Human left atrial appendage anatomy and overview of its clinical significance

İnsanda sol aurikula açıklığının anatomisi ve klinik önemine genel bir bakış

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Abstract

Objective: The left atrial appendage (LAA) is an important anatomic region since it is a source of thromboembolism in patients with atrial fibrillation. Although this anatomic and clinical relation it has received little attention until recent years.
Methods: This descriptive laboratory study was performed in 56 hearts of adult formalin fixed cadavers. The morphological characteristics of LAA were recorded. The distances between the orifices of left superior pulmonary veins (LSPV), circumflex artery, left anterior descending (LAD) artery, mitral valve and LAA were also measured in this study.
Results: The morphological appearance of the LAA was classified into two different ways. There were two types according to the first classification: slender like a crooked finger (in 73.2%) and stump-like (in 26.8%). The lobe number of LAA was two in 64.3% specimens and three in 35.7%. The types of LAA were Cactus (24%), Chicken Wing (12%), Windsock (38%) and Cauliflower (26%) according to the second classification. The LAA orifice was oval-shaped in 37.5% and round-shaped in 62.5%. The bridge on the orifice was determined in one specimen. The longest diameter of LAA orifice was 16.5±4 mm. The presence of accessory left atrial appendage was observed in one specimen. The distance between LAA orifice and oval fossa was 27.5±5.5 mm.
Conclusion: We highlighted the anatomic features of LAA and LAA orifice. LAA diameters, shape and the relation between neighboring structures in relation to atrial fibrillation and surgical approaches were discussed. *(Anadolu Kardiyol Derg 2013; 13: 566-72)*
Key words: Anatomy, atrial fibrillation, left atrial appendage, left atrium, thrombus

Özet

Amaç: Sol aurikula atriyal fibrilasyonlu hastalarda tromboemboli nedeni olduğu için önemli bir anatomik bölgedir. Bu anatomik ve klinik ilişkiye rağmen son yıllara kadar az dikkate alınmıştır.
Yöntemler: Bu tanımlayıcı laboratuvar çalışmasında 56 adet formalinle fikse edilmiş kalp üzerinde çalışıldı. Sol aurikulanın morfolojik özellikleri kaydedildi. Bu çalışmada üst pulmoner venler, sirkumfleks arter, sol ön inen arter ve mitral kapak ile sol aurikula açıklığı arası da ölçüldü.
Bulgular: Sol aurikulanın morfolojik görünümü iki farklı şekilde sınıflandırıldı. İlk sınıflandırmaya göre iki tip mevcuttu: İnce çomak parmak şekilli (%73,2) ve kütük şekilli (%26,8). Sol aurikula lob sayısı ise olguların %64,3'ünde iki iken %35,7'sinde üç idi. İkinci sınıflandırmaya göre sol atriyal aurikula (SAA) tipleri, Kaktüs (%24), Tavuk Kanadı (%12), Rüzgar Hortumu (%38) ve Karnabahar (%26) şeklindeydi. Sol aurikula açıklığı %37,5 olguda oval şekilli iken %62,5 olguda yuvarlak şekilli idi. Sol aurikula açıklığının en uzun çapı 16,5±4,0 mm olarak bulundu. Aksesuvar sol aurikula bir olguda görüldü. Sol aurikula açıklığı ve fossa ovalis arası uzaklık ise 27,5±5,5 mm idi.
Sonuç: Sol aurikula ve sol aurikula açıklığının anatomik özellikleri aydınlatıldı. Sol aurikula açıklığının çapı, şekli ve çevre yapılarla ilişkisinin, atrial fibrilasyon ve cerrahi yaklaşımlardaki önemi tartışıldı. *(Anadolu Kardiyol Derg 2013; 13: 566-72)*
Anahtar kelimeler: Anatomi, atrial fibrilasyon, sol aurikula, sol atriyum, trombüs

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Introduction

The left atrial appendage (LAA) is a small, muscular extension of the left atrium arising near the left pulmonary veins (1). There has been increasing interest in LAA recently as a target for intervention. The embryological remnant functions during conditions of fluid overload as a reservoir. Because of its hooked morphology, the LAA is prone to stasis and it is a site of thrombus formation in patients with atrial fibrillation (2). Occlusion of the LAA is thought to reduce the risk of thromboembolic events in patients with atrial fibrillation. It is important for clinicians to select the appropriate device size for implant and not to damage neighboring structures during the occluding the orifice of LAA (1, 3-6). LAA morphologic differences were associated with variations in anatomical relationships (2, 4).

