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Investigating the relationship between the shape of the left atrial appendage and the incidence of atrial fibrillation in patients diagnosed with atrial fibrillation

Mehdi Moradi [1], Nakisa Khansari [2], Sorour Yari [2]*

[1] Department of Cardiology, Hamadan University of Medical Sciences, Hamedan, Iran
[2] Department of Cardiology, Farshchian Heart Center, Hamadan University of Medical Sciences, Hamadan, Iran

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ABSTRACT

Objective(s): Appendage is the growth of the left atrium, which is different in terms of shape and size. This research aimed to investigate the relationship between the shape of the left atrium appendage and atrial fibrillation incidence.

Methods: In a cross-sectional study, using the census method, 25 patients diagnosed with atrial fibrillation and a candidate for cardioversion were examined for the shape of the left atrial fibrillation in Farshchian Heart Hospital in Hamedan from 2021 to 2022. Three-dimensional echocardiography with an esophageal probe was used to detect LAA morphology. Data, after recording in the checklist, were analyzed with SPSS software (version 26).

Results: Patients had a mean age of 56.64±12.31 years. Males accounted for 32% of the patients and females for 68%. The frequency of chicken-wing, cactus, cauliflower, and windsock in the left atrium was 52%, 40%, 4%, and 4%, respectively. The mean and standard deviation of blood flow velocity in chicken-wing, cactus, cauliflower, and windsock forms were 14.92±3.90, 40.70±9.62, 23.00, and 32.00 cm/s, respectively (P<0.001). Shape of the left atrial appendage had no significant difference with the type of atrial fibrillation regarding age, gender, diabetes, and blood pressure (P<0.05 for all).

Conclusion: In patients with atrial fibrillation, the frequency of left atrial appendage morphology is different. Chicken-wing and cactus forms were the most common forms of left atrial appendage in patients diagnosed with atrial fibrillation. The shape of the left atrium was significantly related to the flow rate, which seems to help predict thrombosis and atrial fibrillation.

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Introduction

A prevalent rapid heart rhythm disorder is atrial fibrillation (AF) (1), in which the left atrial appendage (LAA) has a substantial impact, and changes in its structure and anatomy are closely related to the initiation, advancement, and recurrence of AF (2). In a regular heart rhythm, LAA contracts and relaxes rhythmically. Conversely, in AF, which causes irregular contractions of the left atrium (LA), the LAA loses its typical contraction pattern (3, 4). This leads to decreased contraction strength of the LAA wall and incomplete blood emptying from the LAA (5). Incomplete emptying, slow blood flow, and damage to the cardiovascular endothelium lead to morphologic changes of the LAA, which are likely to result in thrombosis and severe ischemic stroke events. Despite the highly complicated mechanism of initiation of thrombosis, the LAA morphologic change plays a crucial role in

Corresponding author: Sorour Yari: Cardiologist, Hamadan University of Medical Sciences, Hamadan Province, Hamadan, Iran. Tel: +989122835939, Email: soruryari1991@yahoo.com

stroke (6-8).

LAA is a finger-like projection from the main body of the left atrium. It protrudes from the primordial left atrium, which is formed mainly by the adsorption of the primordial pulmonary veins and their branches (9, 10). The junction is well-defined by a narrowing at the orifice of the appendage. The orifice of LAA has few cardiomyocytes, while the body of LAA is rich (11). Thus, the orifice becomes a potential conduction zone for re-entry arrhythmia (12). Substantial variations exist in its size, shape, and relationship with adjacent cardiac structures. According to studies, lobes are protrusions from the main body, with the tail portion representing a lobe, while bends in the tail do not constitute additional lobes (13-15). LAA is structurally different in people so that among Asians and Americans there are one-lobe, two-lobe, and multi-lobe structures (16). Based on some previous research, two lobes (54%) were the most common structures, followed by three lobes (23%), one lobe (20%), and four lobes (3%) (17, 18). In another study, the left atrium was categorized into four types: chicken-wing (48%), windsock (19%), cactus (30%), and cauliflower (3%) (19, 20). The LAA functions contractility as well. The pathological state of AF results in increased left atrial pressure. The left atrium and the LAA can counteract the increased pressure by enlarging the inner diameter and increasing contraction force to maintain adequate blood filling in the left ventricle (21). As AF advances, the LAA will enlarge, reducing blood flow and leading to incomplete emptying, and as mentioned before, it causes thrombosis in the LAA (22).

