ROLE OF ECHOCARDIOGRAPHY IN PATIENT CARE

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DISCLOSURES

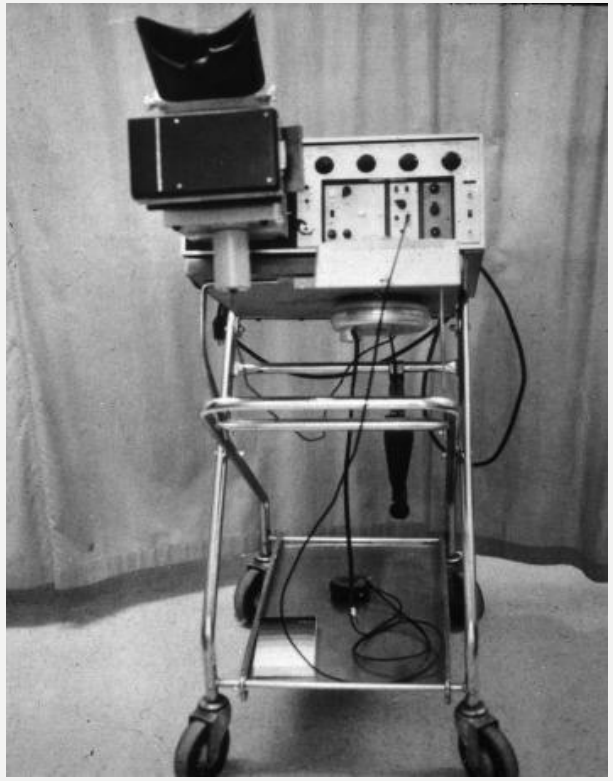
None

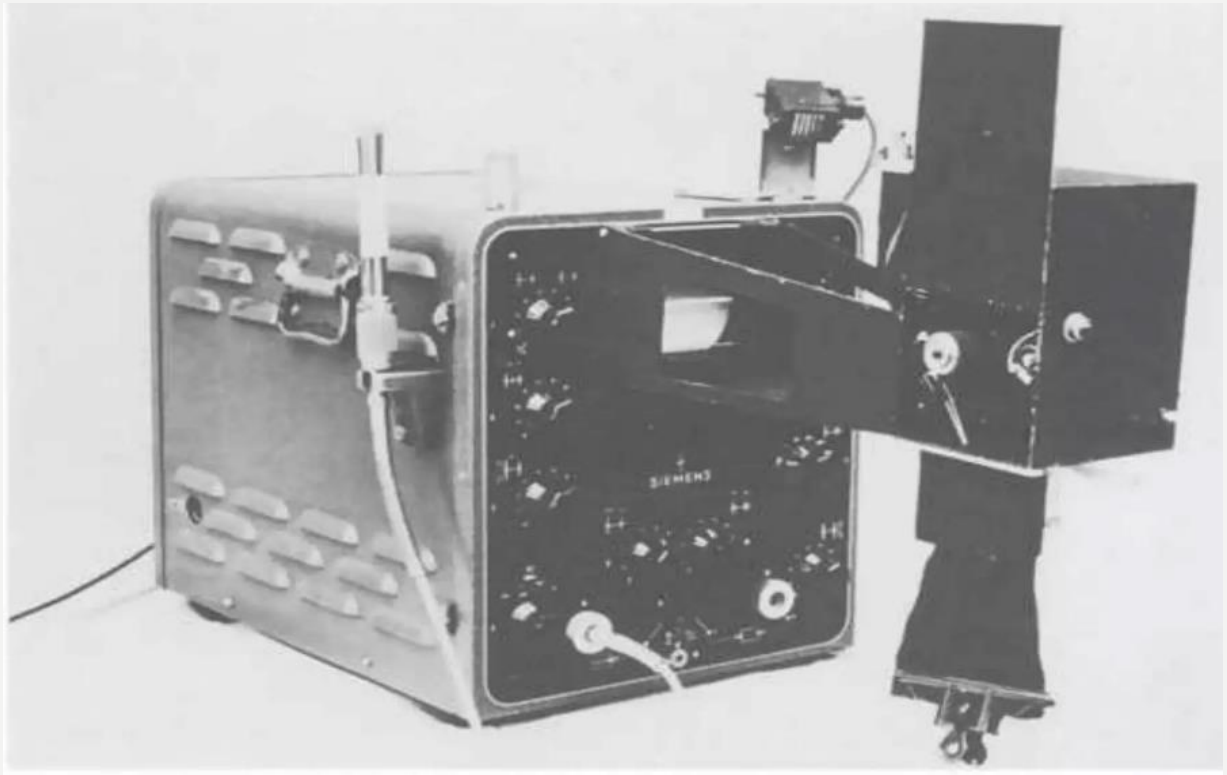
HISTORY OF ECHOCARDIOGRAPHY

FROM BATS TO PATIENT CARE - USG

- History starts with Lazzaro Sphallanzani (1729 – 1799), an Italian physiologist and priest who conducted series of experiments explaining how bats were able to fly at night. Blinded→ able to fly; Deaf→ Could not fly; concluded that bats were able to fly in the dark due to sound and not due to vision.
- 1826: Jean-Daniel Colladon and his assistant Jacques Charles-Francois Sturm demonstrated that speed of sound in water is faster than its speed inn air (solid>water>air). 1912-Titanic sinking→ Iceberg avoidance system (by converting an underwater Morse code generator into an echo sounder.
- 1938: Coined "Echolocation" by two Harvard students, Donald Griffin and Robert Galambos, explaining how bats generate high-frequency sounds that bounce off surfaces and use these received echoed sounds to calculate the exact location of the object.
- WWI: Paul Langevin created hydrophone, consisting of small quartz crystals glued between two steel plates, this device was able to detect the returning echoes from submerged submarines.
- WWII: Sonar (***so***und ***n***avigation ***a***nd ***r***anging)

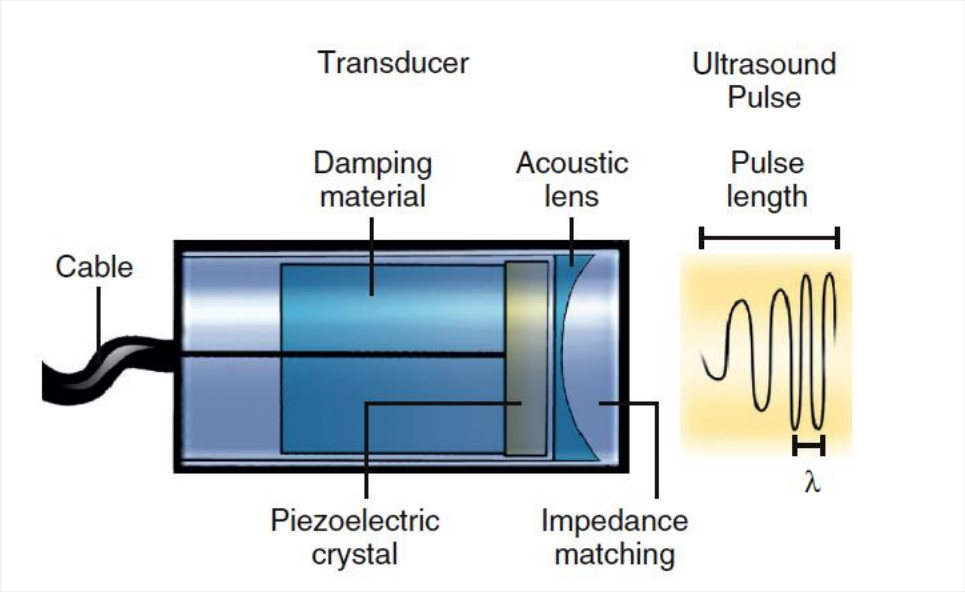
- First physician to use ultrasound for medical imaging was Karl Dussik (considered as "Father of Ultrasound")→ Neurologist, changes in brain ventricle size secondary to tumor growth.
- The first use of echocardiography, autopsy and mitral stenosis: Paul Edler and Hellmuth Hertz. Edler made a film on the cardiac structures in echocardiography and was presented at the European Congress of Cardiology in Rome in 1960; published review article in "Acta Medica Scandinavia" in 1961.
- Dr. Feigenbaum: M-mode, review article





ECHOCARDIOGRAPHY

- Uses high-pitched sound waves to produce an image of the heart
- Piezoelectric crystal is a material like quartz or a titanate ceramic. Piezoelectric crystals have unique electromechanical properties. When an electric current is applied to a piezoelectric crystal, it starts to vibrate and these vibrations generate sound waves with frequencies between 1.5 and 8 MHz (ultrasound). Thus, they convert electric current into ultrasound waves, likewise and vice-versa, when these crystals are hit by the reflected ultrasound waves from the heart, they convert ultrasound waves into an electric current which is sent to the ultrasound machine, where the electrical energy is translated into an echo image.
- Acoustic lens: Ensure no other sound waves affect the transducer
- Backing layer/Damping material: Suppresses the vibration of the crystals, to send sound waves in short pulses that improves resolution.
- Impedance matching: Reduces the difference in the impedance between the crystals and the tissue to be studied.