A detailed anatomic knowledge of LAA and neighboring structures may facilitate surgical approaches and implant procedures to LAA.

The aim of the study was to describe a detailed LAA morphology to facilitate the clinical approaches to LAA.

Methods

Study design

This was a descriptive laboratory study that carried out in Ege University Faculty of Medicine Anatomy Department.

Material

Fifty six heart specimens obtained from 10% formalin fixed adult cadavers were examined grossly (mean age 59±11 years). None of the specimens showed any evidence of pathology, congenital heart malformation or previous surgery. The dissection was approved by a suitably constituted Ethics Committee of the institution within which the work was undertaken and the study conforms to the provisions of the Helsinki Declaration of 1964 and all subsequent revisions.

Anatomic measurements

The morphological characteristics of LAA were recorded. Two different classification were used for evaluating the LAA morphology (2, 6, 7). The diameter of LAA orifice; the distances between the orifices of left superior pulmonary veins, left anterior descending (LAD) artery, circumflex artery, mitral valve, oval fossa and LAA orifices were measured. All measurements were taken with machinist's calipers to the nearest 0.1 mm and expressed in millimeters and centimeters.

Statistical analysis

All analyses were performed using the SPSS 15.0 (SPSS Inc., Chicago, Illinois, USA) software package. Results were presented as mean±standard deviation. The morphological appearances of LAA, the shapes of LAA orifice rims, the relation between the levels of LAA orifice and LSPV were presented as the percentage.

Results

LAA morphology

LAA morphology were evaluated according to two different classifications (2, 6, 7).

According to the first classification: The morphological appearance of the LAA was classified into two types: slender like a crooked finger in 41 specimens (in 73.2%) and stump-like in 15 specimens (in 26.8%) (Fig. 1). In 28 specimens (in 50%) the LAA with crooked finger appearance were inferiorly and 13 specimens (in 23.2%) were superiorly (Fig. 2). The LAA with

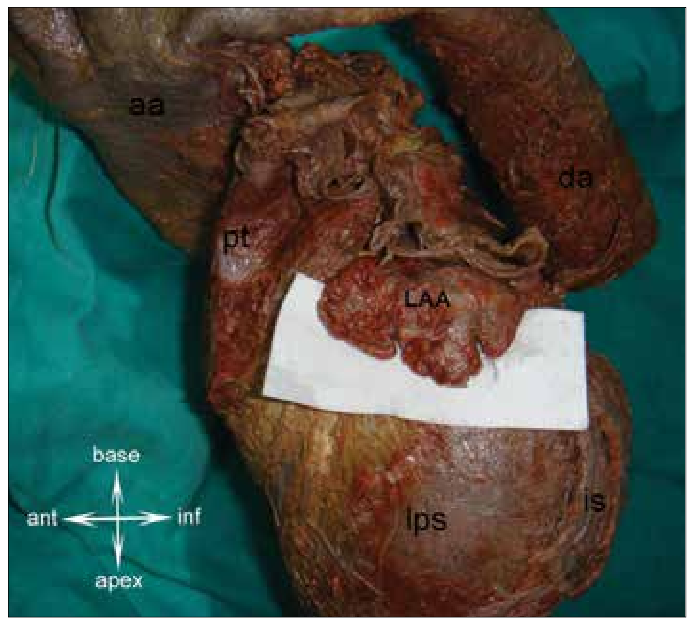

Figure 1. External view of the stump-like left atrial appendage with three lobes, Cauliflower type
aa - aortic arch, da - descending aorta, is - inferior surface, LAA - left atrial appendage, lps - left pulmonary surface, pt - pulmonary trunk

