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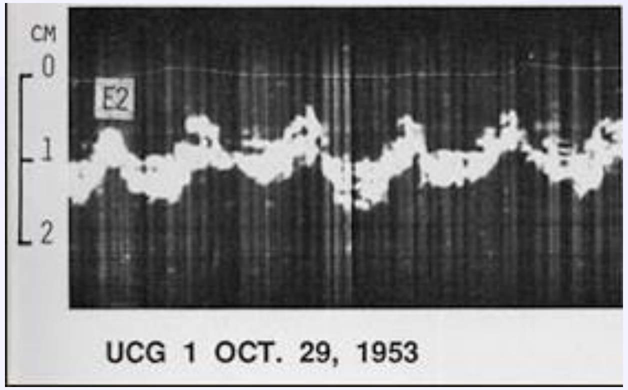
Introduction to Perioperative TEE, Basic Views

July 10, 2019

Department of Anesthesia and Pain Management- TGH, Toronto

History

- **1953. The first non-invasive image of moving structures in the heart was demonstrated by Dr. Edler and Hertz in Loud, Sweden**



- **1976. The first clinical use of TEE was introduced by Lee Frazin in University of Illinois, Chicago. He used a modified rigid endoscopic probe with a single M-mode crystal to image the heart.**
- **1972. The first use of M- mode epicardial echo in OR during mitral valve repair.**
- **1980. Masayuki Matsumoto from Albert Einstein Medical School described the first use of M-mode intraoperative TEE for continuous monitoring of LV function in 21 patients during cardiac surgery.**




Philips, iE 33, 2008

Philips, EPIQ 7, 2014

Siemens, Acuson SC 2000

GE Vivid E95

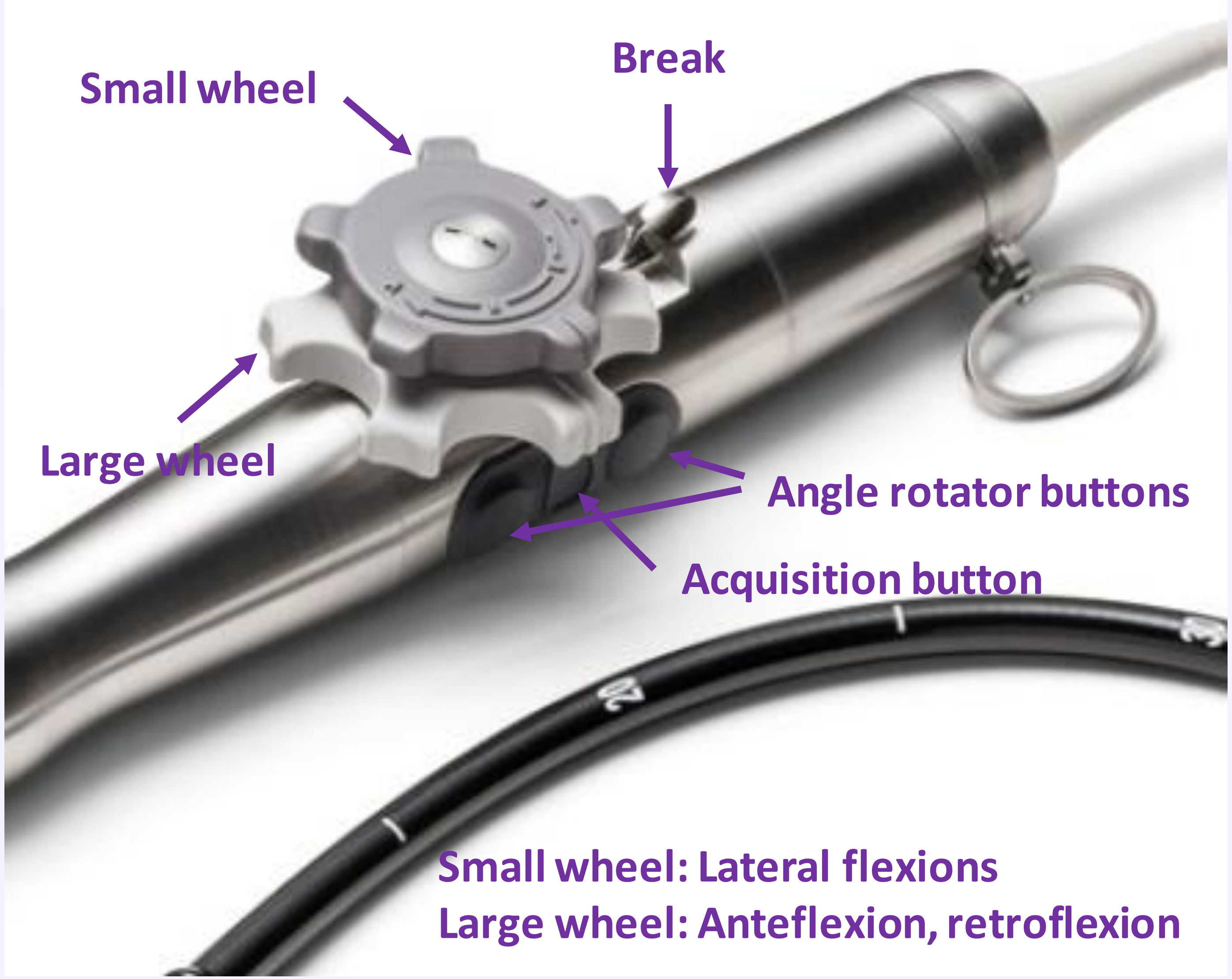
S8- 3t

X8- 2t

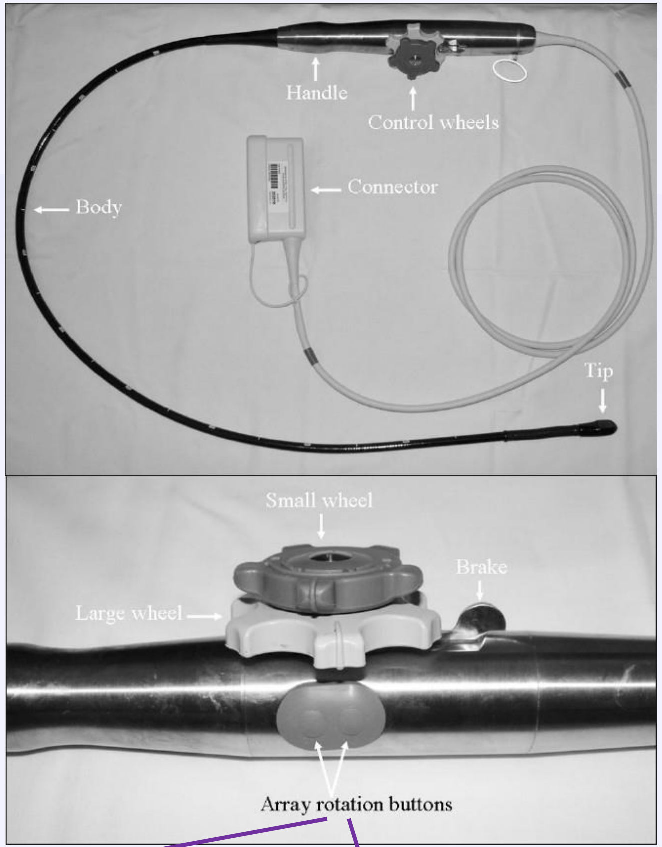
S8- 3t, Micro TEE probe for pediatric use, tip dimensions 7-8 mm, no 3D capability

X8- 2t, Adult 3D TEE probe with matrix array technology, tip dimensions 13- 14 mm

