

ECHO ROUNDS Section Editor: Edmund Kenneth Kerut, M.D.

Anatomy of the Left Atrial Appendage

Edmund Kenneth Kerut, M.D.

Departments of Physiology and Pharmacology, Louisiana State University Health Sciences Center, New Orleans, Louisiana and Heart Clinic of Louisiana, Marrero, Louisiana

(ECHOCARDIOGRAPHY, Volume 25, July 2008)

The left atrial appendage (LAA) is a long, hook-like true diverticulum of the left atrium (LA). While parallel-running pectinate muscles are contained within the tubular LAA (Fig. 1), the body of the LA is a smooth-walled structure.¹⁻³ The LAA lies within the pericardium, next to the superior lateral aspect of the main pulmonary artery, and superior to the left ventricular free wall.³ It is often multilobed. Veinot et al.⁴ defined a lobe anatomically as: (1) a visible "outpouching" from the main tubular LAA, often demarcated externally by a "crease," (2) able to accept a 2-mm probe internally, (3) may be associated with a change in the main

Address for correspondence and reprint requests: Edmund Kenneth Kerut, M.D., 1111 Medical Center Blvd, Suite N613, Marrero, Louisiana 70072. Fax: (504) 249-6621; E-mail: kenkerut@pol.net

tubular LAA direction, and (4) could lie in a different plane from the main tubular LAA (Fig. 2 and Video Clip 1).

LAA structure varies significantly. An autopsy study of 220 cases with resin casts of the LAA found a range of volumes from 0.7 to 19.2 ml, minimum diameter from 5 to 27 mm, maximum diameter from 10 to 40 mm, and a variation in length from 16 to 51 mm. In 70% of the cases, the long axis was significantly "bent" or spiral-shaped.⁵ A subgroup ($n = 55$) of patients was in atrial fibrillation prior to death. They had a larger LAA volume, larger orifice, and fewer "lobes." Similar LAA findings were noted by multidetector computed tomography (MDCT) when comparing patients with atrial fibrillation to those in sinus rhythm.⁶

An autopsy study ($n = 500$) with 25 males and 25 females for each decade of life (age

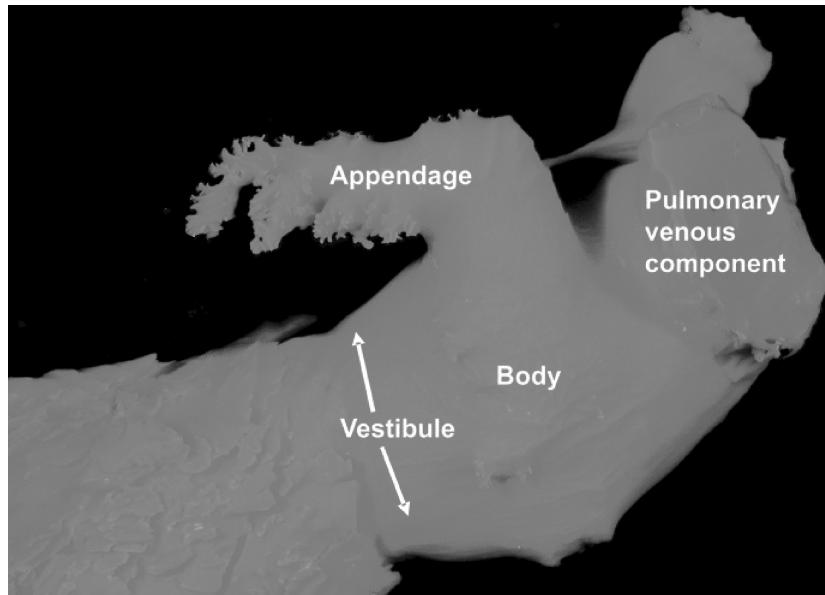


Figure 1. Synthetic resin cast of the LA demonstrates that the LAA (appendage) contains pectinate muscles, while the body of the LA (body) is a smooth-walled structure. Pulmonary venous component = pulmonary veins; vestibule = vestibule of the mitral orifice. (With permission from Anderson et al.¹).