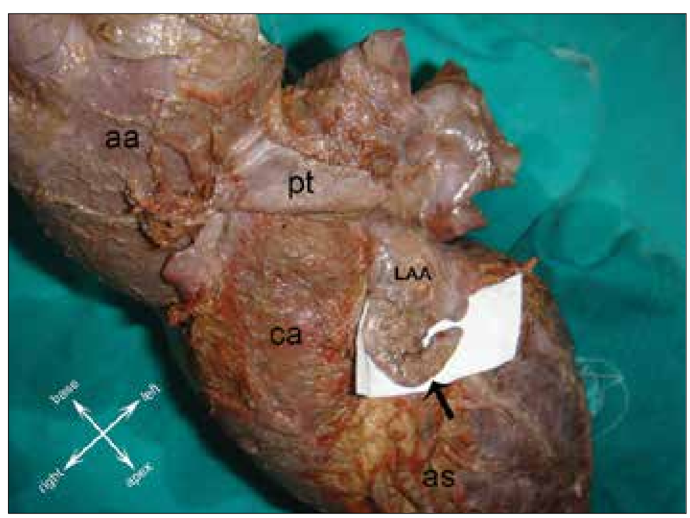

Figure 2. External view of the crooked finger appearance lying to inferiorly left atrial appendage with two lobes, Windsock type
aa - aortic arch, as - anterior surface, ca - conus arteriosus, LAA - left atrial appendage, pt - pulmonary trunk

crooked finger was lying to aortic root in one specimen (Fig. 3). In another specimen it was lying to superior vena cava (Fig. 4). The lobe number of LAA was two in 36 specimens (in 64.3%) and three in 20 specimens (in 35.7%) (Figs. 1, 2).

According to the second classification, LAA with sharp bend (Chicken Wing) was found in 7 of specimens (12%) (Fig. 3). Windsock type was observed in 21 of specimens (38%). Cauliflower type was seen in 15 of specimens (26%) and Cactus type was in 13 of specimens (24%). The Cactus LAA morphology was presented a dominant central lobe with secondary lobes. The Cauliflower LAA had many lobes with lack of dominant lobe (Fig. 1). The Windsock LAA had a dominant lobe as the primary structure (Fig. 2).

The anatomic features of LAA orifice

The mean anteroposterior length from apex to orifice of LAA was 34.5±8.6 mm.

The rim of the LAA orifice was smooth and pectinate muscles were clear in the LAA. The LAA orifice was oval-shaped in 21 specimens (in 37.5%) (Fig. 5) and round-shaped in 35 specimens (in 62.5%) (Fig. 6). The bridges on the round-shaped orifice were determined in one specimen (1.8%) (Fig. 7). A semilunar valve was seen on the round-shaped orifice in two specimens (3.6%).

The mean of longest diameter of LAA orifice was 16.5±4.0 mm. The mean of short diameter right to the longest diameter was 10.7±3.9 mm.

The distances between the orifices of left superior pulmonary veins (LSPV) and LAA orifice was 7.7±3.2 mm. The distance between the origin of LAD artery and LAA orifice was 9.9±2.8 mm. The distance between the origin of circumflex artery and LAA orifice was 6.3±1.6 mm. The distance between mitral valve and LAA orifice was 10.1±2.5 mm. The distance between LAA orifice and oval fossa was 27.5±5.5 mm.

The relation between the levels of LAA orifice and LSPV recorded. They were at the same level in 43 specimens (76.8%). LAA orifice was inferior to LSPV in 11 specimens (19.6%) and superior to LSPV in two specimens (3.6%) (Fig. 8-10). The left lateral prominent ridge presence was seen in 51 specimens (91.1%). This ridge was between the pulmonary veins and the left atrial appendage. The thickness of this ridge was 7.1±1.8 mm. Two variants of the ridge were determined: The prominent ridge was anterior to LSPV and left inferior pulmonary vein (LIPV) in Type A (Fig. 8). The prominent ridge was lying anterior to LSPV in type B (Fig. 10). Type A was seen in 46 specimens (82.1%) and Type B in five specimens (8.9%).

Accessory LAA and its orifice

The presence of accessory LAA was observed in one specimen (Fig. 11, 12). It had stump-like appearance according to the first classification of LAA. According to the second classification, accessory LAA with Cauliflower. The location of accessory LAA was on the junction of lateral and inferior walls. The longest diameter of accessory LAA orifice was 7.3 mm. The short diameter right to the longest diameter was 5.6 mm. The anteroposterior length from apex to orifice of accessory LAA was 8.9 mm.