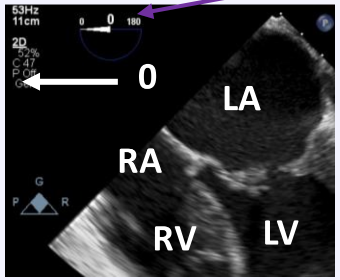
Philips X7- 2t



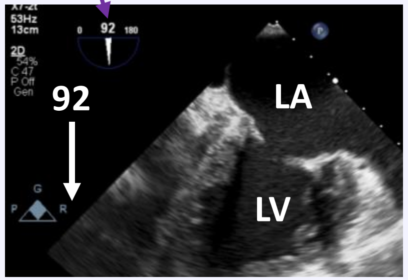
Small wheel
Break
Large wheel
Angle rotator buttons
Acquisition button
Small wheel: Lateral flexions
Large wheel: Anteflexion, retroflexion



Handle
Control wheels
Connector
Body
Tip
Small wheel
Brake
Large wheel
Array rotation buttons



0
LA
RA
RV
LV



92
LA
LV

EXPERT CONSENSUS STATEMENT

Basic Perioperative Transesophageal Echocardiography Examination: A Consensus Statement of the American Society of Echocardiography and the Society of Cardiovascular Anesthesiologists

Scott T. Reeves, MD, FASE, Alan C. Finley, MD, Nikolaos J. Skubas, MD, FASE, Madhav Swaminathan, MD, FASE, William S. Whitley, MD, Kathryn E. Glas, MD, FASE, Rebecca T. Hahn, MD, FASE, Jack S. Shanewise, MD, FASE, Mark S. Adams, BS, RDCS, FASE, and Stanton K. Shernan, MD, FASE, for the Council on Perioperative Echocardiography of the American Society of Echocardiography and the Society of Cardiovascular Anesthesiologists, *Charleston, South Carolina; New York, New York; Durham, North Carolina; Atlanta, Georgia; Boston, Massachusetts*

(J Am Soc Echocardiogr 2013;26:443-56.)

JASE May 2013

ASE GUIDELINES AND STANDARDS

Guidelines for Performing a Comprehensive Transesophageal Echocardiographic Examination: Recommendations from the American Society of Echocardiography and the Society of Cardiovascular Anesthesiologists

Rebecca T. Hahn, MD, FASE, Chair, Theodore Abraham, MD, FASE, Mark S. Adams, RDCS, FASE, Charles J. Bruce, MD, FASE, Kathryn E. Glas, MD, MBA, FASE, Roberto M. Lang, MD, FASE, Scott T. Reeves, MD, MBA, FASE, Jack S. Shanewise, MD, FASE, Samuel C. Siu, MD, FASE, William Stewart, MD, FASE, and Michael H. Picard, MD, FASE, *New York, New York; Baltimore, Maryland; Boston, Massachusetts; Rochester, Minnesota; Atlanta, Georgia; Chicago, Illinois; Charleston, South Carolina; London, Ontario, Canada; Cleveland, Ohio*

(J Am Soc Echocardiogr 2013;26:921-64.) **JASE September 2013**

GUIDELINES AND STANDARDS

Guidelines for Performing a Comprehensive Transesophageal Echocardiographic Examination in Children and All Patients with Congenital Heart Disease: Recommendations from the American Society of Echocardiography

Check for updates

Michael D. Puchalski, (Chair), MD, FASE, George K. Lui, MD, FASE, Wanda C. Miller-Hance, MD, FASE, Michael M. Brook, MD, FASE, Luciana T. Young, MD, FASE, Aarti Bhat, MD, FASE, David A. Roberson, MD, FASE, Laura Mercer-Rosa, MD, MSCE, Owen I. Miller, BMed (Hons), FRACP, David A. Parra, MD, FASE, Thomas Burch, MD, Hollie D. Carron, AAS, RDCS, ACS, FASE, and Pierre C. Wong, MD, *Salt Lake City, Utah; Stanford, San Francisco and Los Angeles, California; Houston, Texas; Seattle, Washington; Chicago, Illinois; Philadelphia, Pennsylvania; London, United Kingdom; Nashville, Tennessee; Boston, Massachusetts; and Kansas City, Missouri*

JASE February 2019

Table 4 Basic PTE examination content outline

1. Patient safety considerations
2. Echocardiographic imaging: acquisition and optimization
3. Normal cardiac anatomy and imaging plane correlation
4. Global ventricular function
5. Regional ventricular systolic function and recognition of pathology
6. Basic recognition of cardiac valve abnormalities
7. Identification of intracardiac masses in noncardiac surgery
8. Basic perioperative hemodynamic assessment
9. Related diagnostic modalities
10. Basic recognition of congenital heart disease in adults
11. Surface ultrasound for vascular access

Source: National Board of Echocardiography.[80]