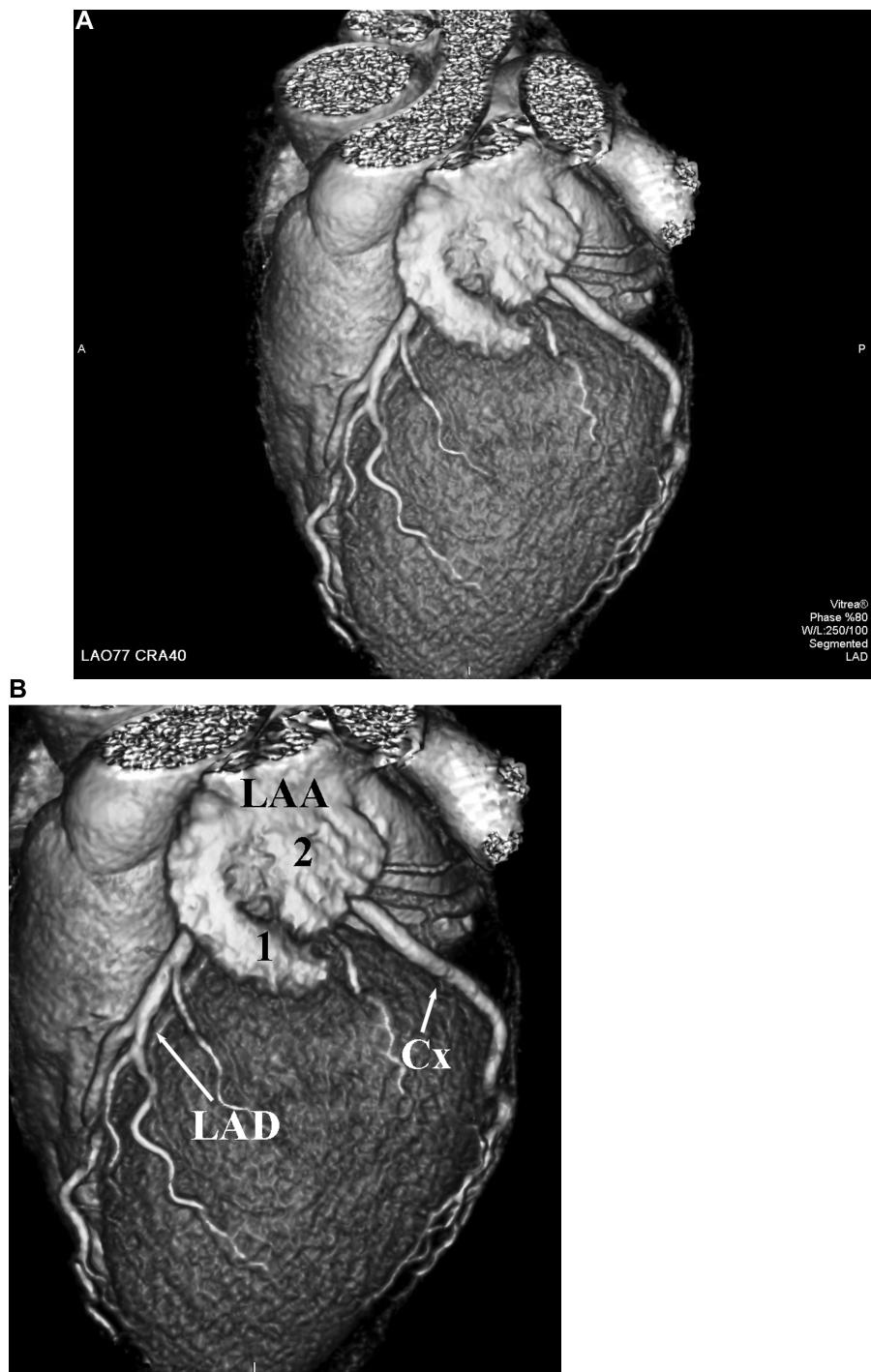


Figure 2. **A.** Demonstration of the multilobed anatomy of the LAA by multidetector computed tomography (3D volume-rendered cardiac CTA using Toshiba Aquilion 64 CFX, 0.5-mm slices of the heart acquired in 7 seconds with Vitrea EP software). **B.** Imaging is shown from a left anterior oblique and cranial angulation to highlight the LAA. One lobe (1) is long and curvilinear, while the second (2) is "flat and wide." Also shown are the left anterior descending coronary artery (LAD) with its diagonal branches and the circumflex coronary artery (Cx).