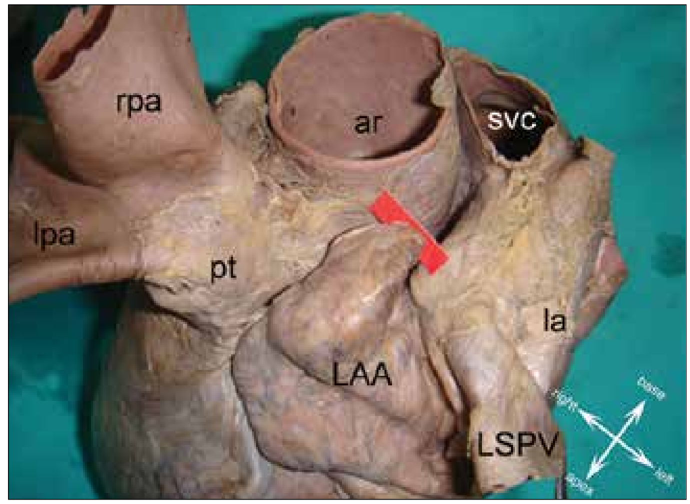

Figure 3. Superior view of the crooked finger LAA lying to the aortic root, Chicken Wing type

ar - aortic root, LAA - left atrial appendage, la - left atrium, lpa-left pulmonary artery, LSPV - left superior pulmonary vein, pt - pulmonary trunk, rpa - right pulmonary artery, svc - superior vena cava

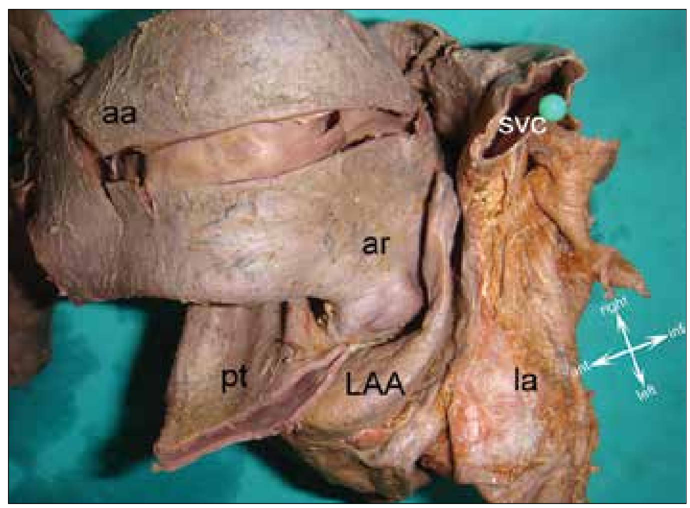

Figure 4. Superior view of the crooked finger LAA lying to the superior vena cava, Windsock type

aa - aortic arch, ar - aortic root, LAA - left atrial appendage, la - left atrium, pt - pulmonary trunk, svc - superior vena cava

The distances between the orifice of LSPV and accessory LAA orifice was 26 mm. The distance between the origin of LAD artery and accessory LAA orifice was 1 mm.The distance between the origin of circumflex artery and accessory LAA orifice was 6.3 mm. The distance between mitral valve and accessory LAA orifice was 12.7 mm. The distance between accessory LAA orifice and oval fossa was 45.1 mm.

Pectinate muscle

The thickness of pectinate muscle on lateral wall of left atrium (LA) was 1.7±0.5 mm. It was bigger than 1mm in 53 specimens (94.7%).

The average weight of 56 hearts was 291.2±33.5 g.

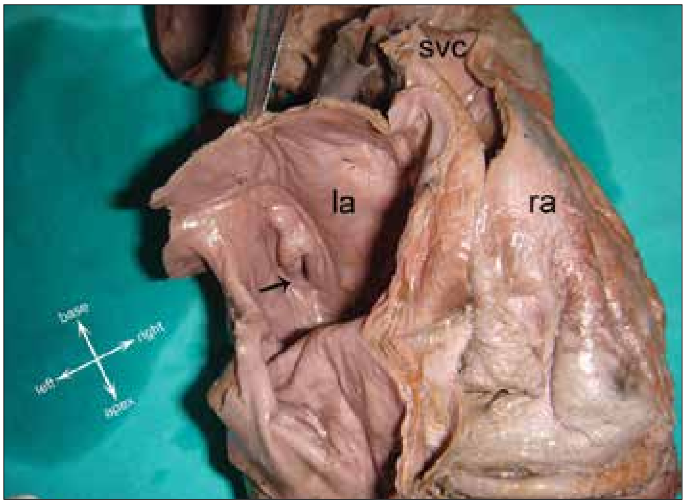

Figure 5. Internal aspect of oval-shaped left atrial appendage orifice
arrow - oval-shaped left atrial appendage orifice, la - left atrium, ra - right atrium, svc -superior vena cava