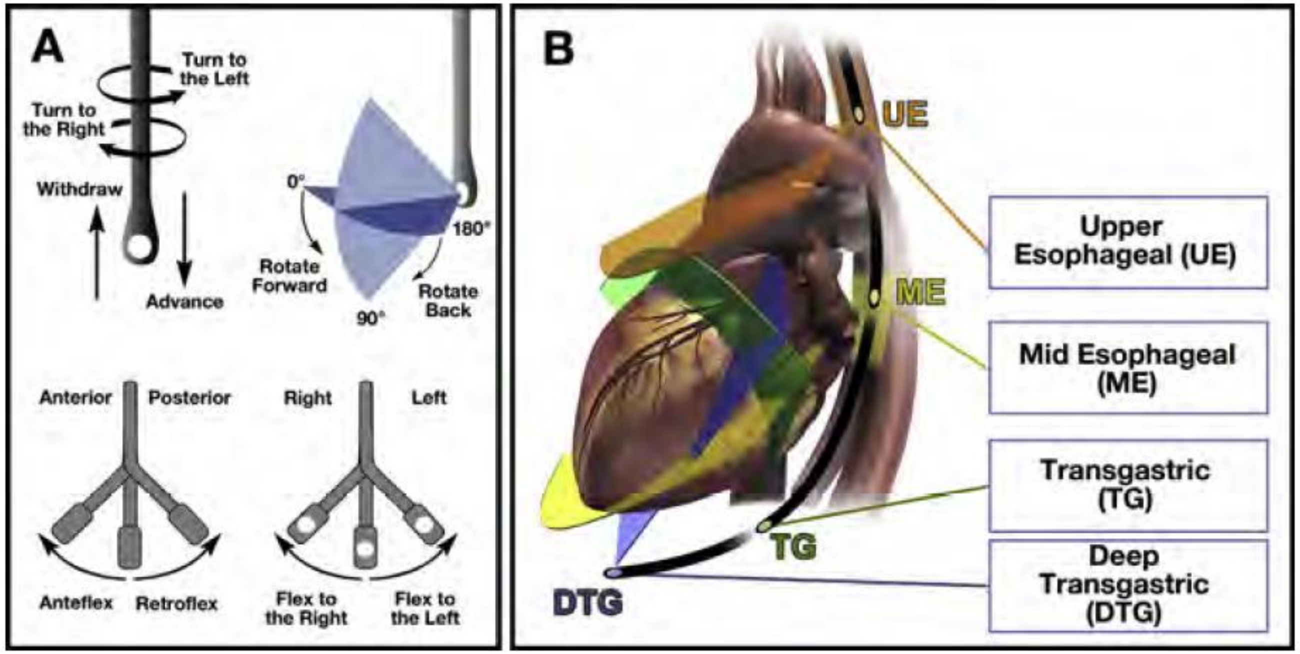
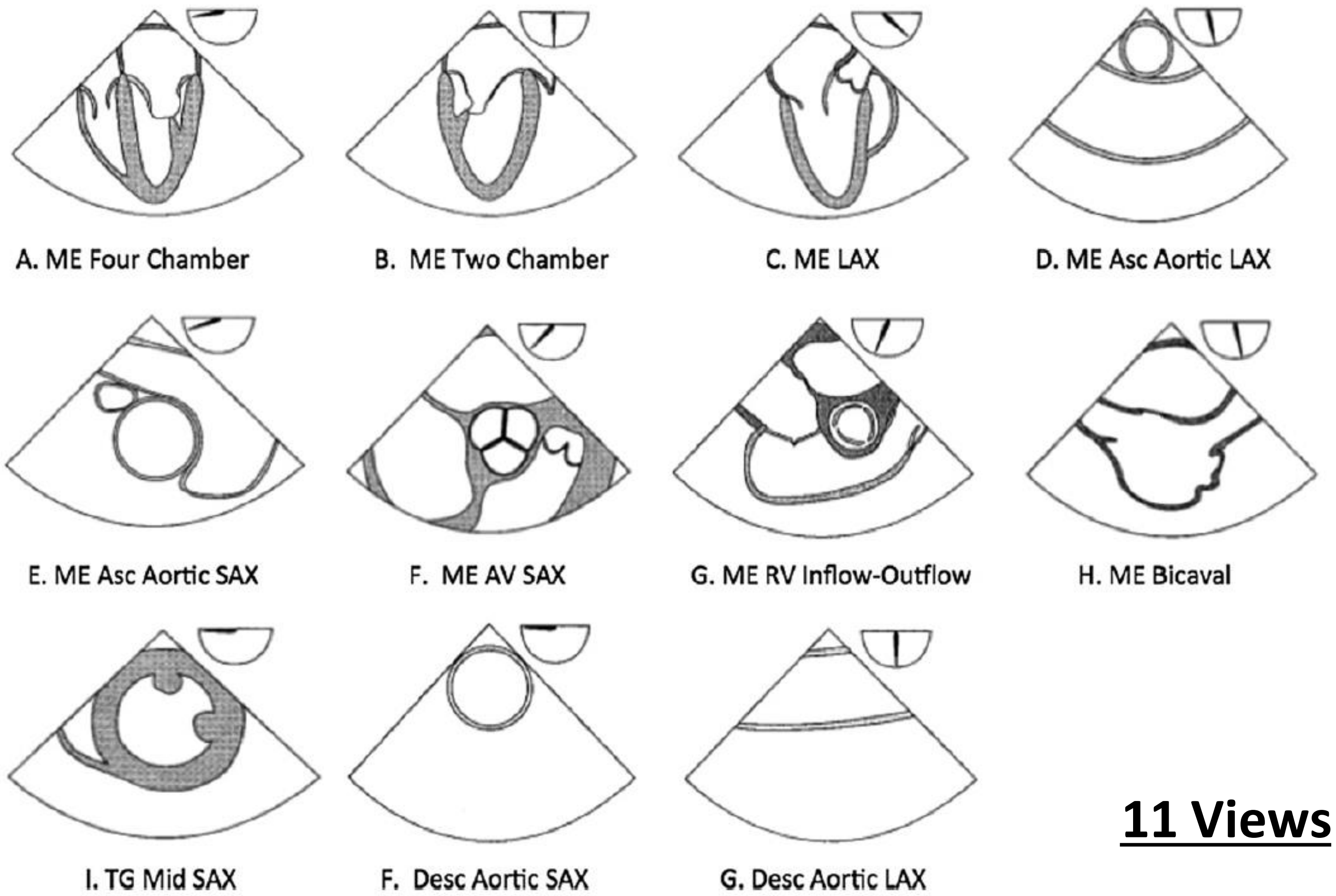


Figure 1 Terminology used to describe manipulation of the transesophageal echocardiographic probe during image acquisition. **(A)** Terminology used for the manipulation of the transesophageal echocardiographic probe. **(B)** Four standard transducer positions within the esophagus and stomach and the associated imaging planes.

Terminology in manipulation of TEE probe



11 Views

Figure 1 Cross-sectional views of the 11 views of the ASE and SCA basic PTE examination. The approximate multiplane angle is indicated by the icon adjacent to each view. *Asc*, Ascending; *Desc*, descending; *UE*, upper esophageal.

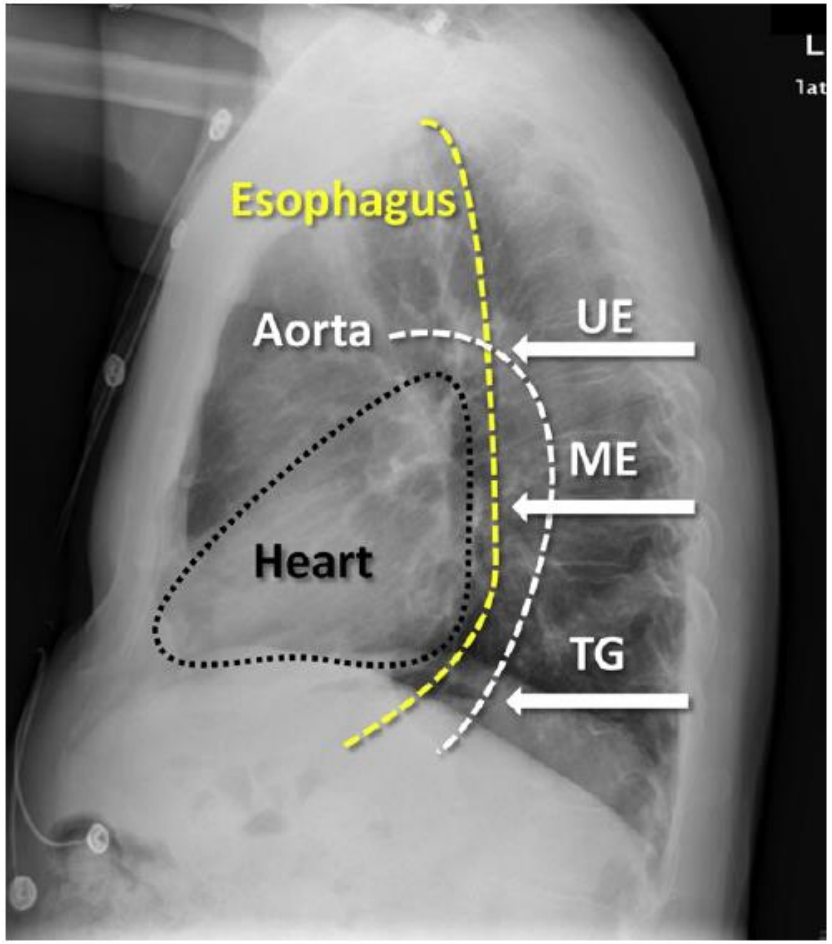


Figure 2 Lateral chest x-ray depicting relative positions of the heart (*black outline*), aorta (*white line*), and esophagus (*yellow line*). *Arrows* indicate the upper esophageal (UE), ME, and TG positions of the transesophageal echocardiographic probe.

