Where Is the Left Atrial Appendage Wall? Caution during Transesophageal Echocardiography

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INTRODUCTION

In the era of catheter intervention for structural heart disease, appropriate image acquisition facilitates the assessment of device candidacy, procedural planning, and intraprocedural guidance.[1]

Atrial fibrillation (AF) is the most common arrhythmia in the elderly population, and the left atrial appendage (LAA) is the main location of thrombus formation.[2,3] Transesophageal echocardiography (TEE) is a commonly used imaging modality for assessment of the LAA. Its importance has increased because of the need for careful evaluation before structural intervention or cardioversion. Obtaining clear visualization of the border of the wall and lumen of the LAA is essential for assessing a thrombus and/or for these interventions with avoidance of complications. However, difficulties are sometimes encountered when there is poor echo visualization or when artifacts exist.

We present examples of high echoic partition mimicking the LAA wall or an artifact and how it occurs when performing TEE. The first case had high echoic partition around the LAA. The second case had high echoic partition with pericardial effusion. The third case had no high echoic lesion.

CASE PRESENTATION 1

A 73-year-old patient was diagnosed with AF 6 years previously. At that time, the patient refused to undergo catheter ablation. The patient felt shortness of breath at this time. Transthoracic echocardiography revealed moderately reduced left ventricular (LV) systolic function (LV ejection fraction 42%) with moderate mitral regurgitation and moderate tricuspid regurgitation. The left atrial (LA) dimension was 52 mm, and LA volume was 114 mL (LA volume index 74 mL/m^2).

The patient underwent TEE and cardiac computed tomography (CCT) to evaluate the LA and LAA and the pulmonary veins before catheter ablation for AF. High echoic partition existed around the LAA, and it was difficult to identify the border between the wall and lumen of the LAA (Figures 1A and B, Videos 1 and 2). There were three possibilities for the location of the LAA wall: inside the high echoic partition, the high echoic partition itself, and outside the high echoic partition (another high echoic border).

A comparison of TEE and CCT indicated that the high echoic partition was the noncalcified pericardium attached to the lung (Figures 2A and B), not the LAA wall or an artifact. The correct location of the LAA wall should be inside the high echoic partition. We also speculate that the other high echoic border outside of the high echoic partition could have been a reflection artifact.

CASE PRESENTATION 2

A 75-year-old patient was admitted for acute decompensated heart failure with complete atrioventricular block. Transthoracic echocardiography revealed a severely dilated left ventricle and severely reduced LV systolic function (LV diastolic dimension 79 mm, LV systolic dimension 66 mm, LV ejection fraction 23%), with severe aortic regurgitation and mitral regurgitation. After temporary pacemaker insertion, the patient underwent aortic valve replacement (INSPIRIS 27 mm; Edwards Lifesciences) and mitral valvuloplasty (Physio Flex® 32 mm; Edwards Lifesciences). The patient also underwent cardiac resynchronization therapy. After these procedures, the patient experienced AF. The patient underwent TEE before electrical cardioversion for AF.

TEE revealed that there was no LAA thrombus. The patient had high echoic partition outside the LAA wall. Between the LAA and high echoic partition, there was an echo-free space that was considered to be a pericardial effusion (Figures 1C and D, Videos 3 and 4). CCT revealed that there was no calcification at the pericardium or abnormal structure outside the pericardium but the lung (Figures 2C and D).

CASE PRESENTATION 3

A 68-year-old patient felt shortness of breath and noticed tachycardia. The patient was diagnosed with paroxysmal AF. The patient underwent TEE and CCT to evaluate the left atrium, pulmonary veins, and LAA before catheter ablation for AF.

TEE revealed no LAA thrombus and no high echoic partition around the LAA (Figures 1E and F, Videos 5 and 6). A comparison of TEE and CCT indicated that the LAA was surrounded by fat, and the angle between the esophagus and the LAA was nearly parallel with the source of the ultrasound (Figures 2E and F).