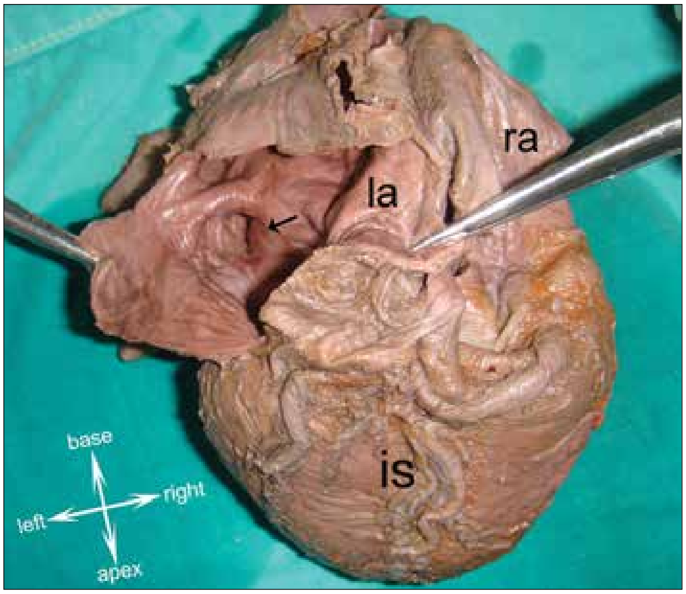

Figure 6. Internal aspect of round-shaped left atrial appendage orifice
arrow-round-shaped left atrial appendage orifice, is - inferior surface, la - left atrium, ra - right atrium

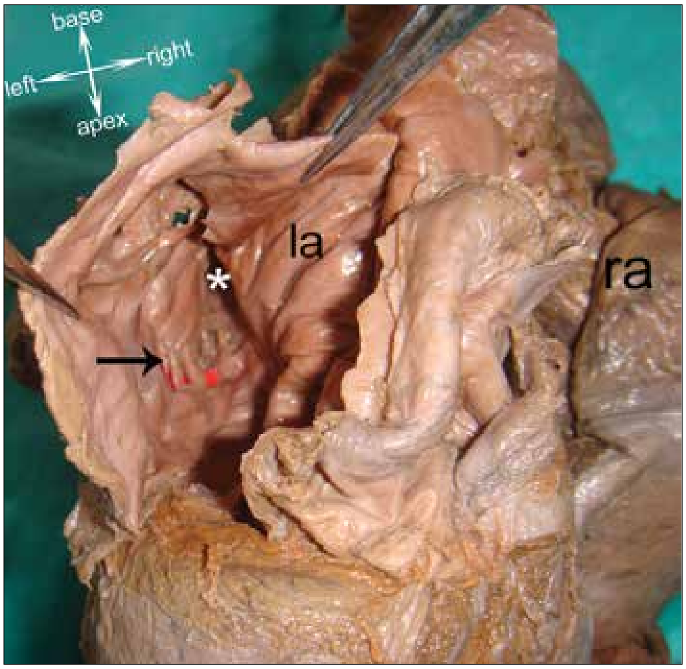

Figure 7. Internal aspect of round-shaped left atrial appendage orifice with bridges
arrow - bridges, *- LAA orifice, la - left atrium, ra - right atrium