It is crucial to carefully examine the LAA when assessing patients with AF to ascertain the risk of cardiac complications, mainly before starting cardioversion procedures (23). Transesophageal echocardiography allows for precise evaluation of the structure and function of the appendage using 2D imaging and Doppler flow analysis (24). Distinct flow patterns that indicate appendage function have been recognized for various normal sinus rhythms and abnormal cardiac rhythms (25). Appendage dysfunction is related to the presence of spontaneous echo contrast, thrombus formation, and thromboembolism (26). This relationship has been extensively researched in patients with atrial fibrillation or atrial flutter, those undergoing cardioversion for atrial arrhythmias, and individuals with mitral valve disease.

Material and Methods

Data collection method

The study was a cross-sectional observational analysis aiming to determine the relationship between LAA morphology and AF occurrence in patients referred to Farshchian Heart Hospital in Hamedan over two years (April 2021 to March 2022). A total of 25 patients diagnosed with atrial fibrillation, eligible for cardioversion, were invited to participate in the study. A specialist in cardiac echocardiography conducted an echocardiogram, which involved recording patient demographics and examining the morphology of the left atrial appendage. Three-dimensional transesophageal echocardiography diagnosed LAA morphology. Patients fasted for 4-6 h before the examination and received local anesthesia with 2% lidocaine. Study parameters were subsequently evaluated using transesophageal echocardiography.

Definition of LAA morphology

In this study, the LAA morphology was displayed using transesophageal echocardiography (Figure 1). The “chicken-wing” is characterized by a dominant lobe with a noticeable bend in its proximal or middle part, folding back on itself at a distance from the orifice, and it may have secondary lobes. The “cactus” features a dominant central lobe with secondary lobes arising from it superiorly and inferiorly. The “cauliflower” has a short overall length, complex internal characteristics, a variable number of lobes without a dominant lobe, and a more irregular shape of the orifice. The “windsock” has a dominant lobe as the primary structure, with variations in the location and number of secondary or even tertiary lobes (27).

Inclusion criteria

Participants who met the following criteria were included in the study:

- Suffering from atrial fibrillation
- Age over 18 years
- Declaration of patient’s consent to participate in the research.

Exclusion Criteria

Participants who met any of the following criteria were excluded from the study:

- Increased pulmonary artery pressure
- Congenital heart diseases
- Pectus excavatum
- History of catheter ablation or other percutaneous cardiac interventions
- History of heart surgery
- Insufficient image quality and complete lack of access to information
- Severe mitral or aortic valve diseases
- Coronary artery diseases

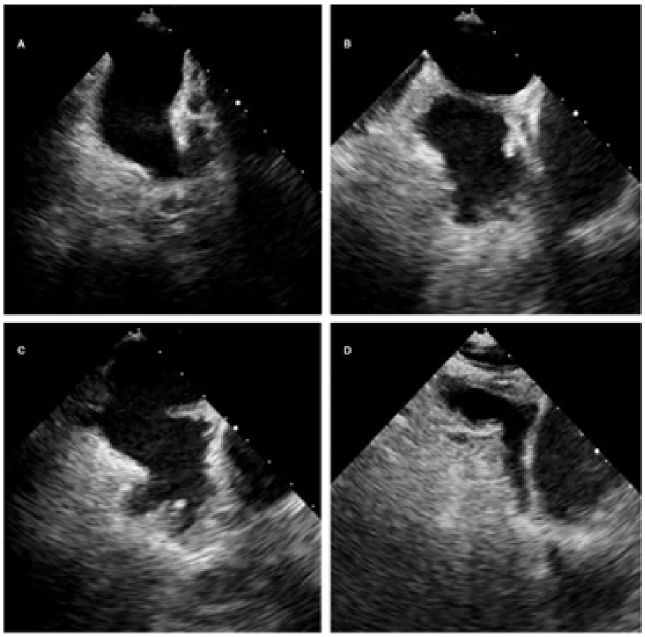

Figure 1. Left atrial appendage morphology by 2D transesophageal echocardiography: (A) Chicken-wing. (B) Cauliflower. (C) Cactus. (D) Windsock

Data analysis method

The information obtained was analyzed using SPSS20 software. Qualitative variables were described as percentages and quantitative variables as mean scores. One-way analysis of variance was employed to compare the frequency of LAA shapes by age, Fisher's exact test was utilized for gender and comorbidities comparison, and the Wilcoxon test was applied for flow velocity analysis (due to the non-normal distribution of the data). In this study, the significance level was considered at 5%.