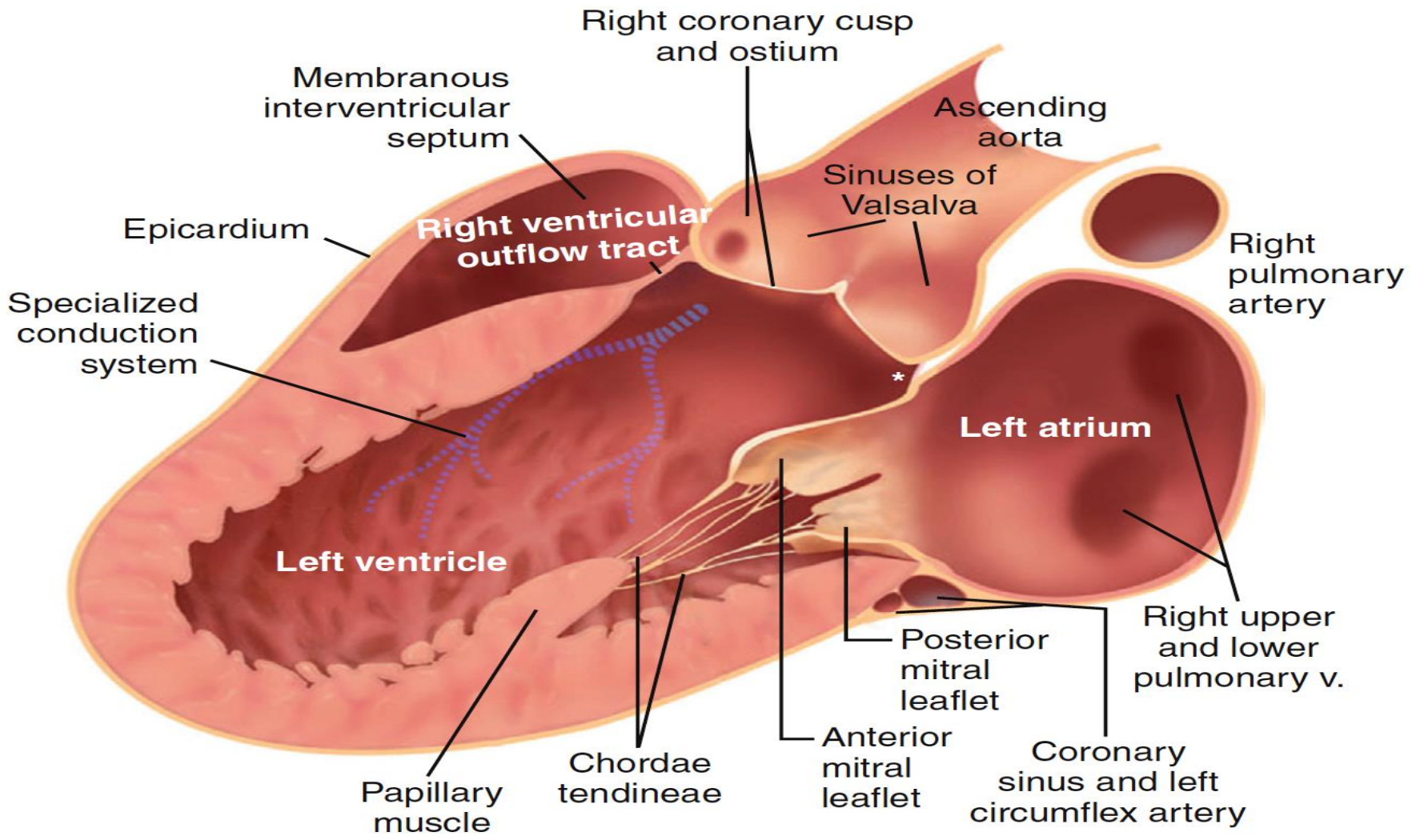


TYPES OF ECHO

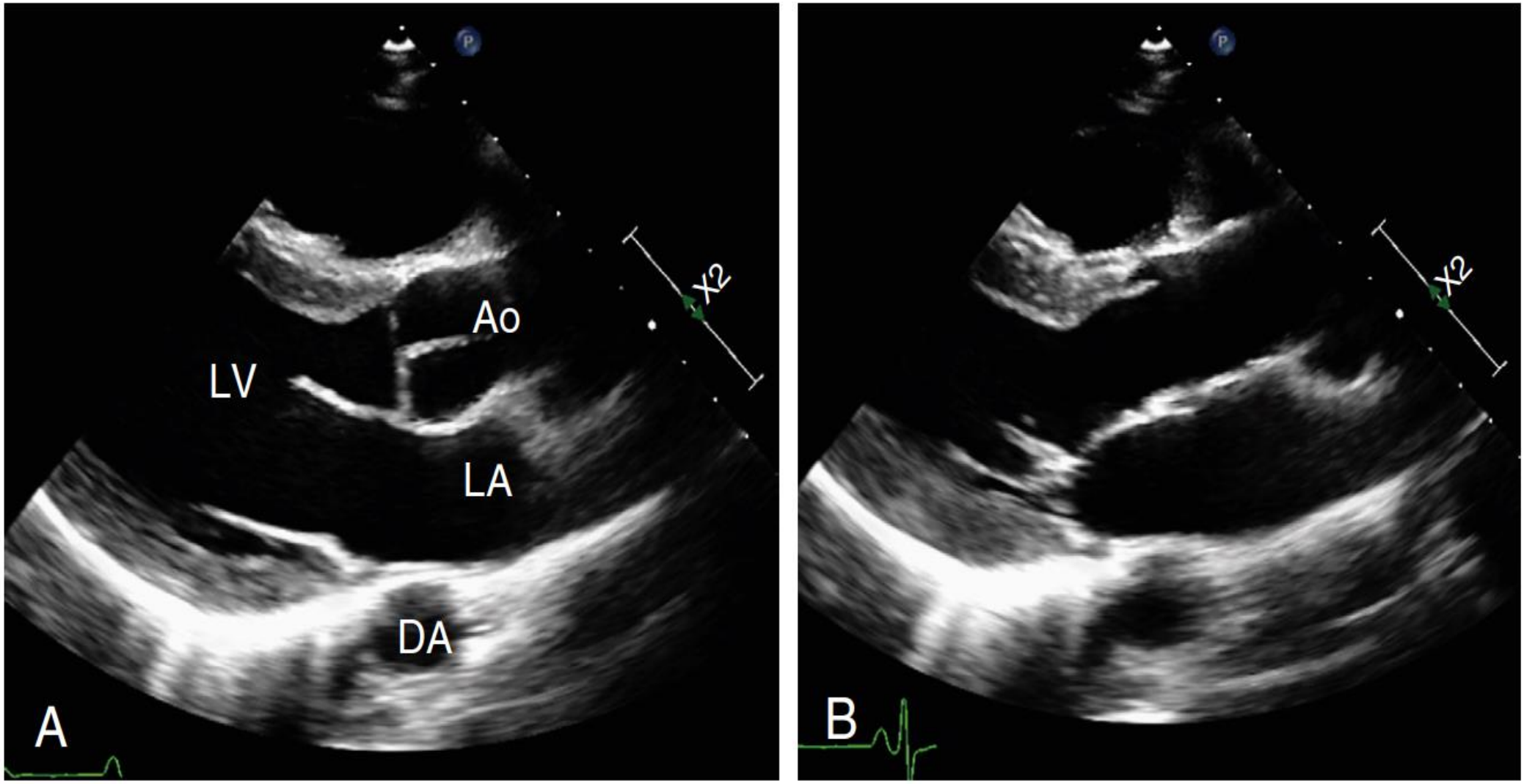
- TTE
- TEE
- Stress Echo

TTE VIEWS

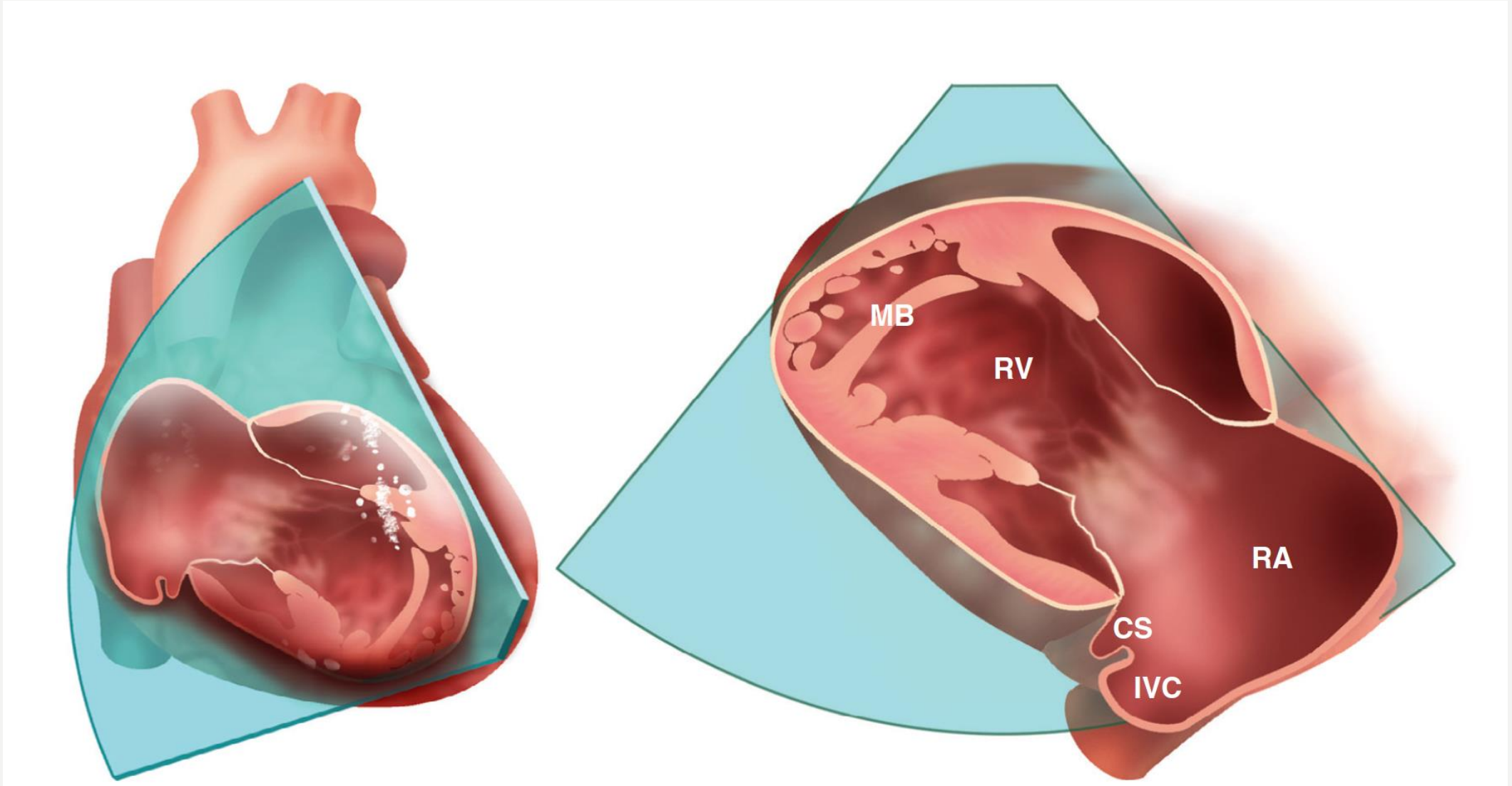
PARASTERNAL LONG AXIS



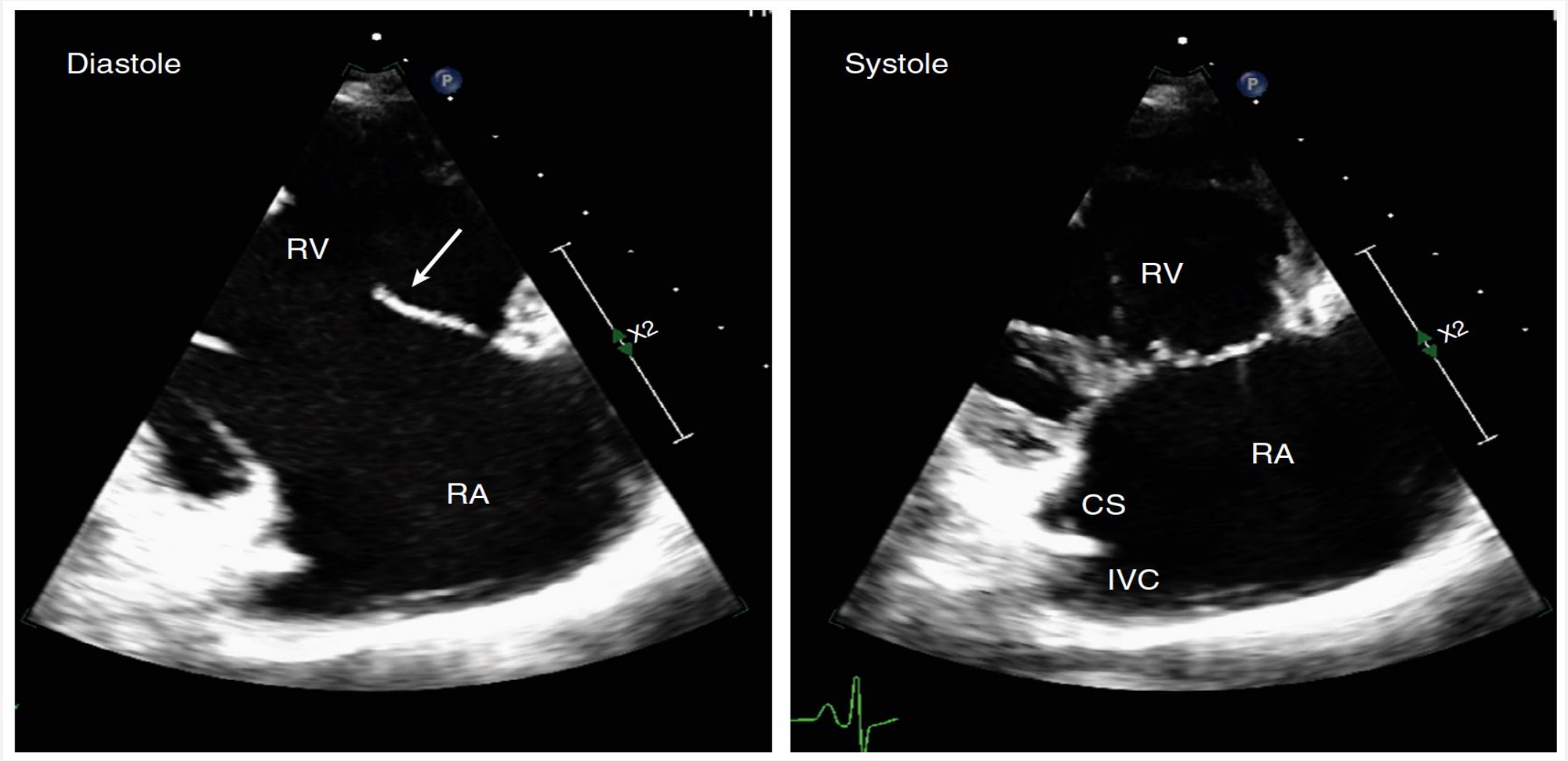
PARASTERNAL LONG AXIS CONT'D



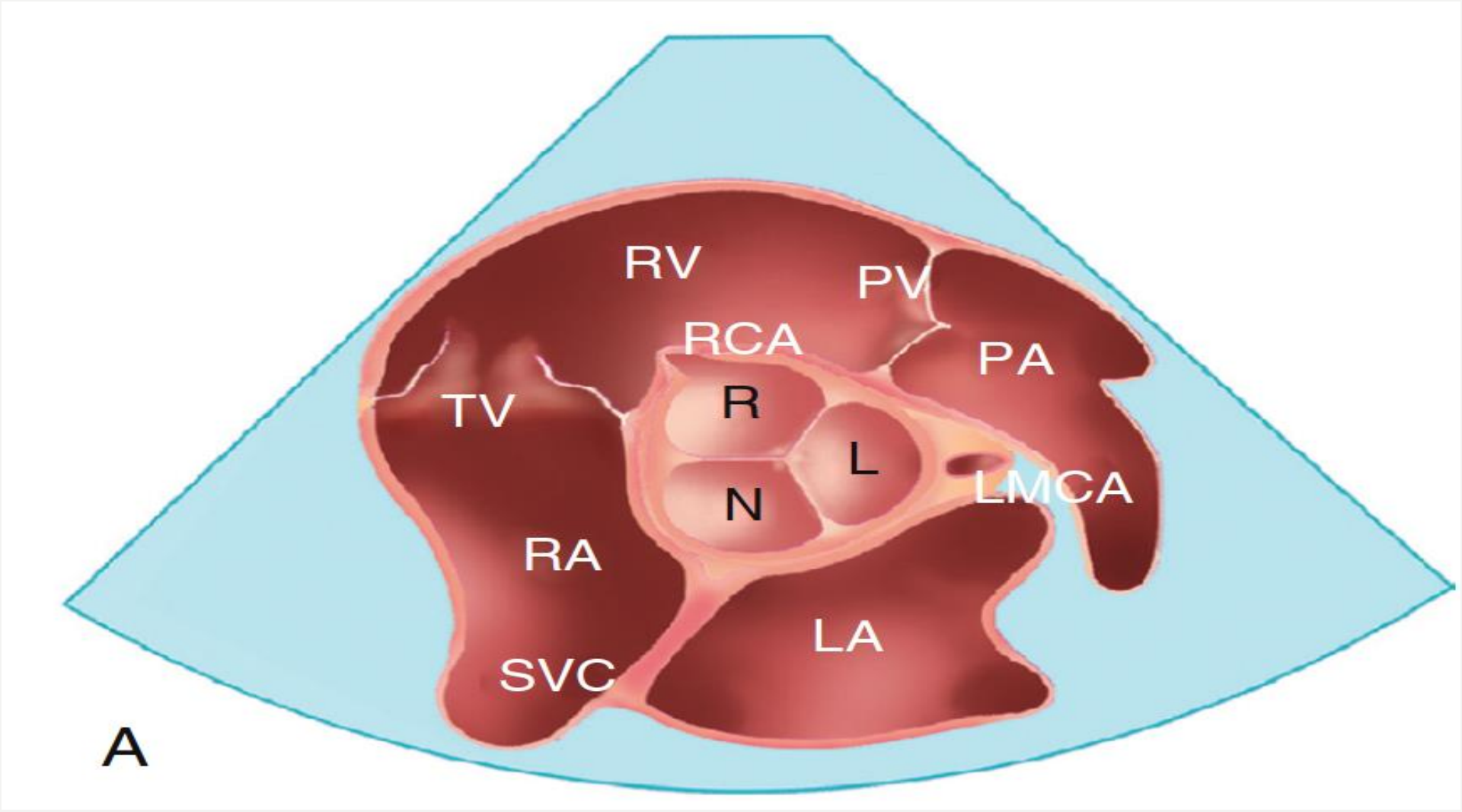
RV INFLOW VIEW



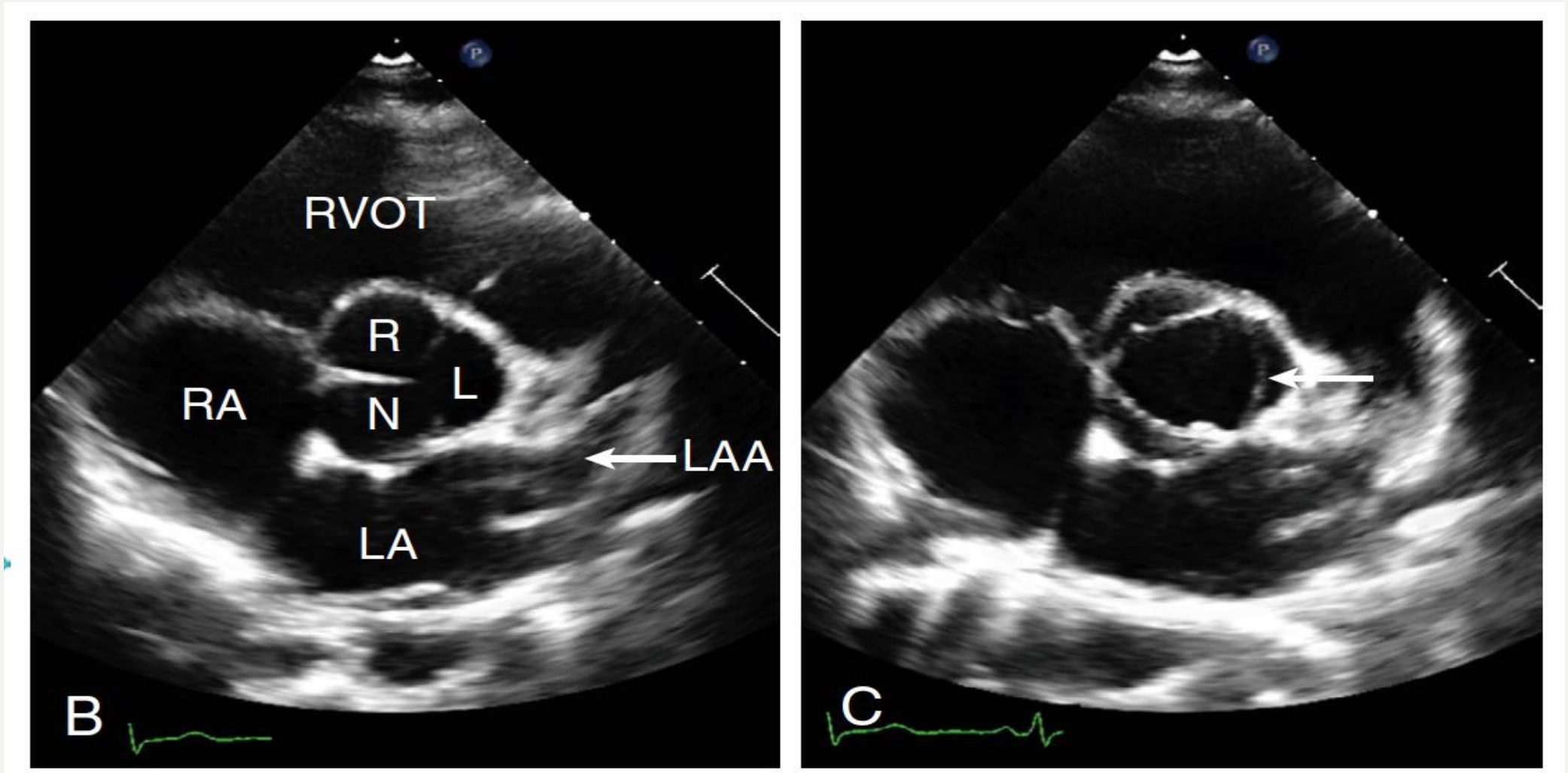
RV INFLOW VIEW CONT'D



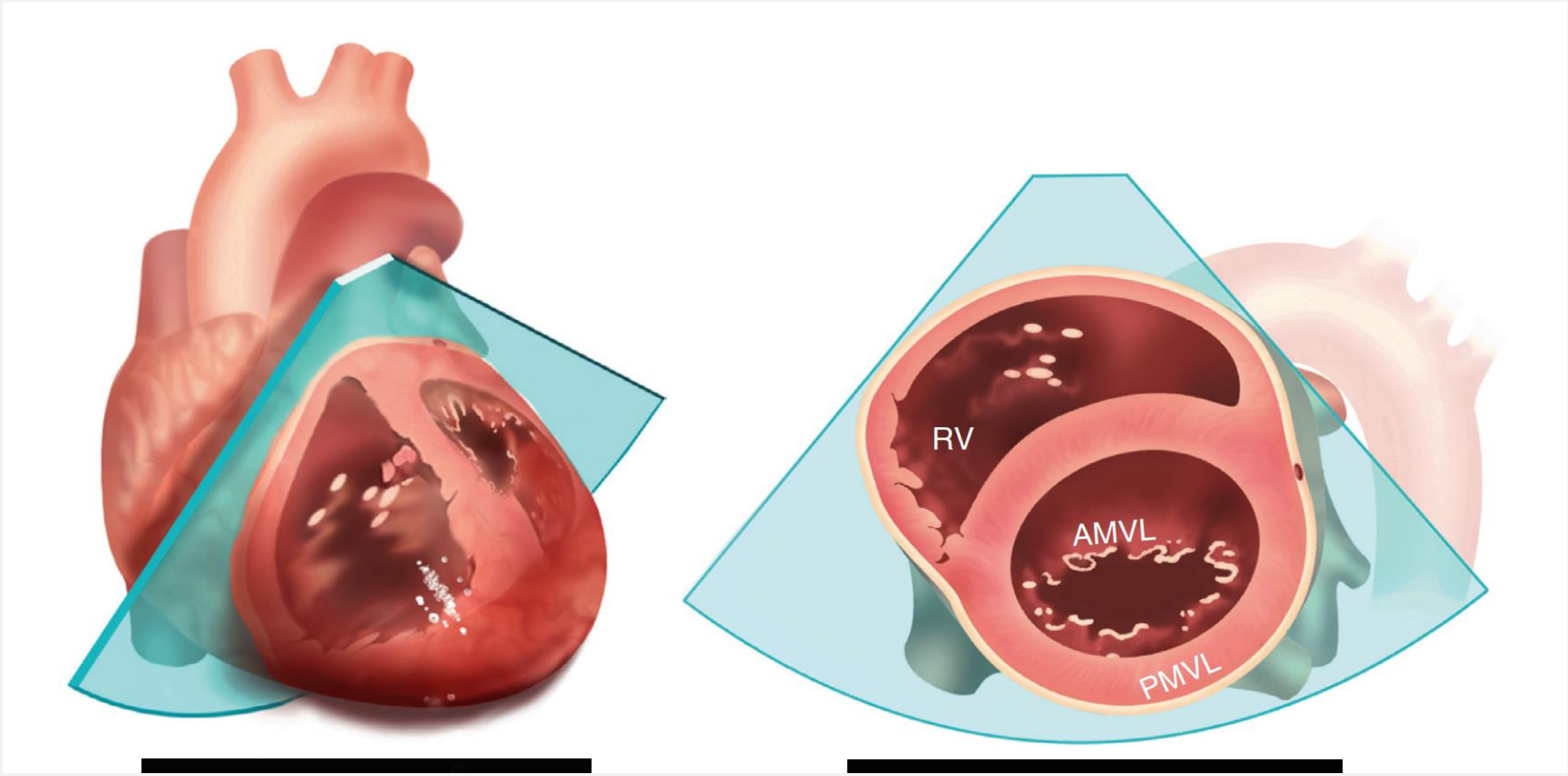
AORTIC VALVE SAX VIEW



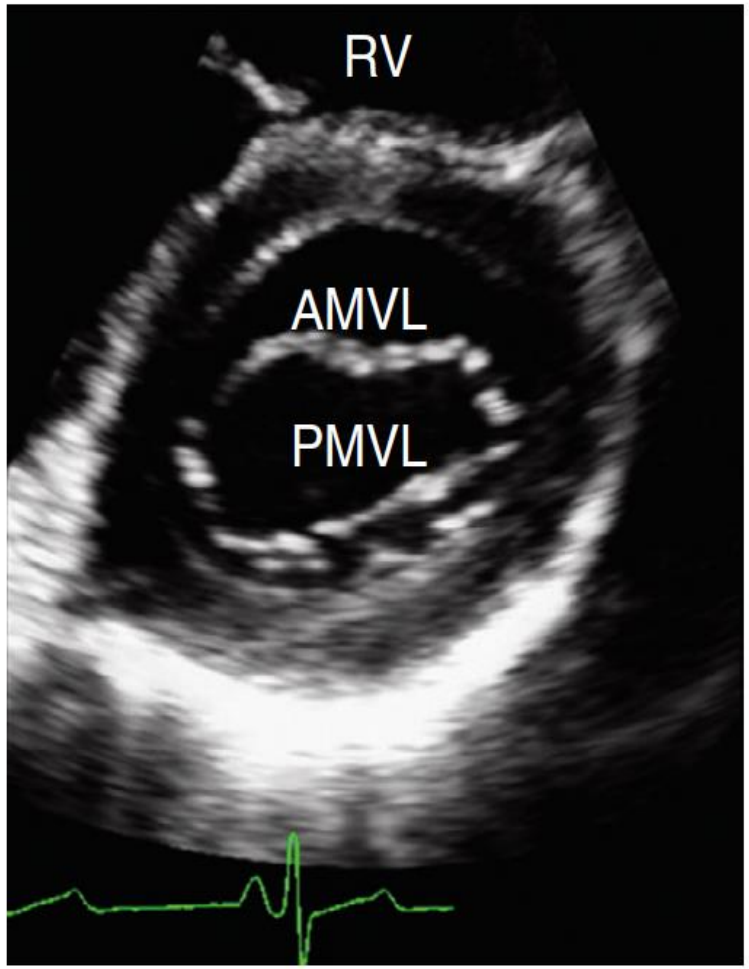
AORTIC VALVE SAX VIEW CONT'D

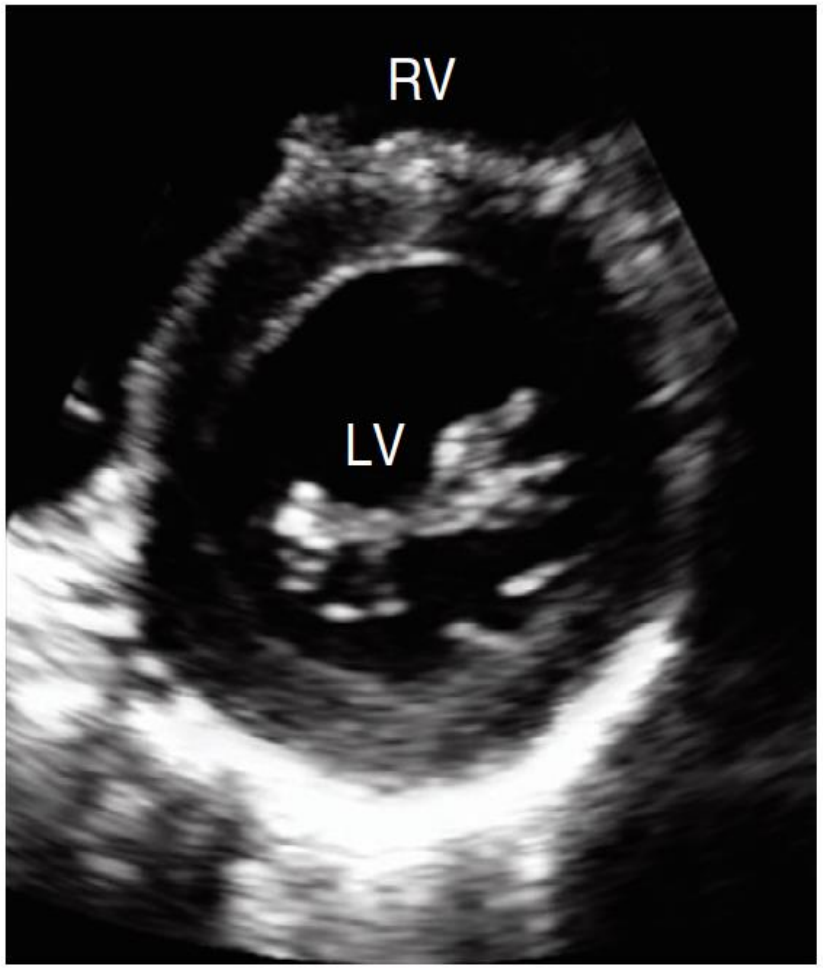


MITRAL VALVE SAX VIEW

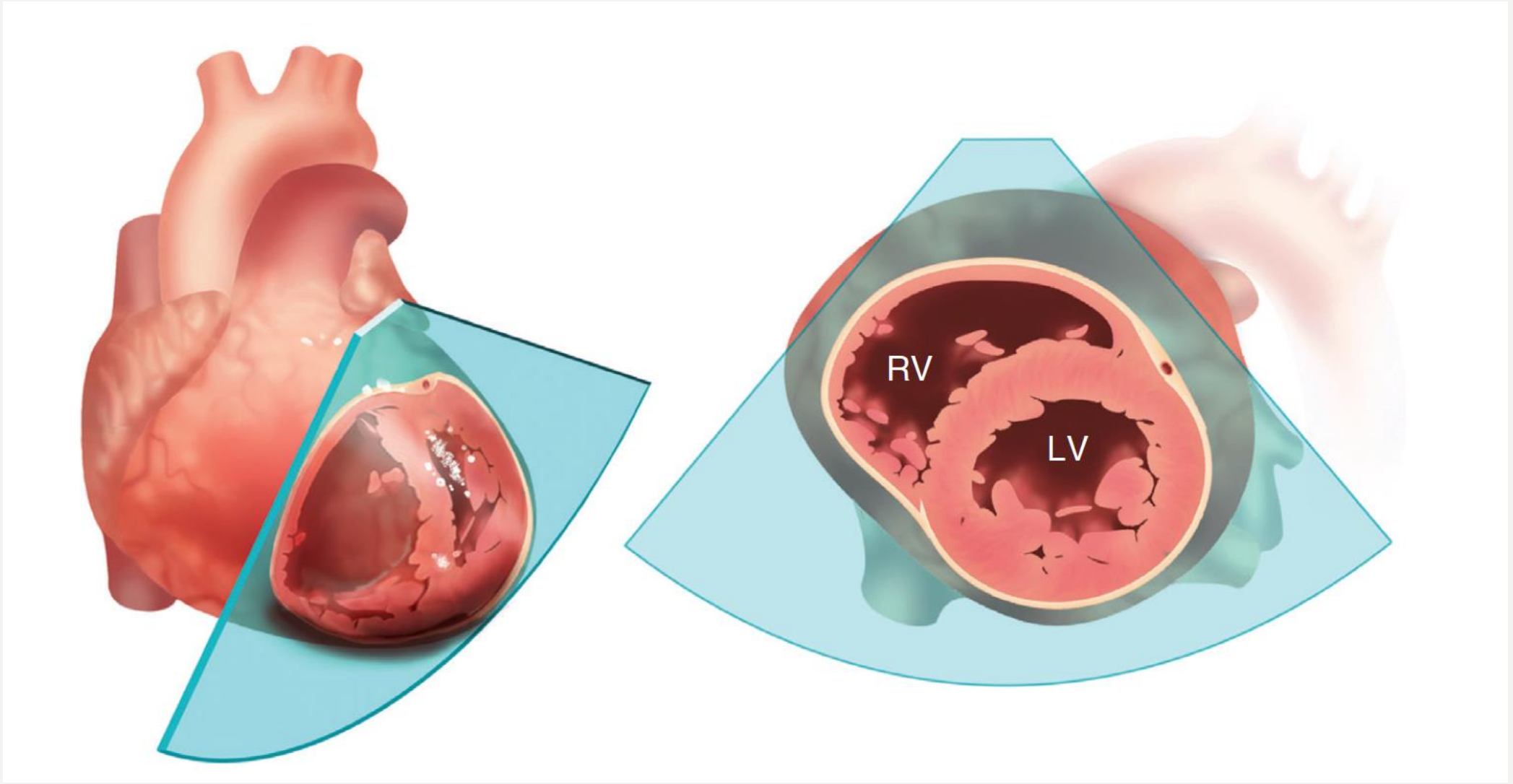


MITRAL VALVE SAX VIEW

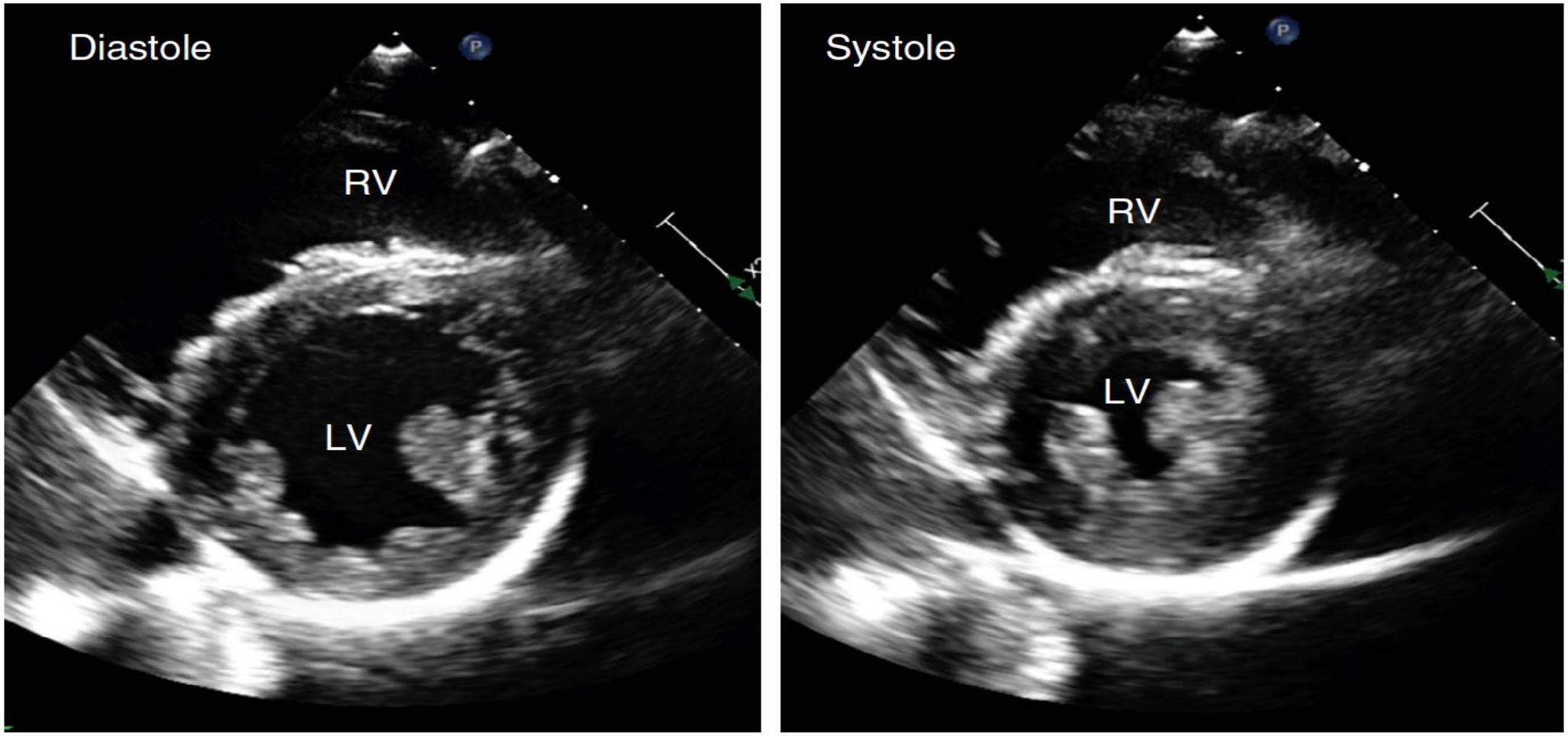




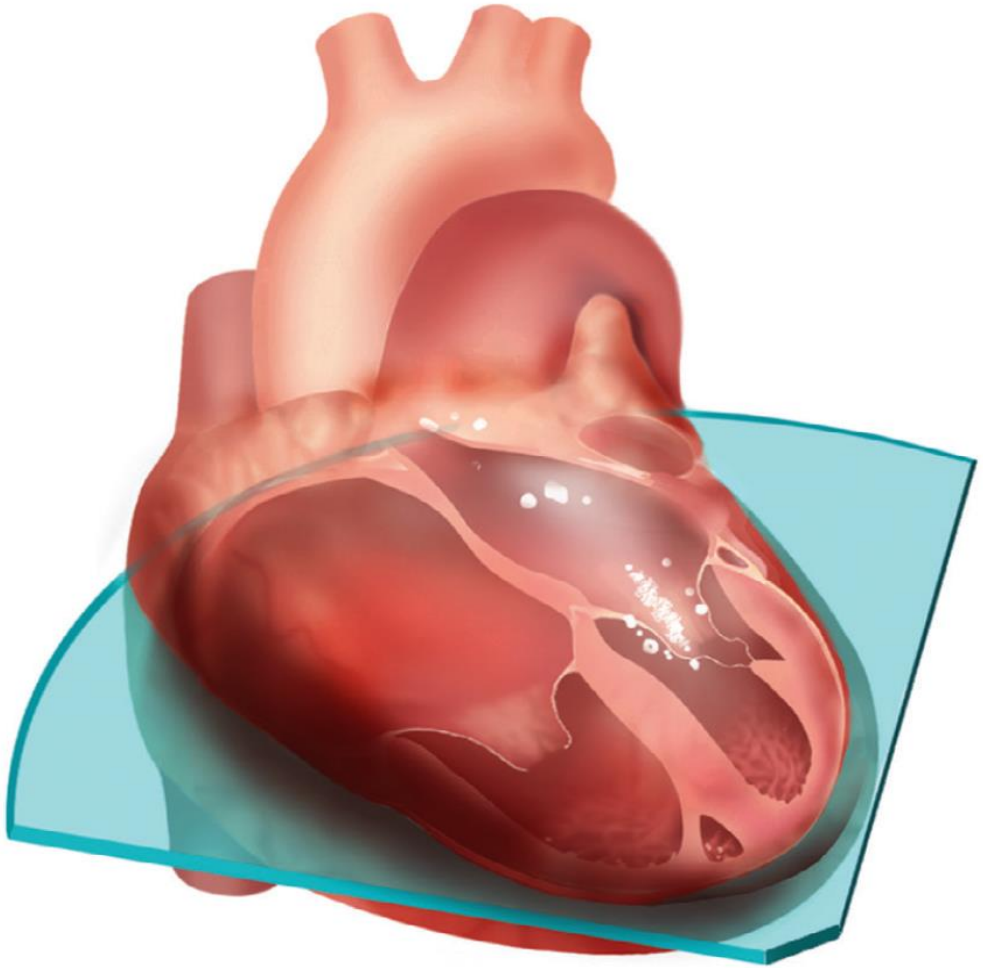
PAPILLARY MUSCLE SAX VIEW