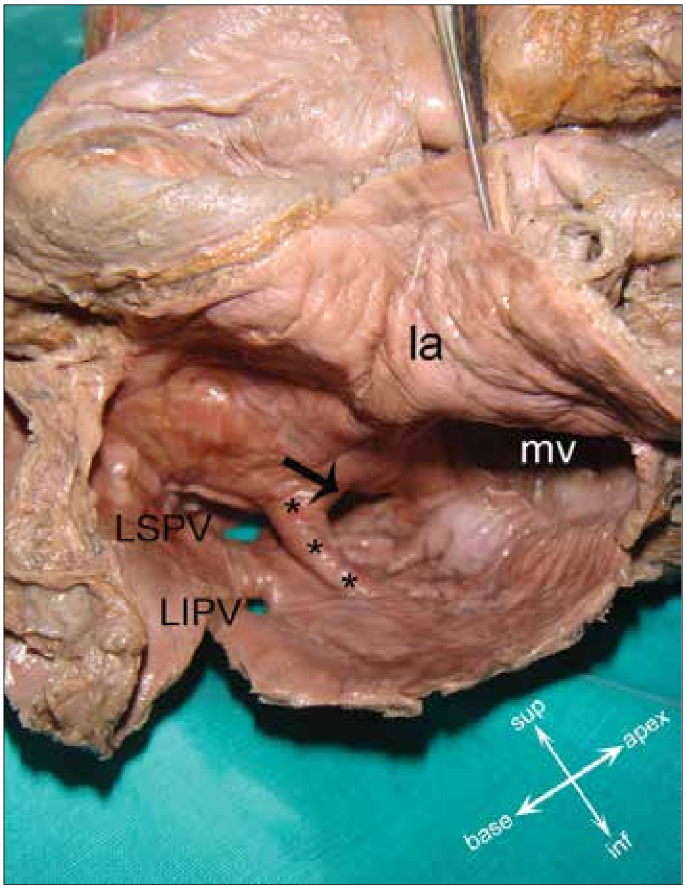

Figure 8. LAA orifice and LSPV at the same level, the prominent ridge lying anterior to LSPV and LIPV in Type A
la - left atrium, mv - mitral valve, arrow - LAA orifice, ***-prominent ridge, LIPV -left inferior pulmonary vein, LSPV - left superior pulmonary vein

Discussion

The LAA is a small, muscular extension of the left atrium. It has been described as a long, narrow, tubular appendage.

LAA morphology

The LAA is muscular extension of left atrium and smaller than right atrial appendage. It is a complex and multiform structure. It tends to have a tubular, narrow, long and crooked finger shape (1, 6-10). The heart specimens were evaluated in two different classifications. Interindividual variation in LAA morphology may have importance for the development of new technologies for interventional procedures for this region (4, 7).

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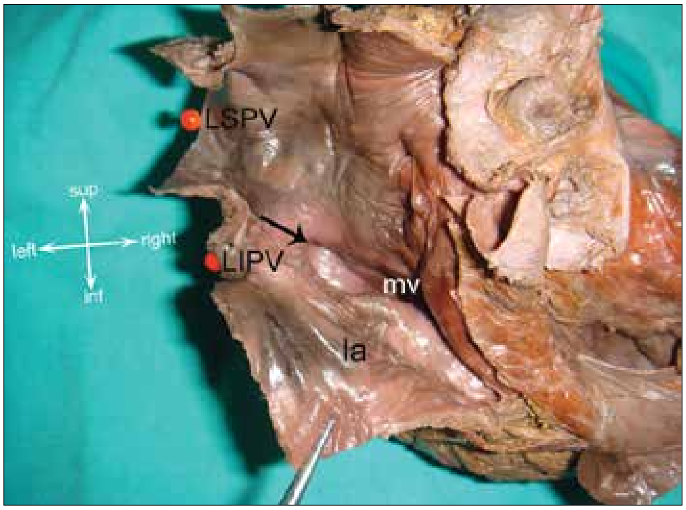

Figure 9. LAA orifice inferior to LSPV

la - left atrium, mv - mitral valve, arrow - LAA orifice, LSPV - left superior pulmonary vein, LIPV - left inferior pulmonary vein

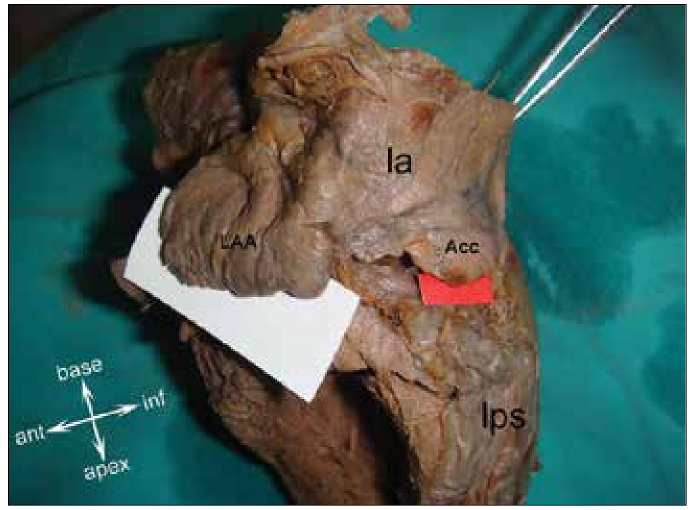

Figure 11. External view of the stump-like accessory left atrial appendage, Cauliflower type

Acc - accessory left atrial appendage, la - left atrium, LAA - left atrial appendage, lps - left pulmonary surface

