SCIENTIFIC RESEARCH

THE LEFT ATRIAL APPENDAGE MORPHOLOGY IN PATIENTS WITH ATRIAL FIBRILLATION BY CARDIAC COMPUTED TOMOGRAPHY

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SUMMARY

Purpose: To describe the morphological characteristics of left atrial appendage (LAA) on multislice computed tomography in patients with atrial fibrillation.

Materials and methods: A prospective descriptive study on 44 patients diagnosed with atrial fibrillation (AF) and underwent multislice computed tomography at Bach Mai Hospital from August 2022 to July 2023.

Results: Mean age 64.45 ± 10.50. The most common morphology of LAA is "windsock" with 40.91%, followed by "chicken wing" with 34.09%, then "cauliflower" with 13.64%, and finally "cactus" with 11.36%. The most common LAA orifice position is in the middle (63.64%), the average length of the LAA is 47.03 ± 11.69 mm, and the mean volume of the LAA is 14.39 ± 8.00 ml. There is little relationship between gender and morphological characteristics of the LAA.

Conclusion: The most common LAA morphology in patients with atrial fibrillation is "windsock". Gender has little association with left atrial appendage morphology.

Keywords: *atrial fibrillation, left atrial appendage, multislice computed tomography*

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I. INTRODUCTION

Atrial fibrillation (AF) is a common arrhythmia in clinical practice, accounting for approximately 1/3 of patients hospitalized due to arrhythmias [1]. AF can easily form blood clots, which is the main cause of ischemic stroke and other embolic complications, causing serious consequences and increased mortality. Methods to help detect thrombosis and anticoagulation therapy are believed to be one of the main treatments to improve prognosis in patients with AF. The left atrial appendage (LAA) is the most common source of thromboembolism in patients with AF. Many thrombi originate in the left atrial appendage due to the presence of many grooves, relatively small ostium, narrow neck, and blood stasis, increasing the risk of clot formation [2]. Over 90% of cardiac thrombi are formed in the LAA in patients with nonvalvular AF and 15% to 38% in non-AF patients with cardiomyopathy [3].

In recent years, research on the anatomy of the LAA and its relationship with surrounding structures has received increasing attention, as ultrasound techniques to exclude the left atrial appendage and radiofrequency ablation have become increasingly popular. However, the morphology of the LAA is quite complex and exists in different spatial planes, it is difficult for echocardiography to access all aspects and determine the shape of the LAA. Multi-slice computed tomography (MSCT) with three-dimensional spatial rendering can determine the anatomical structure and relationship of the LAA with surrounding structures [4]. In Vietnam, there have not been many studies on the morphological characteristics of the LAA on MSCT in patients with AF, therefore in this study, we aimed to investigate the morphological characteristics of the LAA on MSCT in patients with AF.

I. MATERIALS AND METHODS

Study population

The study population consisted of 44 consecutive patients diagnosed with AF presenting for cardiac computed tomography (CCT) at Bach Mai Hospital from October 2022 to July 2023. The research protocol was approved by the ethics committee, and informed consent was obtained from all patients. We included in the study patients diagnosed with atrial fibrillation on electrocardiogram (ECG) or Holter ECG, full medical records with research information. Exclusion criteria for missing CT images stored on DVDs or PACs systems, image quality is not enough for image analysis.

Imaging

Cardiac MDCT imaging was performed using a 128-slice MDCT scanner (Somatom Definition Edge, Siemens Medical Solutions, Germany) or a 256-slice MDCT scanner (Somatom Definition Flash, Siemens Medical Solutions, Germany). Scanning parameters included tube current of 195–210 mAs, voltage of 80-120 kV, rotation time of 0,27s, and collimation of 128 × 0.6 mm. All examinations were ECG-based. Axial source images were acquired in helical mode and two- and three-dimensional reconstruction images were created in four segments at 40 to 70% of the R to R interval. The reconstruction images were processed on a separate workstation (Syngo-Via) with the multiplanar format and volume rendering to display individual cardiac structures in high detail.

