REVIEW ARTICLE

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Left Atrial Appendage, Intraoperative Echocardiography, and the Anesthesiologist

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THE ANATOMY AND FUNCTION of the left atrial appendage (LAA) recently have received clinical attention. The LAA's role in the generation of intracardiac thrombi and eventual embolism has been investigated significantly.[1] The LAA is not merely an embryologic remnant but an integral anatomic and physiologic component of the left atrium (LA). It has a complex shape and functions as a reservoir and a neurosecretory organ with arrhythmogenic potential.[2] Importantly, the LAA is the most common cardiac source of embolism with resultant stroke.[1] When compared to oral anticoagulation, ligation of the LAA provides equal protection from thromboembolic phenomena in patients with atrial fibrillation (AF).[3] As a result, surgical ligation of the LAA may be performed as an adjunct procedure during cardiac surgery.[3]

Due to its shape and location, transthoracic echocardiography does not provide adequate windows for comprehensive evaluation and exclusion of thrombi. As a result, transesophageal echocardiography (TEE) forms the mainstay of echocardiographic evaluation of the LAA.[4] Precardioversion TEE examination routinely is performed by cardiologists to exclude the presence of thrombi in cases of AF without prior anticoagulation.[5] Intraoperatively, the location of the LAA in proximity to the anterolateral commissure of the mitral valve provides a landmark for anatomic orientation during three-dimensional (3D) imaging. A combination of two-dimensional (2D) and Doppler interrogation techniques can be used to evaluate its structure, function, and suitability for surgical intervention.[6] Using 2D TEE, its complex shape and position necessitate interrogation from multiple probe positions and scan plane rotations.

A comprehensive assessment of LAA includes structural and functional evaluation with a combination of 2D and Doppler echocardiography. Improved spatial orientation with 3D imaging has the potential to improve imaging of this complex anatomic structure. Intraoperative imaging of LAA can impact surgical decisionmaking and, therefore, therapeutic implications. The role of 3D imaging is not limited to providing structural information; it has been used to verify the completeness of surgical LAA ligation as well as reliably excluding residual LAA pouches.

With percutaneous interventions for structural heart diseases becoming more popular, the role of imaging for LAA-related procedures has expanded. Considering the clinical importance of this information and the relative paucity of literature on imaging of LAA, the authors have drawn upon their experience to describe the intraoperative echocardiographic assessment of LAA. In this manuscript, the authors review the embryology, anatomy, and functions of the LAA; its echocardiographic evaluation; and the principles of surgical therapy. The roles of 2D and 3D echocardiographic imaging in comprehensive evaluation of LAA are discussed and the utility of echocardiographic imaging in surgical interventions of the LAA is outlined.

ANATOMY

Embryology

Development of the LAA begins during the third week of the embryonic period. It is the only structure derived from the embryonic LA, with the remainder of the LA developing from the incorporation of the branches of the primordial pulmonary veins (Fig 1).[7] This difference in origin of the two can be observed grossly on examination of their internal surfaces. The endocardial aspect of the appendage is lined with pectinate muscles that run in parallel with one another, producing a rough, trabeculated appearance, whereas the rest of the LA appears smooth (Fig 2).

Location, Size, and Shape

The LAA is located within the pericardium, next to the superior lateral aspect of the main pulmonary artery (Fig 3). It extends anterolaterally from the pulmonary trunk to the left upper pulmonary vein and lies in the left atrioventricular sulcus atop the proximal portion of left circumflex artery. Based on autopsy studies, there is significant variation in the structure of

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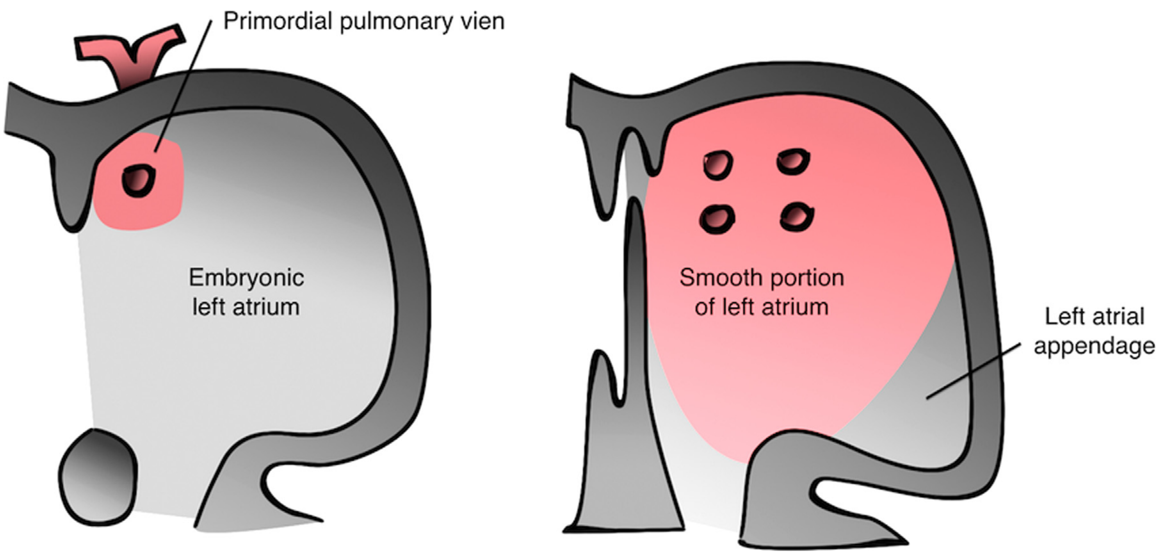