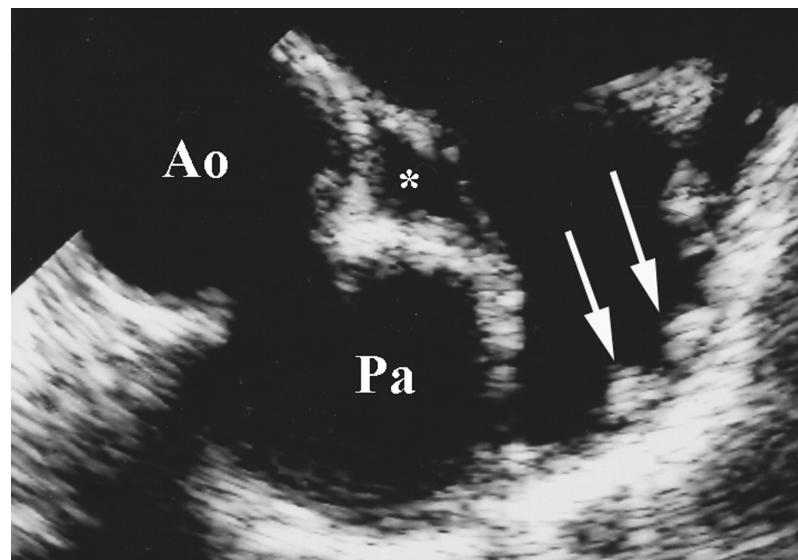


Figure 3. TEE in the horizontal plane (0°) demonstrates a normal LAA with prominently noted pectinate muscles (arrows). Located between the ascending aorta (Ao), pulmonary artery (Pa), and the LAA is the transverse sinus (*) (see text). (Modified with permission from Kerut et al.²⁰, p. 273).

1–100 years) was performed in patients without a history of heart disease.⁴ Over 97% had pectinate muscles of $>1\text{mm}$ in size. Those with pectinate muscles of $<1\text{mm}$ in size were noted only from the first or last decade of life. Most had

two lobes (54%), followed by three lobes (23%), one lobe (20%), and four lobes (3%). Results from the Stroke Prevention: Assessment of Risk in a Community (SPARC) study, in which the LAA was evaluated by transesophageal

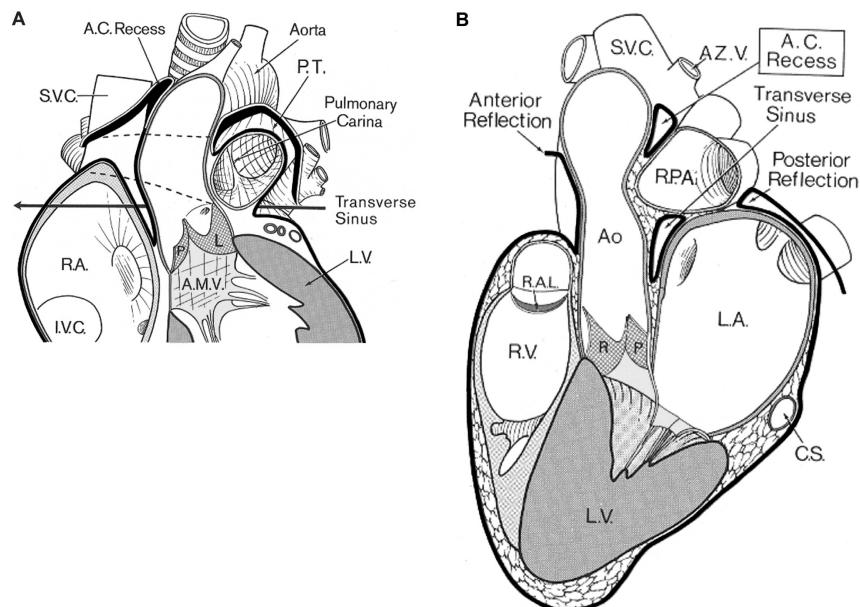


Figure 4. Schematic drawings of the transverse sinus in (A) a sagittal plane and (B) transection through the aorta. Pericardial reflections are black colored in these images. The transverse sinus (long black arrow) runs between the anterior aspect of the left atrium and the posterior wall of the ascending aorta and main pulmonary trunk (PT). It is located above the level of the aortic sinuses. AC recess = aortocaval recess; AMV = anterior mitral valve leaflet; AZV = azygous vein; CS = coronary sinus; IVC = inferior vena cava; L = left coronary cusp aortic valve; LV = left ventricle; P = noncoronary cusp aortic valve; RA = right atrium; RAL = right anterolateral pulmonary valve; RPA = right pulmonary artery; RV = right ventricle; SVC = superior vena cava. (With permission from: McAlpine Wallace A. Heart and Coronary Arteries: An Anatomical Atlas for Clinical Diagnosis, Radiological Investigation, and Surgical Treatment. Springer-Verlag, Berlin, 1975, pp. 128–129).

