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Original Article

Correlation Between CHA$_2$DS$_2$-VASc Scores and Left Atrial Measurements: A Single-Center Retrospective Study

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Abstract

Background: Left atrial (LA) and left atrial appendage (LAA) remodeling are critical indicators of adverse cardiovascular outcomes linked to various risk factors. This study aims to investigate the correlation between CHA2DS2-VASc and left atrial measurements in patients with sinus rhythm.
Methodology: The retrospective, single-center study included 250 patients who underwent coronary computed tomography angiography (CCTA) imaging at a state hospital in Turkey. LA dimensions, volumes, LAA types, and LAA orifice area and volume were assessed using CCTA images. Additionally, we evaluated CHA$_2$DS$_2$-VASc scores and cardiovascular risk factors.
Results: This present study indicated that patients with low CHA$_2$DS$_2$-VASc scores had smaller appendage orifice area (270.69±84.72 vs. 300.97±97.65 mm^2, p=0.01), LA long diameter (60.73±6.83 vs. 64.53±7.66 mm, p<0.001), LA short diameter (40.32±5.88 vs. 43.02±6.54 mm, p=0.001), and LA volume (101.55±34.14 vs. 114.34±32.58 mm^3, p=0.003). There was a significant relationship between patient age and all LA and LAA measurements, including LAA volume (r=0.204, p<0.001), LAA orifice area (r=0.342, p<0.001), LA long diameter (r=0.329, p<0.001), LA short diameter (r=0.257, p<0.001), and LA volume (r=0.231, p<0.001).
Conclusion: Cardiovascular risk factors and CHA$_2$DS$_2$-VASc scores are valuable markers for assessing atrial cardiomyopathy and left atrial appendage (LAA) remodeling, and they may aid in predicting stroke risk.

Keywords: Coronary Computed Tomography Angiography; Atrial Cardiomyopathy; CHA$_2$DS$_2$-VASc Score; Left Atrial Appendage.

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Introduction

Cardiovascular diseases (CVD) are a leading cause of morbidity and mortality worldwide, with their prevalence and incidence continually rising [1]. Among these, stroke stands out as a significant contributor to both mortality and long-term disability, often resulting from thromboembolic events. Atrial fibrillation (AF), the most common sustained cardiac arrhythmia, is a significant risk factor for stroke, primarily due to the formation of thrombi in the left atrial appendage (LAA) [2, 3].

Atrial fibrillation is a significant contributor to stroke, with cardiac embolisms, mainly arising from the LAA, being a common cause. The pathophysiology of AF-related thromboembolism involves a complex interplay of hemodynamic and structural changes within the atria, contributing to blood stasis and thrombus formation[4]. Moreover, various diseases, conditions, and cardiovascular risk factors contribute to atrial cardiomyopathy, which promotes AF and thrombus formation [5-8].

The CHA_2DS_2-VASc scoring system is a widely recognized tool for estimating thromboembolic risk in AF patients. This score considers age, gender, cerebrovascular event, congestive heart failure, hypertension, diabetes, and coronary artery disease. Some of these parameters are also considered clinically cardiovascular risk factors [9, 10]. Scoring systems are used to predict the risk of embolism in patients with AF, but these scores cannot precisely show the risk of embolism in all patients. Observations indicate that patients with equal scores did not have the same risk of embolism, and anatomical differences in LAA and left atrium (LA) measurements of the patients might be an essential predictor[11, 12]. Therefore, assessing LAA and LA measurements might provide essential predictive insights.

This study aims to investigate the correlation between CHA2DS2-VASc and left atrial measurements in patients with sinus rhythm. Understanding this relationship is crucial, as it could provide deeper insights into the early detection and management of cardiovascular diseases. By identifying specific risk factors that significantly influence left atrial dimensions, clinicians can tailor preventive strategies and interventions more effectively. Additionally, this research may contribute to the existing body of knowledge, paving the way for future studies to explore targeted treatments and improve patient outcomes.

Methodology

Study Population:

The retrospective, single-center study included a total of 326 patients who underwent CCTA imaging at a state hospital in Turkey between March 1, 2015, and November 1, 2016. After applying the inclusion and exclusion criteria, 250 patients were included in the final analysis. The study included patients who were 18 years of age or older and were classified as having intermediate cardiovascular risk according to ESC criteria [13], which encompass factors such as mildly elevated blood pressure, borderline high cholesterol levels, a family history of cardiovascular disease, pre-diabetes or well-managed diabetes, mild chronic kidney disease, and other moderate risk indicators such as smoking, obesity, or physical inactivity. Patients were excluded if they had a history of atrial fibrillation (n=32), hypothyroidism or hyperthyroidism (n=12), cardiac surgery (n=14), moderate to severe valvular disease (n=10), prosthetic heart valves (n=6), or congenital heart disease (n=2).