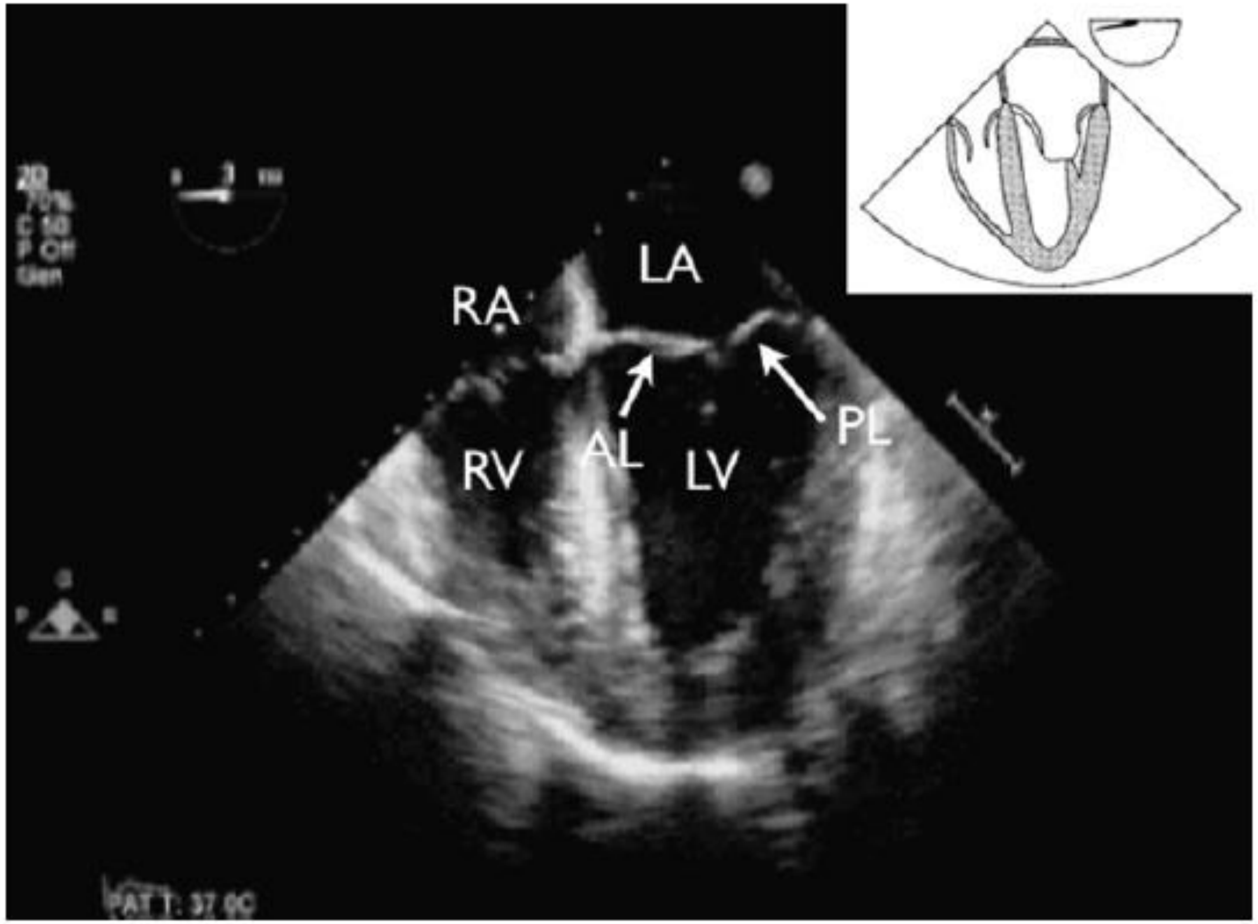
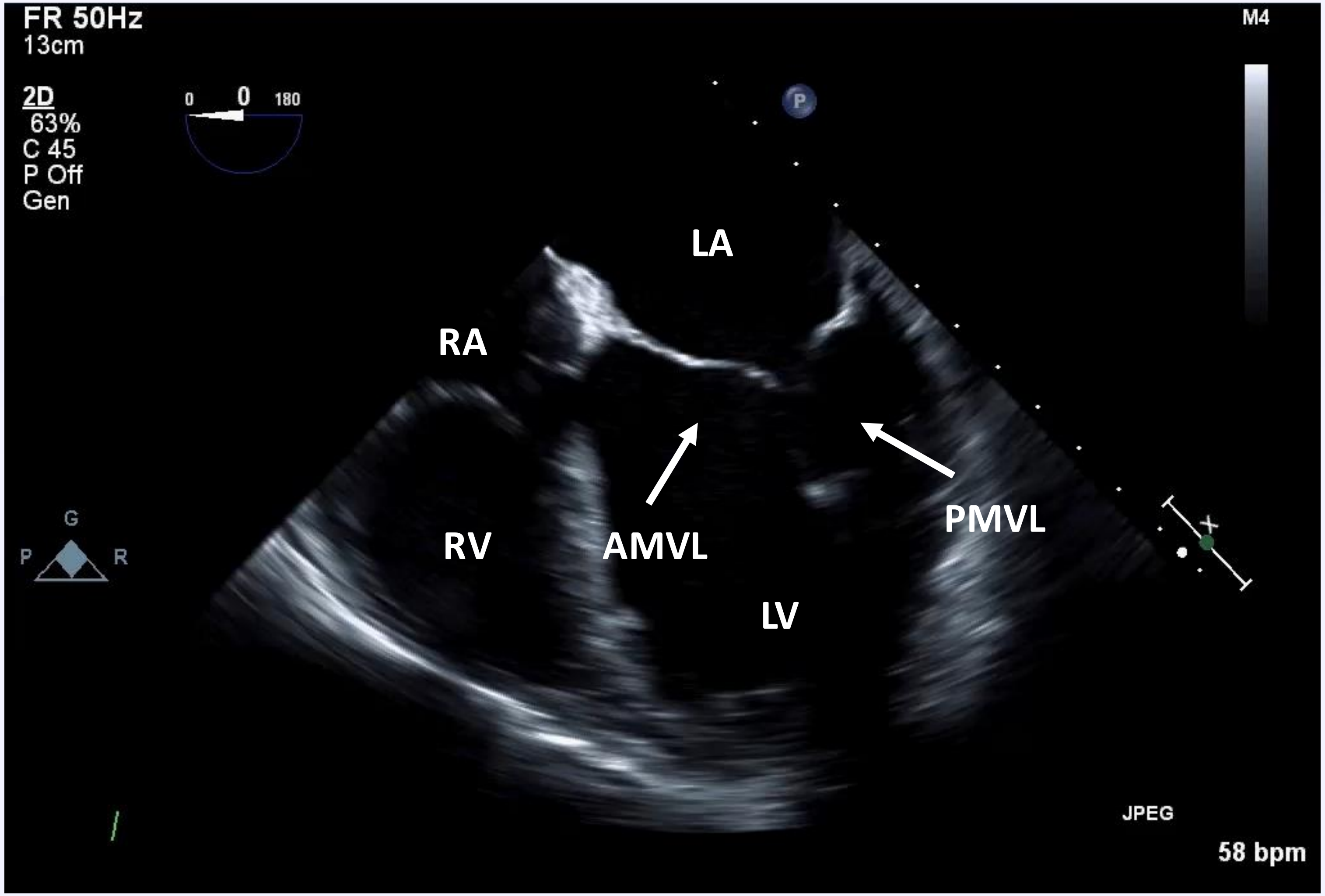


Figure 3 ME four-chamber view. *AL*, Anterior leaflet of the MV; *LA*, left atrium; *LV*, left ventricle; *PL*, posterior leaflet of the MV; *RA*, right atrium; *RV*, right ventricle.