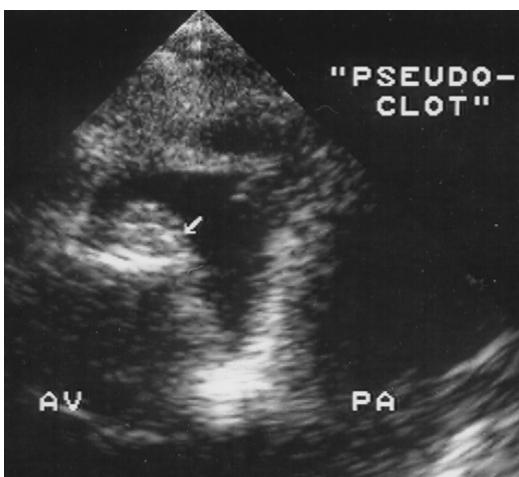


Figure 5. TEE of the transverse sinus with material noted within the space. This may simulate a LAA clot, but by rotating the transducer, and following the echo free space, one notes that it is not “attached” to the LA. (With permission from Kerut et al.²⁰, p. 273).

echocardiography (TEE), revealed a single lobe in 29.1%, two lobes in 49%, and the remainder (22%) to have multiple lobes.⁷

It appears that the LAA is more distensible than the LA, holding a relatively larger volume of blood as LA pressure increases.^{3,8,9} Clamping of the LAA during surgery will result in noticeable LA distension, along with an increase in transmitral and pulmonary diastolic flow velocities.¹⁰

When investigating the LAA by TEE, it is important to keep in mind that the LAA is a three-dimensional (3D), multilobed structure.¹¹ Therefore, evaluation should include imaging in multiple planes, including orthogonal views, in order to image the entire 3D complex structure. Pectinate muscles should not be confused with thrombus (Fig. 3 and Video Clip 2). Measurement of the two-dimensional (2D) LAA area is not reproducible or helpful, in view of the complex structure.¹²

The transverse sinus lies between the anterior LA and posterior wall of the ascending aorta and pulmonary artery, above the level of the aortic sinuses (Fig. 3). It is also anterior to the superior vena cava^{13–18} (Fig. 4). It may contain fluid with or without echo dense fibrinous material and be mistaken for thrombus (Fig. 5). By rotating the TEE transducer, and “following” the echo free space, one will note that this space is not “attached” to the LA.^{19–21} When pericardial fluid is within the transverse

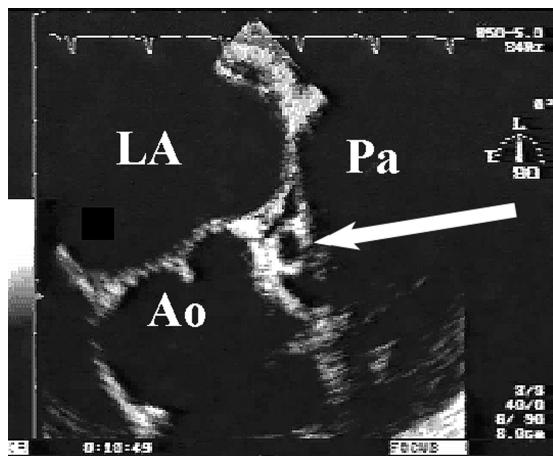


Figure 6. TEE in the vertical plane (90°) demonstrates a fluid-filled transverse sinus in which the LAA appears in cross-section as a circular object (arrow). By changing the transducer imaging angle (see Video Clip 3), this “circle” will become readily evident as the LAA and open into the LA. LA = left atrium; Pa = pulmonary artery; Ao = aortic root.

sinus, the LAA itself may appear as a mass. Rotating the transducer and/or changing the transducer imaging angle will this time reveal that the structure becomes the LAA and opens into the LA (Fig. 6 and Video Clip 3).

The summarizing points about LAA anatomy include:

- (1) The LAA is a 3D structure, most often having two or more lobes.
- (2) Pectinate muscles should not be confused with pathology.
- (3) Evaluation of the LAA should include multiple planes so as to evaluate each lobe.
- (4) Echo dense fibrous material within the adjacent transverse sinus should not be confused with LAA thrombus.
- (5) When pericardial fluid is present within the transverse sinus, one should not confuse a normal LAA lobe seen in cross-section as a “mass.”