Data Collection:

In this study, data were collected using a structured questionnaire that was specifically designed to capture comprehensive information on patients' demographic characteristics, clinical parameters, and LAA types. The information recorded in the questionnaire was obtained directly from the patients' medical records and laboratory results. This included variables such as age, gender, BMI, cardiovascular risk factors (e.g., hypertension, diabetes, coronary artery disease), LAA measurements (e.g, appendage volume, orifice area, long and short diameters), and CHA_2DS_2-VASc scores. We categorized LAA types and calculated LA dimensions, volume, LAA orifice area, and volume using CCTA images. Quantitative measurements of LAA [appendage volume, orifice area] and LA [atrial volume, long diameter, short diameter] were evaluated, and all were compared to determine whether the CHA_2DS_2-VASc score was less than or equal to two or more [14].

Coronary computed tomography angiography imaging of the heart is performed using a 128-slice dual-source computed tomography (CT) system (GE Optima 660 SE 64 Detector 128-slice CT, GE Healthcare, Milwaukee, USA). Contrast-enhanced coronary angiography was performed using a retrospective electrocardiographic gating technique, collimation 64 × 0.6 mm (128 reconstructed sections per gantry rotation). The whole heart, from the carina to the diaphragm visualized in the craniocaudal direction. 0.625 mm cross-sectional thickness and ECG gating were performed at the workstation of Advantage Workstation version 4.6 (GE Healthcare, Milwaukee, USA)

Oblique coronary images in the axial plane atrial appendix annulus short diameter, long diameter, and circumference were measured manually. The annulus area was calculated automatically from the same images connected to the device. The length and depth measurements of the appendix in the axial plane were performed manually. The machine calculated volume automatically after sequential area measurements were drawn manually. The left atrium's long and short diameters were measured manually at the workstation. Left atrial volume measurement was performed automatically via the workstation.

Statistical Analysis: The data were analyzed using The Statistical Package for Social Sciences (SPSS) version 21.0 (SPSS Inc., Chicago, IL, USA). Data are expressed as the mean, standard deviation, median (minimum-maximum), counts, and percentages. Differences between groups were tested for significance using an unpaired Student's t-test. The Chi-square test was used to compare categorical variables. The relationship between left atrial appendix and left atrium measurements with CHA_2DS_2-VASc score and coronary artery disease risk factors was evaluated by Pearson correlation coefficient (r).

Ethical Considerations: All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964Helsinki Declaration and its later amendments or comparable ethical standards. Ethical approval for this study was obtained from the Diskapi Research and Training Hospital Ethics Committee (Date: 01.12.2016; Decision No: 63/02).

Results

A total of 326 patients were initially considered for the study; however, 76 patients were excluded based on predefined criteria, leaving 250 patients for the final analysis. The mean age of the patients included in the study was 54 ± 12 years and 51.6% were male. 46% of the patients had HT, and 47% were smokers. 3.2% of the patients had a cerebrovascular event, and 0.8% had heart failure. None of the patients had a significant coronary stenotic lesion. The baseline demographic, laboratory, and clinical parameters of the study population are summarized in Table 1. LAA and LA measurements of all patients were made quantitatively. According to the criteria previously determined by Wang et al. [14], the LAA was morphologically categorized into four groups: (1) chicken wing (CW), (2) windsock (WS), (3) cauliflower (CF), or (4) cactus (CS). The prevalence of CW, WS, CF, and CS morphologies in patients was 39.2%, 26.4%, 21.6%, and 12.8%, respectively (Table 1).