ME four-chamber view

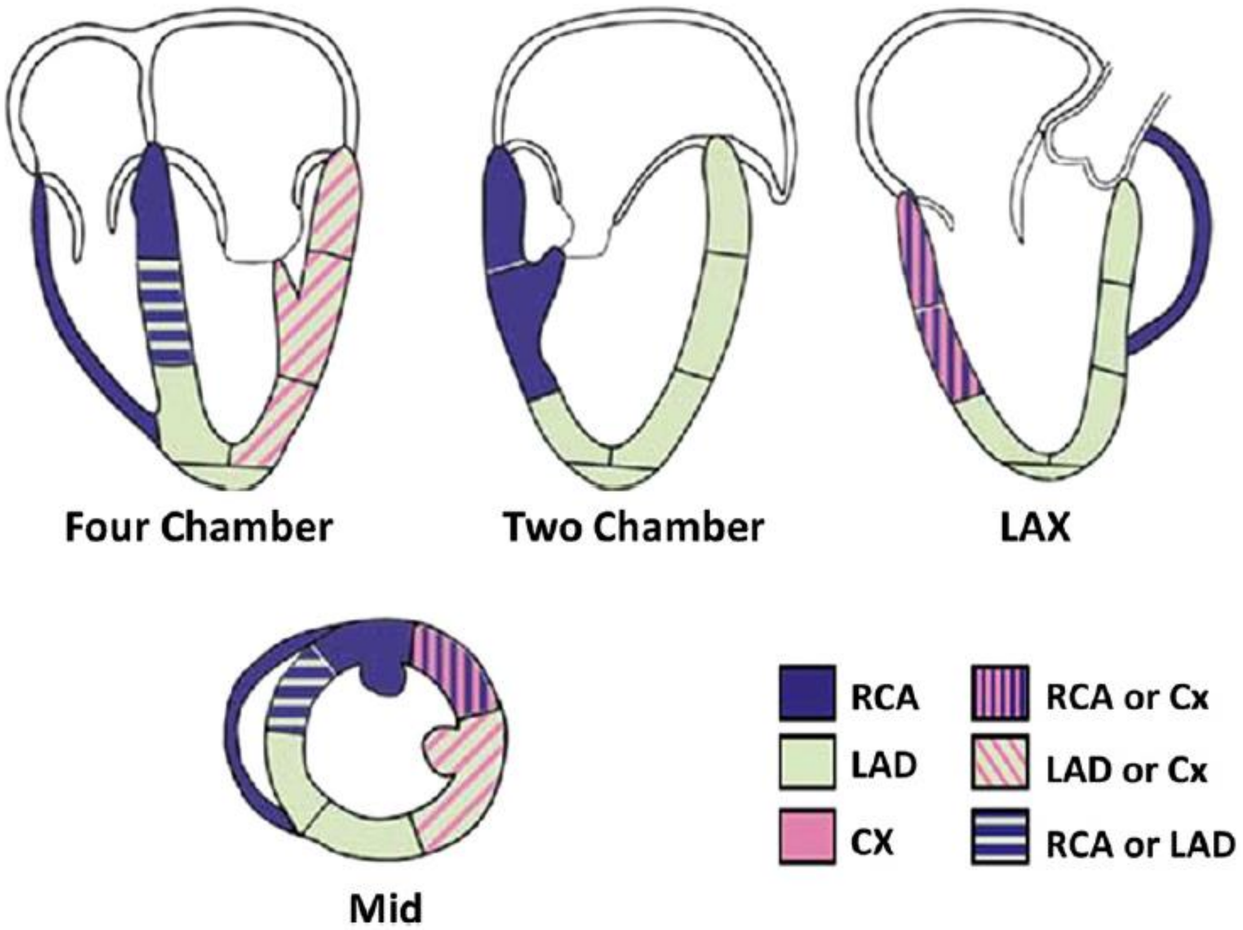


Figure 4 Typical distributions of the RCA, the LAD coronary artery, and the circumflex (CX) coronary artery from transesophageal views of the left ventricle. The arterial distribution varies among patients. Some segments have variable coronary perfusion. Modified with permission from Lang *et al*.[17]

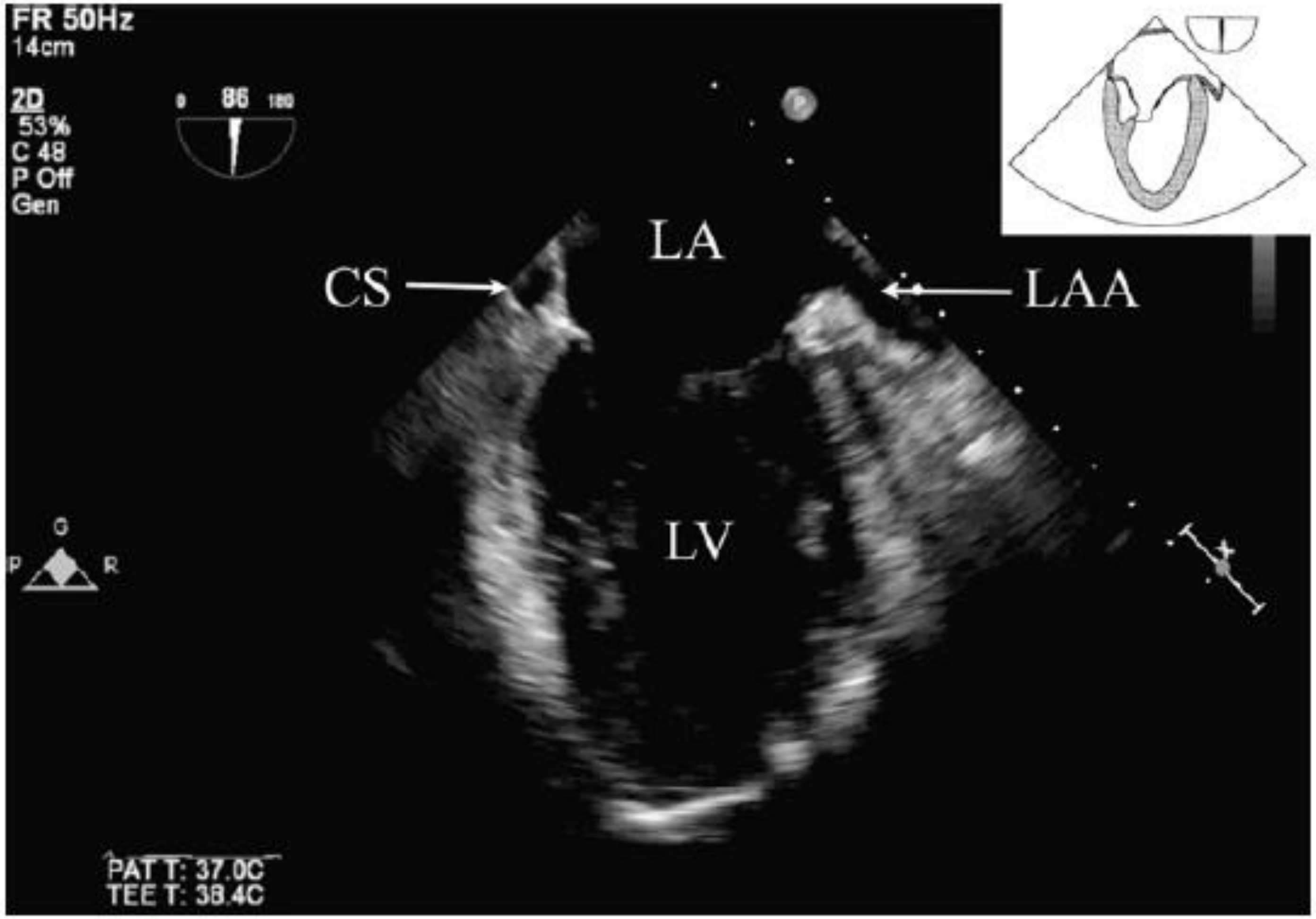
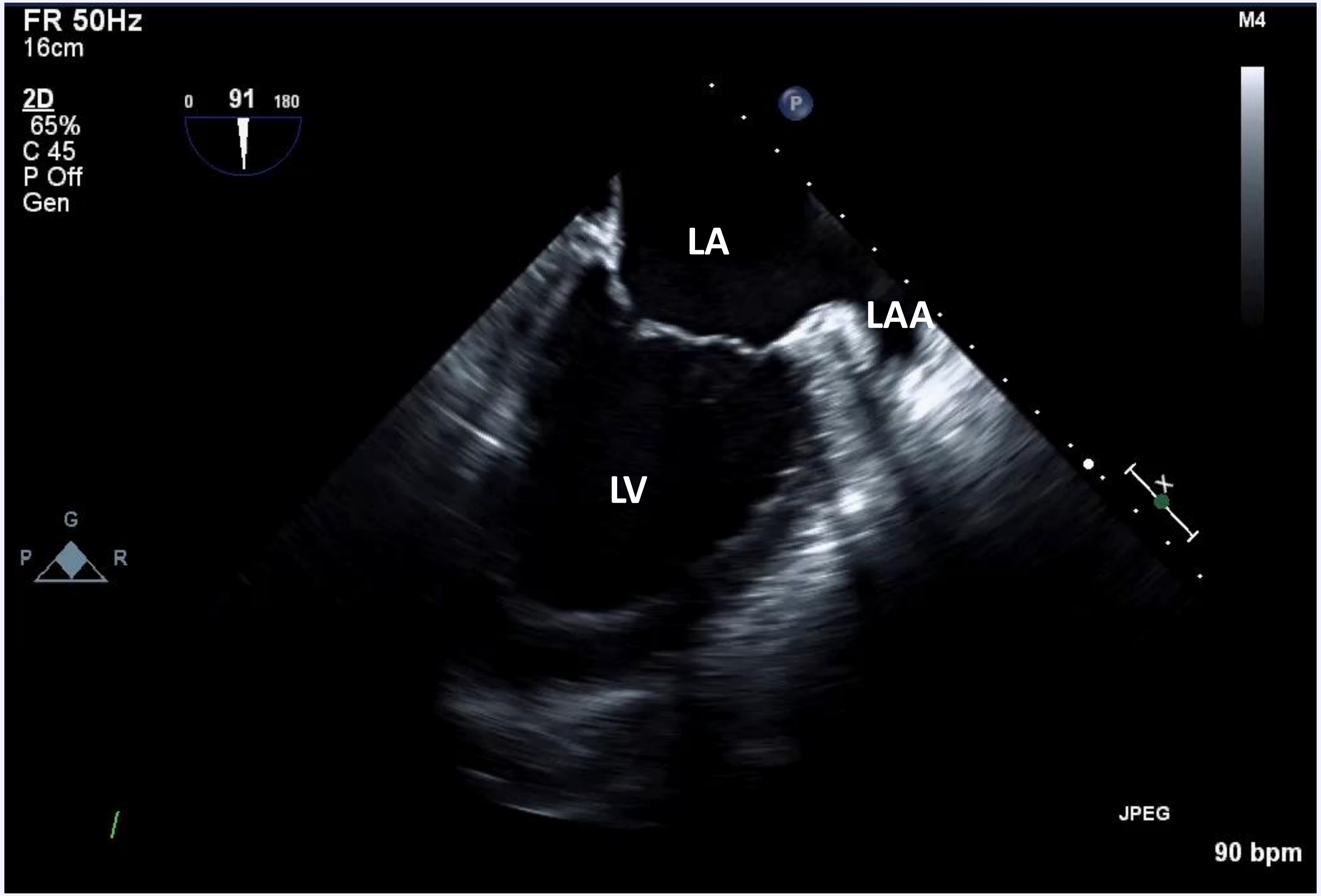