References

1. Anderson RH, Razavi R, Taylor AM: Cardiac anatomy revisited. *J Anat* 2004;205:159–177.
2. Ho SY, McCarthy KP, Josen M, et al: Anatomic-echocardiographic correlates: Introduction to normal and congenitally malformed hearts. *Heart* 2001;86(Suppl II):II3–II11.
3. Al-Saady NM, Obel OA, Camm AJ: Left atrial appendage: Structure, function, and role in thromboembolism. *Heart* 1999;(82):547–555.

4. Veinot JP, Harrity PJ, Gentile F, et al: Anatomy of the normal left atrial appendage: A quantitative study of age-related changes in 500 autopsy hearts: Implications for echocardiographic examination. *Circulation* 1997;96:3112–3115.
5. Ernst G, Stolberger C, Abzieher F, et al: Morphology of the left atrial appendage. *Anat Rec* 1995;242:553–561.
6. Wongcharoen W, Tsao HM, Wu MH, et al: Morphologic features of the left atrial appendage, roof, and septum: Implications for the ablation of atrial fibrillation. *J Cardiovasc Electrophysiol* 2006;17(9):951–956.
7. Meissner I, Whisnant JP, Khandheria BK, et al: Prevalence of potential risk factors for stroke assessed by transesophageal echocardiography and carotid ultrasonography: The SPARC Study. *Mayo Clin Proc* 1999;74:862–869.
8. Hoit BD, Shao Y, Tsai LM, et al: Altered left atrial compliance after atrial appendectomy. Influence on left atrial and left ventricular filling. *Circ Res* 1993;72:167–175.
9. Davis CA, Rembert JC, Greenfield JC: Compliance of left atrium with and without left atrium appendage. *Am J Physiol* 1990;259:H1006–H1008.
10. Tabata T, Oki T, Yamada H, et al: Roles of left atrial appendage in left atrial reserve function as evaluated by left atrial appendage clamping during cardiac surgery. *Am J Cardiol* 1998;81:327–332.
11. Varga-Barron J, Espinola-Zavaleta N, Roldan FJ, et al: Transesophageal echocardiographic diagnosis of thrombus in accessory lobes of the left atrial appendage. *Echocardiography* 2000;17:689–691.
12. Agmon Y, Khandheria BK, Gentile F, et al: Echocardiographic assessment of the left atrial appendage. *J Am Coll Cardiol* 1999;34:1867–1877.
13. Shernan S: Echocardiographic evaluation of pericardial disease. In Konstadt SN, Shernan S, Oka Y, (eds): *Clinical Transesophageal Echocardiography*. Philadelphia: Lippincott Williams & Wilkins, 2003, pp. 203–213.
14. Maisch B, Severovic PM, Ristic AD, et al: Guidelines on the diagnosis and management of pericardial disease. *Eur Heart J* 2004;25:587–610.
15. Spodick DH: Macrophysiology, microphysiology, and anatomy of the pericardium: A synopsis. *Am Heart J* 1992;124:1046–1051.
16. Walinsky P: Pitfalls in the diagnosis of pericardial effusion. *Cardiovasc Clin* 1978;9:111–122.
17. Tajik AJ: Echocardiography in pericardial effusion. *Am J Med* 1977;63:29–40.
18. Hollinshead WH. *Textbook of Anatomy*, 3rd Ed. Hagerstown, Maryland, Harper & Row, 1974, pp. 524–525.
19. Savage RM, Aronson S: *Comprehensive Textbook of Intraoperative Transesophageal Echocardiography*, Lippincott Williams & Wilkins, 2005, pp. 273–274.
20. Kerut EK, McIlwain EF, Plotnick GD: *Handbook of Echo-Doppler Interpretation*, 2nd Ed. Elmsford, New York, Blackwell Futura, 2004, pp. 272–273.
21. Isbell DC, Dent JM: The role of transesophageal echocardiography in atrial fibrillation. In David E. Haines (guest editor): *Cardiol Clin* 2004;22(1):113–126.

Supplementary Material

The following supplementary material is available online:

Video Clip 1. Video of the same patient in Figure 2 demonstrating the complex 3D structure of the LAA.

Video Clip 2. Video of a normal LAA with pectinate muscle.

Video Clip 3. TEE in the vertical plane (90°) demonstrates the transverse sinus is fluid filled, with the LAA visualized as a “circle” within it. By changing the angle to 75° and on to 60° and 45° , the LAA becomes readily apparent. It appears bilobed and is seen to be “attached” to the LA.