All images were evaluated for LA diameter and volume, as well as LAA volume, length, morphology length, and location ostium. LA diameter was measured at its maximum anteroposterior dimension in axial images. LA and LAA volumes were measured from three-dimensional reconstructed images. The LAA ostium was defined as the narrowest part of the LAA ostium, and its location was classified according to its superior aspect relative to the ostium of the left superior pulmonary vein into high, intermediate, and low (superior, aligned with, and below the opening of the left superior pulmonary vein). LAA morphology was classified based on Wang et al. and previous classifications by Kimura et al.5,6 into four distinct morphological variants: wind (with a dominant central lobe > 40 mm in length and secondary lobes arising in a direction or curvature of more than 100°), chicken wing (with dominant lobe > 40 mm with sharp curvature of less than 100° in the proximal or medial part), cactus (with middle lobe < 40 mm long and secondary lobes arising from both upper and lower directions), and cauliflower (length < 40 mm, complex internal structure).

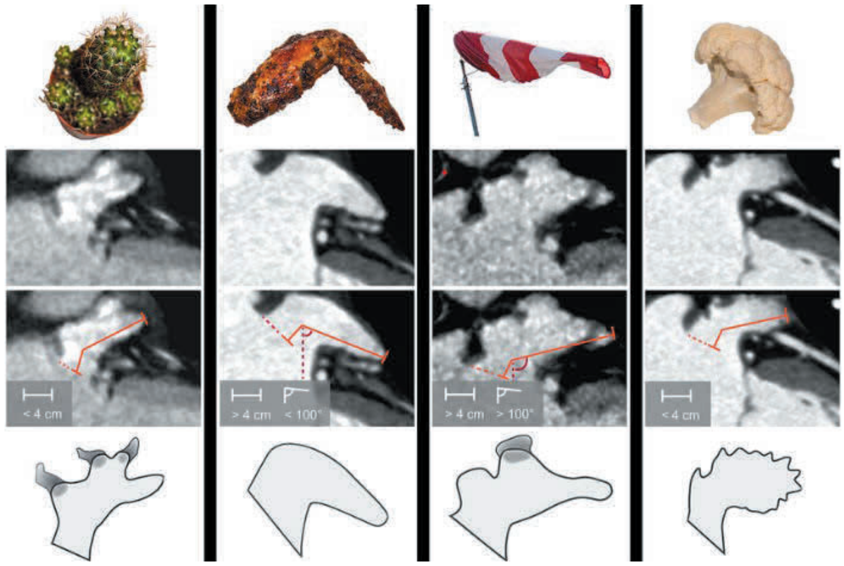


Figure 1. LAA morphology types based on Wang's classification and Kimur [5], [6].

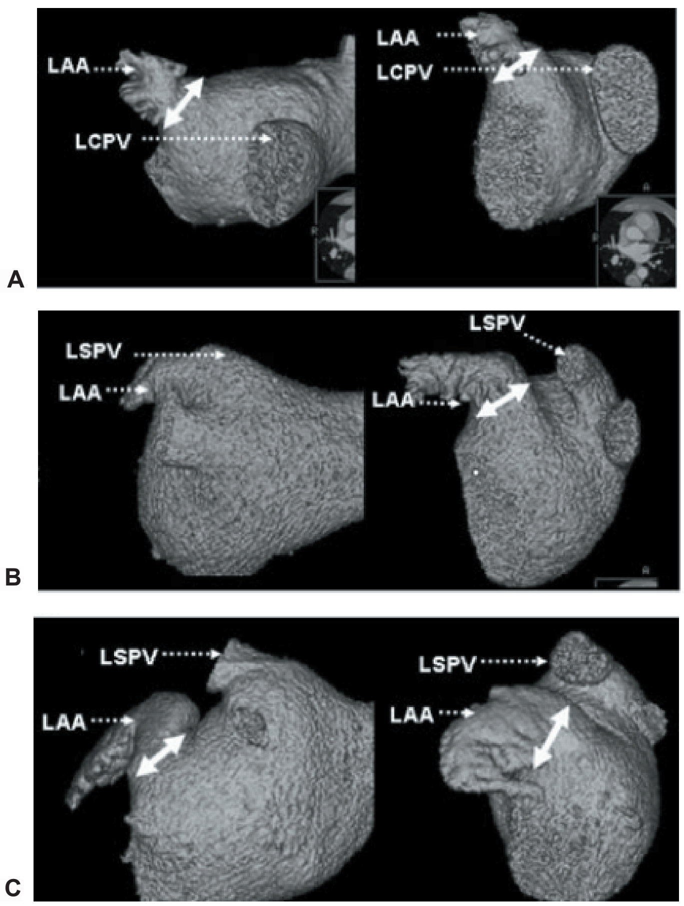


Figure 2. The three different left atrial appendage orifice positions in our three-dimensional reconstruction MDCT images: superior aspect of the orifice is above (a), in line with (b) or below(c) the opening of the upper left pulmonary vein, based on Wang et al [5].

