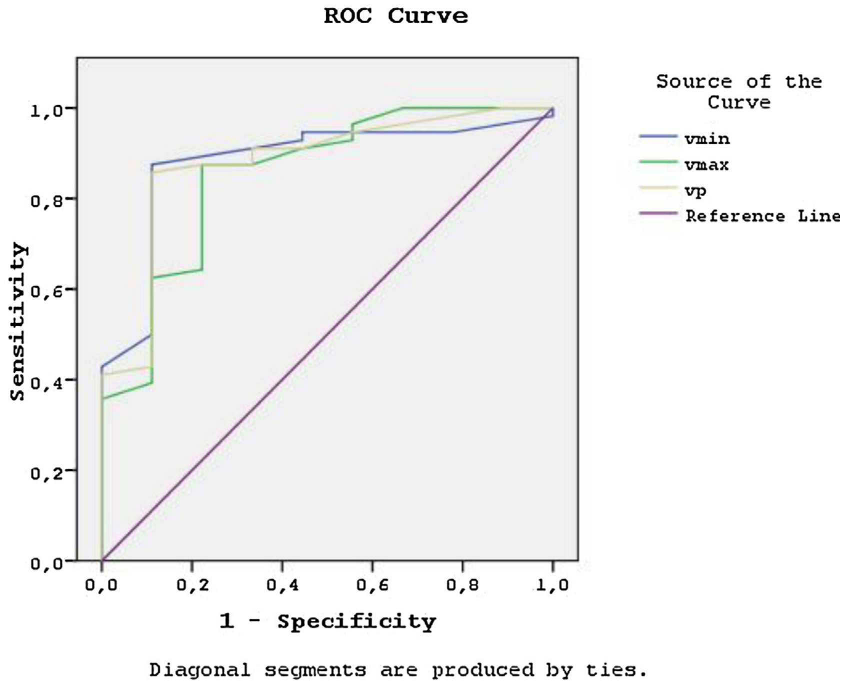

Fig. 1. Diagnostic value of receiver operating characteristics (ROC) curve of echocardiographic parameters [V_{max}: maximal left atrial volume; V_{min}: minimal left atrial volume; V_p: left atrial volume at the beginning of atrial systole].

electromechanical functions in predicting PAF of CHA2DS2-VASc score $\geq$2. $V_{max} \geq 25$ ml/m^2 had a 88% sensitivity and 78% specificity (ROC area 0.85, $p < 0.001$, CI [0.71–0.99]), $V_{min} \geq 11$ ml/m^2 had a 88% sensitivity and 89% specificity (ROC area 0.88, $p < 0.001$, CI [0.76–0.99]) and $V_p \geq 18$ ml/m^2 had a 86% sensitivity and 89% specificity (ROC area 0.88, $p < 0.001$, CI [0.76–1.0]) for predicting CHA2DS2-VASc score $\geq$2 (Fig. 1).

Discussion

In our study, we demonstrated a link between LA mechanical remodeling and CHA2DS2-VASc score in patients with PAF. We also revealed that echocardiographic parameters reflecting LA mechanical remodeling, V_{max}, V_{min} and V_p, had a predictive value in assessing CHA2DS2-VASc risk score of $\geq$2. However, no significant correlation was found between electrical remodeling of the left atrium and this scoring system.

CHA2DS2-VASc score has been widely applied in clinical practice to stratify stroke risk and to identify patients eligible for anticoagulation in patients with PAF [4,5].

Although CHA2DS2-VASc is an excellent predictor of stroke, the pathophysiologic mechanism is not yet fully understood. Nevertheless, PAF and concomitant stroke risk factors in CHA2DS2-VASc score can lead to extensive electrophysiological and ultrastructural abnormalities in LA, including alterations in the expression of ion channels, changes in atrial refractoriness, structural changes in atrial myocytes (increase in cell size, perinuclear accumulation of glycogen, central loss of sarcomeres, fragmentation of sarcoplasmic reticulum, and the changes in mitochondrial shape), and fibroelastic infiltration of the extracellular matrix. The ultrastructural changes may be partly or wholly responsible for atrial enlargement, loss of atrial contractility and increased atrial chamber stiffness [9–11,14–16]. These structural remodelings of the LA in PAF patients could contribute to further echocardiographic changes.