Table 1: Baseline demographic, laboratory, and clinical parameters of the study population

Demographics and Clinic Parameters	Mean ± SD	n (%)
Age (years)	54.4±12.3	
Male		129(51.6)
Female		121 (48.4)
Hypertension		115 (46)
Diabetes Mellitus		45 (18)
Coronary artery disease		84 (33.6)
Family History		88 (35.2)
BMI (kg/m2)	26.91±4.9	
Smoking		118 (47.2)
Congestive heart failure		2 (0.8)
Cerebrovascular event		8 (3.2)
CHA2DS2-VASc	1.66±1.2	
LVEF (%)	64.7±3.9	
Laboratory		
Leukocyte (109/L)	7.77 ± 1.91	
Hemoglobin (g/dL)	14.15±1.59	
Platelet (10^3/[illegible]L)	251.32±59.93	
Creatinine (mg/dL)	0.92 ± 0.15	
LDL (mg/dL)	136.35 ± 33.92	
Triglyceride (mg/dL)	169.77 ± 82.32	
LAA types		
Chicken wing		98 (39.2)
Cactus		32 (12.8)
Cauliflower		54 (21.6)
Windsock		66 (26.4)

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Among patients with low CHA_2DS_2-VASc scores, we observed smaller LAA orifice area, LA long diameter, LA short diameter, and LA volume compared to those with higher scores. Appendage orifice area (270.69±84.72 vs 300.97±97.65 mm2, p = 0.01), left atrium long diameter (60.73±6.83 vs. 64.53±7.66 mm2 p=0.001), left atrium short diameter (40.32±5.88 vs. 43.02±6.54 mm2, p = 0.001), left atrial volume (101.55±34.14 vs.114.34±32.58 mm3, p = 0.003) was found smaller in patients with low CHA_2DS_2-VASc score compared to those with high score. There was no association between CHA_2DS_2-VASc score and appendix volume (6.25±2.38 vs. 6.55±2.38 mm3, p=0.326) (Table 2).

Table 2. Comparison of LA and LAA measurements according to the CHA2DS2-VASc

Measurements	CHA2DS2-VASc<2 (n=121)	CHA2DS2-VASc≥2 (n=129)	p-value
Appendage volume (ml)	6.25±2.38	6.55± 2.38	0.326
Appendage orifice area (mm²)	270.69±84.72	300.97±97.65	0.01
Left atrium long diameter (mm)	60.73±6.83	64.53±7.66	0.001
Left atrium short diameter (mm)	40.32±5.88	43.02±6.54	0.001
Left atrium volume (ml)	101.55±34.14	114.34±32.58	0.003

When examining the relationship between LA and LAA measurements and the components of the CHA_2DS_2-VASc score separately, we observed a significant correlation with age across all LA and LAA measurements. The correlation coefficients were moderate but statistically significant for LAA volume (r=0.204, p=0.001), LAA orifice area (r=0.342, p=0.001), LA long diameter (r=0.329, p=0.001), LA short diameter (r=0.257, p=0.001), and LA volume (r=0.231, p=0.001). Additionally, there was a notable relationship between LA measurements and the presence of hypertension, with LA long diameter (r=0.203, p=0.001), LA short diameter (r=0.224, p=0.001), and LA volume (r=0.727, p=0.006). When assessing the correlation between patients' CHA_2DS_2-VASc scores and LA and LAA measurements, we found a correlation with specific measurements, including appendage orifice area (r=0.222, p<0.001), LA long diameter (r=0.244, p<0.001), LA short diameter (r=0.216, p<0.001), and LA volume (r=0.162, p<0.001). However, no significant correlation was observed with other parameters of LA and LAA measurements (Table 3).

Table 3. Correlation between LA and LAA measurements with cardiovascular risk factors and CHA2DS2-VASc

Measurements	Age		Gender		CVE		CHF		HT		DM		CAD		CHA2DS2-VASc	
	r	p	r	p	R	P	r	P	r	p	R	p	r	p	R	p
Appendage volume	0.204	**0.001**	-0.077	0.225	0.021	0.742	0.03	0.630	0.110	0.083	0.150	0.018	-0.015	0.814	0.117	0.065
Appendage orifice area	0.342	**0.001**	0.083	0.192	-0.05	0.689	0.25	0.689	0.091	0.152	0.132	**0.036**	0.113	0.074	0.222	**0.001**
Left atrium long diameter	0.329	**0.001**	-0.081	0.199	0.053	0.405	0.14	0.828	0.203	**0.001**	-0.015	0.819	0.176	**0.005**	0.244	**0.001**
Left atrium short diameter	0.257	**0.001**	-0.118	0.063	0.009	0.889	-0.028	0.662	0.224	**0.001**	0.126	**0.047**	0.158	**0.012**	0.216	**0.001**
Left atrium volume	0.231	**0.001**	-0.044	0.491	0.042	0.511	0.193	0.22	0.727	0.006	0.020	0.750	0.085	0.180	0.162	**0.001**

Note: Pearson correlation coefficient was used to evaluate the relationships between variables.