Figure 5 ME two-chamber view. *CS*, Coronary sinus; *LA*, left atrium; *LAA*, left atrial appendage; *LV*, left ventricle.



ME two-chamber view

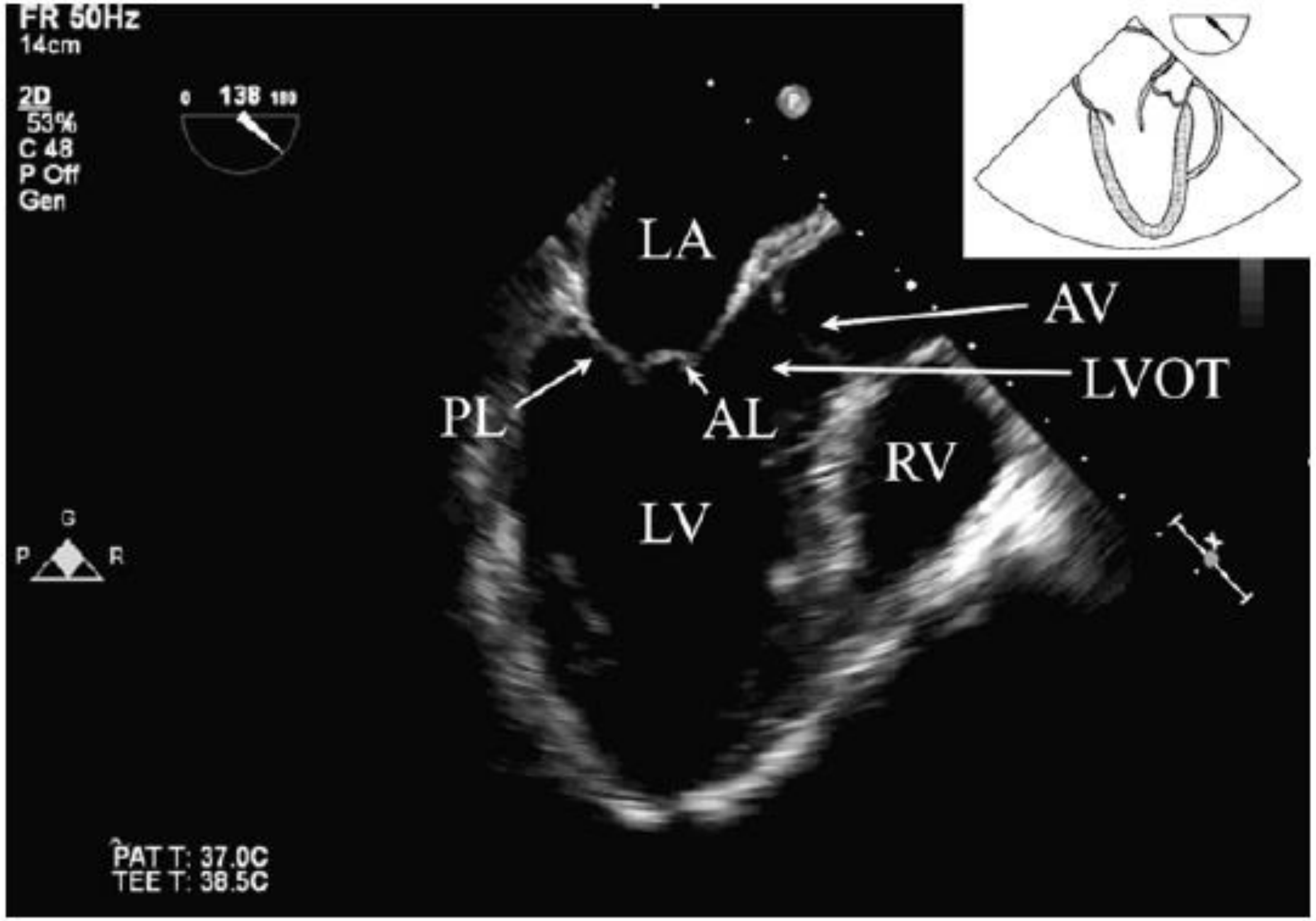
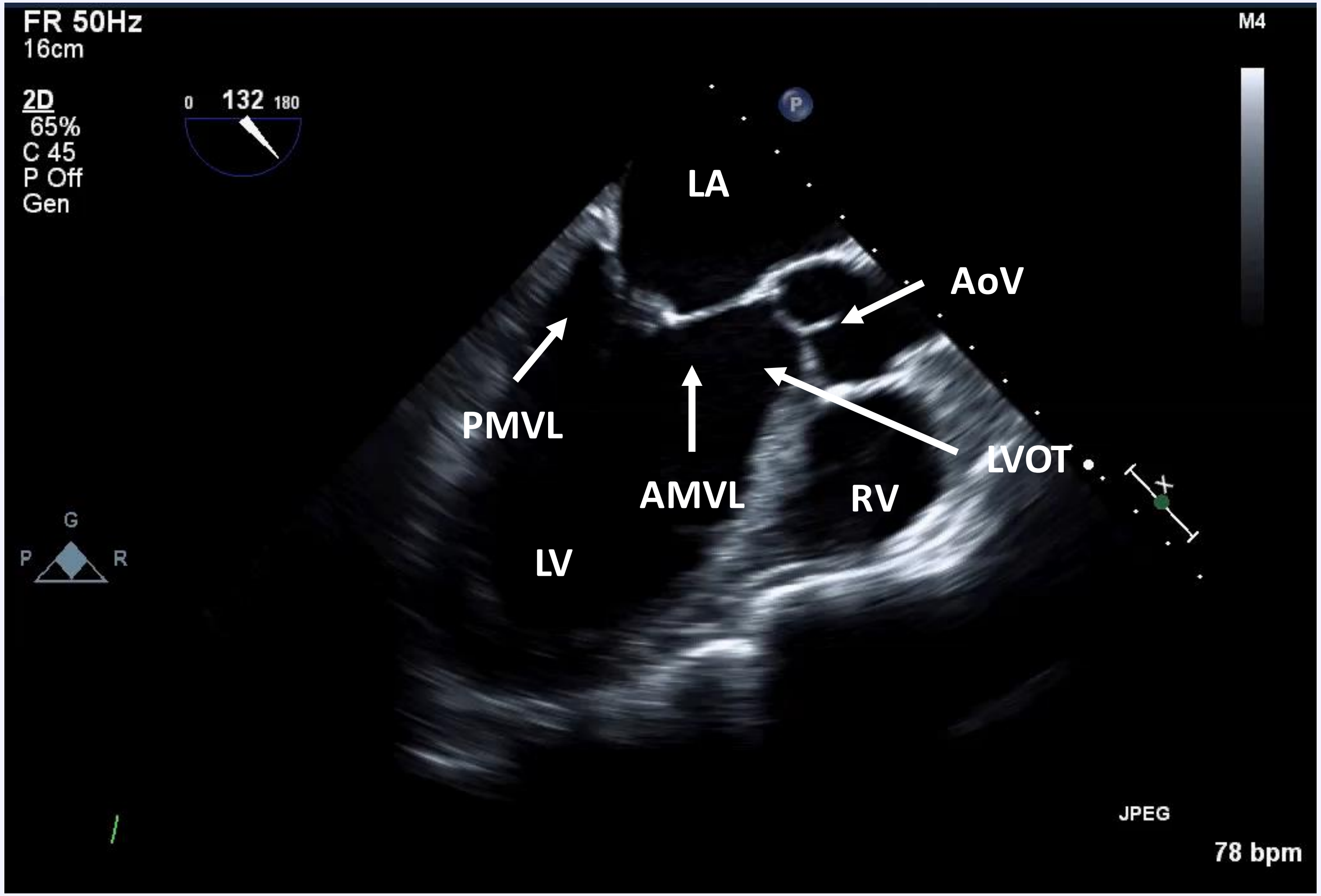