LA anterior–posterior diameter as measured with M-mode is most commonly used in daily clinical practice in assessing LA mechanical remodeling [17]. However, a weak relation between the LA anterior–posterior diameter and stroke risk in AF had been shown in previous studies [18]. Our results demonstrated robust relationship among LA phasic volumes (V_{max}, V_{min}, and V_p), phasic functions (LATEV and LAAEV) and the CHA2DS2-VASc score. The anterolateral portion of the LA predominantly enlarges in the early phases of remodeling. Therefore, predominant enlargement of LA in the medial–lateral and superior–inferior dimensions could alter LA geometry. Thus, anterior–posterior diameter may not represent true size of LA [19]. LA size is more accurately reflected by a measurement of volume rather than area or linear dimension. Furthermore, evaluation of the LA phasic volumes and functions has been shown to be highly feasible and reliable in assessing alteration in the LA geometry and function. The American Society of Echocardiography and the European Association of Echocardiography also recommend the measurement of LA phasic volumes and functions by ellipsoid model and Simpson's method in four- and two-chamber apical views [17]. For these reasons, indexed LA volume measurements were used to assess LA mechanical remodeling in our study.

The leading risk factors for stroke such as age, hypertension, heart failure and diabetes mellitus are clinically measurable indicators promoting atrial remodeling. Early identification of these risk factors and appropriate treatment can prevent, even reverse LA remodeling. These risk factors presumably exert cumulative effects in the left atrial ultrastructure [20–27]. In our study, the patients with extensive stroke risk factors or high CHA2DS2-VASc score had significantly more serious LA mechanical remodeling status.

Aging is one of the risk factors for stroke in PAF. Age-related fibrosis and intracellular age-related changes result in longer atrial conduction time, LA dilation and decreased LA conduit function [20]. Other important and well-established risk factors are hypertension and heart failure. The underlying pathophysiological link for hypertension or heart failure leading to LA remodeling is atrial pressure and/or volume overload as well as diastolic ventricular dysfunction which may lead to atrial dilatation and fibrosis. As LV filling pressures progressively increase, left atrium enlarges, the atrial preload reservoir function increases to upper limit, and the LA serves predominantly as a conduit. The authors suggested that the patients with long-standing hypertension or chronic heart failure have increased left atrial size and LA contractile dysfunction [21,22]. Kleemann et al. had previously described that LV ejection fraction <40% is an independent predictor of left atrial appendage thrombus and dense spontaneous echo contrast [23]. Toh et al. showed that the combination of LA volume and atrial contractile function measurement may be helpful in predicting the risk of stroke in patients with hypertension [24]. Moreover, diabetes mellitus is one of the most common concomitant diseases in patients with AF [25]. The studies indicated that glucose and insulin disturbance can directly affect the atrial myocytes [26]. Left atrial enlargement, low atrial voltage and longer atrial conduction time have been associated with diabetes mellitus and abnormal glucose tolerance [27]. Illien et al. also demonstrated that diabetes mellitus and old age were strongly associated with lower peak emptying velocity of LAA [28]. Besides these common risk factors, data are scarce on association of atherosclerotic vascular disease and female sex with left atrial remodeling properties [26].