Discussion

There is increasing knowledge that the thrombogenic trend in AF is associated with several underlying pathophysiological mechanisms. Alterations in blood flow cause stasis in the LA and appears as spontaneous echo contrast or even a well-formed thrombus in echocardiographic evaluations. This is as a result of changes in atrial walls (anatomical and structural irregularities), progressive atrial dilation, the degradation of the endocardial layer of the extracellular matrix, and edematous or fibroelastic infiltration [12]. The LAA is a complex and diverse structure known to be the most common source of cardiac embolisms [15-17]. Furthermore, an increased LAA measurement, whether valvular or not causes, is associated with a higher risk of thromboembolism [18, 19]. Although several risk scoring systems exist to evaluate these thromboembolic complications, guidelines recommend using the CHA_2DS_2-VASc scoring system [20]. Interestingly, most components of this scoring system are also cardiovascular risk factors. This study investigated the correlation between CHA_2DS_2-VASc scores and left atrial measurements in patients with sinus rhythm. The findings indicate a significant correlation between LA and LAA measurements and the CHA_2DS_2-VASc score in patients with sinus rhythm. Specifically, when the individual risk factors such as age, hypertension, and a history of CAD, components that constitute the CHA_2DS_2-VASc score, there was a statistically significant differences in these measurements.

In the present study, hypertension had a relationship with LA's long diameter, short diameter, and volume but did not exhibit a significant relationship with LAA measurements. This finding aligns with a study by Taina et al., where no differences were observed in LA and LAA volumes between hypertensive and normotensive patients when examining cardiac computed tomographies of patients with cryptogenic stroke[21]. Another study by Bilge et al. reported a significant decrease in LAA emptying velocity in patients with uncontrolled hypertension [22].Additionally, Pierdomenico et al. discovered that elderly hypertensive patients with LA enlargement had a higher incidence of deadly or non-fatal strokes than those without LA enlargement [23].Similar to these findings, our study highlighted the morphological impact of hypertension on LA while showing no structural effect on LAA.

When analyzing the relationship between age and LAA and LA measurements, there was a significant correlation between age and most of the parameters. Tabata et al. noted a negative relationship between age and LAA ejection fraction in their study. Furthermore, Boucebci et al. found a significant increase in

LAA volume as age increased in patients undergoing CT scans[24, 25].These age-related changes are likely attributed to the increasing pressure and volume load on LA and LAA with advancing age.

Although LA measurements remained relatively unchanged in diabetic patients, LAA volume and LAA orifice area were significantly larger. While there is limited literature supporting the enlargement of LAA before LA dilatation in diabetic patients, diabetes may contribute to functional deterioration and impairment in the LAA due to direct glycosylation and inflammation-related fibrotic processes[26].

In a study by Wong et al., they investigated the risk of ischemic stroke or transient ischemic attack in patients with stable coronary artery disease (CAD) who did not have AF, atrial flutter, or anticoagulant therapy at baseline. They observed decreased LA function and an increased incidence of stroke in these patients[27].In this study, LA measurements were statistically higher in patients with CAD, although there was no difference in LAA measurements. When considering these results alongside existing literature, it is suggested that the inflammatory processes associated with coronary artery disease may lead to dysfunction by increasing LA diameter.

Boucebci et al. conducted a study using cardiac computed tomography to evaluate variations in LAA anatomy and function by gender. They reported wider LAA orifice areas in women, while other parameters were higher in men [25].Some studies have found that LAA volume is higher and LAA length is shorter in women[28]. Unlike the findings by Boucebci et al., this study did not find a significant relationship between gender and LA and LAA measurements. Although these features have been linked to a higher thromboembolic risk in some studies, further extensive research is necessary to determine their clinical significance.

Conclusion

In conclusion, this study showed that CHA_2DS_2-VASc risk score affects LA and LAA measurements in patients with sinus rhythm, and we thought that CCTA could be helpful in these measurements. The change in the anatomical measurements of the LA and LAA and the type of appendix may play a role in defining the risk of stroke.Future prospective studies with larger sample sizes and collaboration across multiple centers could enhance the generalizability of the results. Additionally, including additional risk factors and comorbidities in these studies could provide a more comprehensive understanding of their impact on LA and LAA measurements.

Limitations

First, patients are not randomly assigned as a retrospective study, and the sample size is relatively small. Second, patients might undergo CCTA when they might be dehydrated, and LAA sizes are affected by intravascular volume [29]. In addition, a single radiologist performed radiological analyses, potentially affecting the consistency of measurements.

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