Statistical analysis

The IBM SPSS 26.0 software was used for statistical analysis. Continuous variables were presented as mean ± standard deviation while categorical variables were presented as numbers and percentages. Normally distributed parametric data were analyzed with Student's t-test and Pearson correlation. Non-normal distribution parameters and non-parametric data were analyzed with the Mann-Whitney test, Spearman correlation, and Chi-squared.

II. RESULTS

The mean age of our study population (n = 44) was 64.45 years ± 10.05. Almost two-thirds were males (63.6%, n =28) and one-third were females (36.4%, n = 16). Hypertension and heart failure are the most common clinical risk factors (40.9% and 45.5%), with 4 patients having a history of stroke are shown in Table 1.

Table 1. Clinical Characteristics of Patients

Characteristics	N	%
Age **(± SD)**	64.45 ± 10.50	
Males	28	**63.6**
BMI (kg/m^2)	21.61 ± 1.28	
Heart failure	20	45.5
Hypertension	18	40.9
Stroke/TIA	4	9.1
Diabetes	9	20.5
Dyslipidemia	12	27.3
Vascular disease	9	20.5

The distribution of these morphologies, in descending order of frequency, was as follows: windsock (40.91%, n = 18), chicken wing (34.09%, n = 15), cauliflower (13.64%, n = 6), and cactus (11.36%, n = 5). Half the patients had a mid orifice in line with the left upper pulmonary vein (63.64%, n = 28), followed by a low orifice below the left upper pulmonary vein (20.46%, n = 9), the least a high orifice above the left upper pulmonary vein (15.91%, n = 7). The mean LA diameter was 40.65mm ± 9.79 and the mean LA volume was 111.07 ml ± 66.85. The mean LAA volume was 14.39ml ± 8.00 and the mean LAA length was 47.03 mm ± 11.69. The distribution of the different LAA morphologies and mean LA and LAA dimensions are summarized in Table 2.

Table 2. Morphological characteristics of the left atrial appendage

		N=44	%
LAA morphology	Chicken wing	15	34.09
	Windsock	18	40.91
	Cactus	5	11.36
	Cauliflower	6	13.64
LAA orifice position	High	7	15.91
	Mid	28	63.64
	Low	9	20.46
LAA length (mm)		47.03 ± 11.69	
LAA volume (ml)		14.39 ± 8.00	
Left atrial diameter (mm)		40.65 ± 9.79	
Left atrial volume (ml)		111.07 ± 66.85	

There was no significant difference in LA size between men and women but there was a significant difference in LAA size. Females have a smaller mean LAA volume than men, and a smaller mean LAA length (42.77 mm vs 49.47 mm, p value 0.02). There is no difference in the distribution of LAA morphology and the LAA orifice position between men and women.

Table 3. Differences in the LA and LAA dimensions as well as LAA morphological types between males and females

		Male (N=28)	Female (N=16)	P
Left atrial diameter, mm (mean ± SD)		40.90 ± 11.12	40.21 ± 7.1	0.16
Left atrial volume, ml (mean ± SD)		119.63 ± 77.57	96.08 ± 40.04	0.14
LAA length, mm (mean ± SD)		49.47 ± 8.69	42.77 ± 15.00	0.02
LAA volume, ml (mean ± SD)		15.69 ± 8.59	12.10 ± 6.48	0.19
LAA orifice position (%)	Low	17.86	25.00	0.73
	Mid	67.86	56.25	
	High	14.27	18.75	
LAA morphology (%)	Chicken wing	39.29	25.00	0.21
	Windsock	46.29	31.25	
	Cactus	7.14	18.75	
	Cauliflower	7.14	25.00	