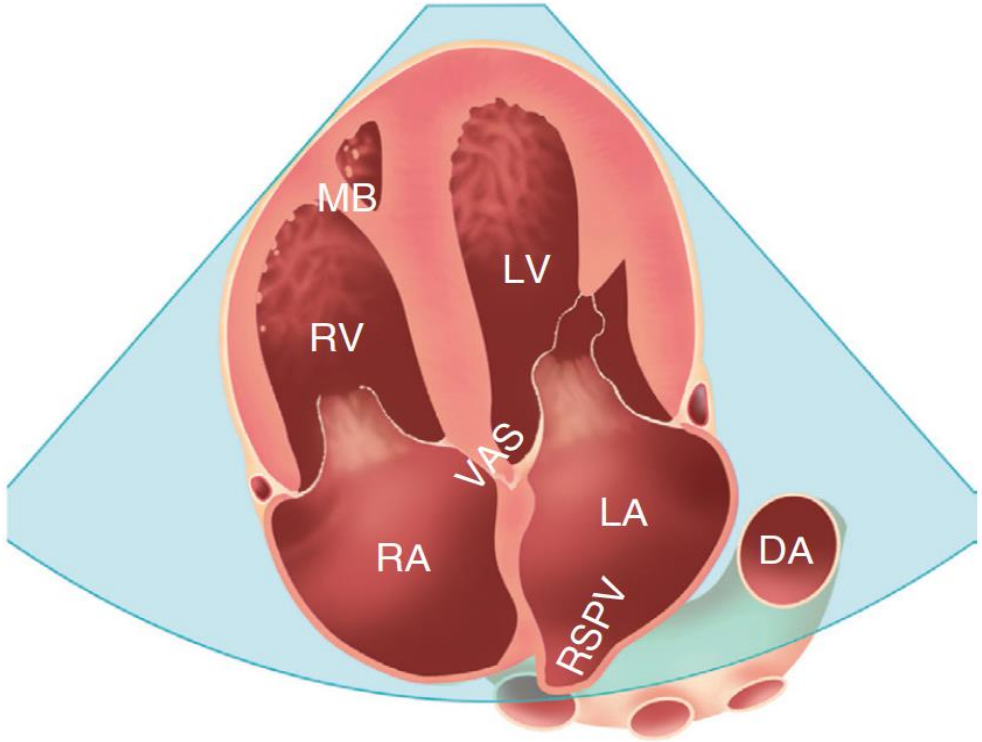


PAPILLARY MUSCLE SAX VIEW CONT'D

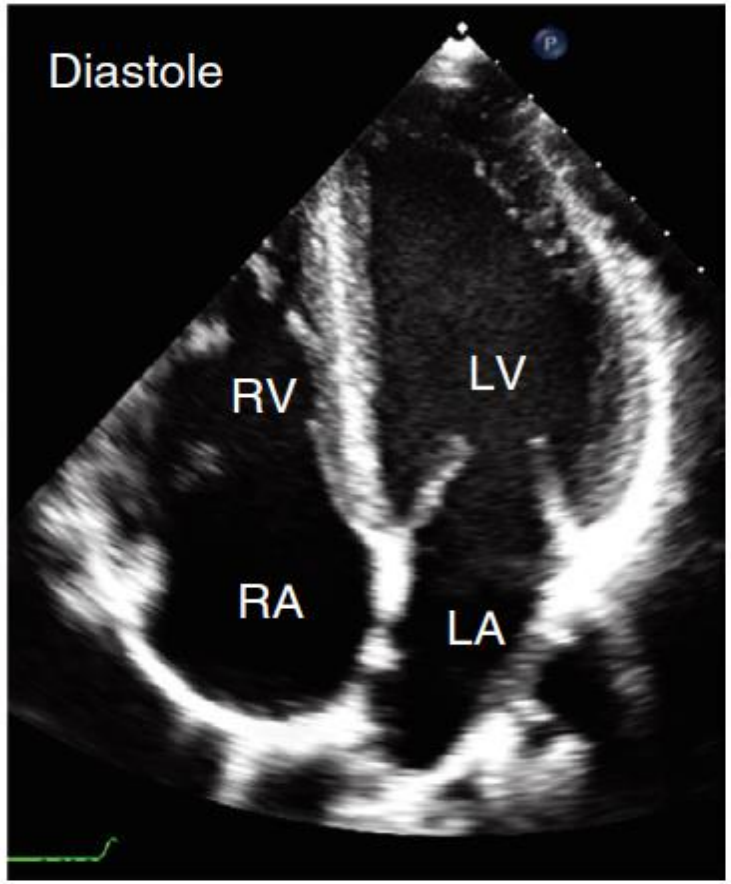


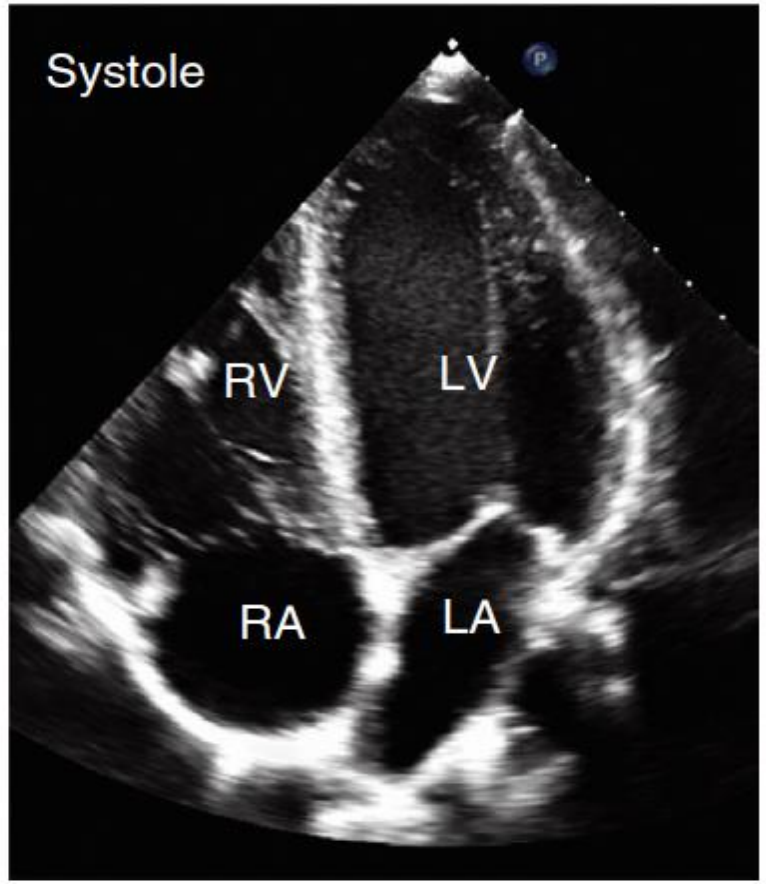
APICAL 4 CHAMBER VIEW



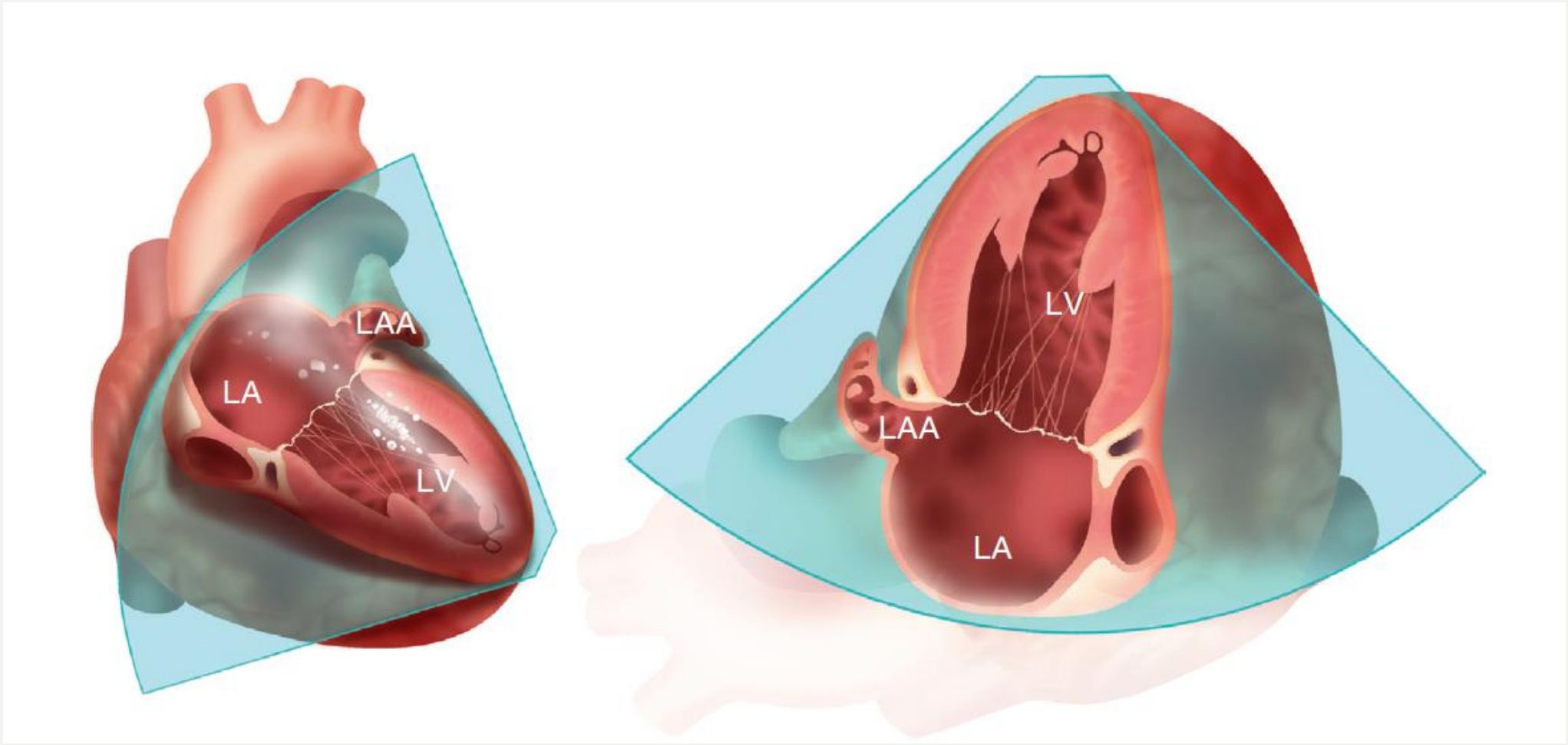


APICAL 4 CHAMBER VIEW CONT'D

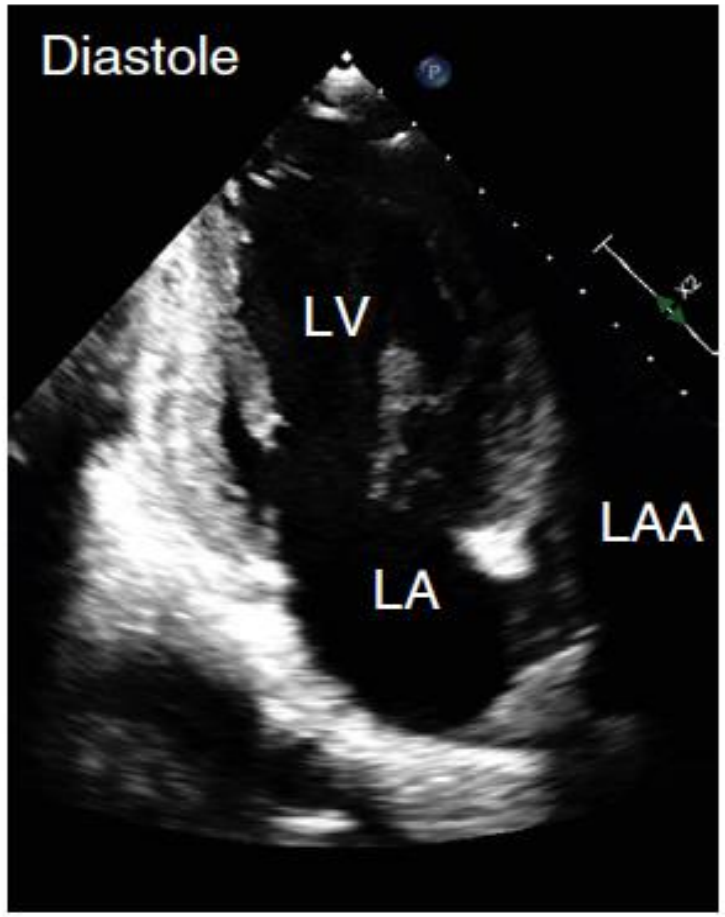


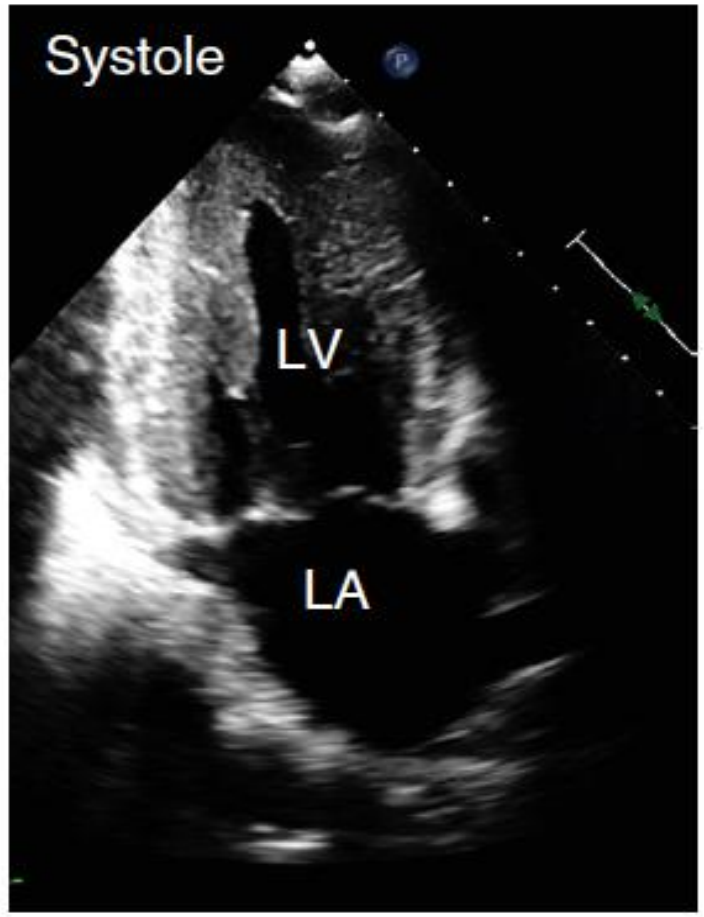


TWO CHAMBER VIEW

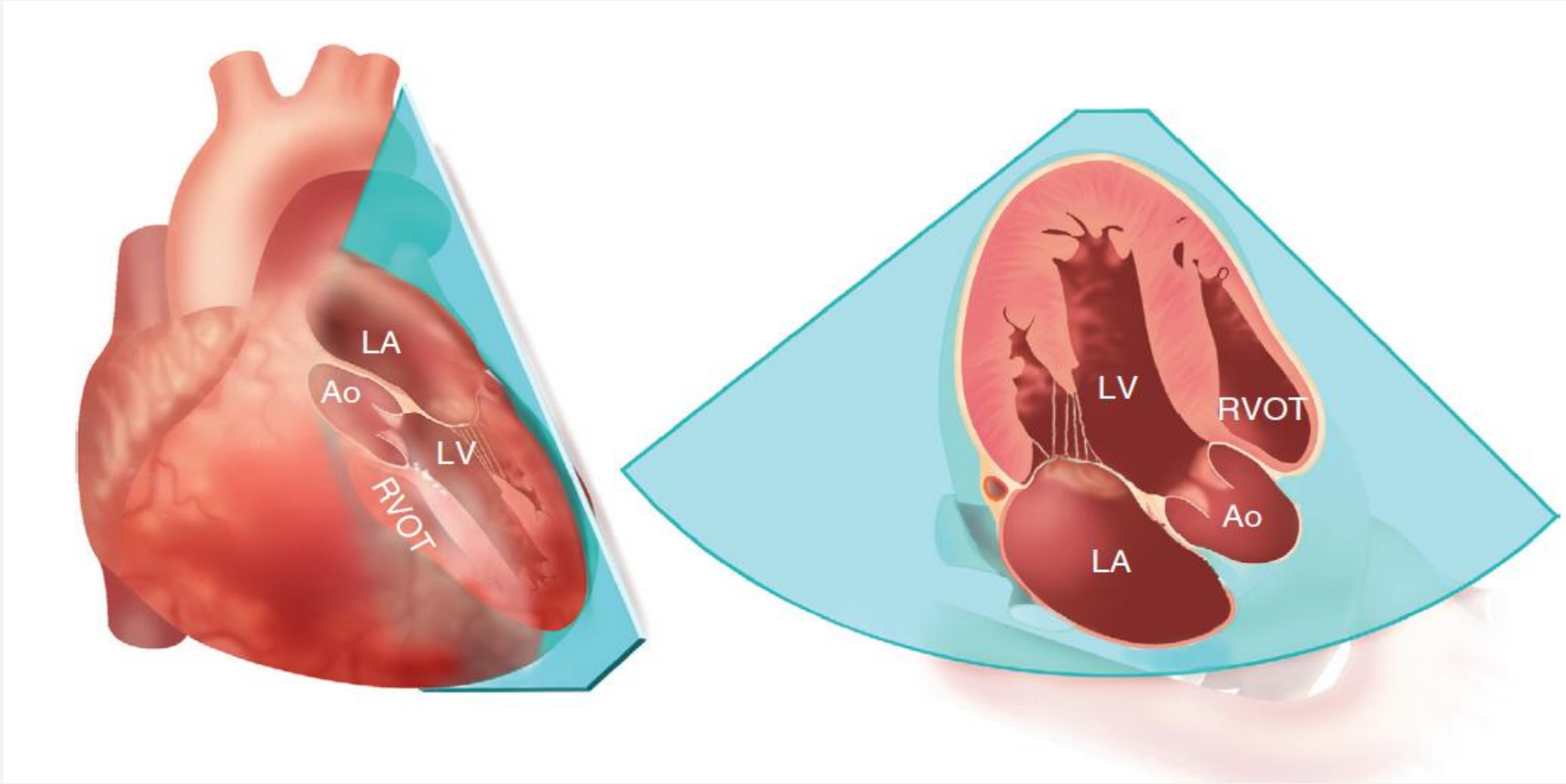


TWO CHAMBER VIEW CONT'D

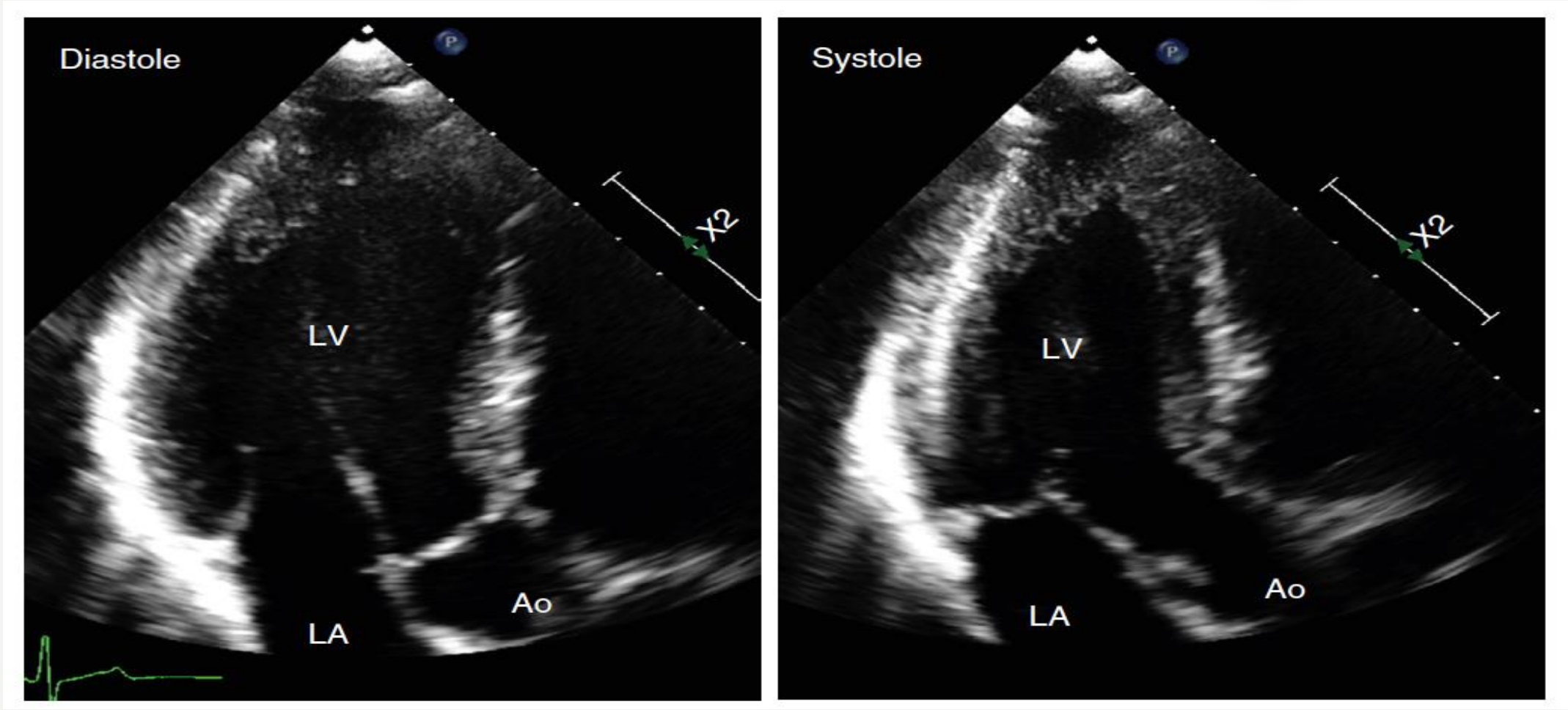




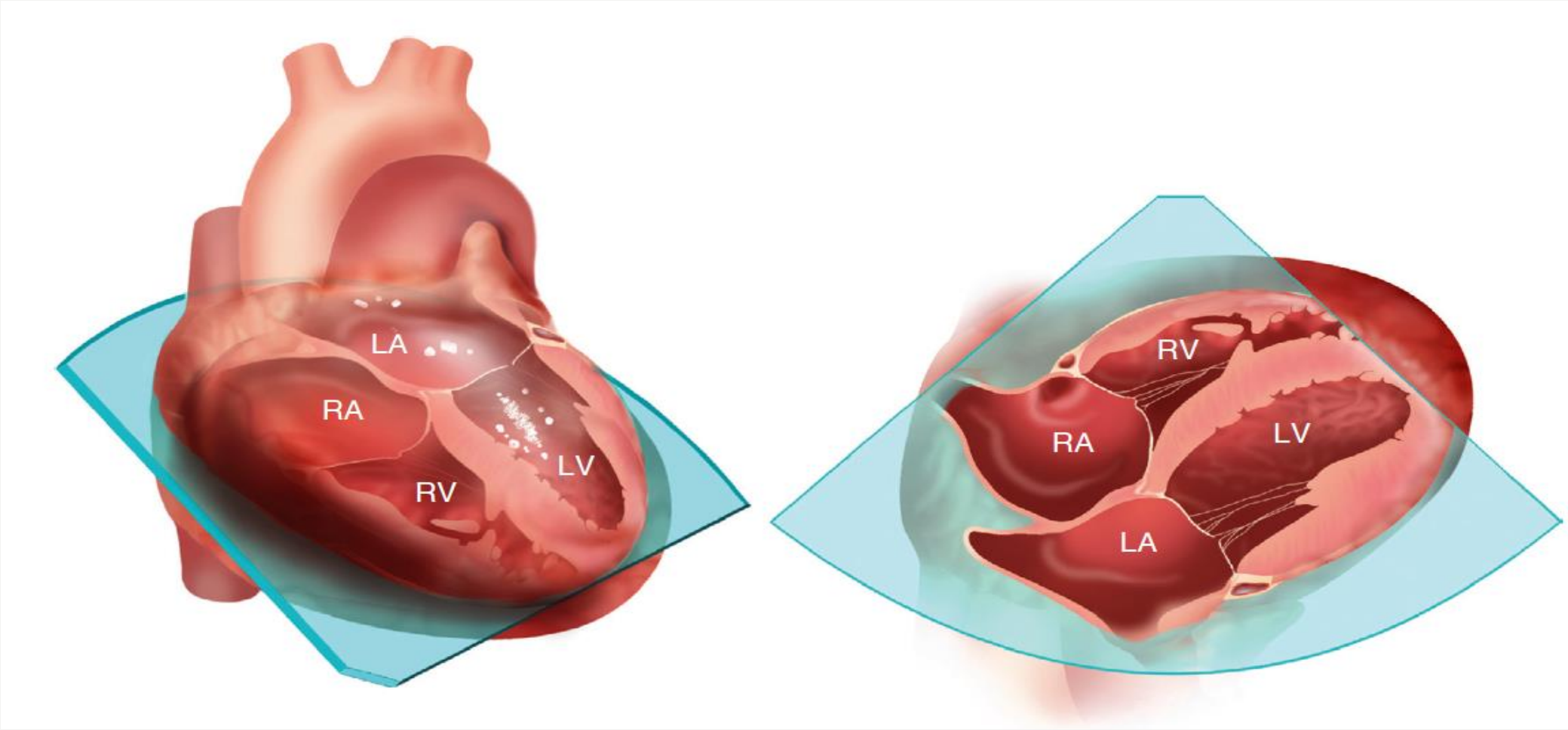
APICAL LONG AXIS VIEW



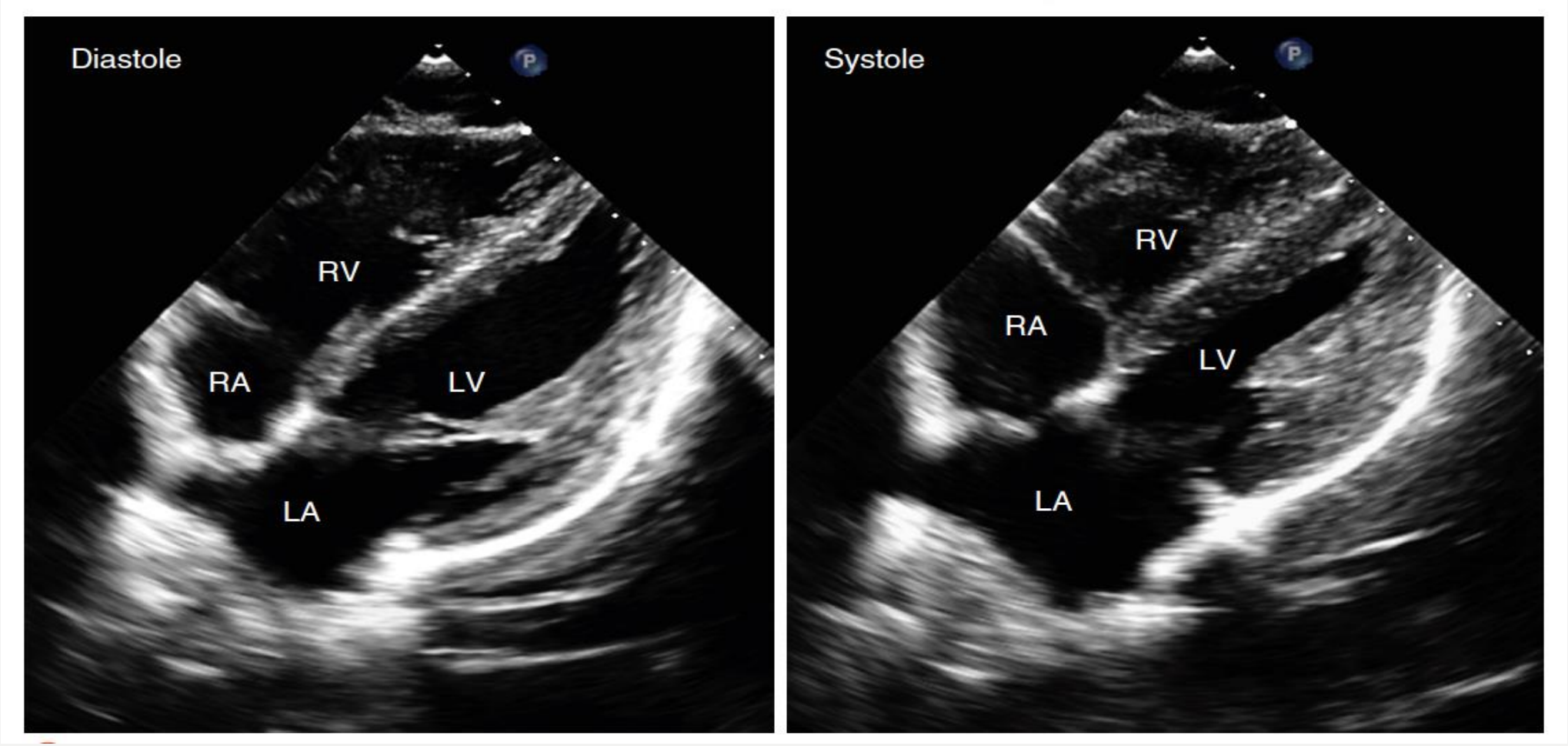
APICAL LONG AXIS VIEW CONT'D



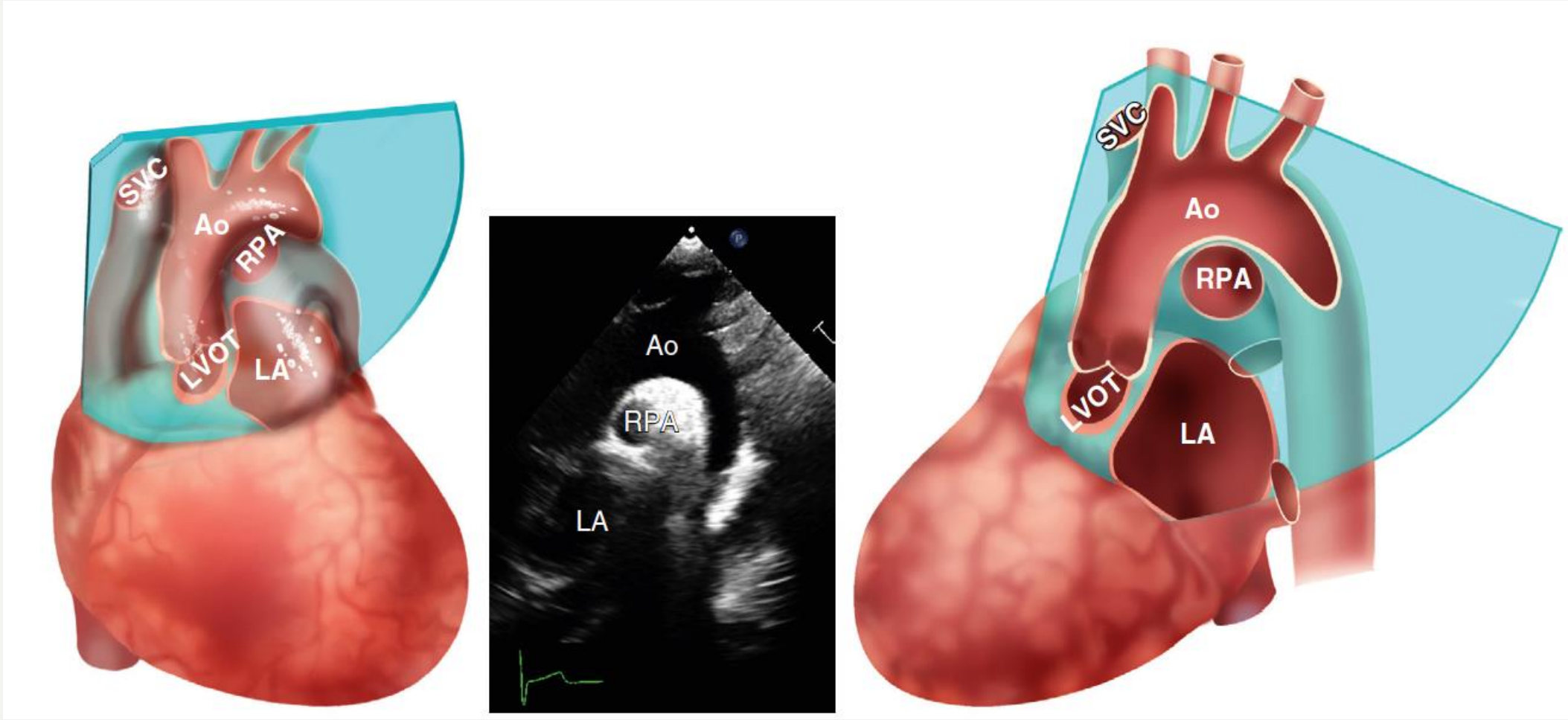
SUBCOSTAL VIEW



SUBCOSTAL VIEW CONT'D

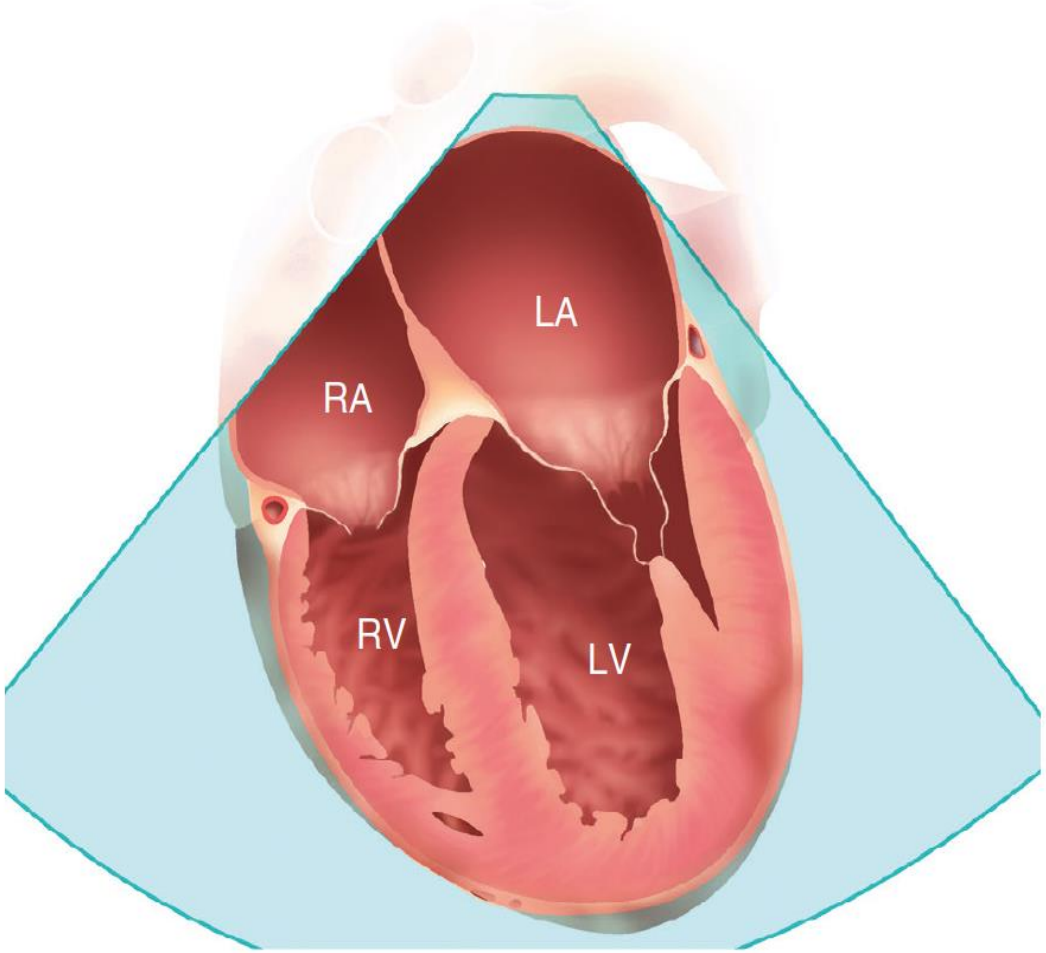


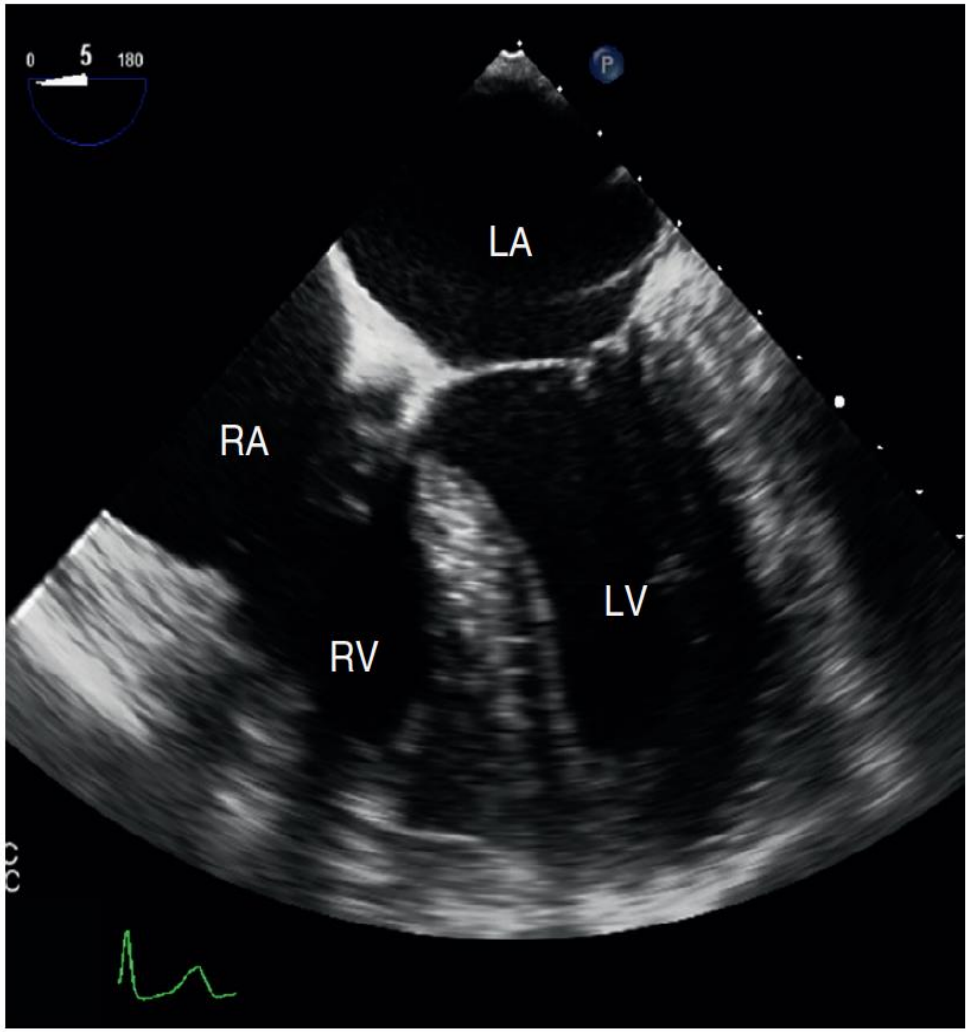
SUPRASTERNAL VIEW