Results

In this study, a census method was employed to select and examine 25 patients diagnosed with atrial fibrillation referring to the educational and medical center of Farshchian Cardiovascular Hospital in Hamedan during 2021-2022, who were potential candidates for cardioversion. Patients had a mean age of 56.64±12.31 years (range 38-81 years).

As illustrated in Figure 2, a significant difference was observed in the gender of patients with these disease with women experiencing a higher rate compared to men (68% vs. 32%). Based on the findings of Table 1, there was no significant difference between the shape of the LAA and the gender of the patients.

The findings of Table 2 show the frequency of underlying diseases in the research population. Accordingly, the frequencies of diabetes and hypertension were 48% each, hyperthyroidism and hypothyroidism were 16% each, and bipolar disorder was 4%. Moreover, none of the patients had a history of taking antiarrhythmic drugs, and no case of thromboembolism was observed.

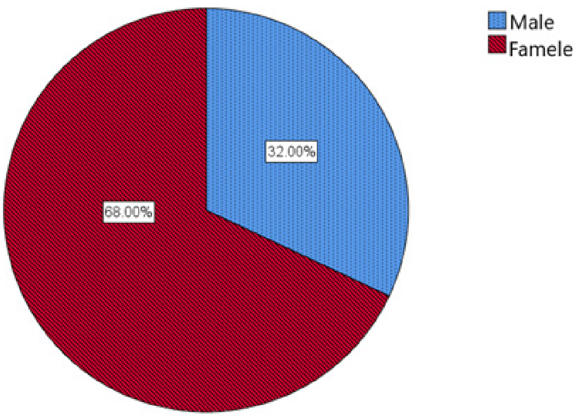

Figure 2. Gender frequency of patients participating in the study

Table 1. Frequency of left atrial appendage morphology in patients with AF by gender

LAA morphology	Gender		*P-value
	Male N (%)	Female N (%)	
Chicken-wing	3 (37.5)	10 (58.8)	0.422
Cactus	4 (50.0)	6 (35.3)	
Cauliflower	1 (12.5)	0 (0)	
Windsock	0 (0)	1 (5.9)	
Total	8 (100)	17 (100)	

Table 2. The frequency of underlying diseases in the research population

Variable	Number	Percentage
Diabetes	12	48.0
High blood pressure	12	48.0
Hypothyroidism	4	16.0
Hyperthyroidism	4	16.0
Bipolar disorder	1	4.0

The information about LAA morphology is provided in Tables 3 and 4. The Fisher test results did not show a significant difference among four types of LAA in terms of AF recurrence (P=0.718). It was found that among the four types, the risk of AF recurrence in chicken-wing LAA was more common than in other morphologies.

According to the findings in Table 5, no significant difference was observed between the shape of the LAA and diabetes, hypertension, hypothyroidism, and hyperthyroidism.

The mean and standard deviation of left atrial volume in chicken-wing, cactus, cauliflower, and windsock forms were 38.80±6.29, 31.22±8.33,

Table 3. Frequency of left atrial auricle shape in patients diagnosed with atrial fibrillation and candidates for cardioversion

LAA morphology	Number	Percentage
Chicken-wing	13	52.0
Cactus	10	40.0
Cauliflower	1	4.0
Windsock	1	4.0
Total	25	100

Table 4. Frequency of LAA according to the type of atrial fibrillation

LAA morphology	Type of AF			P-value*
	Aggressive N (%)	Non-aggressive N (%)	Total N (%)	
Chicken-wing	4 (30.8)	9 (69.2)	13 (100)	0.718
Cactus	3 (30.0)	7 (70.0)	10 (100)	
Cauliflower	0 (0)	1 (100)	1 (100)	
Windsock	1 (100)	0 (0)	1 (100)	