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VIDEO HIGHLIGHTS

Video 1: Two-dimensional upper esophageal TEE at 0° in case 1 demonstrates a poorly contracting LAA with spontaneous echocardiographic contrast and a high echoic partition with high echoic border.
Video 2: Two-dimensional upper esophageal TEE at 120° in case 1 demonstrates a poorly contracting, multilobed LAA with spontaneous echocardiographic contrast and a high echoic partition with high echoic border.
Video 3: Two-dimensional upper esophageal TEE at 0° in case 2 demonstrates a poorly contracting LAA with a high echoic partition and a focal pericardial effusion.
Video 4: Two-dimensional upper esophageal TEE at 120° in case 2 demonstrates a poorly contracting LAA with a high echoic partition and a focal pericardial effusion.
Video 5: Two-dimensional upper esophageal TEE at 0° in case 3 demonstrates that there is no high echoic partition.
Video 6: Two-dimensional upper esophageal TEE at 120° in case 3 demonstrates that there is no high echoic partition.
Video 7: Representative example of two-dimensional upper esophageal TEE (0°) demonstrates a poorly contracting, dilated LAA with spontaneous echocardiographic contrast and a high echoic partition.
Video 8: Representative example of three-dimensional upper esophageal TEE, volume-rendered display, demonstrates a high echoic partition.
Video 9: Representative example of three-dimensional TEE, photorealistic rendering display, clearly demonstrates the LAA walls without a high echoic partition.

View the video content online at www.cvcasejournal.com.

DISCUSSION

We present three cases with and without high echoic partition around the LAA during TEE. High echoic partition mimics the LAA wall or an artifact, but it is actually the pericardium attached to the lung.

The LAA itself has a variable shape and size, with 80% of the population having two or more lobes. Regarding visualization of the LAA, CCT has sometimes been an alternative to TEE,[4] especially in the COVID-19 era. However, TEE is a critical diagnostic tool and a widely used imaging modality for evaluation of the LAA, especially during catheter procedures such as LAA device closure. These devices require a careful approach with a specific focus on echocardiography for preprocedural device implantation evaluation. By using multiplanar reconstruction with alignment of orthogonal planes at the proposed landing zone, the LAA depth and diameter of the landing zone can be measured.[1] Moreover, multiplanes can distinguish the pericardium from the LAA lumen.[5] If we misunderstand the high echoic partition as an artifact or the LAA wall, we might miscalculate the LAA depth for catheter interventions or might seek a thrombus behind it.

Although accurate and reproducible diagnostic techniques are essential for assessing LAA morphology or detecting an LAA thrombus, TEE has several limitations, including poor echo visualization and artifacts. A high echoic structure other than the LAA might be mistaken for the LAA wall, calcified pericardium, or an artifact.

According to ultrasound properties, reflections at boundaries between two different media occur because of differences in a characteristic known as the acoustic impedance (Z) of each substance. Air (lung) has quite low acoustic impedance compared with that of other body tissues. Indeed, the acoustic impedances of air, blood, muscle, and fat are 0.000429, 1.66, 1.70, and 1.34 kg/(m^2 · s), respectively.[6] Intensity reflection (R) can be calculated using acoustic impedance as follows:

$$R = (Z_2 - Z_1/Z_2 + Z_1)^2.$$

The intensity reflections between blood and LAA muscle and between LAA muscle (pericardium) and the lung (air) are $\approx$0.0006 and $\approx$0.9999, respectively.

As explained above, the pericardium attached to the lung has very strong intensity reflection that produces high echo and mirroring of the LAA wall. Indeed, cases 1 and 2 had high echoic partition.

Moreover, we could clearly distinguish the LAA wall from the pericardium because of pericardial effusion in case 2. In fact, a new echo-free space seen in this pattern only after LAA occlusion device placement may in fact represent a new small, but potentially hemodynamically important, localized pericardial effusion. For operators and echocardiologists, our reported findings may help the recognition of this complication.

The incident angle is also important in this phenomenon. In Figure 3, the dotted line (echo beam) has a low incident angle toward the pericardium, and there is low echo at the pericardium. When moving to the solid line from the dotted line, the echo beam has a higher incident angle and the pericardium has higher echo. Changing the incident angle by using lateral flexion of the probe (right flexion and left flexion) might help minimize this artifact during image acquisition.