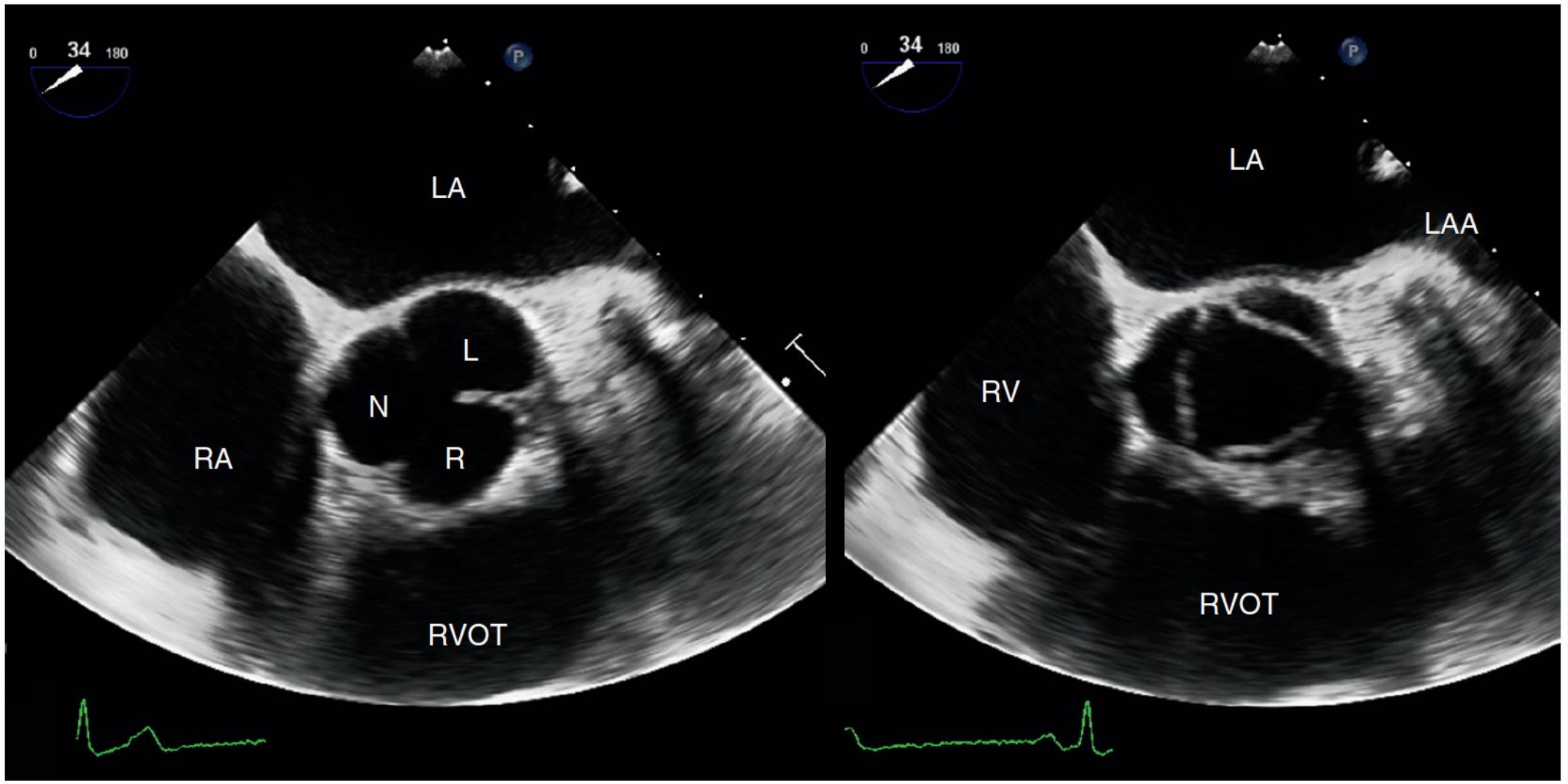
TEE VIEWS

ME 0º – A4C

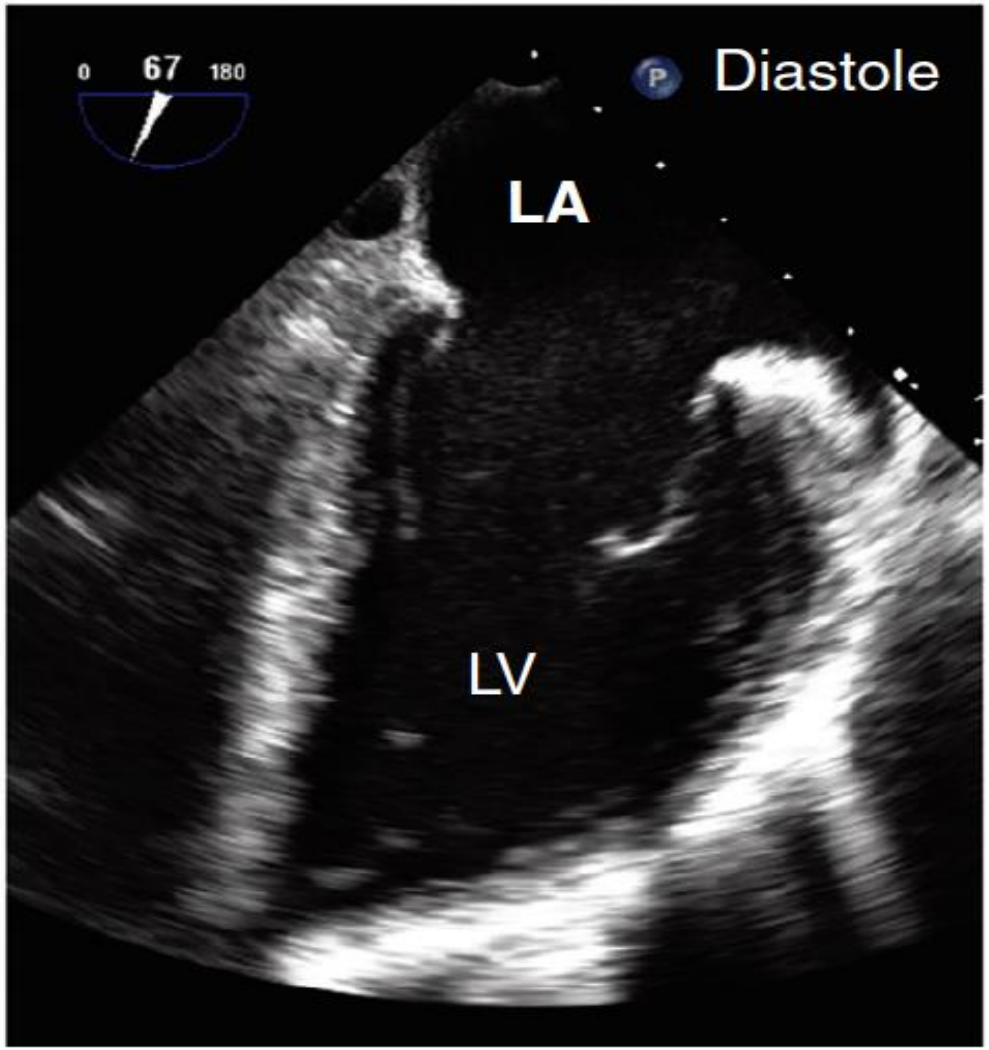


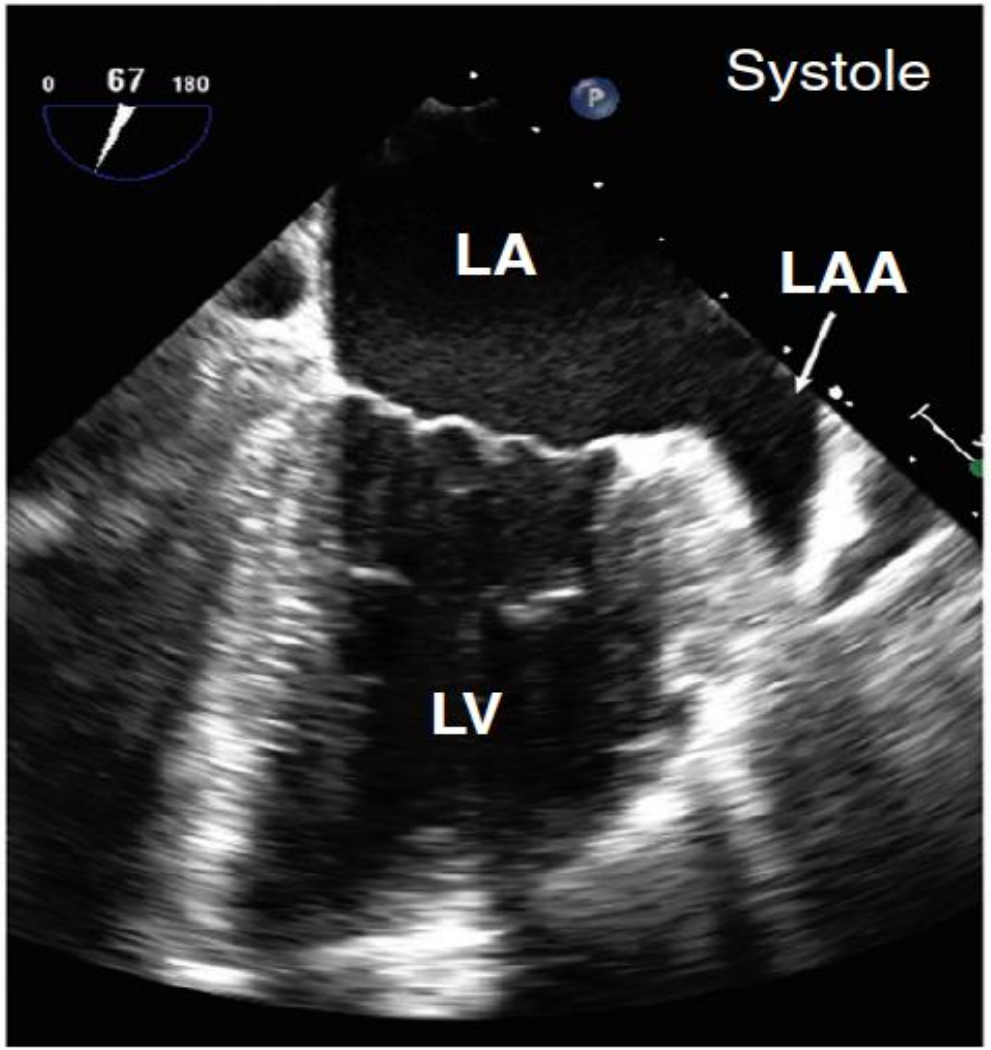


ME 35-45^{0} – AORTIC VALVE SAX VIEW

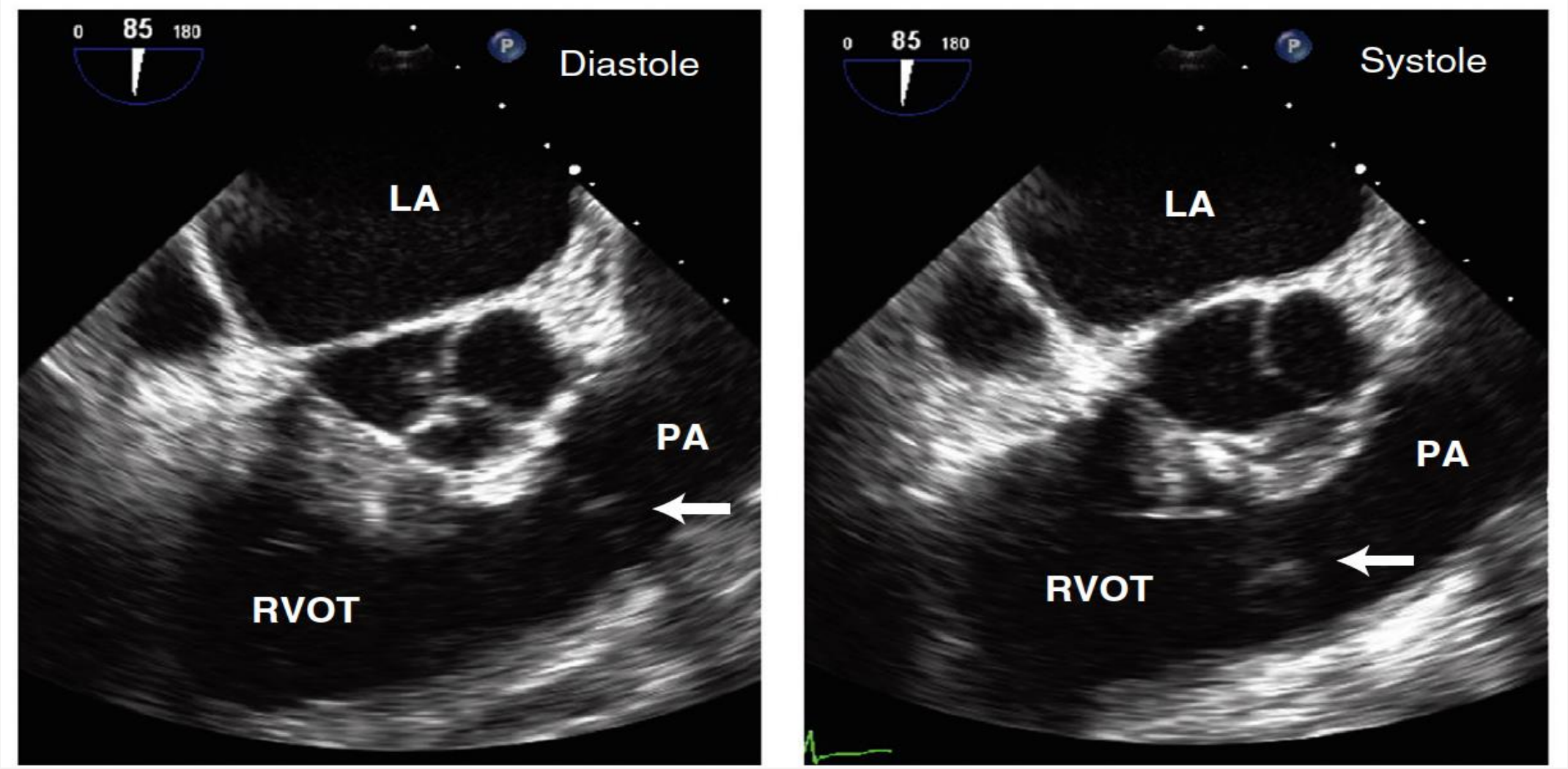


ME 60⁰ – A2C

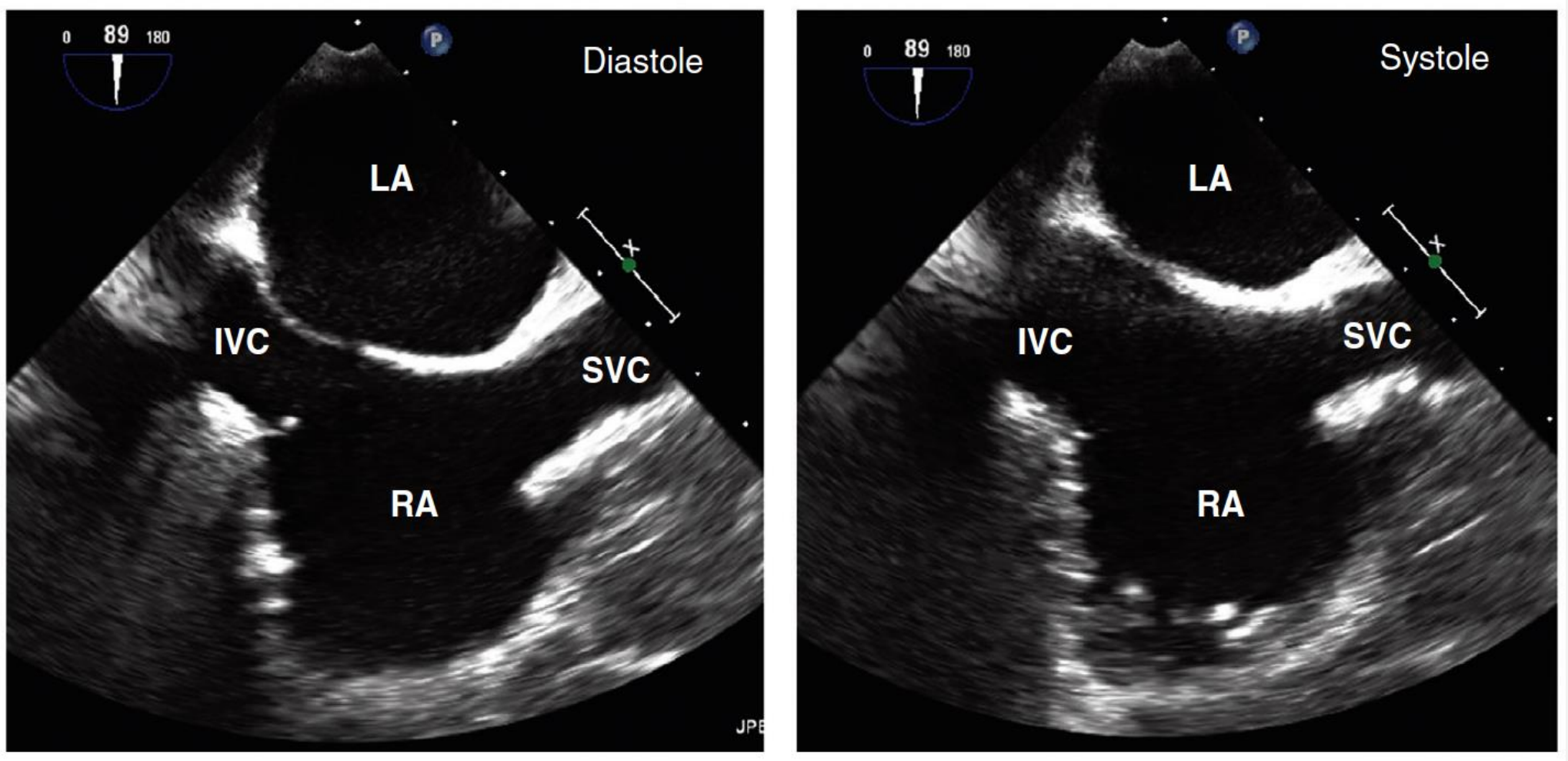




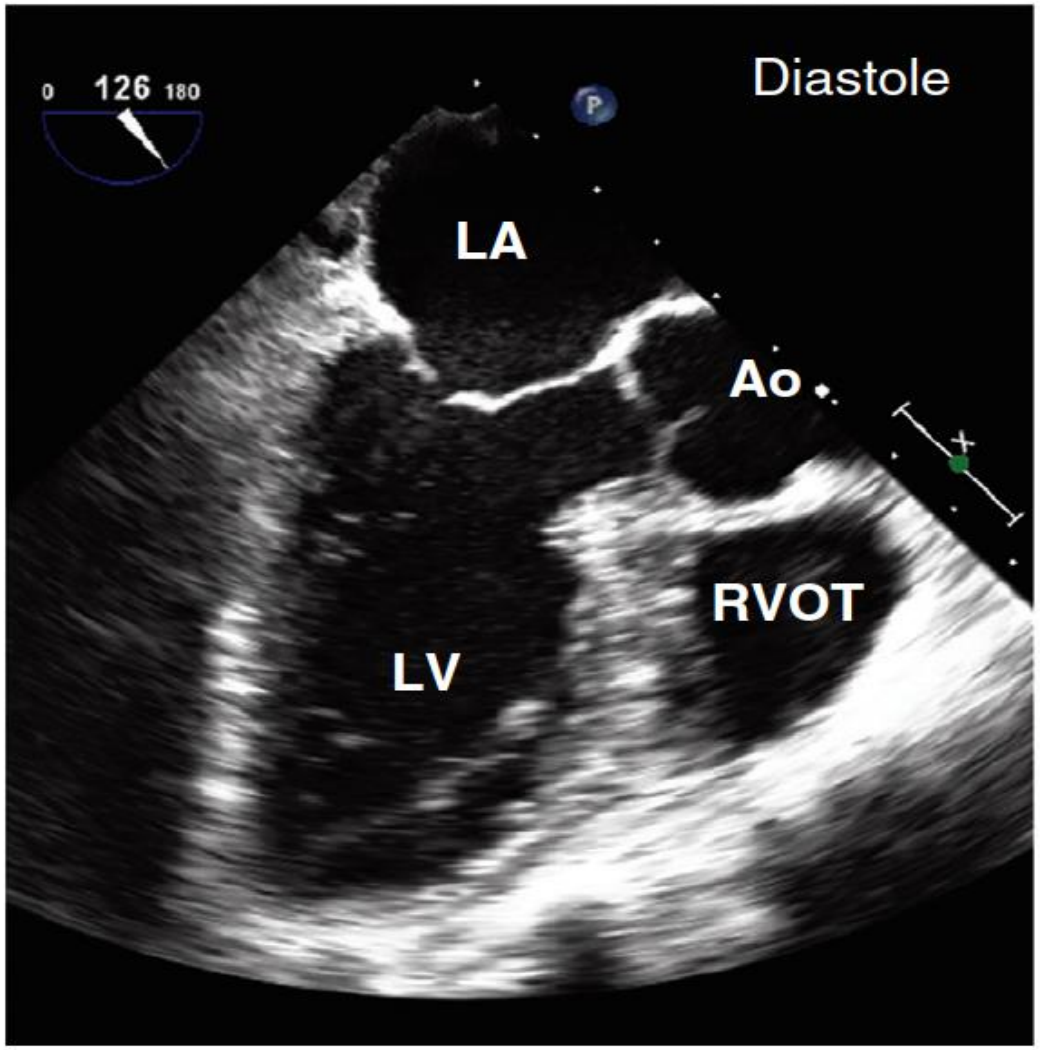
ME 60-80^0 – RV OUTFLOW

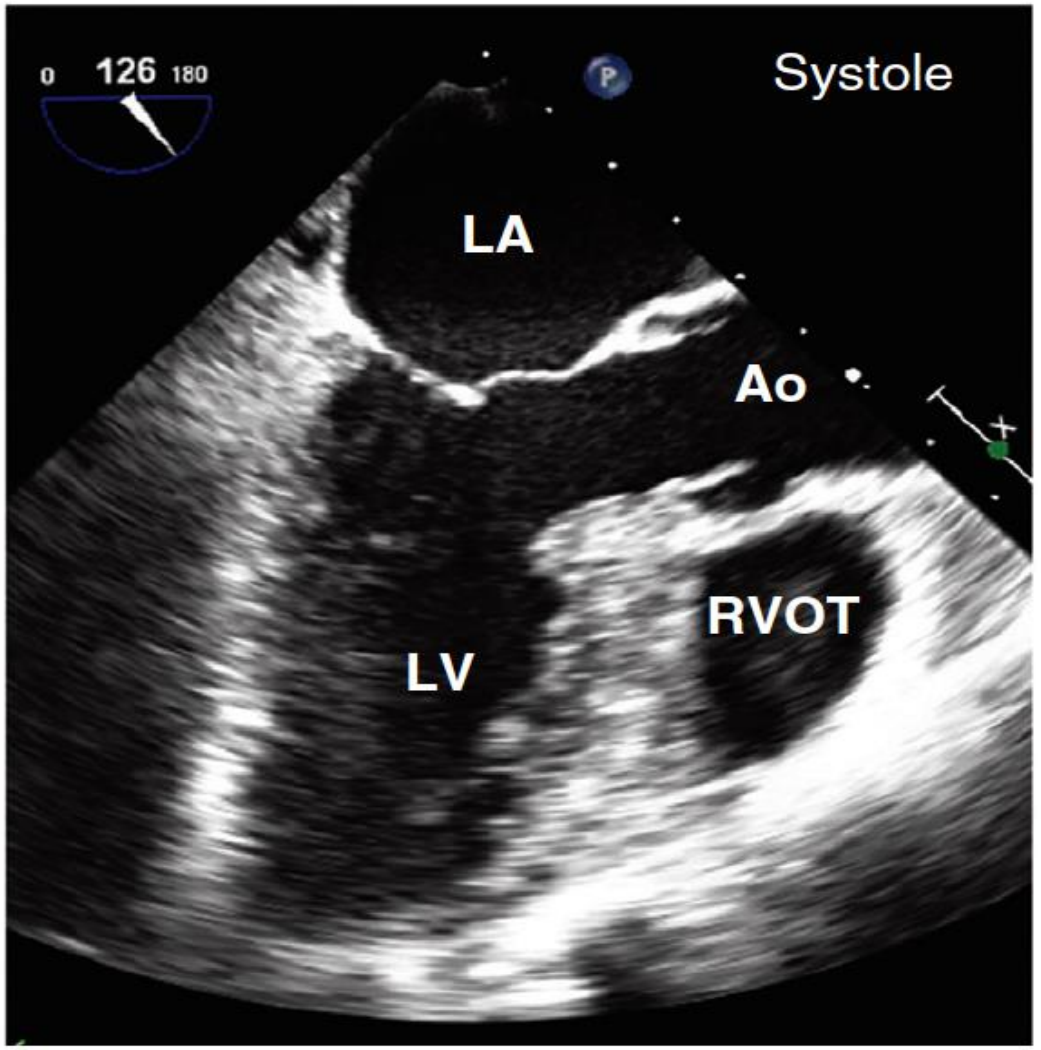


ME 90º – BICAVAL VIEW



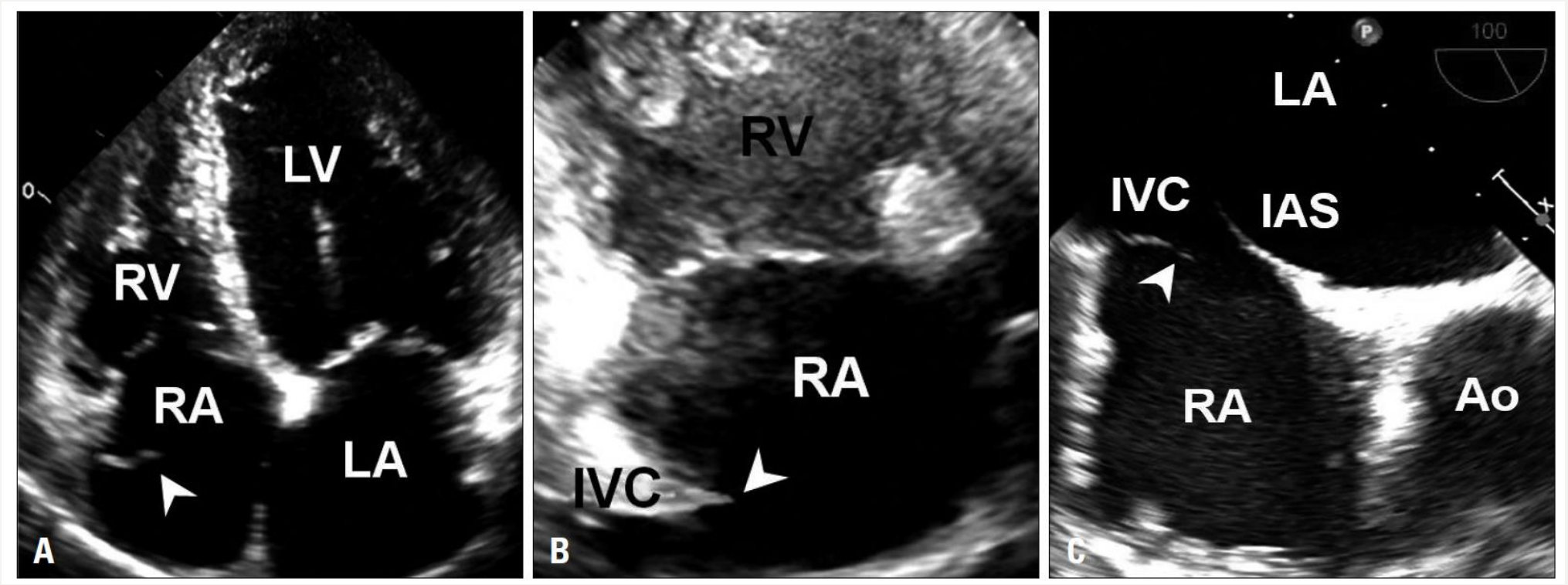
ME 120⁰ – LA VIEW





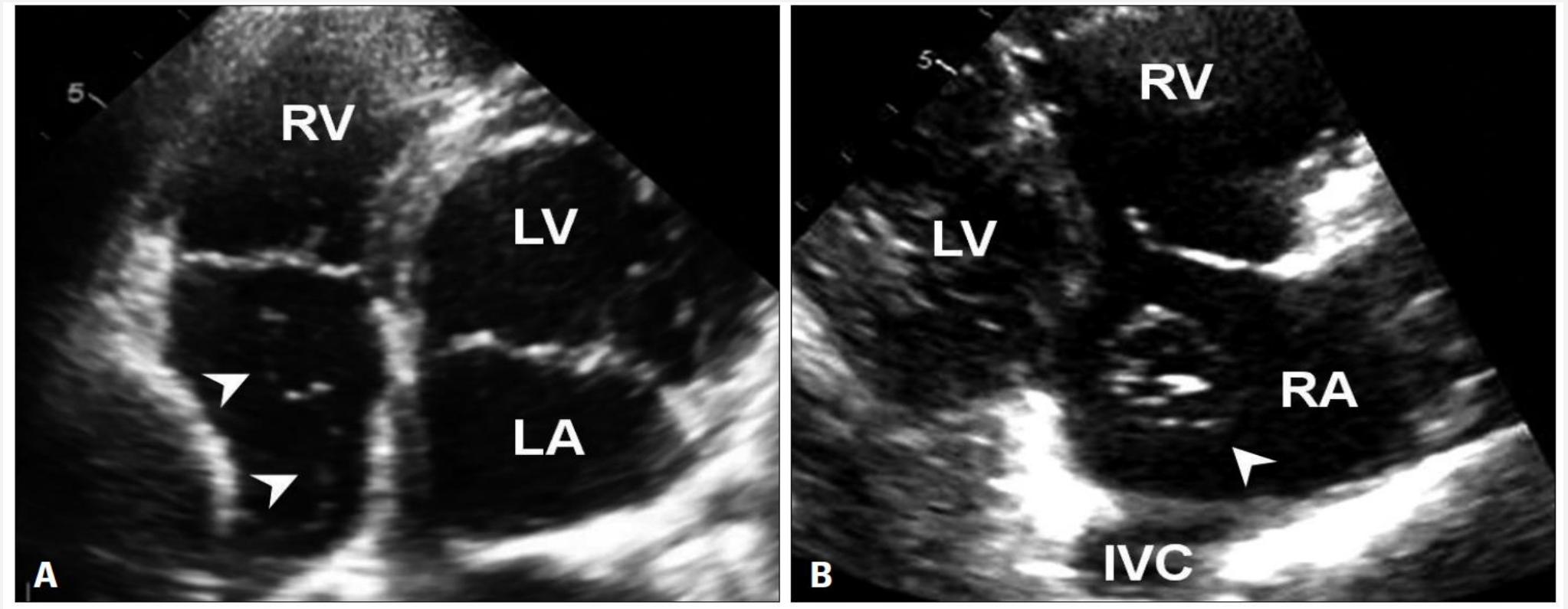
ANATOMIC VARIANTS MIMICKING PATHOLOGY

RIGHT ATRIUM-EUSTACHIAN VALVE



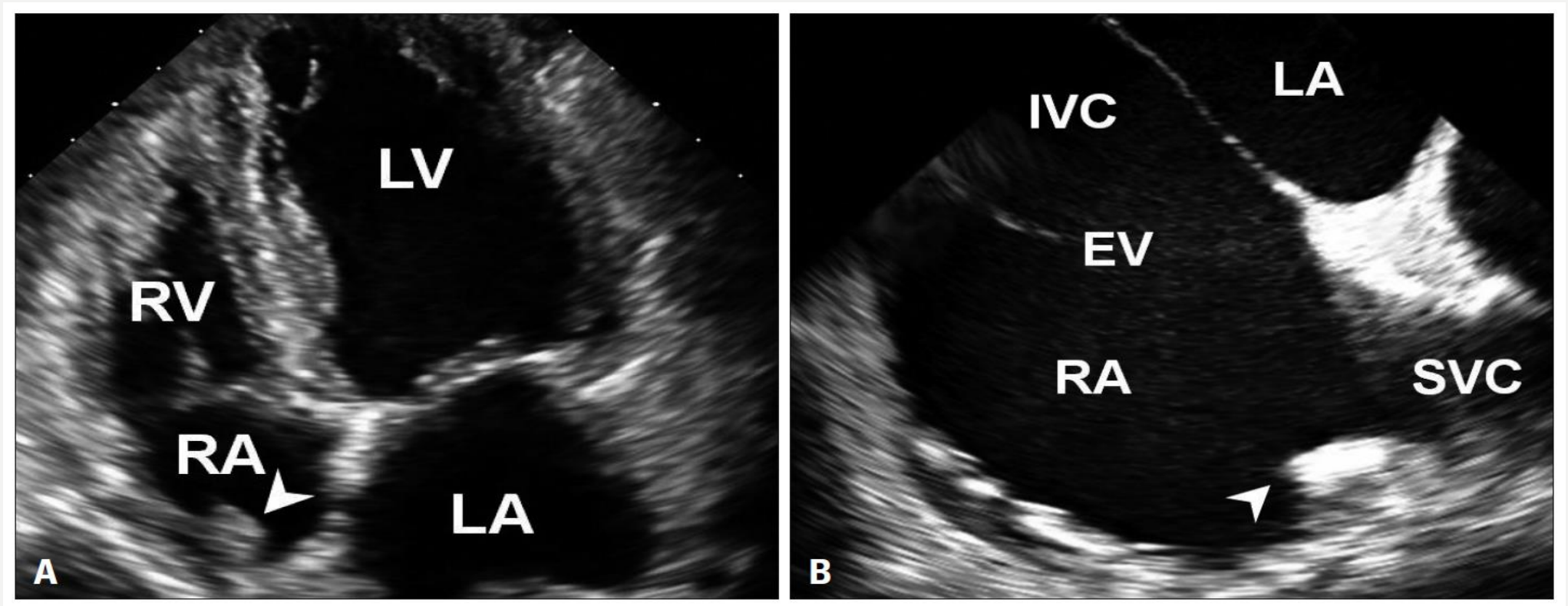
Eustachian valve : Remnant of embryological valve of IVC directed oxygen rich blood from IVC to LA. Leaf like linear and crescent-like fold at the junction of IVC and RA.