* Fisher exact test

Table 5. Frequency of LAA in patients with AF

Disease	LAA morphology				P-value
	Chicken-wing n (%)	Cactus n (%)	Cauliflower n (%)	Windsock n (%)	
Diabetes					
No **Yes** **Total**	5 (38.5) 8 (61.5) 13 (100)	6 (60.0) 4 (40.0) 10 (100)	1 (100) 0 (0) 1 (100)	1 (100) 0 (0) 1 (100)	0.410
Blood pressure					
No **Yes** **Total**	7 (53.8) 6 (46.2) 13 (100)	5 (50) 5 (50) 10 (100)	0 (0) 1 (100) 1 (100)	1 (100) 0 (0) 1 (100)	0.999
Hypothyroidism					
No **Yes** **Total**	11 (84.6) 2 (15.4) 13 (100)	8 (80.0) 2 (20.0) 10 (100)	0 (0) 0 (0) 0 (0)	0 (0) 0 (0) 0 (0)	0.999
Hyperthyroidism					
No **Yes** **Total**	12 (92.3) 1 (7.7) 13 (100)	8 (80.0) 2 (20.0) 10 (100)	1 (100) 0 (0) 1 (100)	0 (0) 1 (100) 1 (100)	0.194

32.00, and 21.00 ml/m^2, respectively (Figure 3). According to the results of a one-way analysis of variance, there was no significant difference between the volume of the left ventricle in different forms of the left atrial appendage (P=0.618).

The mean and standard deviation of LAA velocity in chicken-wing, cactus, cauliflower, and windsock shapes were 92.14±90.3, 70.40±62.9, 0.23, and 0.32 cm/s, respectively (Figure 4). Based the findings of the non-parametric Kruskal-Wallis test, there was a significant difference among different left atrial appendage shapes in terms of LAA velocity (P<0.001). Moreover, according to the Bonferroni post-hoc test, LAA Velocity in the chicken-wing type was significantly lower than the Cactus type (P<0.001); however, there was no significant difference among other shapes regarding LAA velocity (P>0.05).

Discussion

In our study, from a morphological perspective, the most common shapes of left atrial appendage

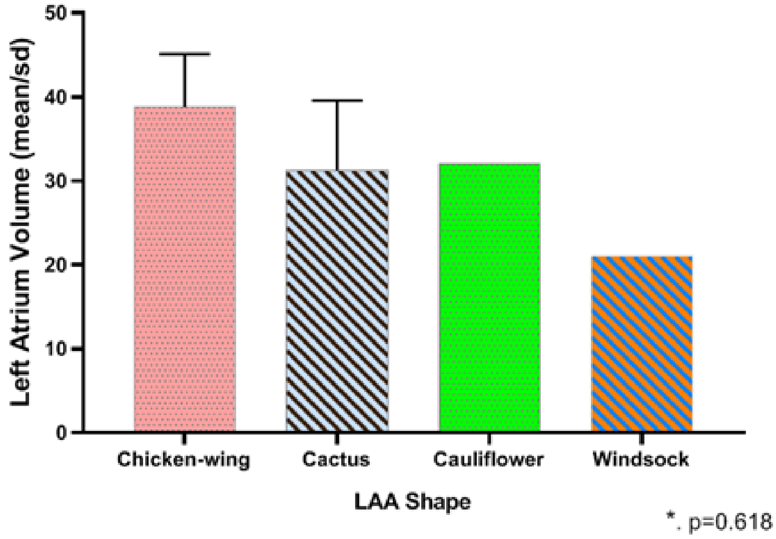

Figure 3. Mean and standard deviation of the LA volume according to the shape of the left atrial appendage

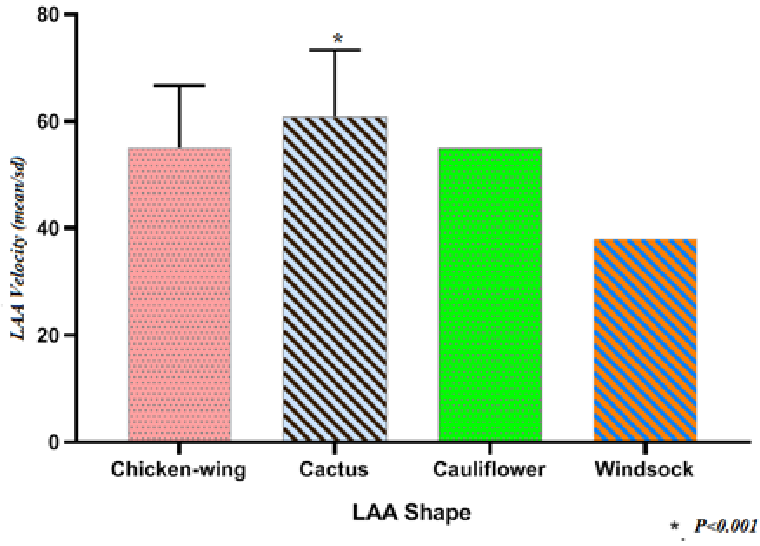

Figure 4. Mean and standard deviation of LAA velocity according to the shape of the LAA