Regarding mirroring of the LAA wall, it was mentioned in several reports that ascites may be mistaken for a pleural effusion because of the lung that produces a mirror image by the same mechanism.[7,8] However, there are few reports about the LAA and artifacts.

For comparison, there was no significant high echoic partition in case 3. We speculated that the LAA was surrounded by fat, which has relatively low acoustic impedance, and/or the echo sound was nearly parallel to the LAA wall to reduce intensity reflection.

A comprehensive transesophageal echocardiographic evaluation of the LAA should include identification of the morphology and function of the LAA, with careful steps including single-plane imaging, biplane or x-plane imaging, and three-dimensional rendering.[1,9] New technology such as photorealistic three-dimensional rendering is also useful.[10] Indeed, photorealistic three-dimensional rendering may eliminate the high echoic partition that was seen on two-dimensional imaging and on ordinary three-dimensional volumetric imaging and enable detection of a clear border of the LAA wall (Figure 4, Videos 7-9). In addition to the aforementioned steps, the use of ultrasound enhancing agents for confirming the actual LAA wall would also be helpful.[9,11]

CONCLUSIONS

High echoic partition appears when the pericardium is attached to the lung and echo sound is perpendicular against the pericardium.

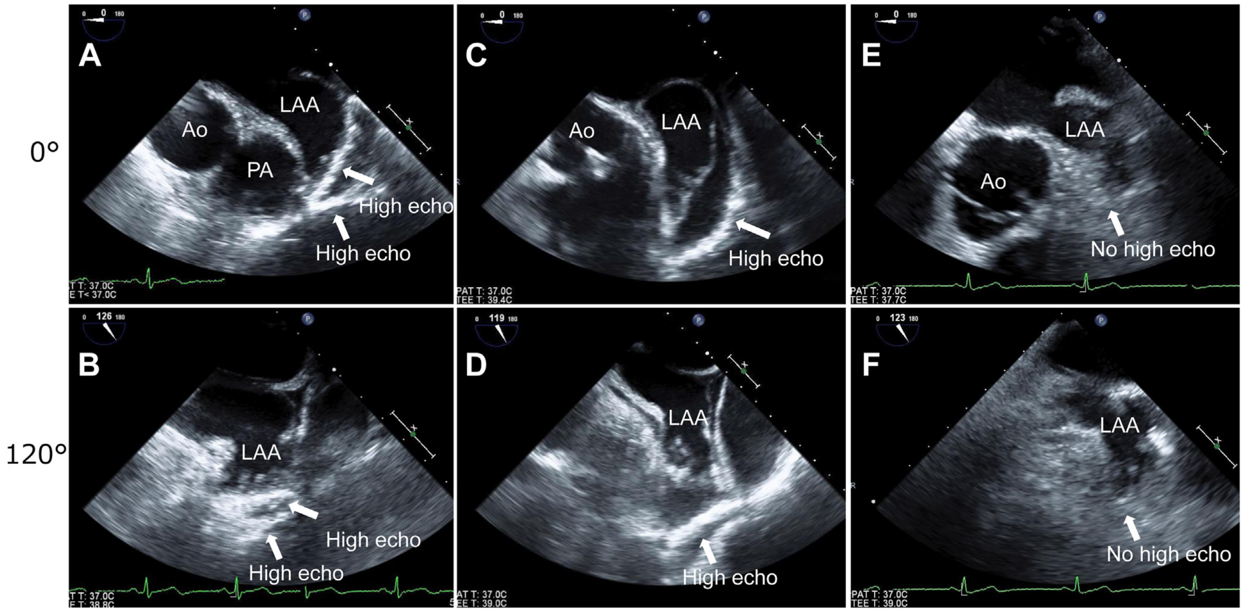

Figure 1 Two-dimensional upper esophageal transesophageal echocardiographic images of the LAA at 0° (*top*) and 119° to 126° (*bottom*). Case 1: high echoic partition **(A, B)**. Case 2: high echoic partition with pericardial effusion **(C, D)**. Case 3: no high echoic partition **(E, F)**. *Ao*, Aorta; *PA*, pulmonary artery.