RIGHT ATRIUM-CHIARI NETWORK



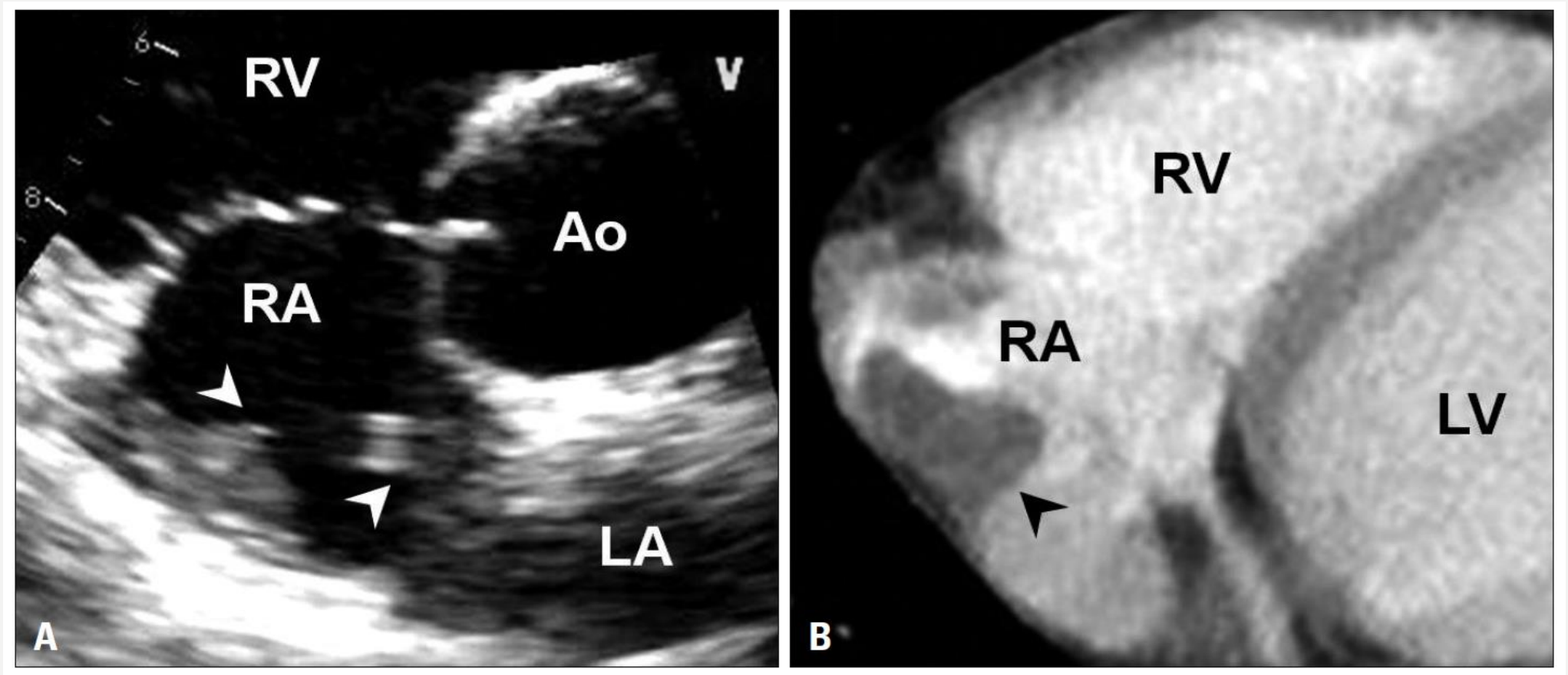
Chiari network : Free floating curvilinear structure that waves with the blood flow in RA. Variant of Eustachian valve (more mobile and thinner than eustachian valve). Arises from the orifice of IVC. Confused for tricuspid vegetation, flail tricuspid valve, free RA thrombus, pedunculated tumors. EP procedures: Entrapment of right heart catheters.

RIGHT ATRIUM-CRISTA TERMINALIS



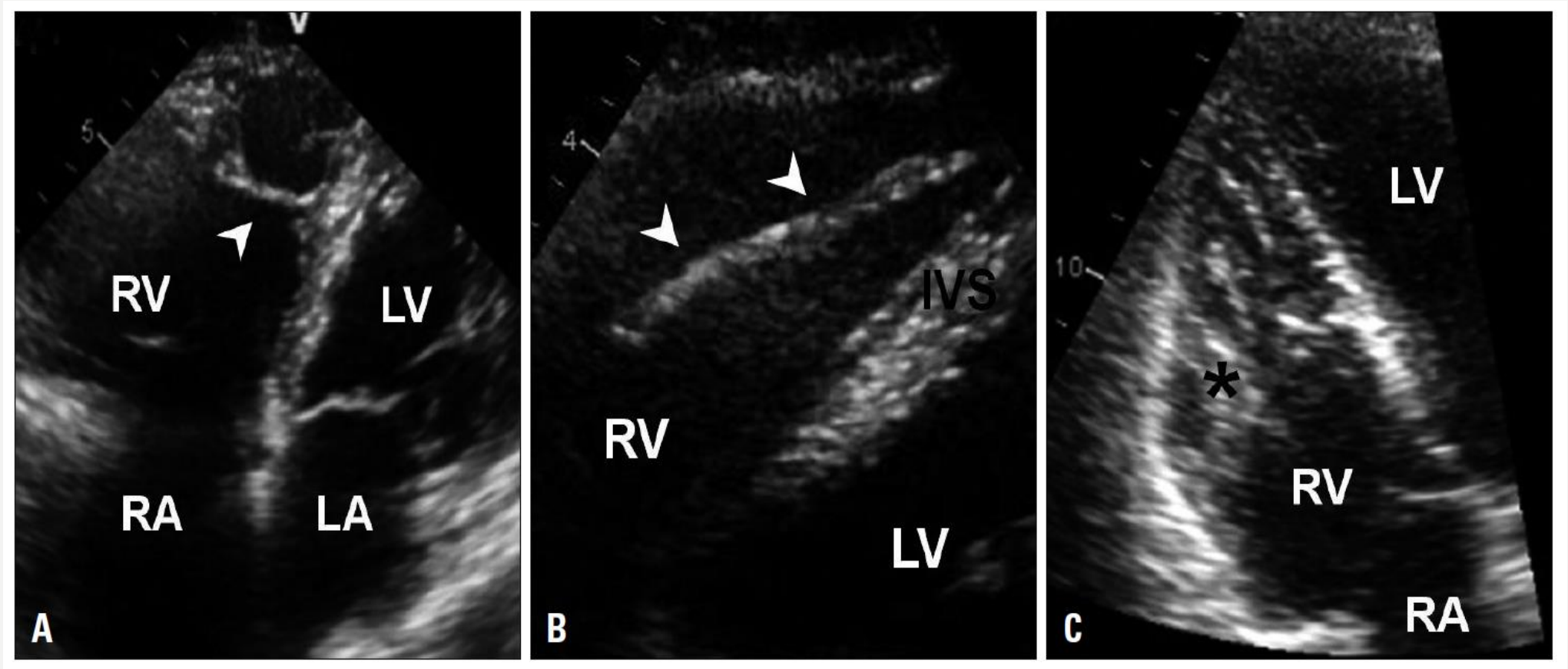
Crista terminalis : Well-defined fibromuscular ridge extending from SVC to IVC along the lateral RA wall. Nodular mass of similar echogenicity with the adjacent myocardium; the location of posterolateral wall of RA near the SVC; the phasic change in size becoming thicker or larger during atrial systole. Bicaval view of TEE best visualizes the crista terminalis.

RIGHT ATRIUM-THROMBUS



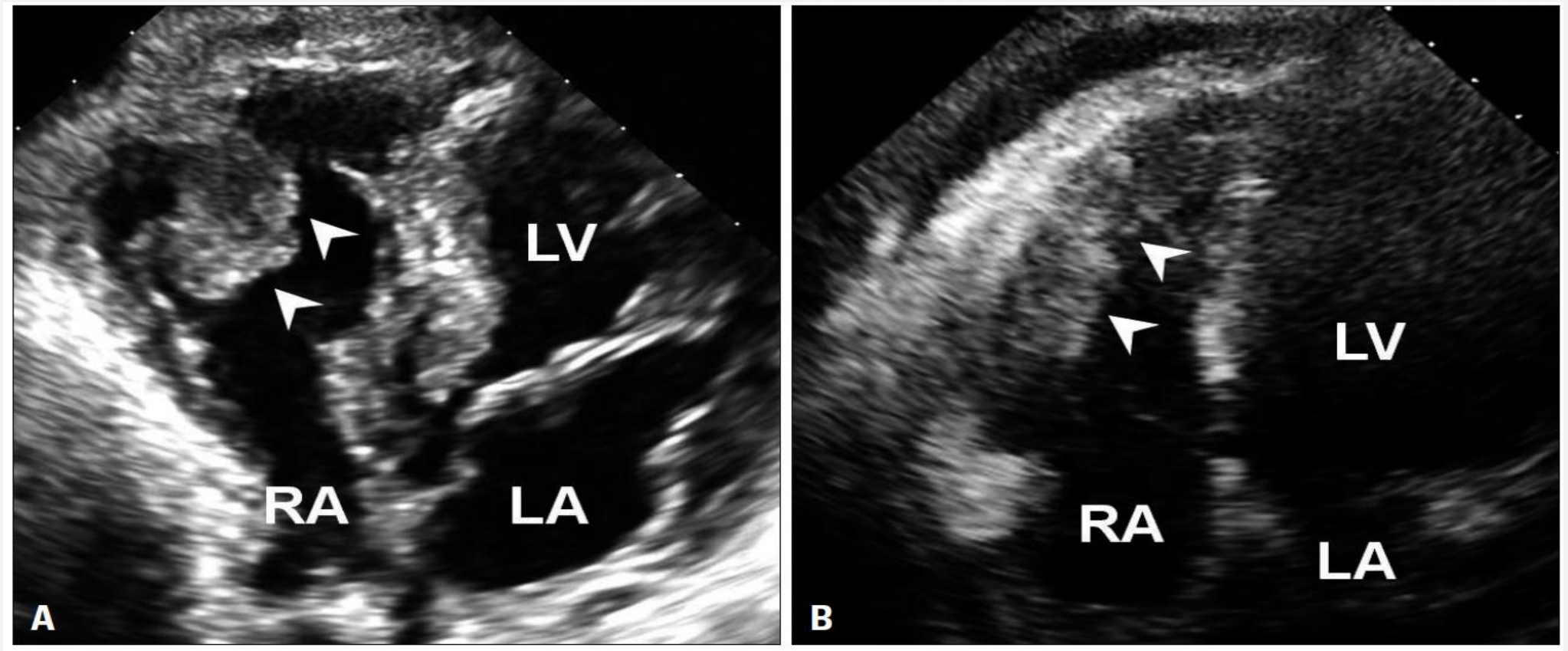
Clinical scenario will aid in the diagnosis like Afib, advanced HF, RV failure, PPM/ICD.

RIGHT VENTRICLE



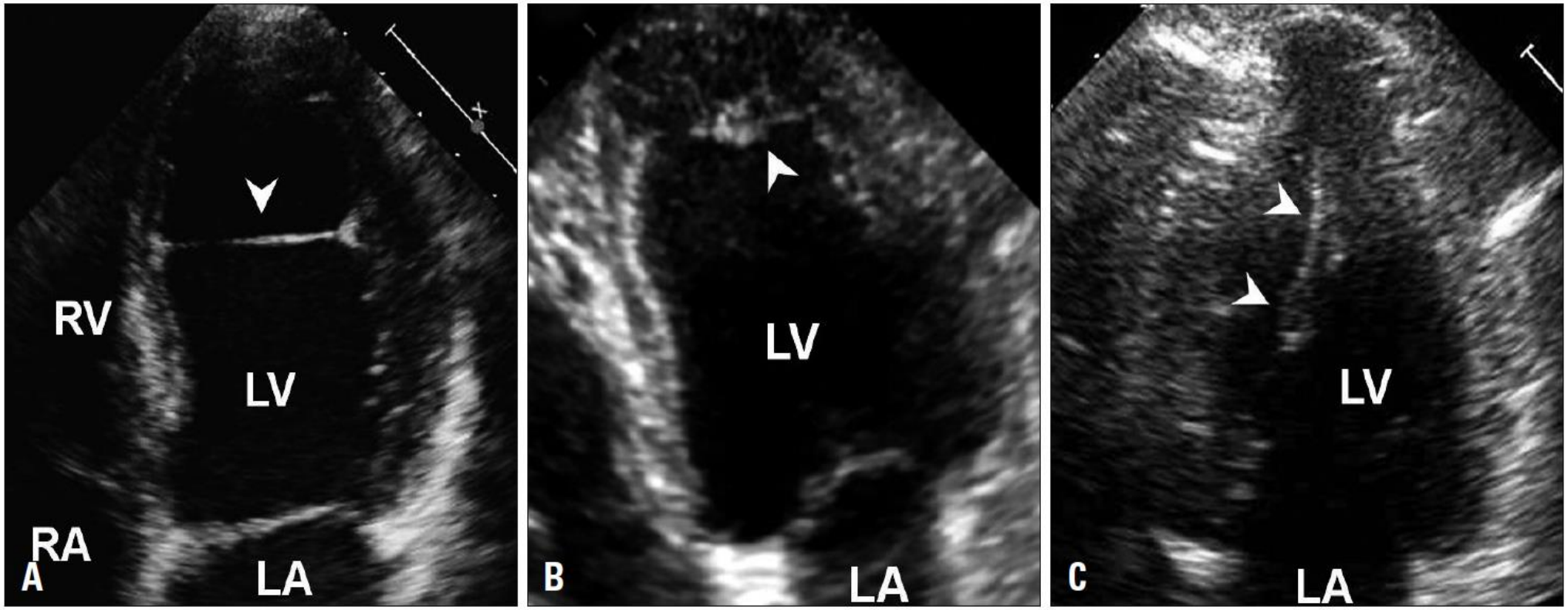
Moderator band (thick echo dense structure across the RV cavity, connects lower IV septum to the anterior papillary muscle), prominent papillary muscle and heavy trabeculation (pathologic-associated with congenital heart lesions) may be normally seen in the RV.

RIGHT VENTRICLE-THROMBUS



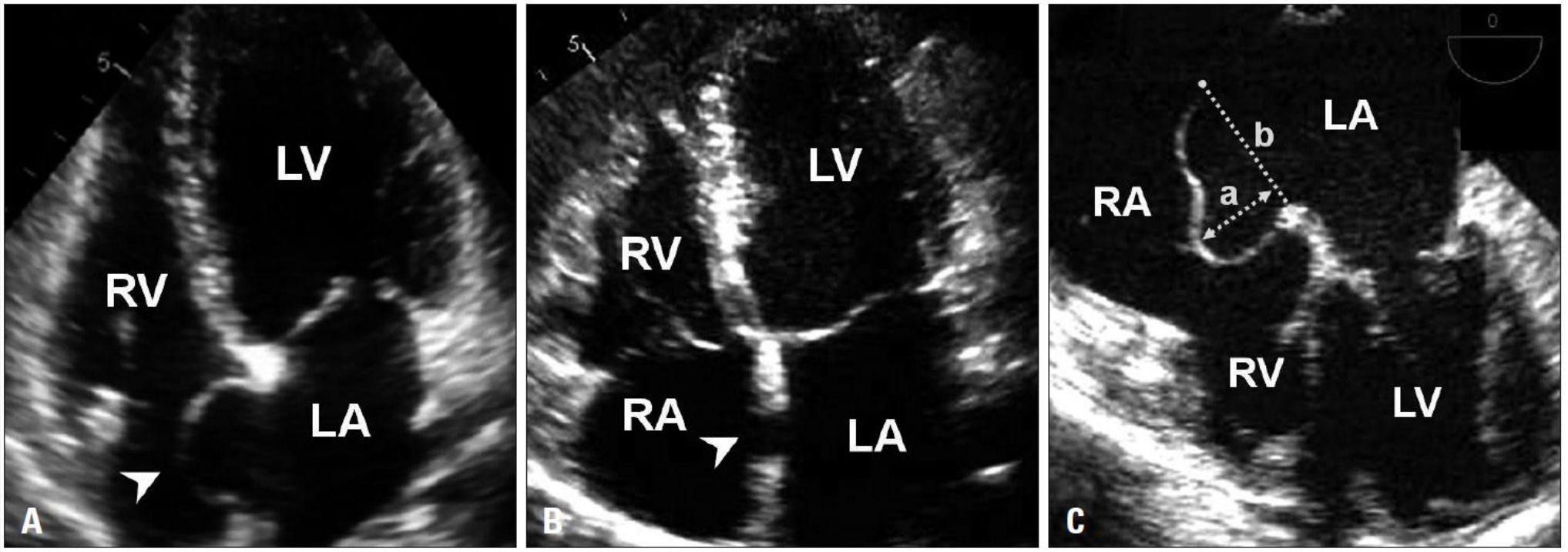
RV thrombi : RV failure, eosinophilic endocarditis, myocardial infarction involving right coronary artery, and rarely RV cardiomyopathy with aneurysm. Difficult to visualize small thrombi esp with heavy trabeculation. Tumors : Direct myocardial invasion.

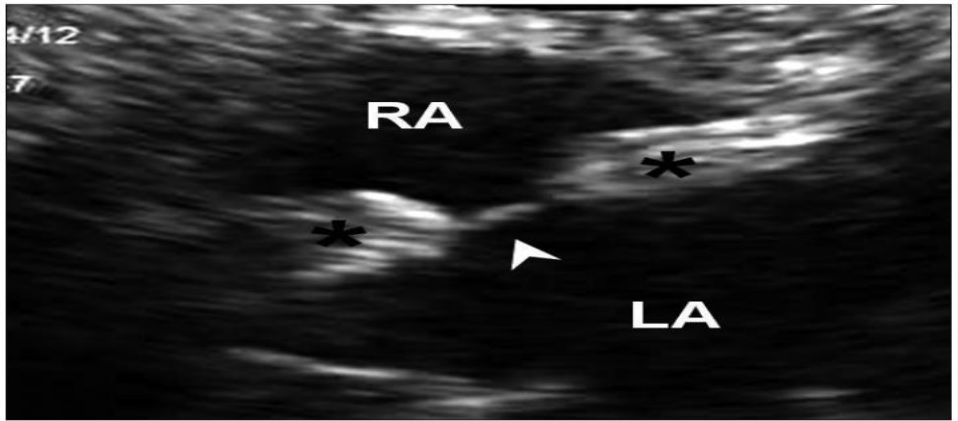
LEFT VENTRICLE



Normal LV variants: Fibrous LV band, Muscular LV band, apically located papillary muscle with chordae tendinae.

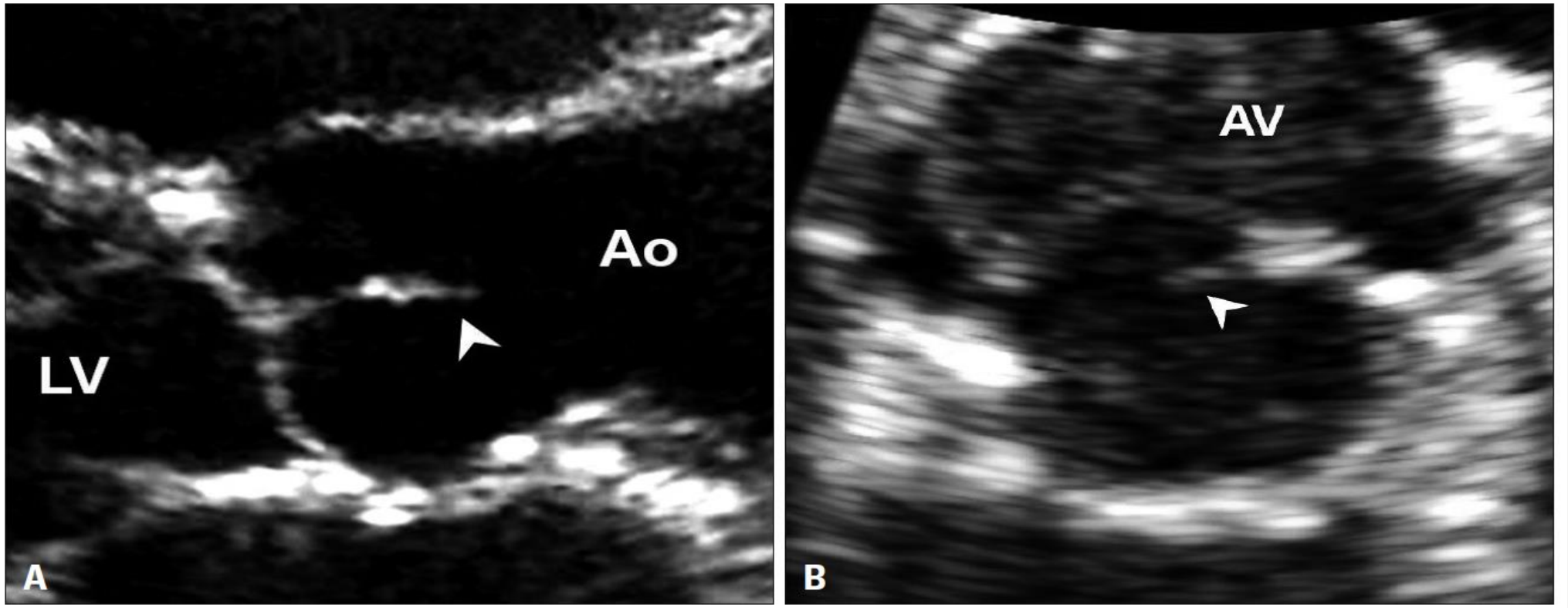
ATRIAL SEPTUM





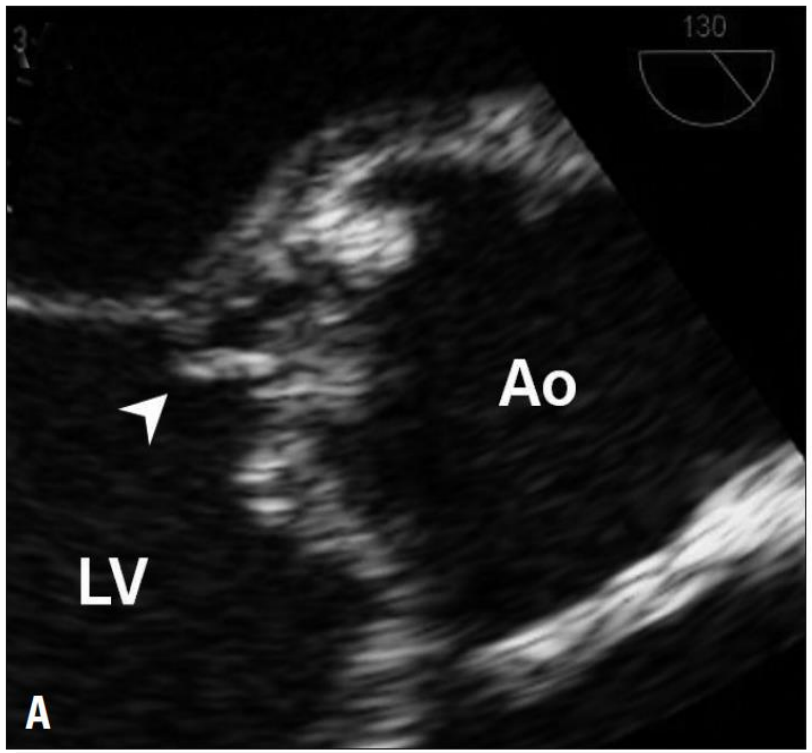
1. Atrial septal aneurysm: Excursion>10 mm, accompanied by PFO. Independent predictor of cryptogenic stroke.
2. Lipomatous hypertrophy of atrial septum: Thickness>15-20mm, dumb-bell shape, spares fossa ovalis. CT/MRI to differentiate fat vs tumor.

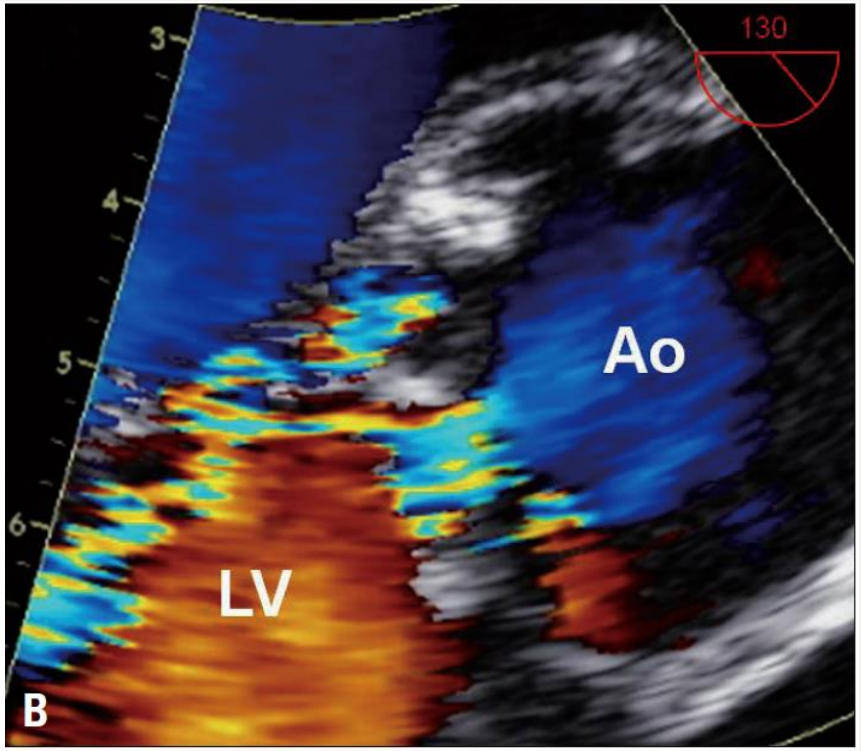
AORTIC VALVE



Lambl's excrescences are fine filamentous lesions of valvular leaflets. In echocardiography, it appears as very thin, delicate, lint-like mobile threads arising from the free borders or ventricular surfaces of aortic leaflets.

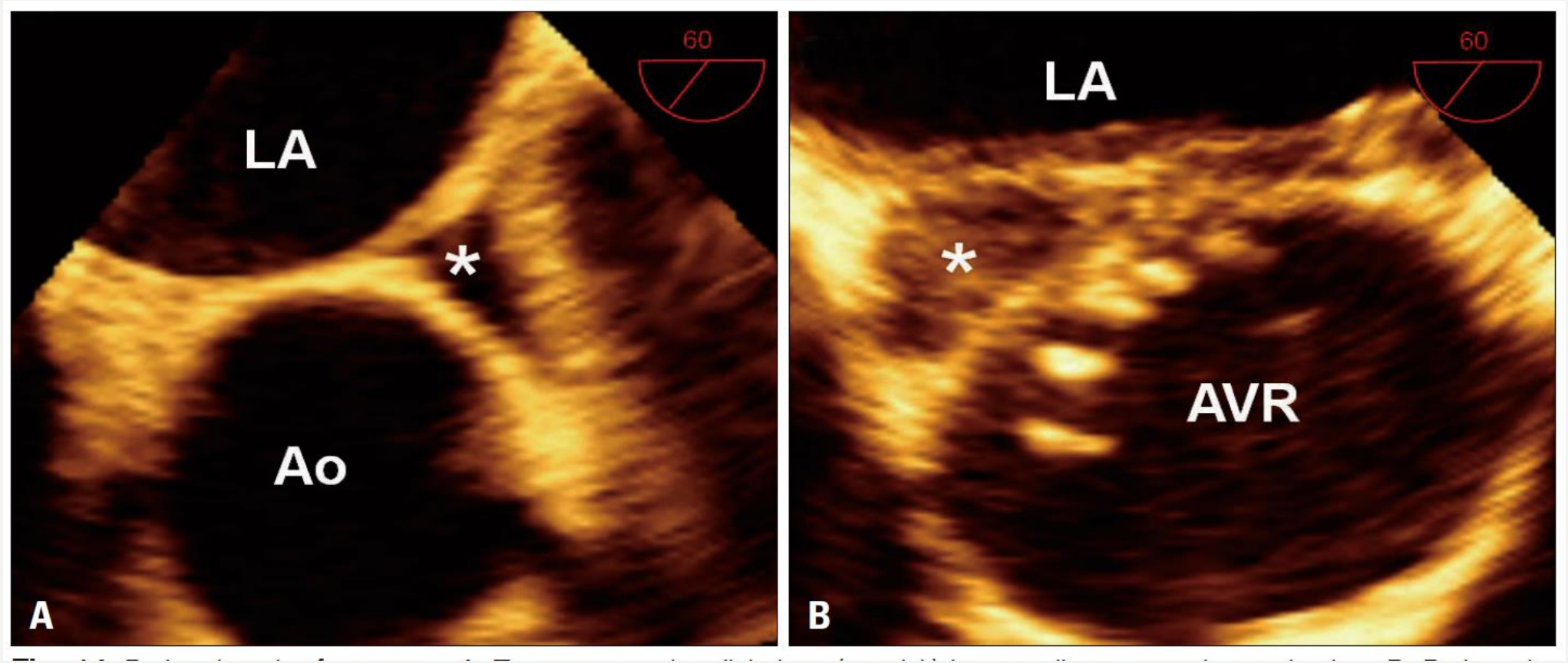
AORTIC VALVE





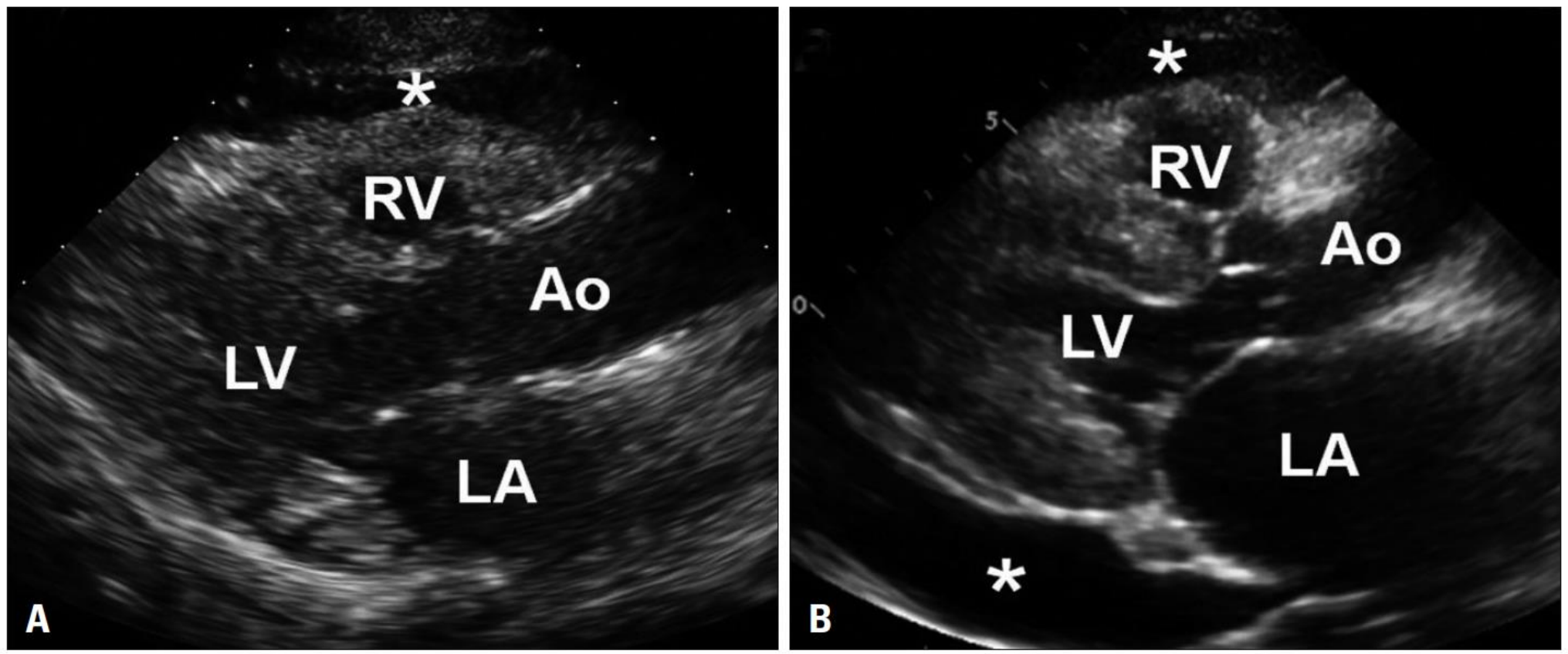
Papillary fibroelastoma is a benign avascular tumor arising from the normal endocardium. In echocardiography, a small mobile tumor with fine frond-like surface attaches to the downstream side of the valve by a small stalk. Aortic valve vegetation.