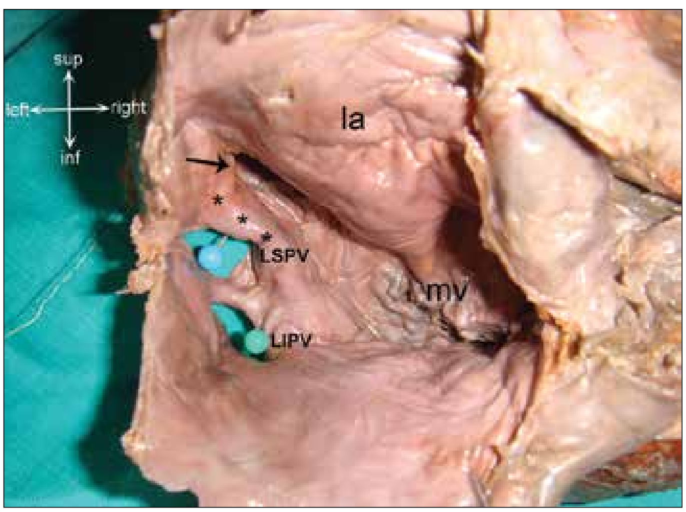

Figure 10. LAA orifice superior to LSPV, the prominent ridge lying anterior to LSPV in Type B

arrow - LAA orifice, la - left atrium, LIPV - left inferior pulmonary vein, ***-prominent ridge, LSPV - left superior pulmonary vein, mv - mitral valve

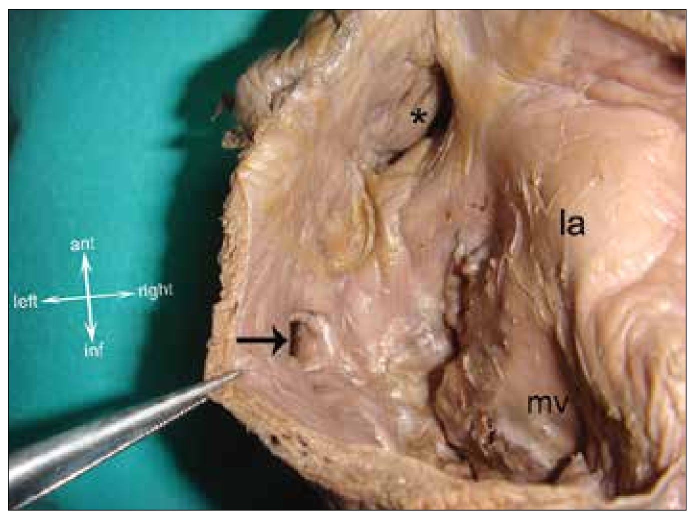

Figure 12. Internal aspect of accessory left atrial appendage orifice

arrow - accessory LAA orifice, *- LAA orifice, la - left atrium, mv - mitral valve

Di Biase et al. (2) analyzed computed tomography (CT) scans of 499 patients and MRI scans of 433 patients. They used a different classification for the macroscopic morphology of LAA. The distribution of different LAA morphologies was Cactus (30%), Chicken Wing (48%), Windsock (19%) and Cauliflower (3%) (2). Since atrial contraction is responsible for blood ejection out of the left atrium and LAA, the absence of contraction leads to blood stagnation, especially in LAA (11). The most of the trombi are located in the LAA and the variations in LAA anatomy may be present in patients with atrial fibrillation (2, 6, 11-16). Di Biase et al. (2) determined that patients with Chicken Wing LAA morphology are less likely to have an embolic event. They found this type LAA in 48% of their population (2). It was seen 12% in present study.

Veinot et al. (10) established that LAA is multilobed in 80% (two or more lobes) in 500 heart specimens from autopsies during a 22-year period. In present study two lobes were determined in 64.3% and three lobes were determined 35.7% of specimens. This difference between the results of these studies can be explained with the number of specimens. The imaging of different structures and lobes has a great importance to diagnose the presence of LAA thrombus.

The anatomic features of LAA orifice

Wang et al. (7) performed a cardiac CT study in 612 cases of patients with or without atrial fibrillation. Wang et al. (7) observed that the shape of orifice was noticably irregular in that study but it was quite smooth in present study. Wang et al. (7) emphasized that the diameter of LAA orifice could assist preoperative planning of LAA closure device placement (7). Although many variables need to be considered to safely place the LAA occlusion device, we consider that the measurements determined in present study will be helpful for clinicians.