Figure 6 ME LAX view. *AL*, Anterior leaflet of the MV; *LA*, left atrium; *LV*, left ventricle; *PL*, posterior leaflet of the MV; *RV*, right ventricle.


FR 50Hz
16cm
2D
65%
C 45
P Off
Gen
0
132
180
M4
LA
AoV
PMVL
AMVL
LVOT
RV
LV
G
P
R
JPEG
78 bpm

ME LAX view

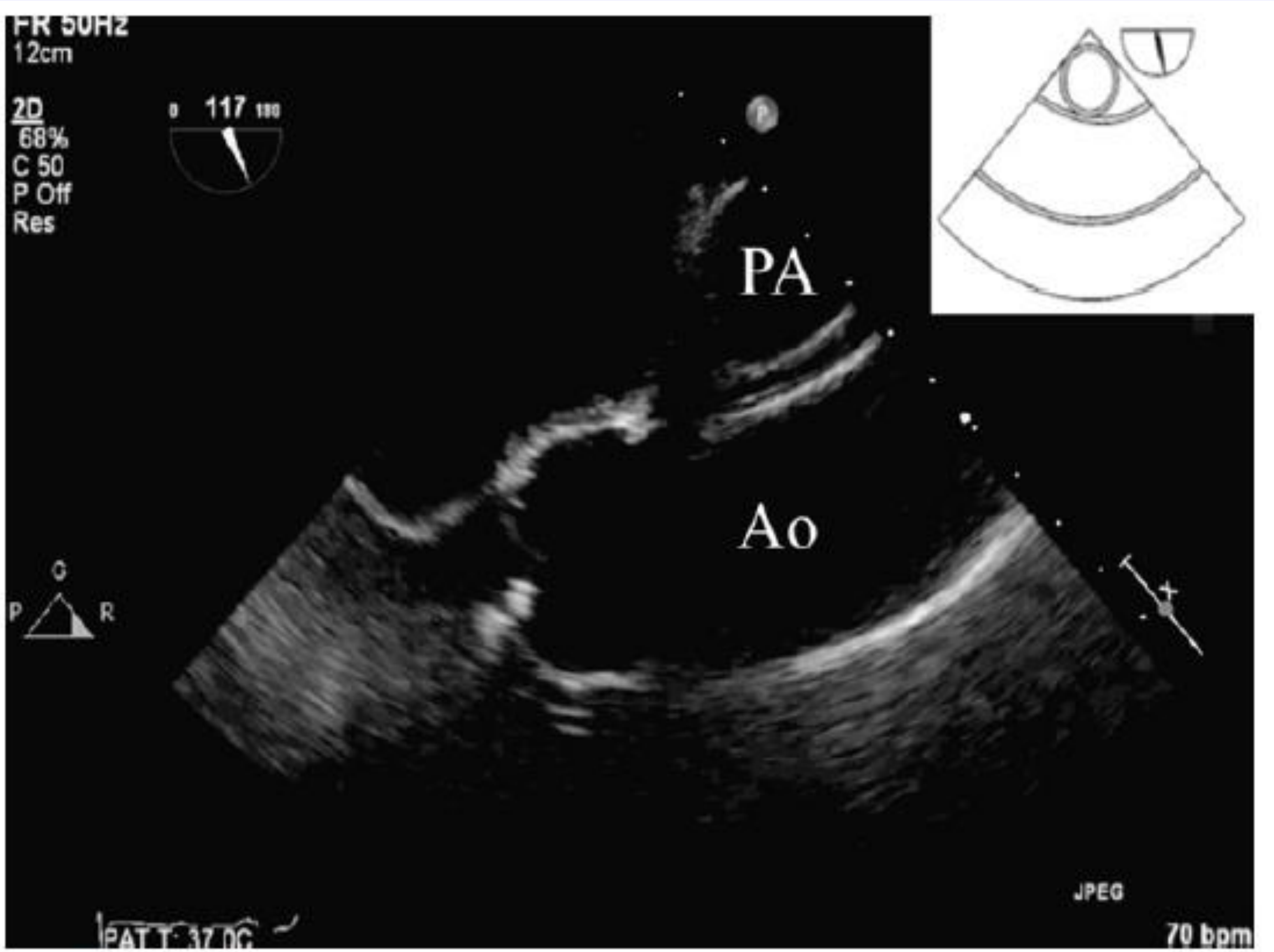
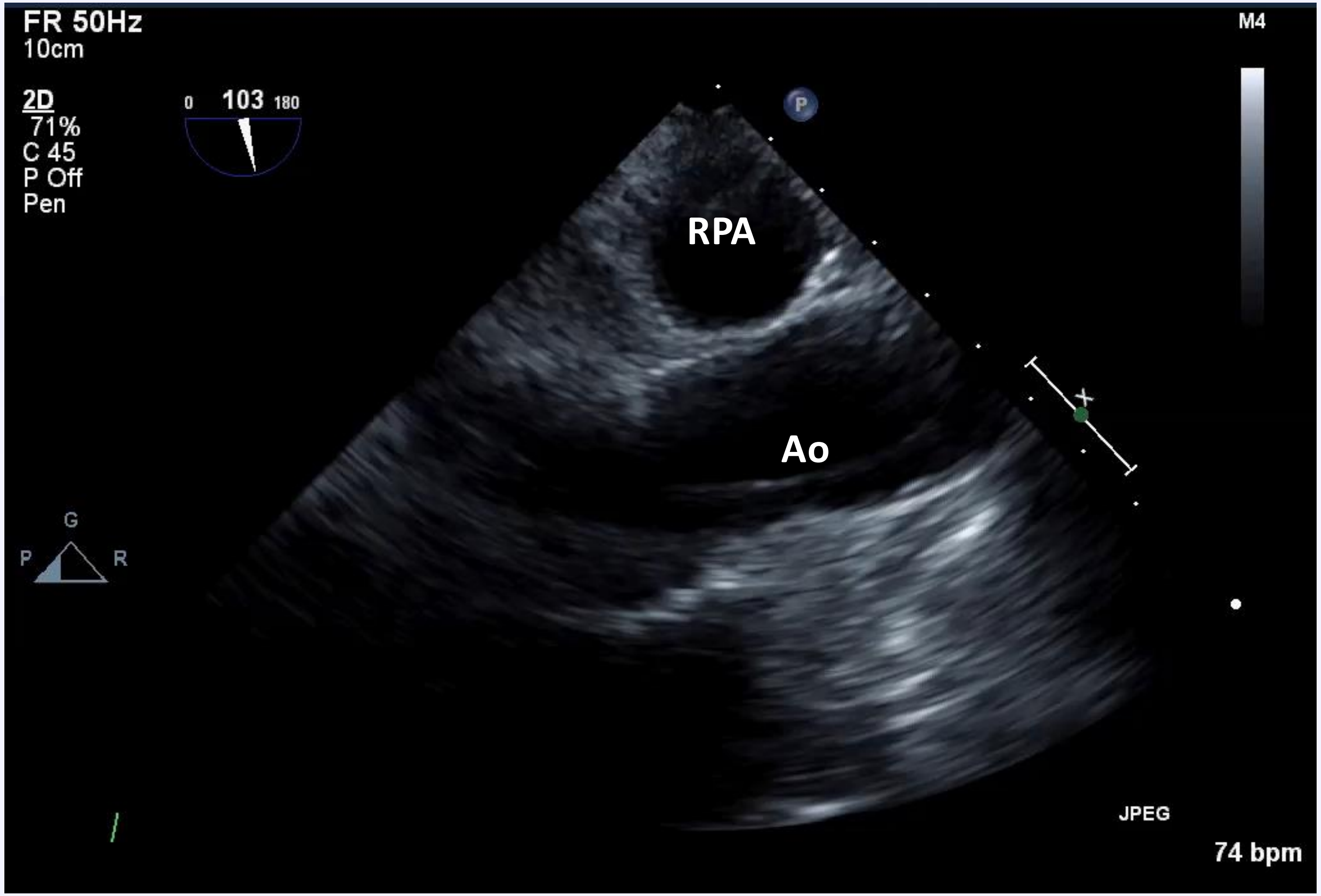