PERIAORTIC ECHO-FREE SPACE



The visceral pericardium covers the surface of heart and the proximal segments of great vessels, and then, reflects as the inner lining layer of parietal pericardium. At the site of reflections, a network of pericardial sinuses and recesses are formed vs peri annular abscess in infective endocarditis in a patient with prosthetic aortic valve.

PERICARDIAL ECHO FREE SPACE



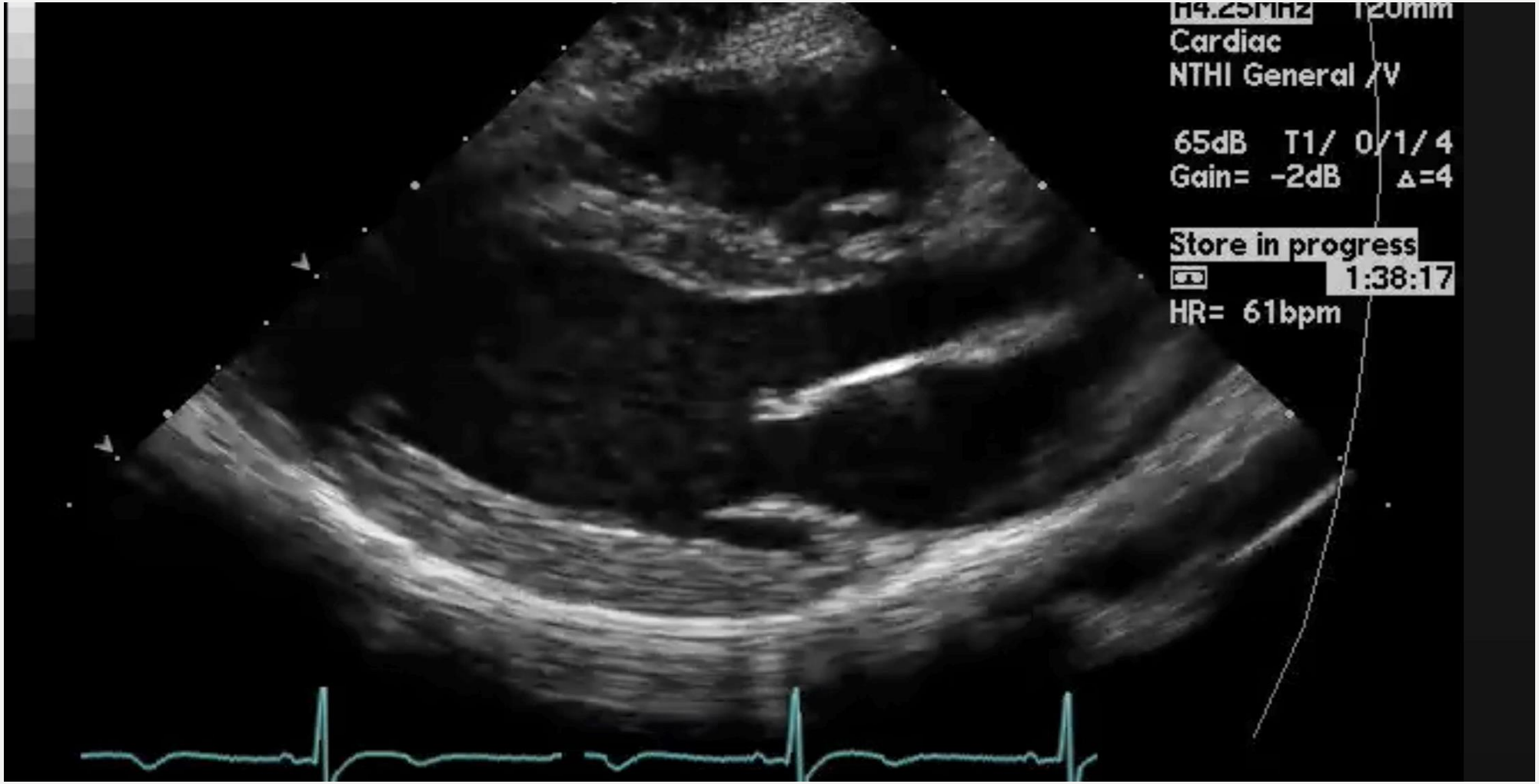
Echocardiographic differentiation of adipose tissue from fluid is based on echogenicity, texture, mobility, and location. Epicardial adipose tissue has granular texture.

CASES

USES OF ECHO

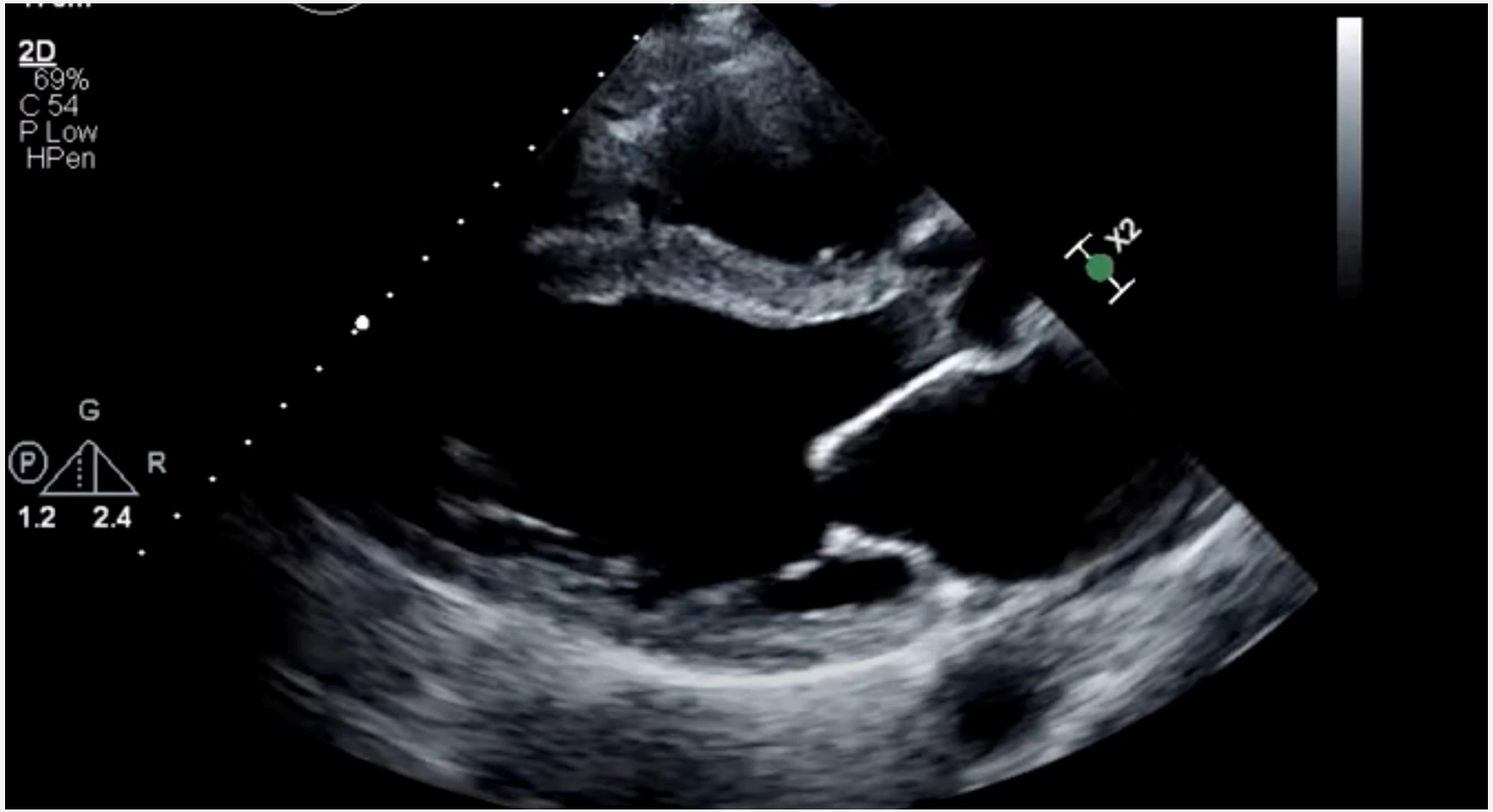
- Evaluation of cardiac structure and function
- Evaluation of HTN, HF or cardiomyopathy
- Evaluation of intracardiac and extracardiac chambers and function
- Evaluation of valvular function, stenoses or regurgitation
- Evaluation of aortic disease
- Evaluation of cardiovascular structures in acute setting
- Evaluation of adult congenital heart disease