III. DISCUSSION

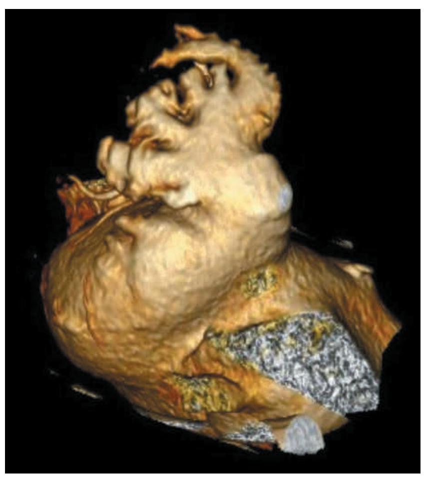
LAA morphology

In our study, the morphology of the LAA in the group of patients with AF was highest in the "windsock" type at 40.91%, followed by "chicken wing" at 34.09%, "cauliflower" at 13.64% and the lowest at "cactus" 11.36%, this result is similar to the study of YAN WANG (2010) with the result "windsock" 46.7%, "cactus" 5.9%, there is a difference in the result "chicken wing" 18.3 %, "cauliflower" 29.1% [5]. On the other hand, this result is also different from many studies on the LAA, showing that chicken wing morphology is the most common and cauliflower is the least common, most commonly in patients with AF undergoing catheter ablation. These studies include those conducted by Di Biase et al [7], Bai et al [8] and Anselmino et al [9]. Other studies found different distributions, including Fukushima et al. on patients in Japan where cactus morphology was found to be most prevalent [10]. This variability in the distribution of LAA morphologies may be due to racial or demographic differences in different populations.

a

(Vu Duy C, ID: 238897570)

Figure 3a. Chicken wing



b

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Figure 3b. Windsock

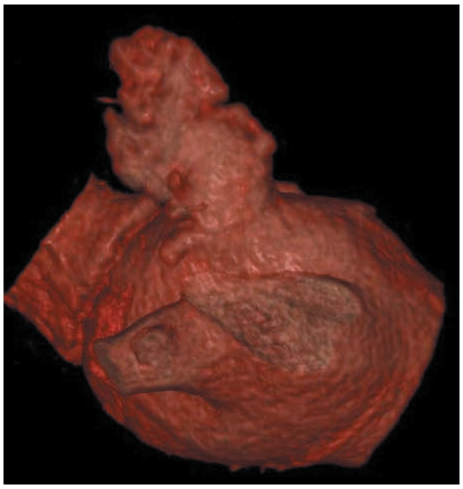

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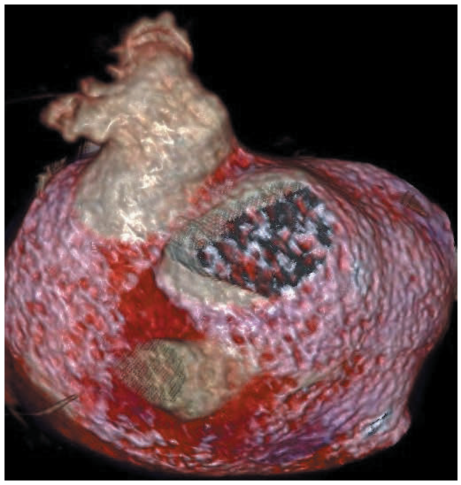
Figure 3c. Catus



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(Ha Quoc H, ID: 338997888)

Figure 3d. Cauliflower

LAA dimensions

The average LAA volume measured in our study was 14.39 ± 8.00, larger than the result measured in Wang et al. of 9.9 ± 6.4ml in the group of patients with AF [5], Korhonen's study. et al (12,6ml) [11], and smaller than the study by Kimura et al (16,1ml) [6]. The average LAA length in our study was 47.03 ± 11.69mm, a result also larger than in Wang et al. of 46.5 ± 12.6mm. [5] This difference may be related to race. This also needs attention because there is increasing evidence that a larger left atrial appendage volume promotes blood stasis and contributes to an increased risk of thrombosis. In our study, there were 2 patients with thrombosis verified with transesophageal echocardiography, the LAA volume in 2 patients was larger than the average volume in the study, volumes were 14.92ml and 17.15ml respectively.