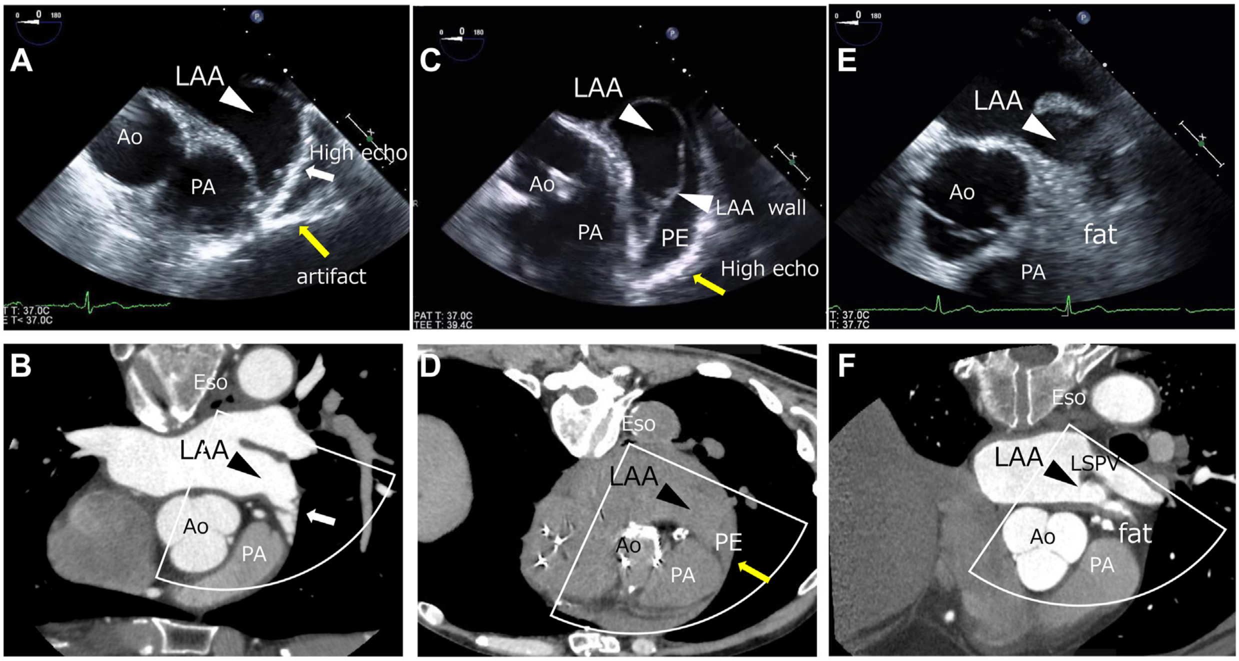

Figure 2 Two-dimensional upper esophageal transesophageal echocardiographic images of the LAA at 0° (upper panels) and comparison CCT images (lower panels). Case 1 (**A, B**): High-echoic partition with reflection artifact. The high-echoic partition (*white arrow* in **A**) corresponds with the pericardium attached the lung (*white arrow* in **B**). The artifact (*yellow arrow* in **A**) corresponds with no significant structure other than the lung. Case 2 (**C, D**): High-echoic partition with pericardial effusion. The high-echoic partition (*yellow arrow* in **C**) corresponds with the pericardium attached the lung (*yellow arrow* in **D**). Case 3 (**E, F**): No high-echoic partition with fat. The LAA is surrounded by fat. Ao, aorta; Eso, esophagus; LAA, left atrial appendage; PA, pulmonary artery; PE, pericardial effusion.