NORMAL ECHO



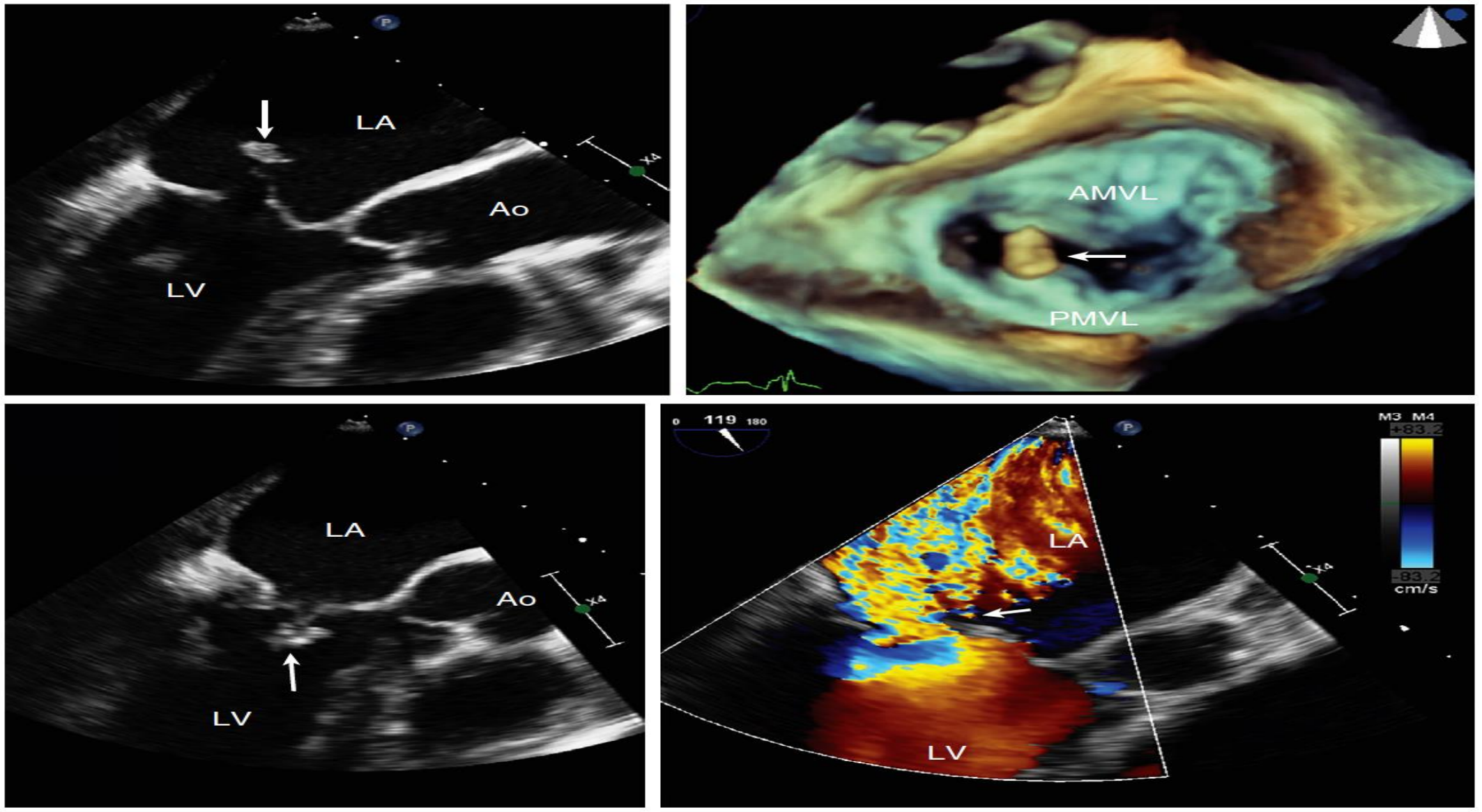
Video: Soundwave imager

DILATED CARDIOMYOPATHY

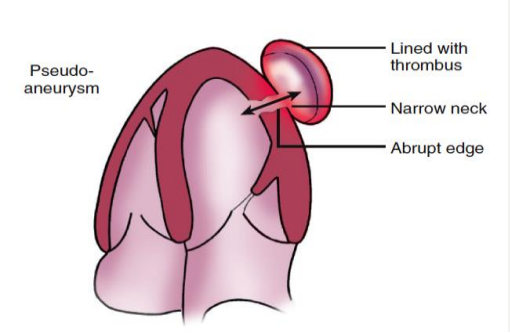


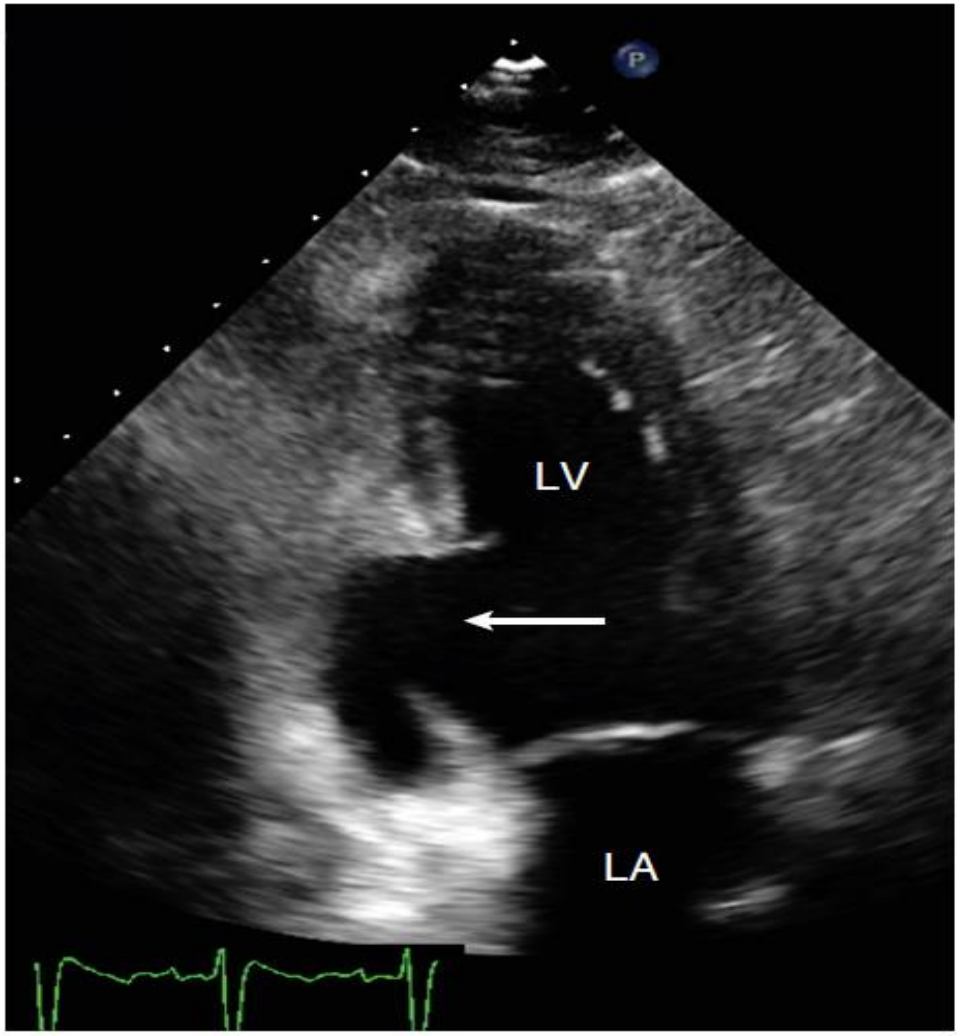
Video: Echocardiographer.org

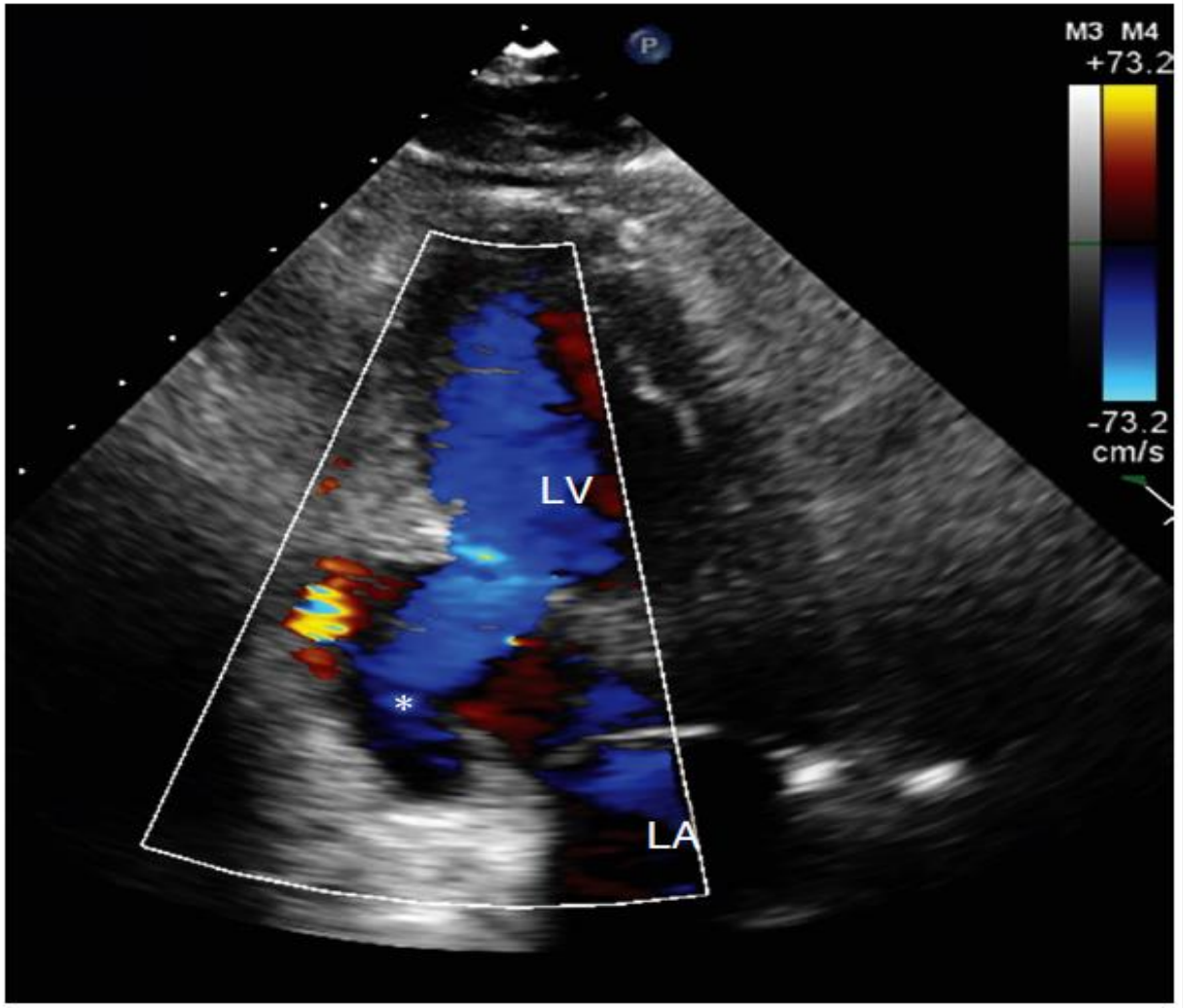
PAPILLARY MUSCLE RUPTURE



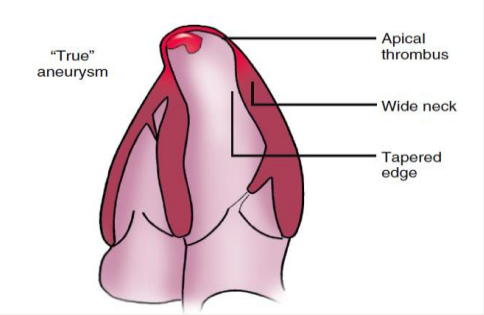
LV PSEUDOANEURYSM

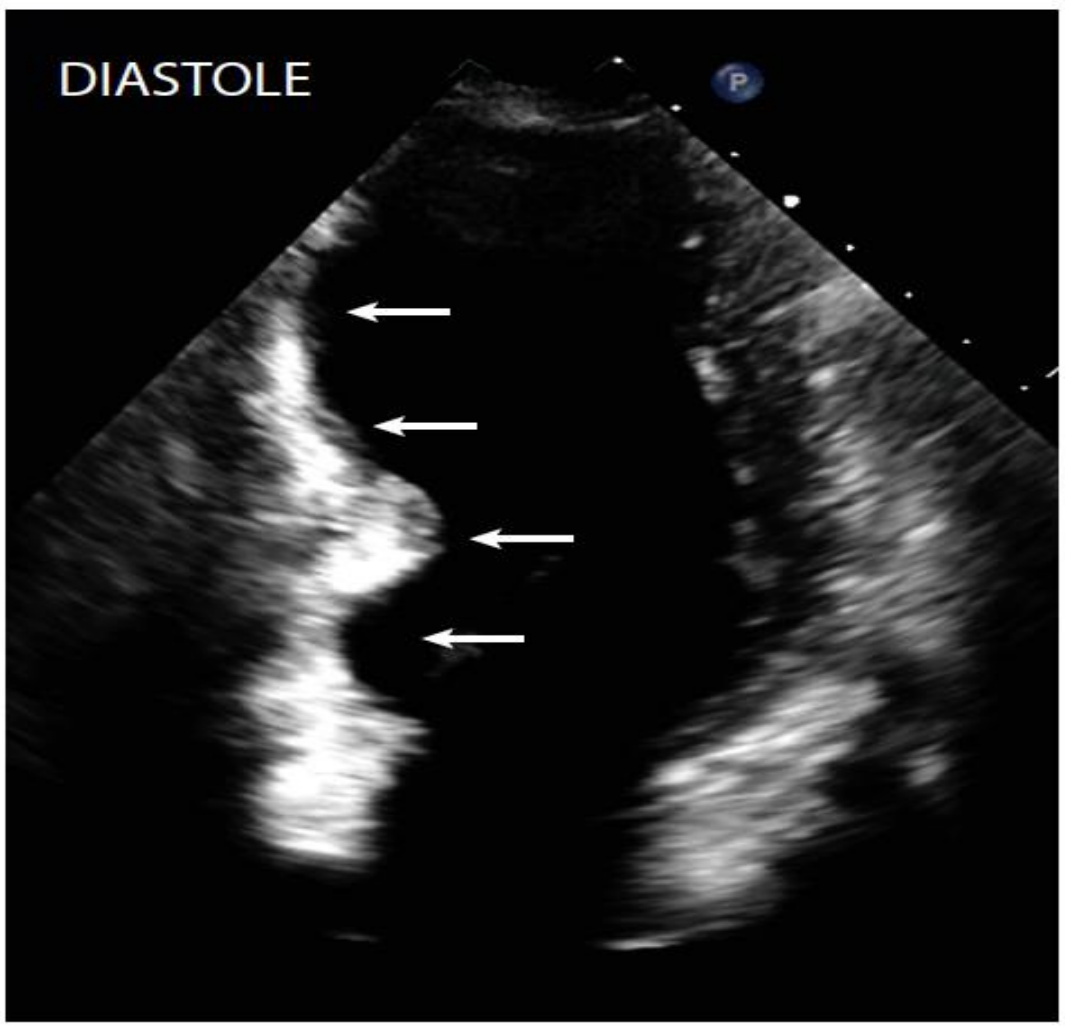


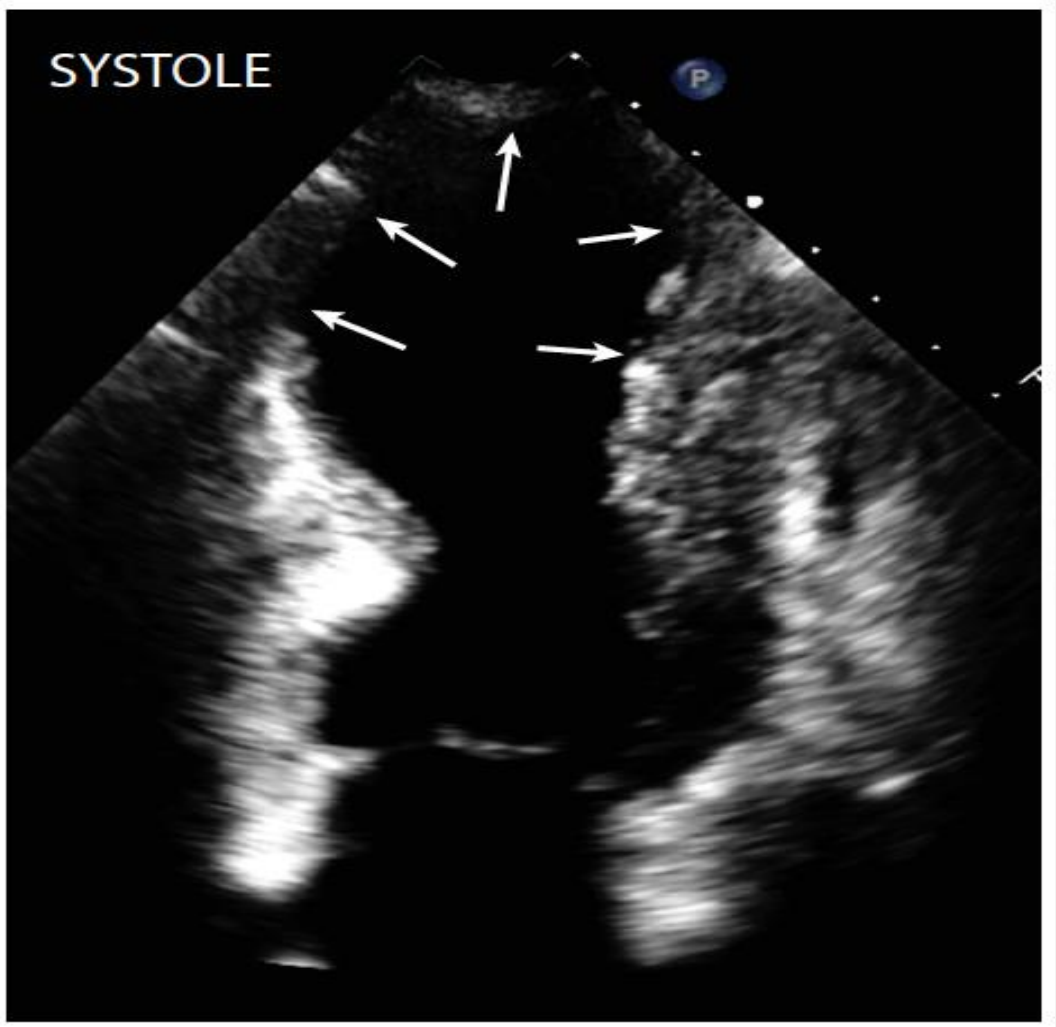




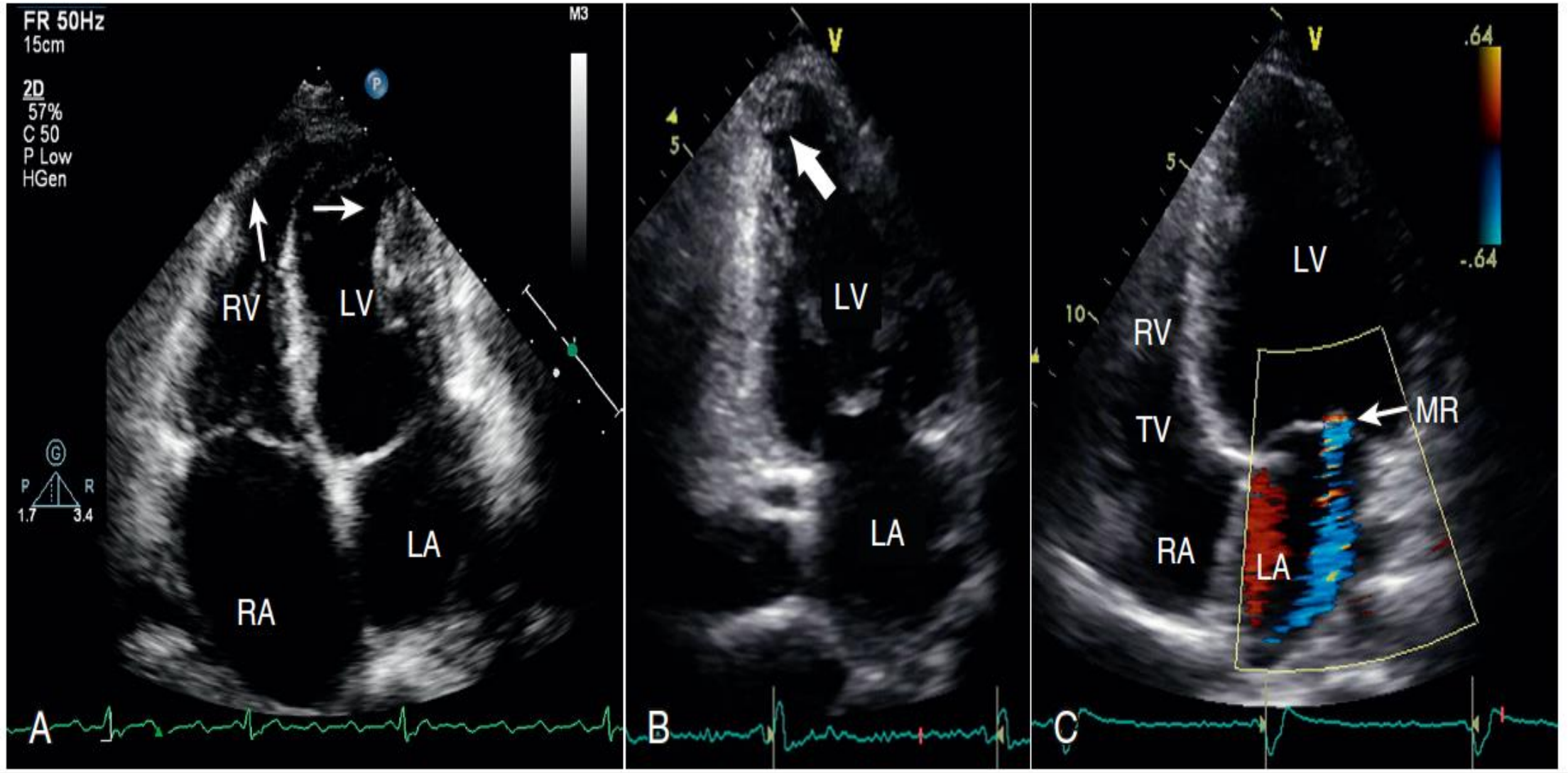
LV TRUE ANEURYSM



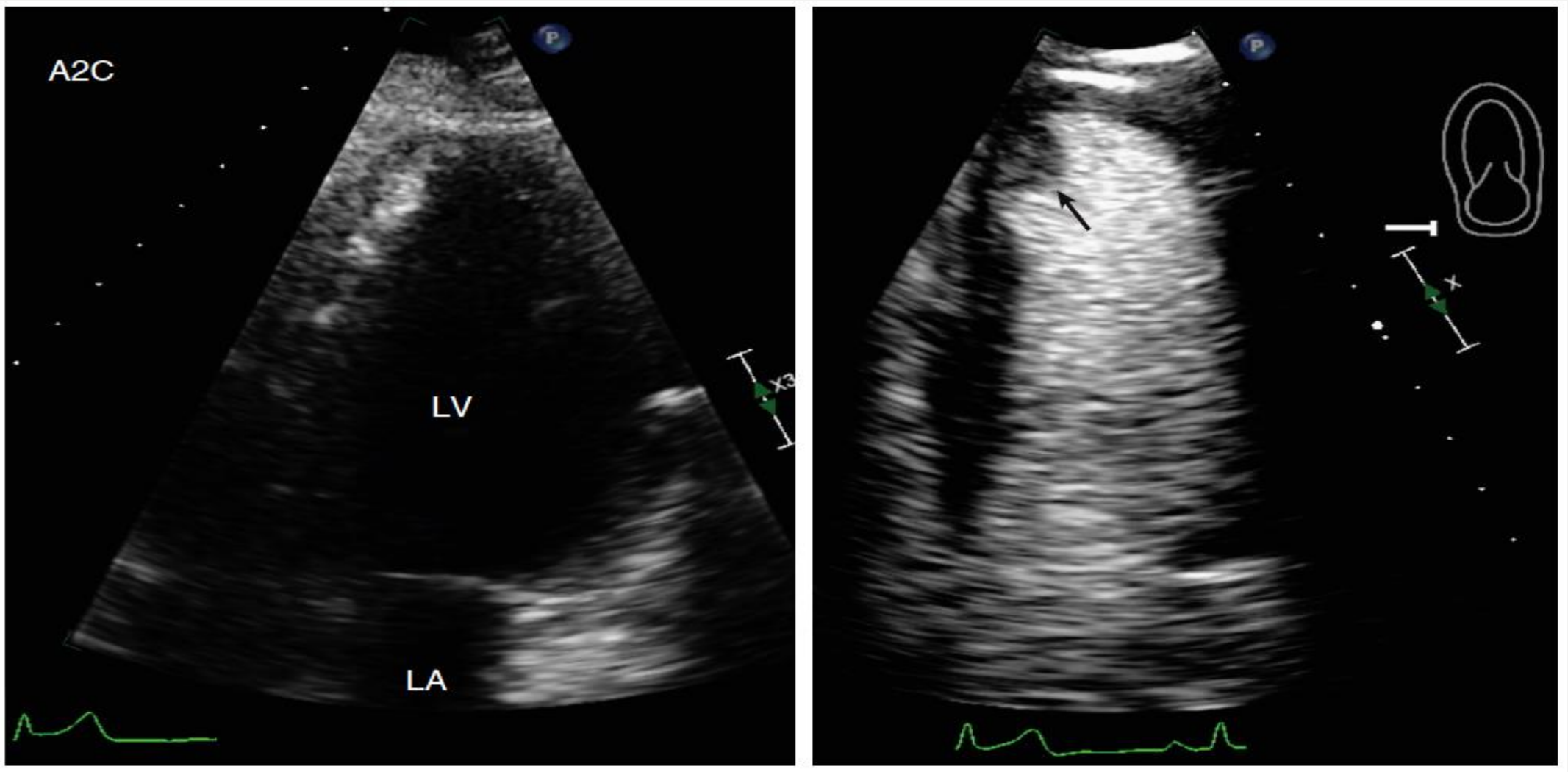




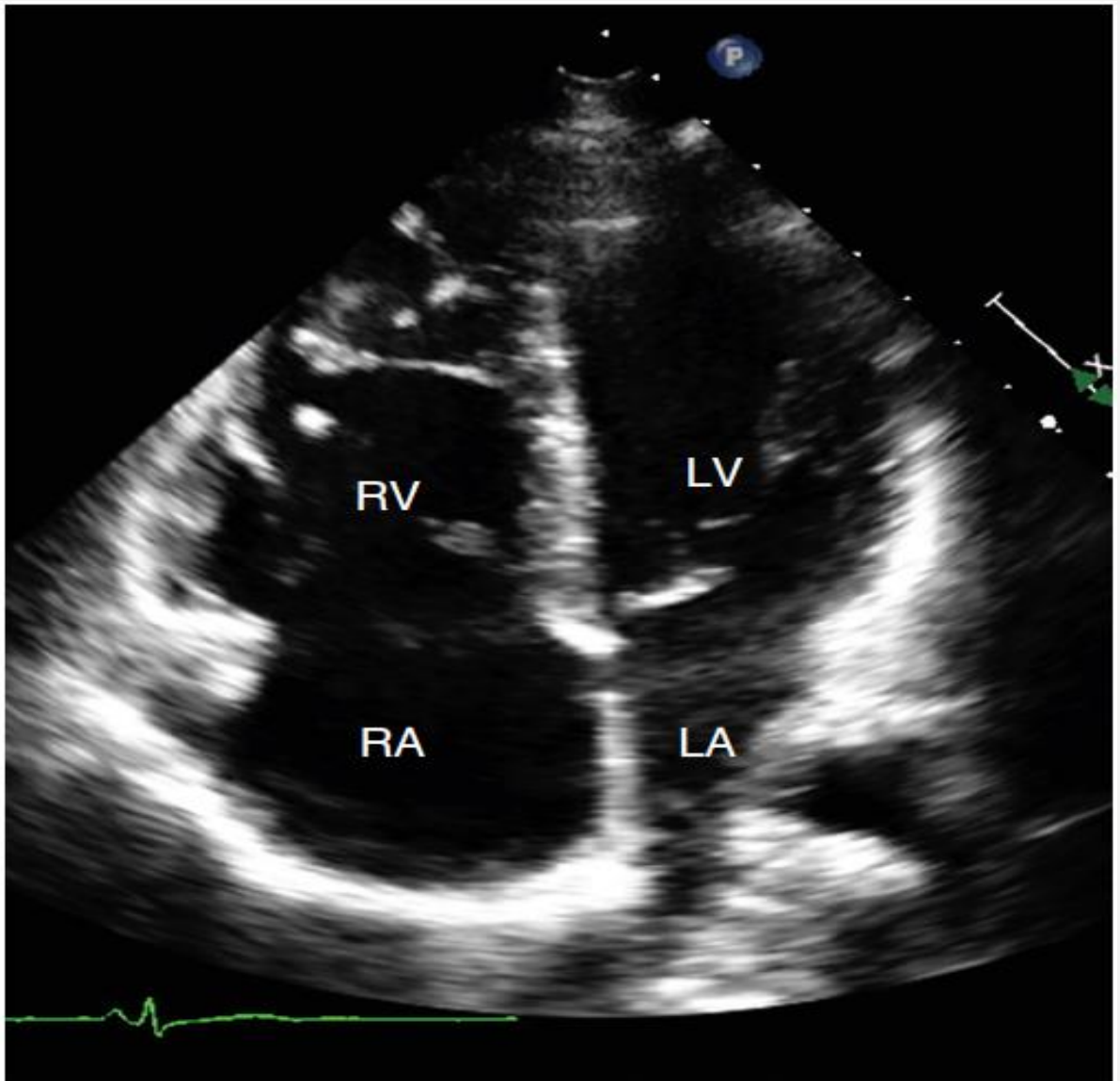
CHAGAS CARDIOMYOPATHY



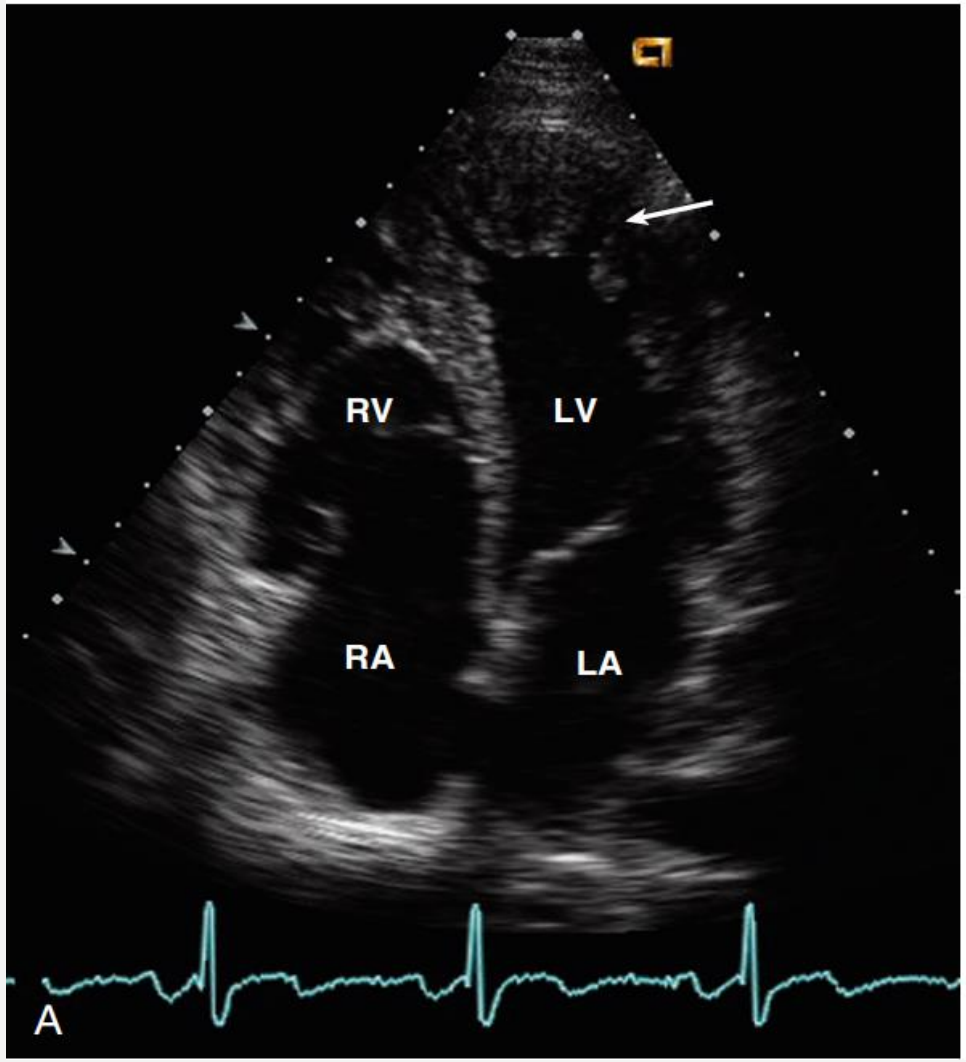
LV APICAL THROMBUS

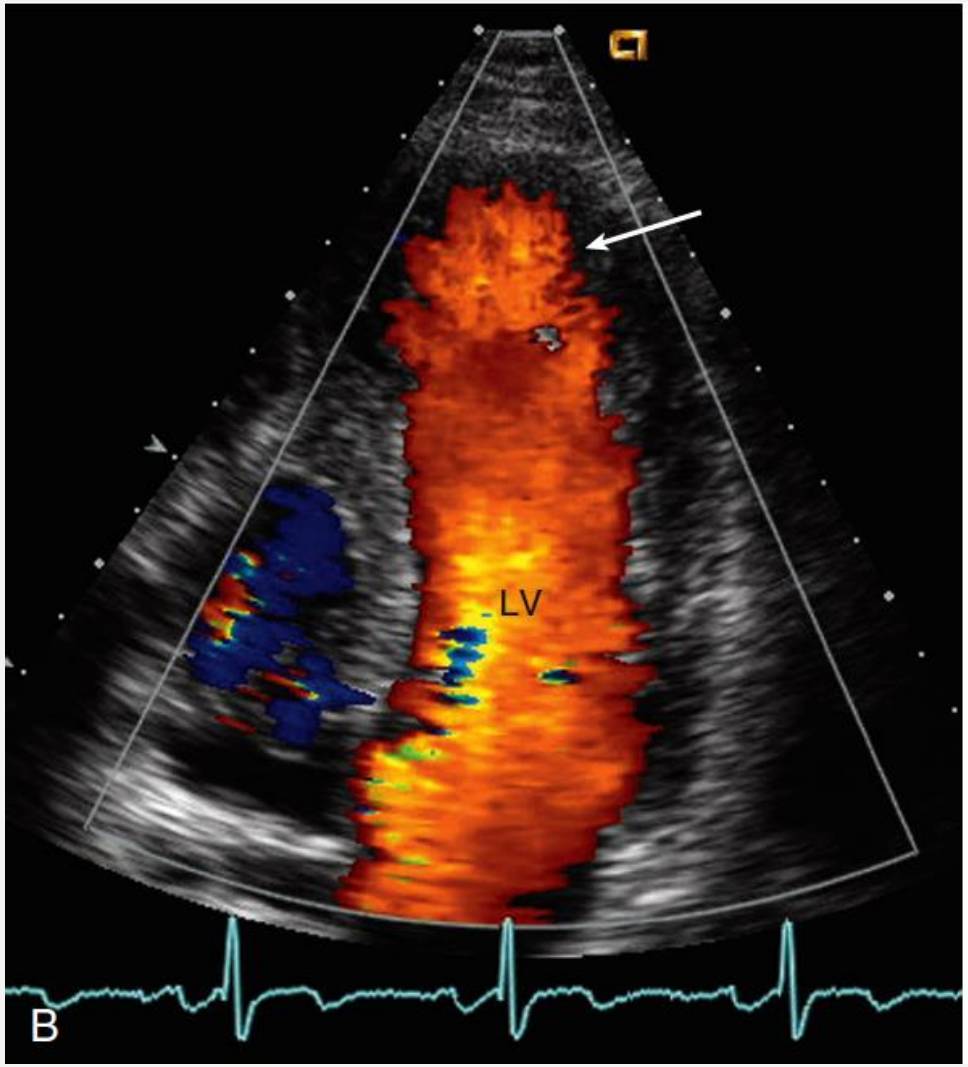


ARRHYTHMOGENIC RV DYSPLASIA

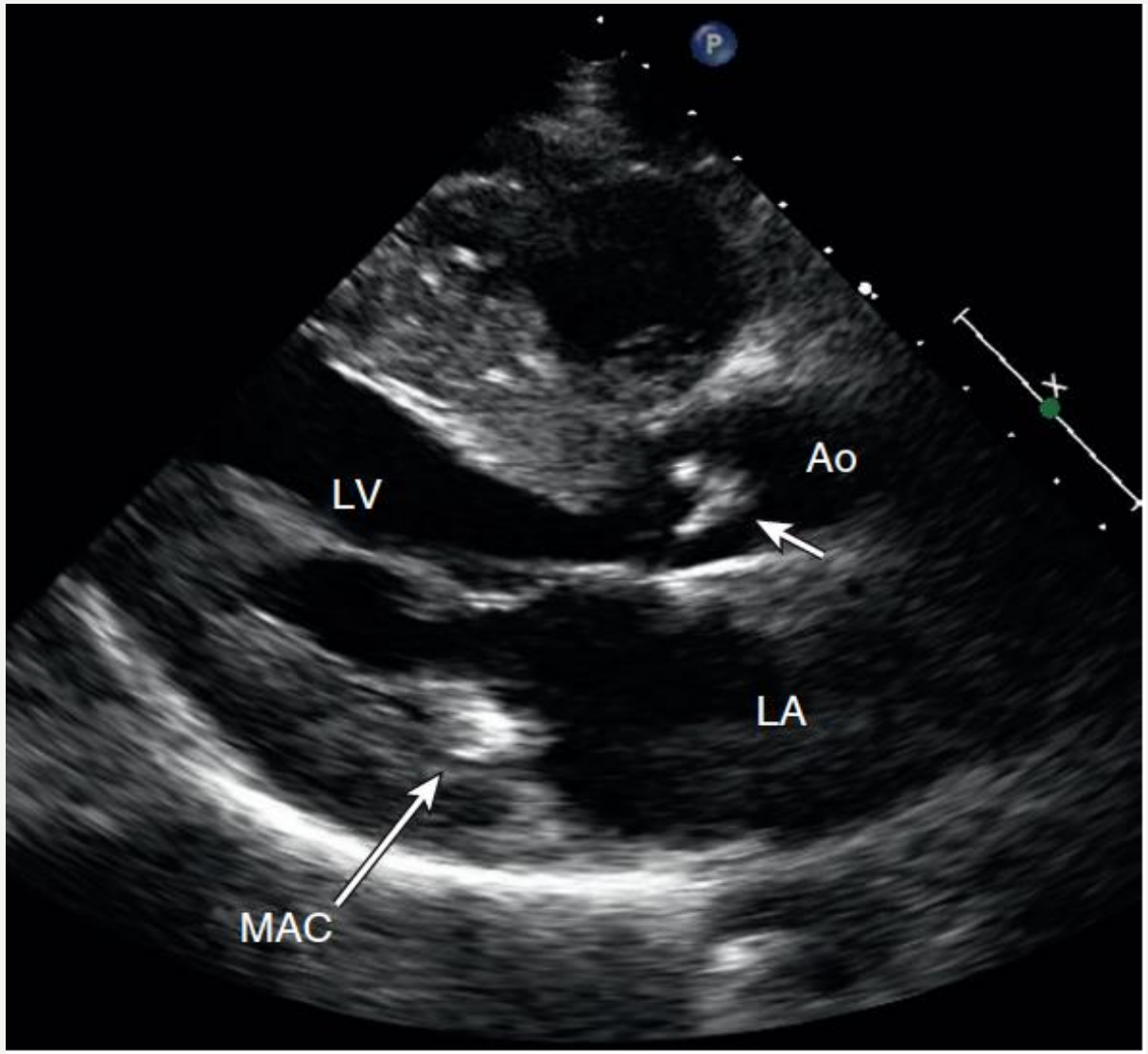


LV NONCOMPACTION

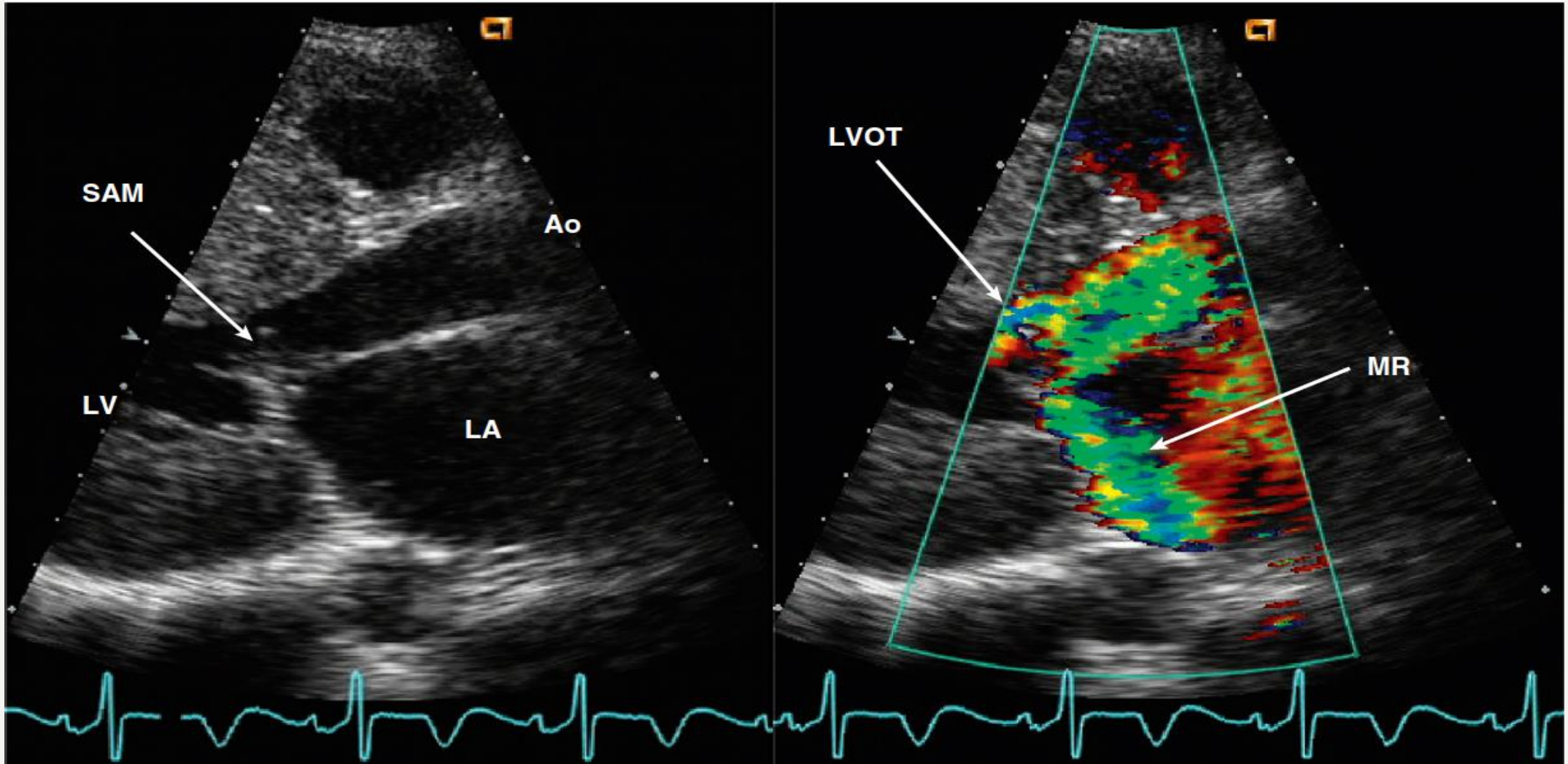




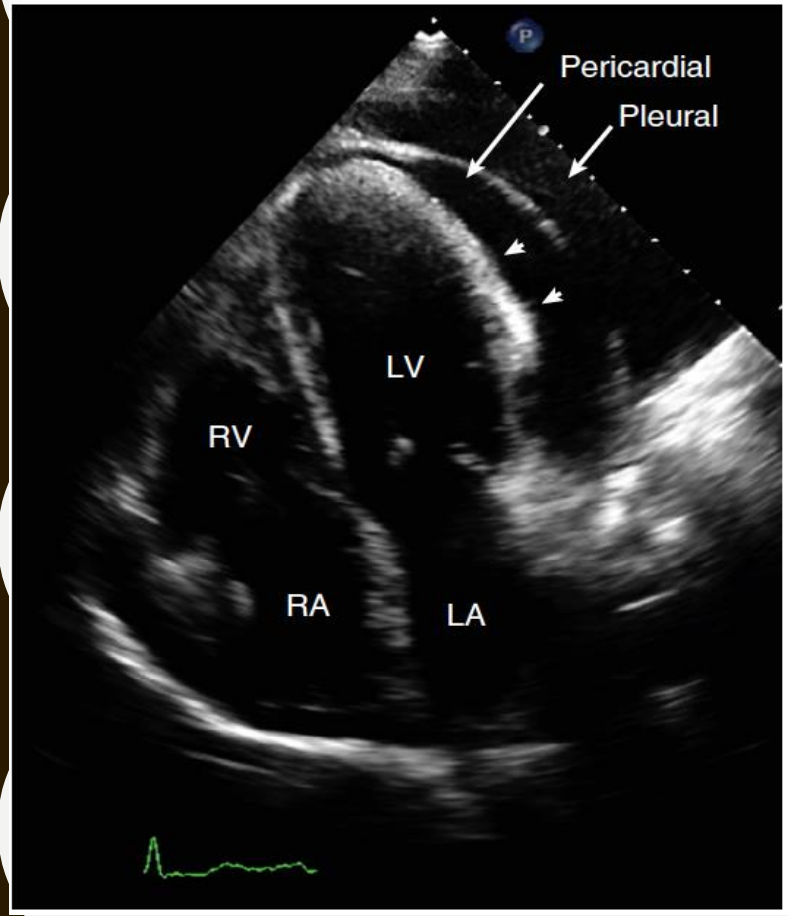
HYPERTENSIVE HEART DISEASE

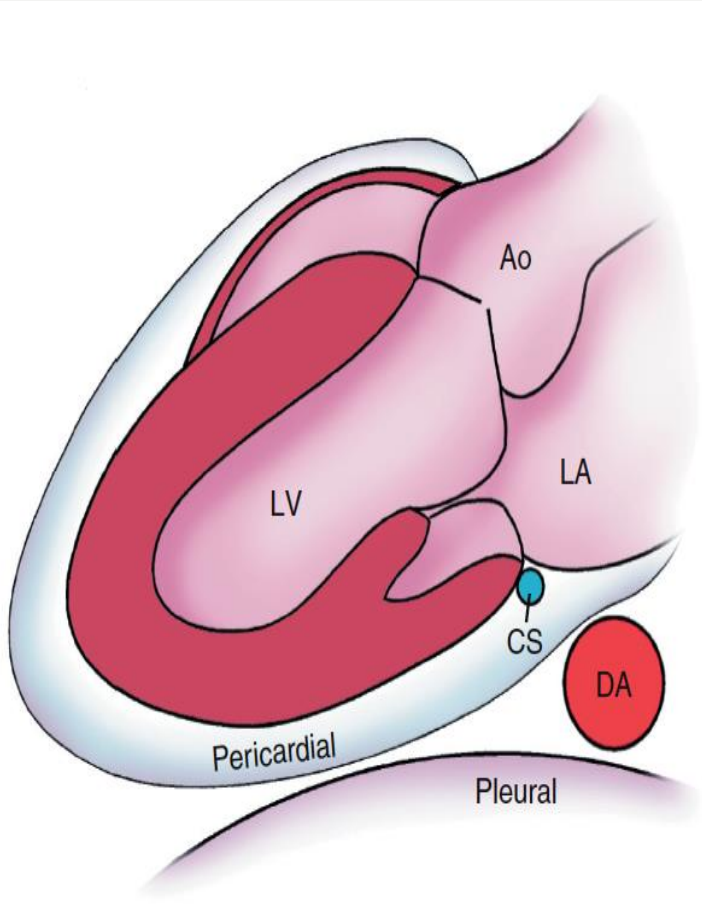


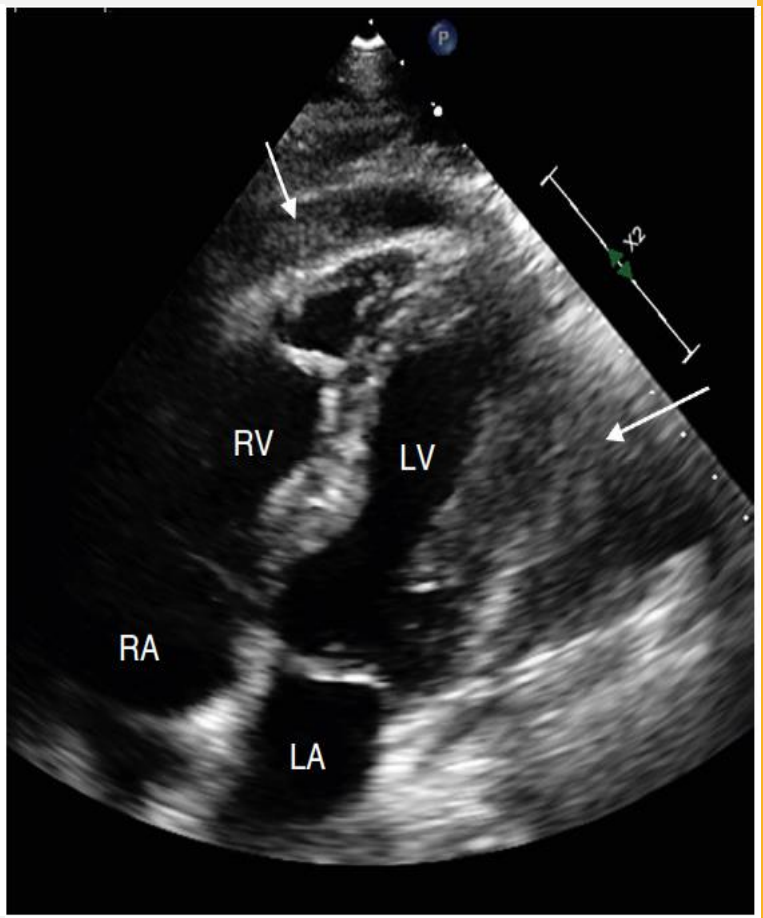
HCM



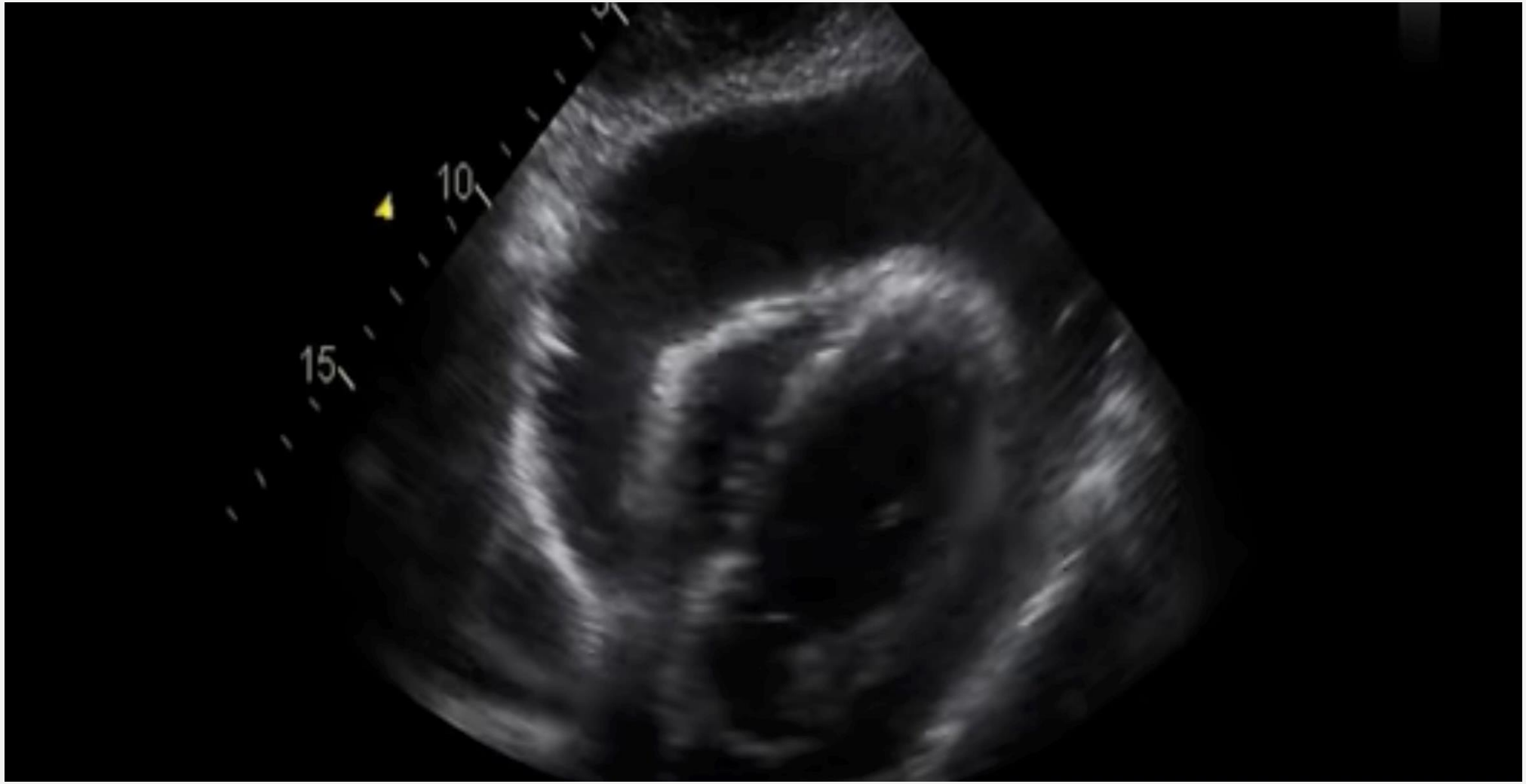
PERICARDIAL VS PLEURAL FLUID



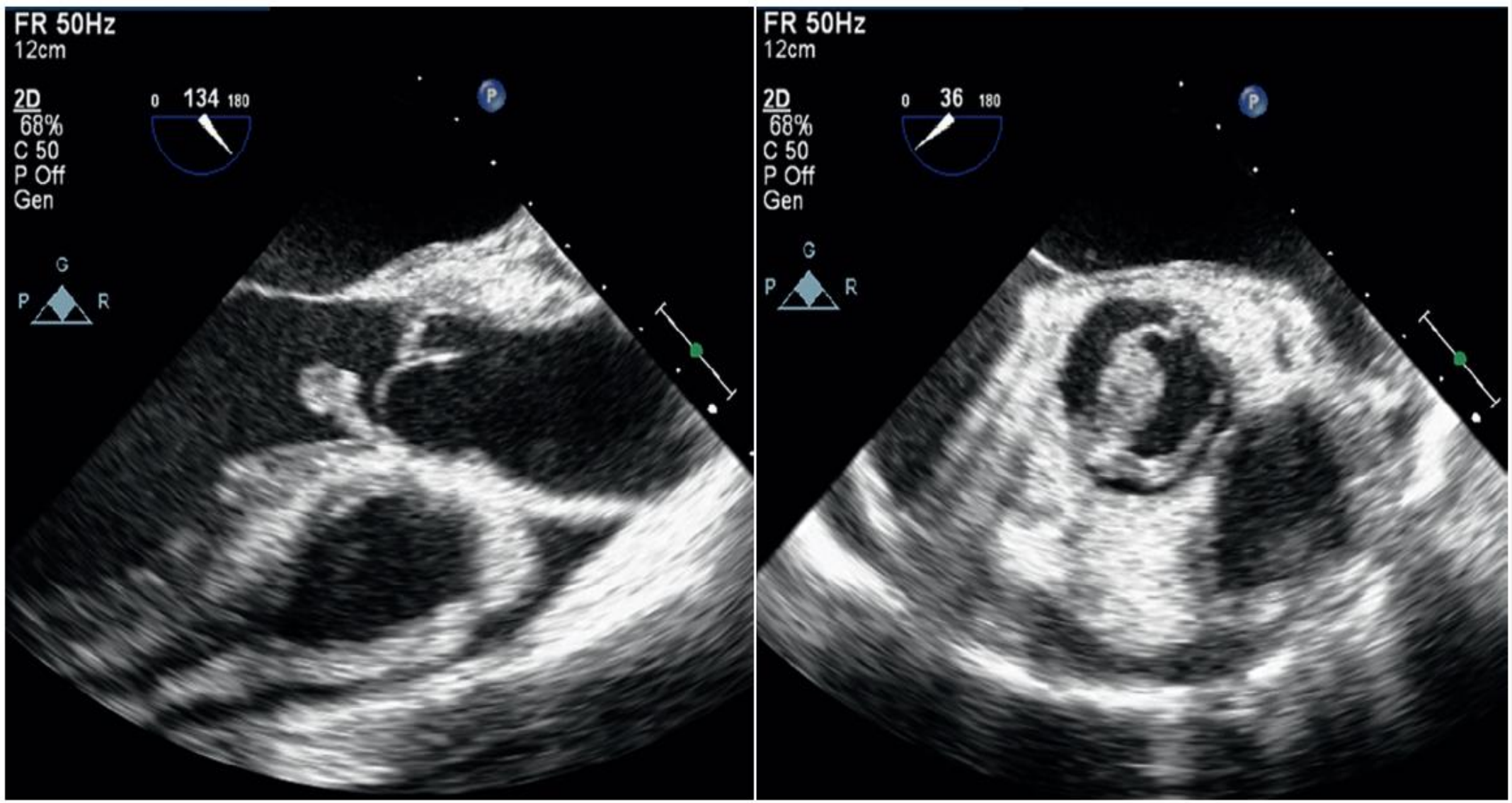


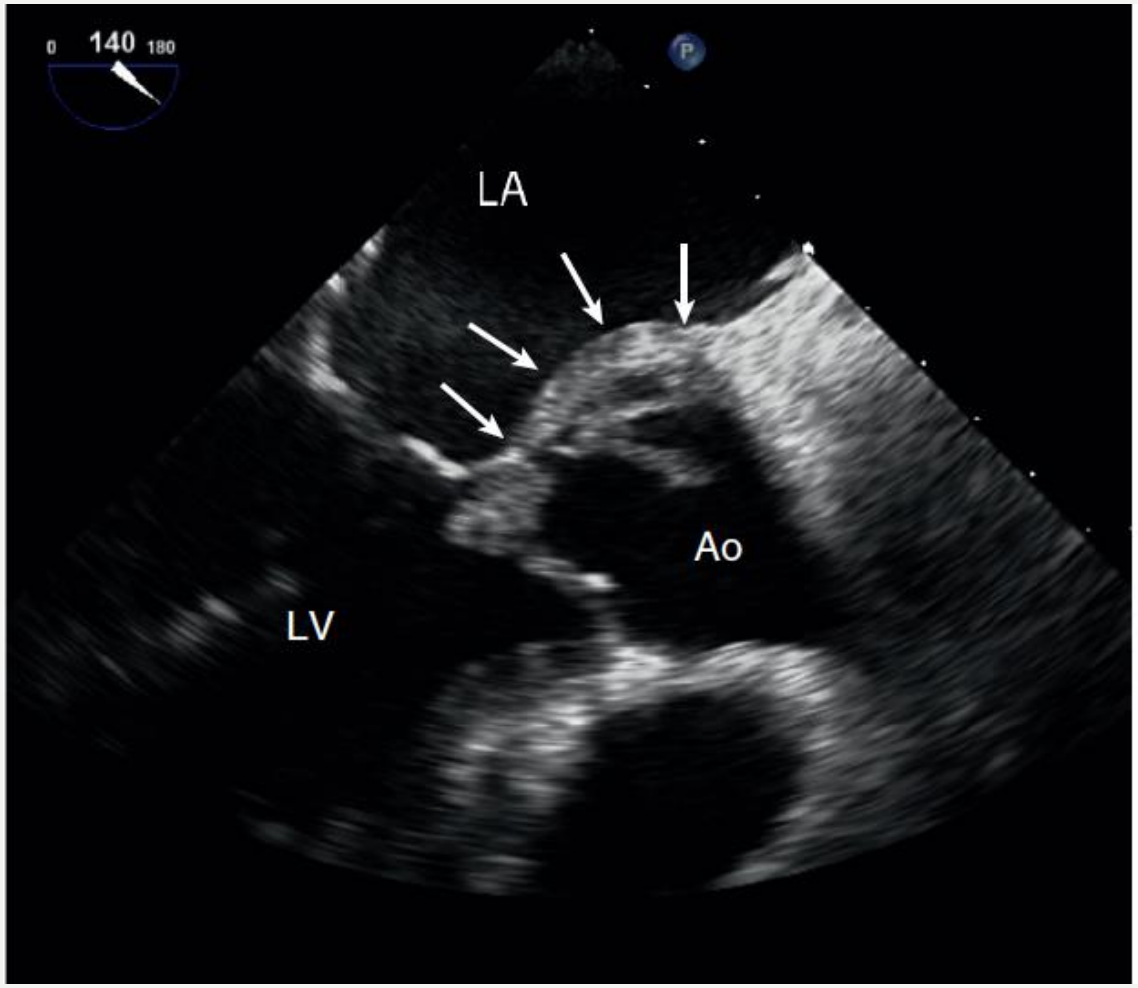


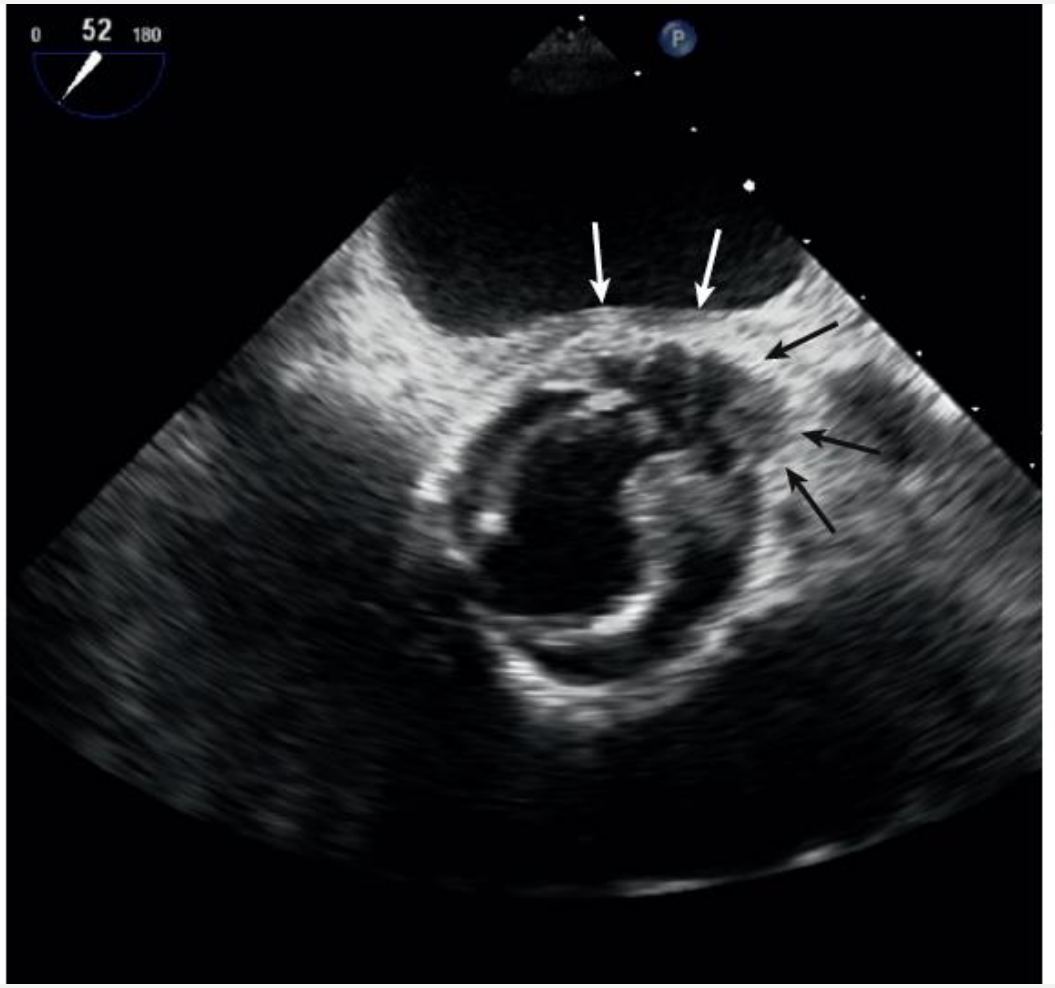
CARDIAC TAMPONADE



AORTIC VALVE ENDOCARDITIS

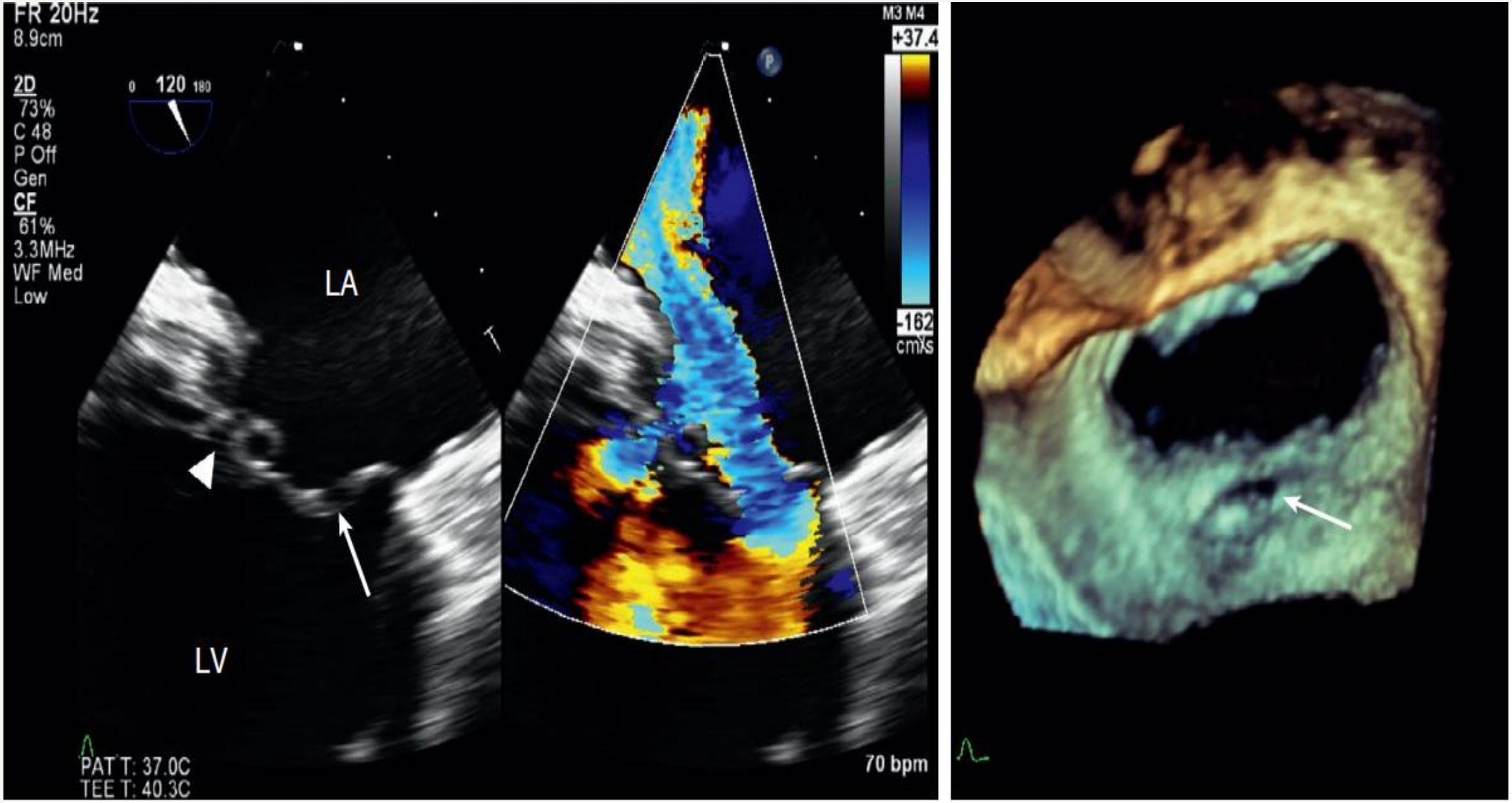




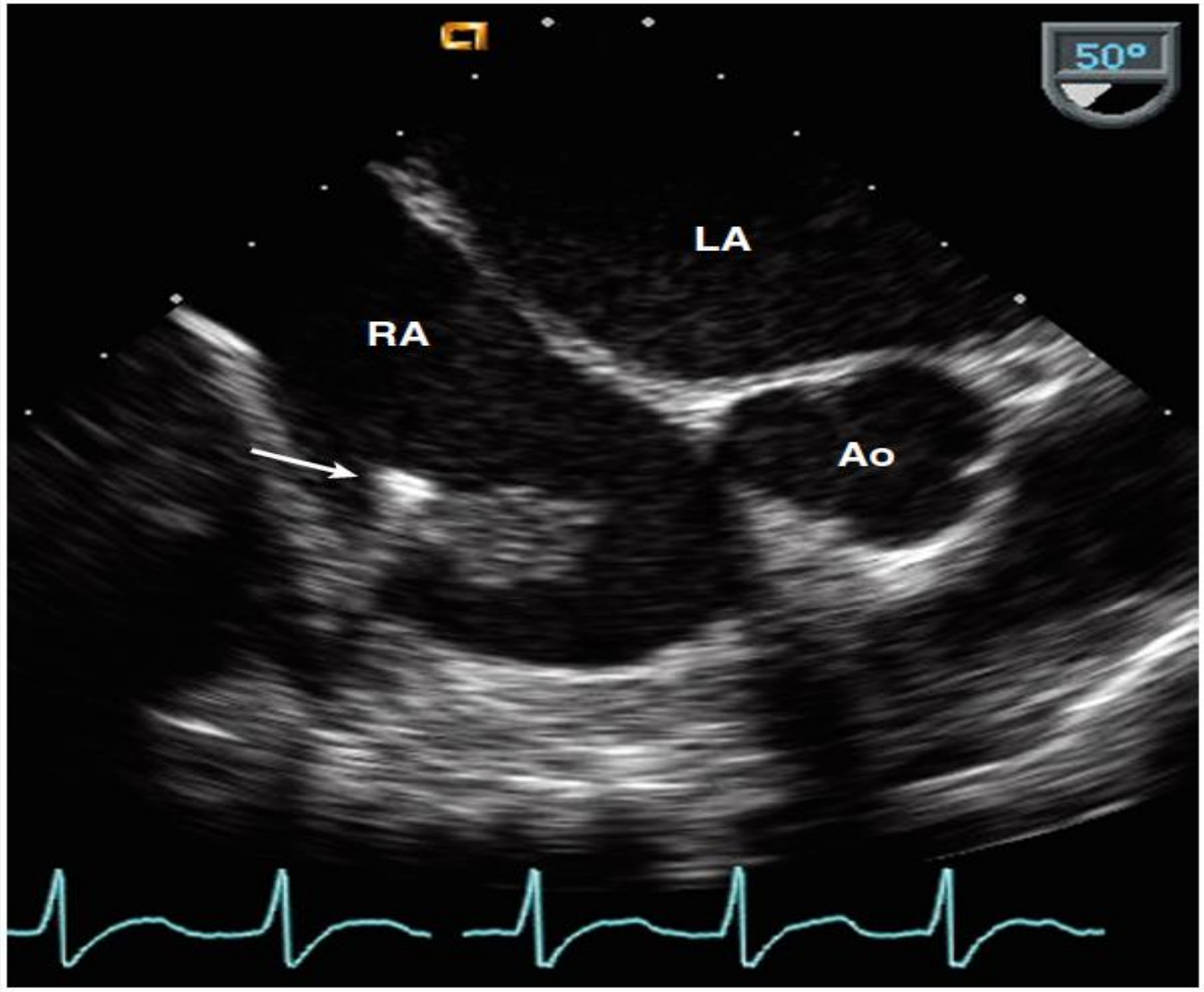


Aortic valve endocarditis : Aortic valve vegetation + paravalvular abscess (thickening of posterior aortic wall and irregular areas of echolucency and echodensity inn the aortic annulus and sinuses).

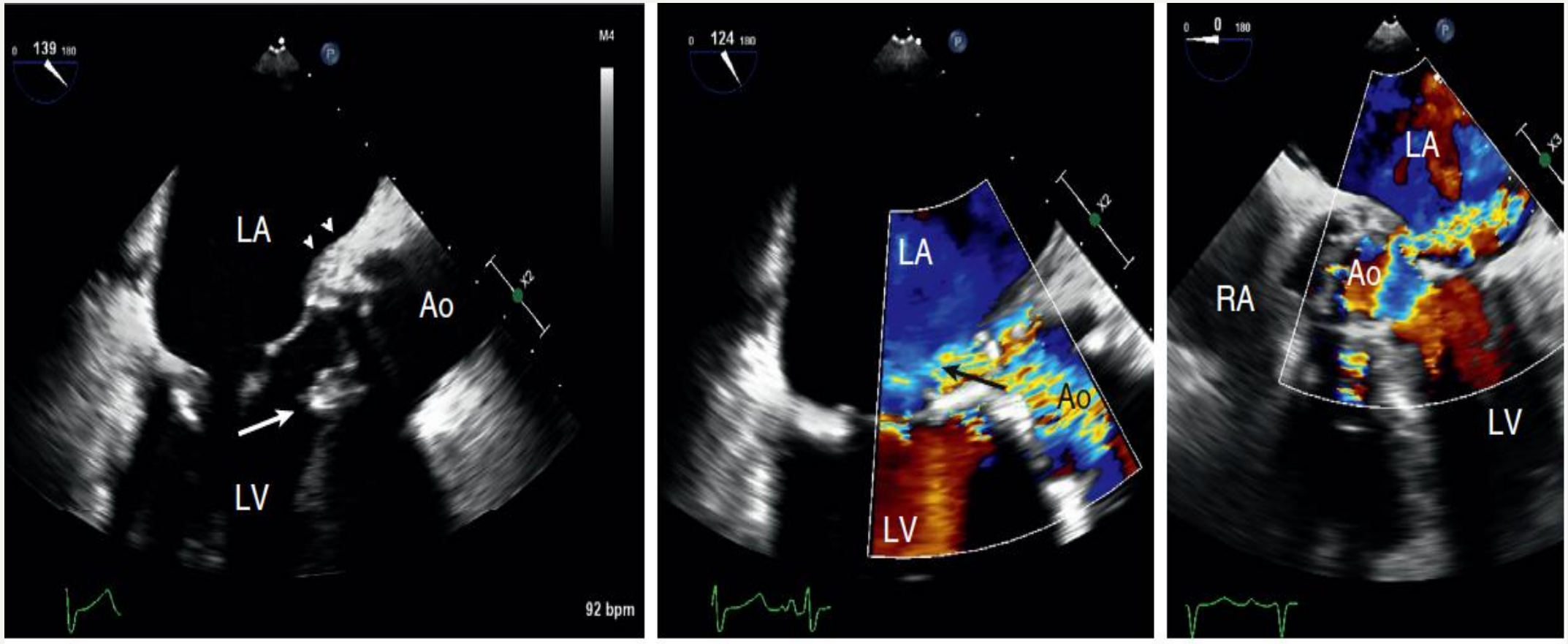
MITRAL VALVE ENDOCARDITIS

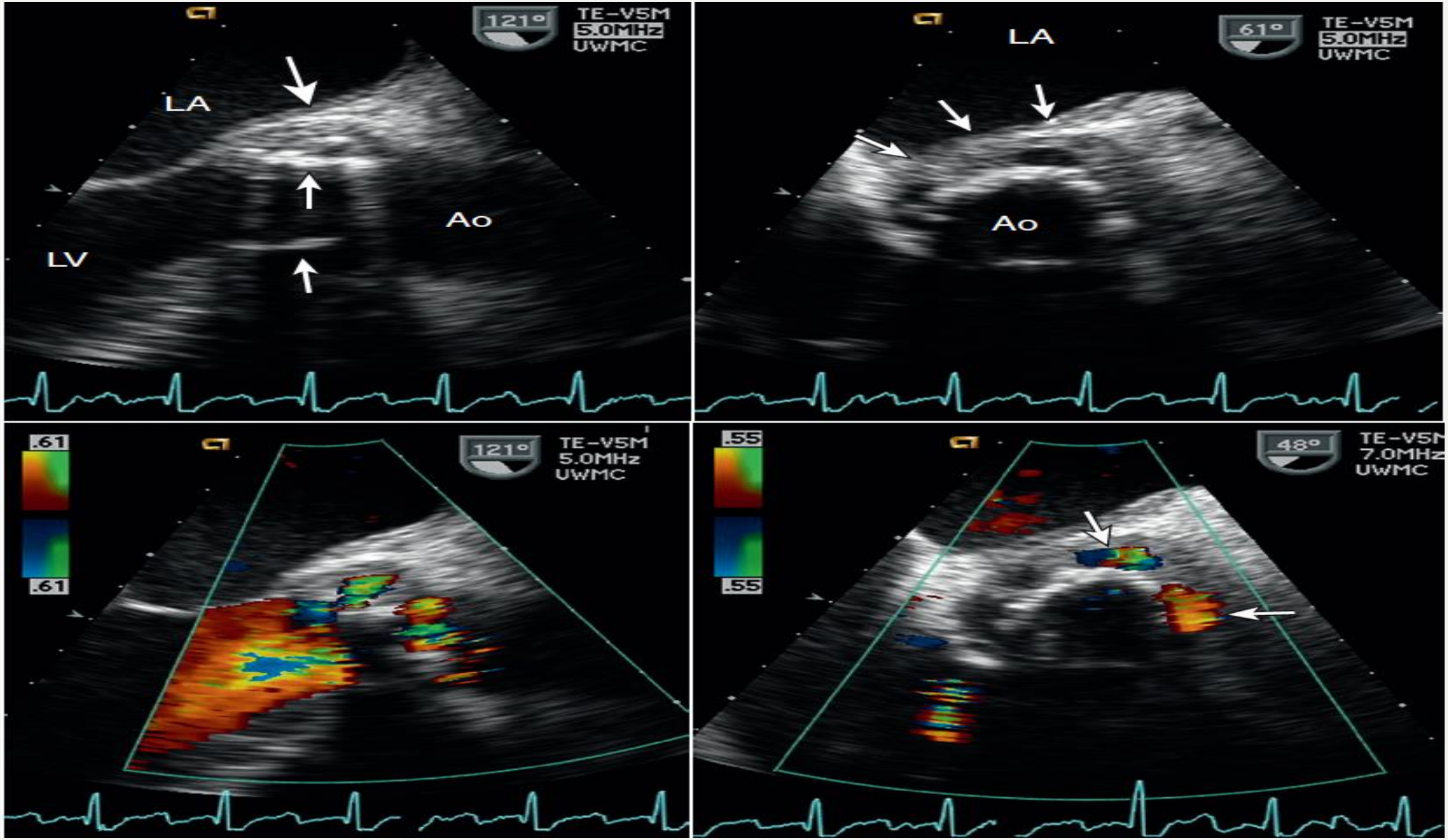


PACER LEAD INFECTION



BIOPROSTHETIC ANNULAR ABSCESS (FISTULA AORTA→LA)





Echolucent areas posterior to the prosthetic valve along with turbulent flow in these areas consistent with partial valve dehiscence and communication with the LV chamber

INDICATIONS OF TTE (AUC)

APPROPRIATE INDICATIONS OF TTE

General Evaluation of Cardiac Structure and Function

→ Suspected cardiac etiology

→ Arrhythmias: Frequent PVCs, exercised induced PVCs; sustained or non-sustained SVT, VT

→ Syncope: Cardiac and non-cardiac

→ Pulmonary HTN diagnosis, okay to repeat study >1 year from prior echo

→ Hypotension of uncertain etiology

→ Chest pain or anginal equivalents

→ ACS and complications

→ Respiratory failure of uncertain etiology

→ Known PE to guide management (thrombolytics versus thrombectomy) and okay to repeat Echo after treatment to re-assess improvement in RV function

→ Chest trauma

APPROPRIATE INDICATIONS CONT'D

Evaluation of Valvular Function

→Cardiac murmur, suspicion for valvular heart disease

→Native valve stenosis: >3 years for mild and >1 year for moderate/severe

→Native valvular regurgitation: >1 year for moderate/severe

→ Prosthetic valve: Postop and >3 years or change in clinical status

→ Infective endocarditis: Diagnosis, change in clinical status/high risk

APPROPRIATE INDICATIONS CONT'D

Evaluation of intracardiac and extracardiac structures and chambers

→Suspected cardiac mass

→Suspected cardiac source of embolism

→Suspected pericardial conditions

→Re-evaluation of known pericardial effusion to guide management

→Guidance for cardiac procedures like pericardiocentesis, RV biopsy, septal ablation etc.,

APPROPRIATE INDICATIONS CONT'D

Evaluation of aortic disease

→Surveillance of ascending aorta dilatation