e

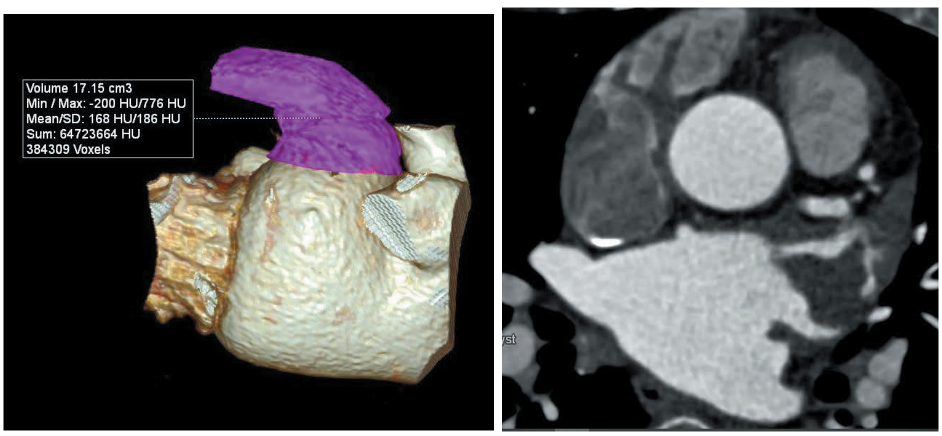

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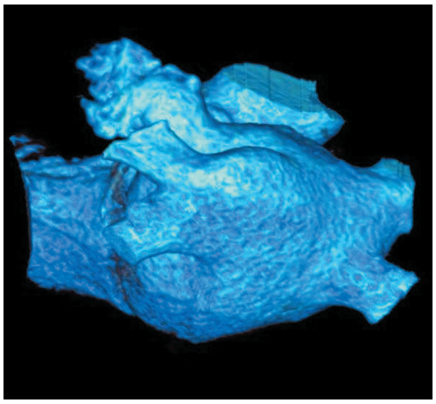
Figure 3e, 3f. Volume and thrombus of the LAA

The LAA orifice position in the middle compared to the left superior pulmonary vein is also more common in our study (63.64%), this result is equivalent to the study by Wang et al. showing that the location rate in the middle (58,1%) [5], also similar to the study of 80 patients with atrial fibrillation ablation by Takehiro Kimura (2013) with the result that the LAA orifice position was high in 8.8%, middle in 63.8% and low in 27.4% [6]. This is important because literature evidence suggests that a higher LAA orifice position is associated with a higher risk of stroke, as slower blood flow contributes to thrombus formation.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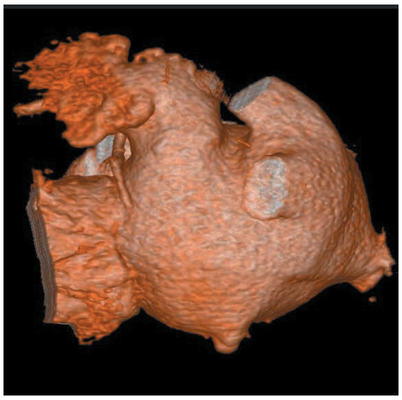
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Figure 3g, 3h. High and mid the LAA orifice positions in comparison to the superior border of the left superior pulmonary vein

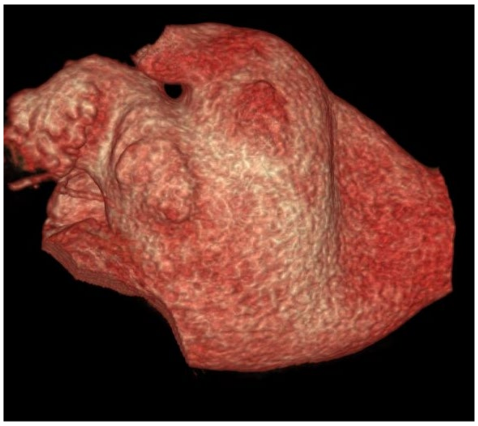
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Figure 3i. Low the LAA orifice positions in comparison to the superior border of the left superior pulmonary vein

Gender considerations

Our results show little significant association between gender and LAA anatomy. Men have larger LAA volume and length than women. Although in some studies these characteristics have been associated with a higher risk of thromboembolism [7], [12], further studies of clinical correlates are needed to translate these differences into risk of thromboembolism. There is little data on sex differences in left atrial appendage morphology. Korhonen et al. reported an association between the female sex and shorter left atrial appendage length that was lost after adjusting for body surface area and was attributed to different amounts of pericardial fat contributing to remodeling atrium [13].

IV. CONCLUSION

The most common LAA morphology in our study population is windsock. The most common location of the left atrium is in the middle. Gender has little relationship with left atrial appendage morphology.

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