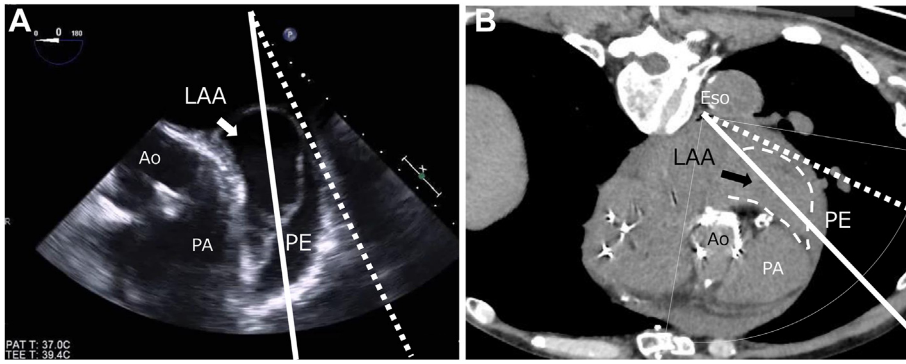

Figure 3 Two-dimensional upper esophageal transesophageal echocardiographic images of the LAA at 0° **(A)** and comparison CCT **(B)** in case 2. The *dotted line* (echo beam) has a low incident angle toward the pericardium, and there is low echo at the pericardium. When moving to the *solid line* from the *dotted line*, the echo beam has a higher incident angle, and the pericardium has higher echo. *Ao*, Aorta; *Eso*, esophagus; *PA*, pulmonary artery; *PE*, pericardial effusion.

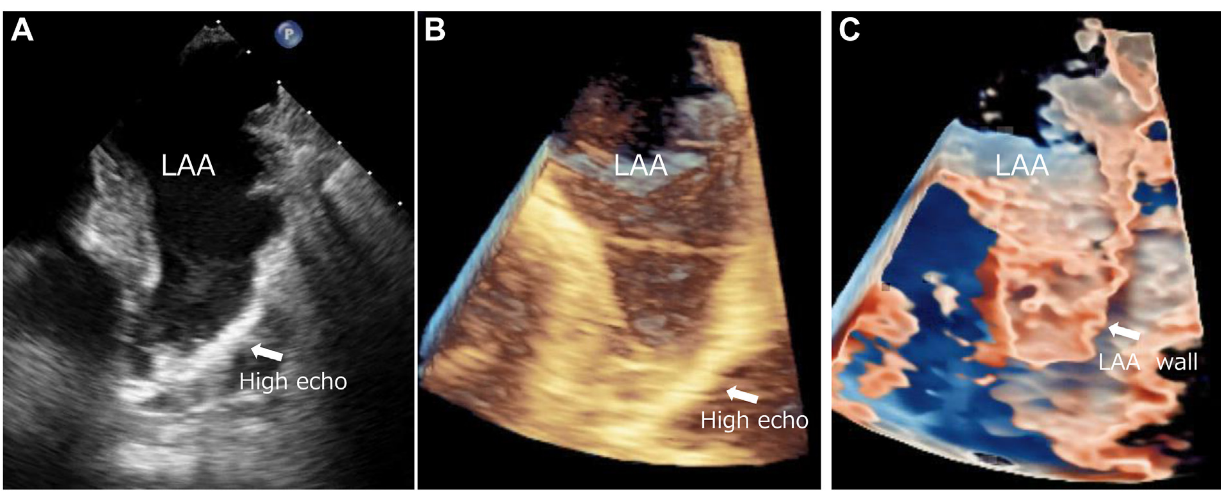

Figure 4 Representative example of two-dimensional **(A)**, three-dimensional volumetric **(B)**, and photorealistic three-dimensional rendering **(C)** upper esophageal transesophageal echocardiographic images of the LAA. The high echoic partition is seen in both **A** and **B**, but there is a clearly defined border of the LAA wall without high echoic partition in **C**.

Clinicians should take into account this phenomenon and be careful when evaluating LAA morphology.

ETHICS STATEMENT

The authors declare that the work described has been carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) for experiments involving humans.

CONSENT STATEMENT

The authors declare that since this was a non-interventional, retrospective, observational study utilizing de-identified data, informed consent was not required from the patient under an IRB exemption status.

FUNDING STATEMENT

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DISCLOSURE STATEMENT

The authors report no conflict of interest.

SUPPLEMENTARY DATA

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