→Evaluation of ascending aorta in patients with known connective tissue disease

APPROPRIATE INDICATIONS CONT'D

Evaluation of HTN, HF or cardiomyopathy

→Suspicion for hypertensive heart disease

→Diagnosis of HF, to guide therapy, ICD candidacy, change in clinical status

→Device complications

→Evaluation for VAD, optimization of VAD and re-evaluation; heart function in a potential heart donor and monitoring for rejection in heart transplant patient

→Initial and re-evaluation of cardiomyopathy (inherited, restrictive, dilated, hypertrophic)

→Screening of first-degree relatives in inherited cardiomyopathy

→Baseline and serial re-evaluations on cardio-toxic drugs

APPROPRIATE INDICATIONS CONT'D

Adult congenital heart disease

→Initial evaluation of known or suspected CHD

→Change in clinical status and re-evaluation

→Routine surveillance > 1 year following incomplete or palliative repair

INAPPROPRIATE INDICATIONS OF TTE

- Infrequent PAC/PVCs
- Asymptomatic sinus bradycardia
- Lightheadedness/pre-syncope + no signs of cardiac disease
- Evaluation of LVEF/RVEF when no change in clinical status
- Preop
- Suspected PE
- No signs/symptoms of valvular or structural heart disease
- Surveillance <3 years for valvular stenosis/regurgitation and <1 year for moderate/severe valvular stenosis without change in clinical status
- Transient fever; Transient bacteremia with a pathogen not typically associated with infective endocarditis and documented non-endovascular source of infection.
- Small pericardial effusion
- HF or HTN or CAD or device (PPM/ICD/CRT) with no change in clinical status

INDICATIONS OF TEE (AUC)

APPROPRIATE INDICATIONS OF TEE

- Non-diagnostic TTE
- Re-evaluation of prior TEE findings for interval change (e.g., resolution of thrombus after AC, resolution of vegetation after antibiotic therapy) when a change in therapy is anticipated.
- Diagnosis of infective endocarditis with a moderate or high pre-test probability (staph bacteremia, fungemia, prosthetic valve or intracardiac device).
- Evaluation of valvular lesions, stenosis and regurgitation.
- Guidance during percutaneous cardiac interventions like closure device, RFA, valve procedures.
- Suspected acute aortic pathology like aortic dissection.
- Evaluation for cardiac source of embolus with no identified non-cardiac source.
- Evaluation to facilitate clinical decision making with regards to AC, DCCV and RFA.

INAPPROPRIATE INDICATIONS OF TEE

- Normal TTE
- Routine assessment of pulmonary veins after PVI
- Surveillance of prior TEE finding when there is no change in management
- Diagnose infective endocarditis with a low pretest probability
- Evaluation of cardiovascular source of embolus with a known cardiac source in which a TEE would not change the management
- Evaluation when decision has been made to anticoagulate and not to perform DCCV

REFERENCES

- ASE guidelines
- Textbook of Clinical Echocardiography by Catherine Otto
- Kim MJ, Jung HO. Anatomic variants mimicking pathology on echocardiography: differential diagnosis. J Cardiovasc Ultrasound. 2013 Sep;21(3):103-12. doi: 10.4250/jcu.2013.21.3.103. Epub 2013 Sep 30. PMID: 24198915; PMCID: PMC3816159.
- The History of US: From Bats and Boats to the Bedside and Beyond: *RSNA Centennial Article*, Katherine A. Kaproth-Joslin, Refky Nicola, and Vikram S. Dogra; RadioGraphics 2015 35:3, 960-970.
- Slideshare

THANK YOU