Various atrial remodeling parameters were also recently studied in permanent AF. These studies demonstrated that the degree of atrial electroanatomical remodeling was directly related to the risk of stroke in patients with atrial fibrillation [29,30]. A study conducted by Chao et al. evaluated whether atrial electromechanical interval (PA–PDI) was a significant predictor of stroke after successful catheter ablation of AF. They revealed that the PA–PDI interval was a useful parameter which may identify patients with high risk of stroke after ablation of AF [31]. In our study, we did not intend to evaluate predictive value of left atrial electromechanical function on future stroke development. Chao et al. also investigated electrical remodeling of the LA in a patient with PAF. They showed that atrial electromechanical interval was closely associated with CHADS2 score [32]. Conversely, we demonstrated that CHA2DS2-VASc score was not significantly correlated with echocardiographic parameters including atrial conduction time, inter-atrial electromechanical delay, and intra-atrial electromechanical delay in PAF. Extensive evidence indicates that structural remodeling commonly caused by LA volume and pressure overload is associated with interstitial fibrosis contributing to the reentry in AF. Atrial fibrosis is also associated with prolongation of tissue conduction times [33]. Accordingly, atrial mechanical remodeling such as changes in left atrial volume may develop earlier than electrical remodeling. Considering PAF as an early stage of overt atrial fibrillation and cross-sectional design of present study, we could not have demonstrated atrial electrical remodeling in contrast to significant changes concerning structural remodeling. In addition, it is well known that the electrical impulse transmitting from sinus node to the left atrium is conducted by different pathways. However, the measurement of atrial electromechanical delay was obtained from only three points at the annulus level in our study. This may be the second reason of the negative result.

In clinical practice, accurate assessment of LA function or concomitant events requires several, rather than single quantitative echocardiographic analysis [34]. So we intended to define basic and single echocardiographic parameter to predict the CHA2DS2-VASc score of $\geq$2. We revealed that $V_{\max} \geq 25$ ml/m^2 (ROC area 0.85), $V_{\min} \geq 11$ ml/m^2 (ROC area 0.88), and $V_{\mathrm{p}} \geq 18$ ml/m^2 (ROC area 0.88) were valuable parameters for predicting CHA2DS2-VASc score $\geq$2.

The 2012 version of the European Society of Cardiology Committee for Practice (ESC) practical guideline for AF suggested antithrombotic therapy to be individualized based on the CHA2DS2-VASc score [35]. Oral anticoagulants are strongly recommended in patients with a CHA2DS2-VASc score of $\geq$2. For patients with a CHA2DS2-VASc score of 1, a weak recommendation for oral anticoagulant therapy is made. The CHA2DS2-VASc score of 0 is defined as low risk and no additional anticoagulant recommended. We revealed that CHA2DS2-VASc score of $\geq$2 might truly represent high LA remodeling level, who would suffer from strokes in the future. The results of our study also implied that LA mechanical remodeling parameters obtained from basic echocardiographic technique may be useful to refine risk assessment and identify eligible patients for anticoagulation.

In conclusion, CHA2DS2-VASc score represents not only a clinical risk scheme for stroke, but is also associated with atrial mechanical remodeling which is important for thromboembolic events in patients with PAF. Also, atrial mechanical remodeling parameters can offer incremental predictive value for the identification of patients with higher CHA2DS2-VASc score of 2. Although, left ventricle ejection fraction is the only echocardiographic parameter represented in CHA2DS2-VASc score, echocardiographic evaluation of left atrial electromechanical function may serve as a useful method to identify patients with high risk.

Limitations

There are some limitations of this study. First, the population of our study was relatively small. Highly selected patients with PAF were included in our study, since atrial electromechanical interval can only be measured in individuals with sinus rhythm. Most patients included in this study had relatively small LA size and volume. Further larger, prospective investigations involving the patients with permanent AF and larger LA size are required to confirm our results. Second, the duration from last PAF attack may affect the atrial electromechanical function. Although, the duration between the last PAF attack and echocardiographic study was longer than 4 weeks in our study, the recovery of atrial stunning after AF termination may prolong. Moreover, asymptomatic shorter duration PAF attacks may be neglected during this period. Third, measurements of atrial electromechanical intervals were obtained only in three points at the annulus level. This condition might have led to underestimation of electromechanical delay in the present study.

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Conflict of interest

The authors declare that there is no conflict of interest.

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