Fig 1. Diagram demonstrating the incorporation of the primordial pulmonary vein into the left atrium, forming the smooth part of the left atrium. The remaining portion of the embryonic left atrium becomes the left atrial appendage.

the LAA.[8] The volume varies between 0.7 and 19.2 mL, the minimum and maximum diameters range between 5 mm to 27 mm and 10 mm to 40 mm, respectively, and the length varies between 16 mm and 51 mm.[8] The lobes vary in number, ranging from 1 to 4, with 2 lobes being the most common number.[9,10] Four different morphologies have been described: cactus, chicken wing, windsock, and cauliflower (Fig 4).[11] The chicken wing variant is the most prevalent and is associated with the lowest risk of stroke.[11] It has been noted that patients with atrial fibrillation have larger volumes, larger orifices, and fewer lobes.[9,12] The size of the LAA has been found to increase gradually with age, with the rate of increase being more rapid

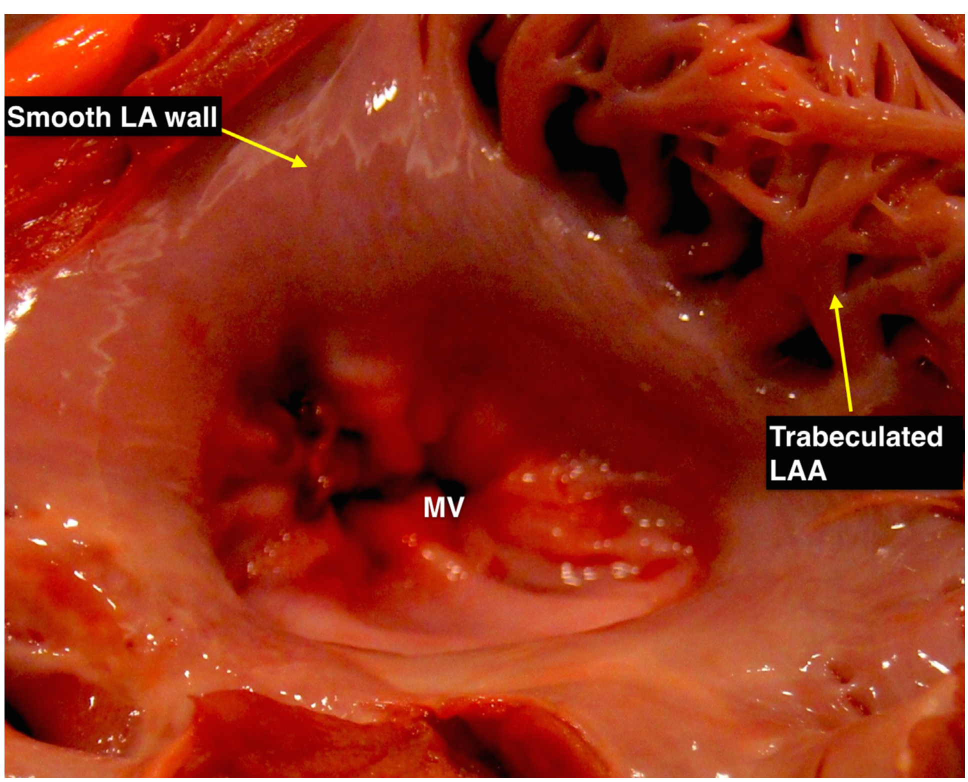

Fig 2. Photograph of the internal surface of the left atrial appendage in a porcine heart; the rough, trabeculated internal surface of the left atrial appendage is visible with the smooth internal surface of the rest of the left atrium. MV, mitral valve; LA, left atrium; LAA, left atrial appendage.