in patients with atrial fibrillation were chicken-wing and Cactus. The atrial appendages are left atrial formations that are very different in terms of volume and shape. This diversity should be noted when interpreting left atrial appendage images, especially when diagnosing heart diseases. In their research on the association between the morphological features of the left atrial appendage and the risk of stroke in patients with atrial fibrillation, Di Biase et al. found that among various LAA morphologies, chicken-wing at 48% and Cactus at 30% were the most common LAA shapes (28).

Among the different shapes of the left atrial appendage, a significant difference was observed in flow velocity. The blood flow velocity was significantly lower in the chicken-wing appendage, compared to that in the Cactus appendage. However, there was no significant difference among the other shapes in terms of blood flow velocity. Fukushima et al. investigated the relationship between different shapes of the left atrial appendage and flow velocity in patients with atrial fibrillation. They found a correlation between LAA morphology and flow velocity. The highest flow was associated with the chicken-wing shape, while the lowest was related to the cauliflower shape (29).

The shape of the left atrial appendage did not show a significant difference in the occurrence of diabetes, hypertension, or other diseases. In a study by Korhonen et al., no significant correlation was found between the morphological features of LAA and diabetes, hypertension, and dyslipidemia, which can be consistent with our findings (30).

The association between LAA and cardiovascular diseases has been noted, with individuals having a chicken-wing-shaped left atrial appendage being at a higher risk for embolic events compared to other shapes. The morphology of LAA may be a congenital risk factor for the formation of LAA thrombosis in patients with AF. Gong et al. investigated the relationship between the morphology of the left atrial appendage and the recurrence of atrial fibrillation after ablation. They found that patients with a chicken-wing morphology of the left atrial appendage had a higher risk of atrial fibrillation recurrence after ablation. Therefore, assessment of the shape of LAA in cardiac patients may be beneficial in predicting the risk of thrombosis or recurrence of atrial fibrillation after ablation, as well as in adopting preventive measures (31).

In our investigation, there was no significant difference between age and gender in patients with atrial fibrillation in terms of the shape of the left atrial appendage. In a study performed by Korhonen et al. on patients undergoing coronary angiography with and without atrial fibrillation, a significant and positive relationship was found between the length of the appendage and age, as well as a significant association with female gender. Male patients were more likely to have multi-lobed LAA manifestations (30).

The increase in age and heart weight is accompanied by the enlargement of LAA. Elzenini et al. carried out a study in Egypt using multidetector computed tomography to investigate the morphology of the left atrial appendage and gender differences in the Egyptian population. They discovered that the most common LAA morphology in the study population was windsock, which may indicate the Egyptian population or patients in sinus rhythm. Women were less likely to have a chicken-wing LAA morphology and had a larger LAA volume and shorter LAA length (32).

In the current research, the shape of the LAA did not differ significantly based on the type of atrial fibrillation (paroxysmal and non-paroxysmal). A study was conducted by Takaya et al. to investigate the relationship between left atrial appendage morphology and the progression of atrial fibrillation in 299 patients divided into four groups: without AF, paroxysmal AF, persistent AF, and long-standing persistent AF. In the mentioned research, there was no significant difference between the chicken-wing shape and other non-chicken-wing shapes in terms of the type and severity of ventricular fibrillation, which was almost similar to the findings of our study (33).

Limitations

The limitation of this research was the small sample size as the conditions that could affect the relationship between the shapes of the left atrial appendage and other variables were not very common.

Conclusion

The morphology of the left atrial appendage varies in patients with atrial fibrillation. Chicken-wing and Cactus shapes were the most common forms of left atrial appendage in patients diagnosed with atrial fibrillation. Left atrial appendage morphology was significantly associated with flow velocity, which appears to be beneficial in predicting thrombosis and the prognosis of atrial fibrillation.

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