Wongcharoen et al. (17) studied in 49 specimens on multidetector CT scan. They examined LAA orifice and LSPV at the same level in 64%, LAA orifice inferior to LSPV in 13% and LAA orifice superior to LSPV in 22% of specimens; consecutively 76.8%, 19.6% and 3.6% in present study. In the other hand, Wang et al. (7) determined the anatomical relationship of the LAA to the LSPV as follows: superior to LSPV (30.2%), parallel to LSPV (58.1%) and inferior to LSPV (11.7%). All these variations also need to be considered to safely place the occlusion device. Wongcharoen et al. (17) emphasized that LAA orifice and LSPV not at the same level had higher incidence in patients with atrial fibrillation.

Cabrera et al. (18) and Wongcharoen et al. (17) reported that the most prominent ridge in the LA is the left atrial ridge between the orifices of the left pulmonary veins and the orifice of LAA. The ridge lying between LSPV and the LAA is a critical structure during catheter ablation procedures (16) and has the potential of allowing interatrial conduction (8). The left lateral prominent ridge presence was seen in 51 specimens (91.1%) in present study. This ridge was at the same location that was described in the study of Cabrera et al. (18).

The orifice shape of LAA had differences between our study and the previous studies (6, 7). Su et al. (6) examined 31 formalin fixed heart specimens grossly and they observed that the shape of LAA orifice was oval in all hearts. Wang et al. (7) determined five types of orifice shape including oval (68.9%), foot-like (10%), triangular (7.7%), water drop-like (7.7%) and round (5.7%). The LAA orifice was oval-shaped in 37.5% and round-shaped in 62.5% in present study. Since the size and shape of devices are important to catch on complete occlusion, this variation related to orifice shape should be given attention before the procedure for designing percutaneous occlusion devices (6, 7).

More than 90% of thrombi are located within the LAA in atrial fibrillation (15). Transcatheter occlusion of the LAA is performed to reduce the risk of thromboembolic events in patients especially with atrial fibrillation who are not suitable candidates for oral anticoagulation therapy. Potentially; the LSPV, mitral valve and LAD artery can be at risk during this procedure (6, 11-16). In the other hand, Shi et al. (19) emphasized that the design of occluding devices must take into account the size and shape of the LAA in patients with atrial fibrillation (19). Our findings about the distances between LAA and surrounding structures will help clinicians during this occlusion procedure.

Transesophageal echocardiography (TEE) has been used for visualizing LAA to detect thrombus and intra-atrial masses and to diagnose LAA (1, 10, 13, 20). Stöllberger et al. (20) compared TEE measurements of LAA with postmortem casts. They demonstrated that LAA size and orifice can be assessed reliably by TEE especially in the horizontal plane (20).

It is known that LAA size tend to be larger in patients with atrial fibrillation than the patients with sinus rhythm (21). The measurements related to LAA in normal population may be helpful for these clinical evaluations also.

Ha et al. (1) reported a thin membranous structure at the orifice of LAA by performing TEE. This finding was confirmed at surgery. This anomaly that is unreported in any other literature created a hemodynamically significant narrowing during systole and atrial contraction in patient (1). Postacı et al. (22) described a case with nonobstructive thin membrane within the body of LAA. The echocardiographer should pay attention to the LAA during examination (22). We also observed semilunar valve on the round-shaped orifice in our two specimens.

Accessory LAA and its orifice

Lee et al. (23) reported a 69-year-old woman with atypical chest pain. They determined a cauliflower-like accessory LAA at the anterior roof of the LA. They considered that accessory atrial appendage might be the source of the unexplained embolic stroke (23). We determined accessory LAA in only one specimen. Missing an LAA thrombus in an accessory lobe might be possible if one is not aware of this variation of the LAA. Collier et al. (24) determined congenital absence of LAA in a 73-year-old woman with atrial fibrillation. This anomaly was not observed in present specimens.

Pectinate muscle

Veinot et al. (10) determined pectinate muscle size bigger than 1 mm in 97% of their normal autopsy hearts. It was bigger than 1 mm in 53 specimens (94.7%) in present study. To be aware of the size of pectinate muscle provide to avoid misestimation in the evaluation of patients with atrial fibrillation or stroke (10). Pectinate muscles should not be confused with thrombus (9).

Study limitations

The major limitation of present study was relatively small sample size.

Conclusion

The present study demonstrated the anatomic characteristics of LAA in normal population. The knowledge of LAA anatomy will support a better understanding of atrial activation, the more safely interventions and will reduce risks during interventional procedures.

Conflict of interest: None declared.

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