Figure 7 ME ascending aortic LAX view. *Ao*, Aorta.



ME ascending aortic LAX view

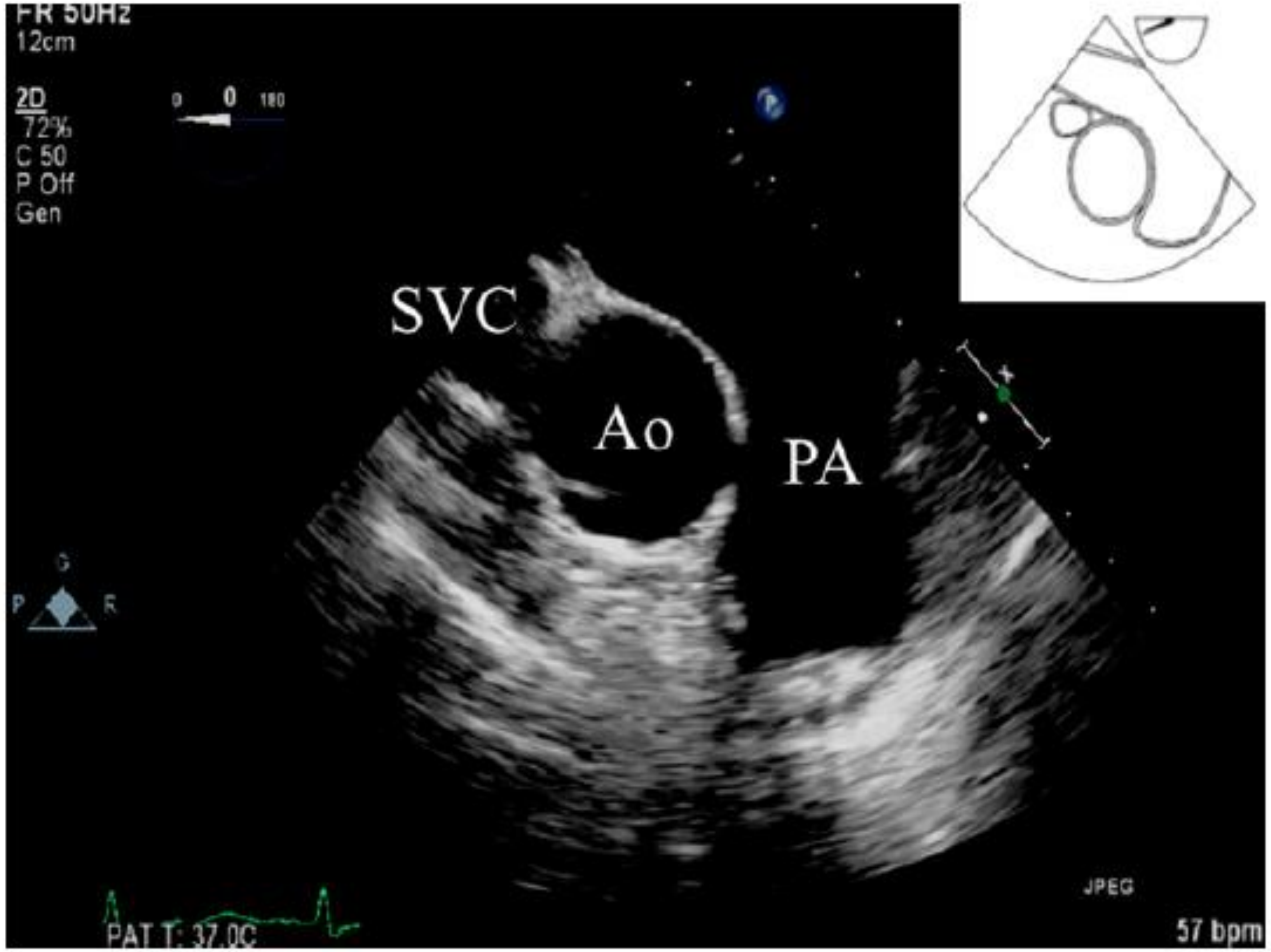
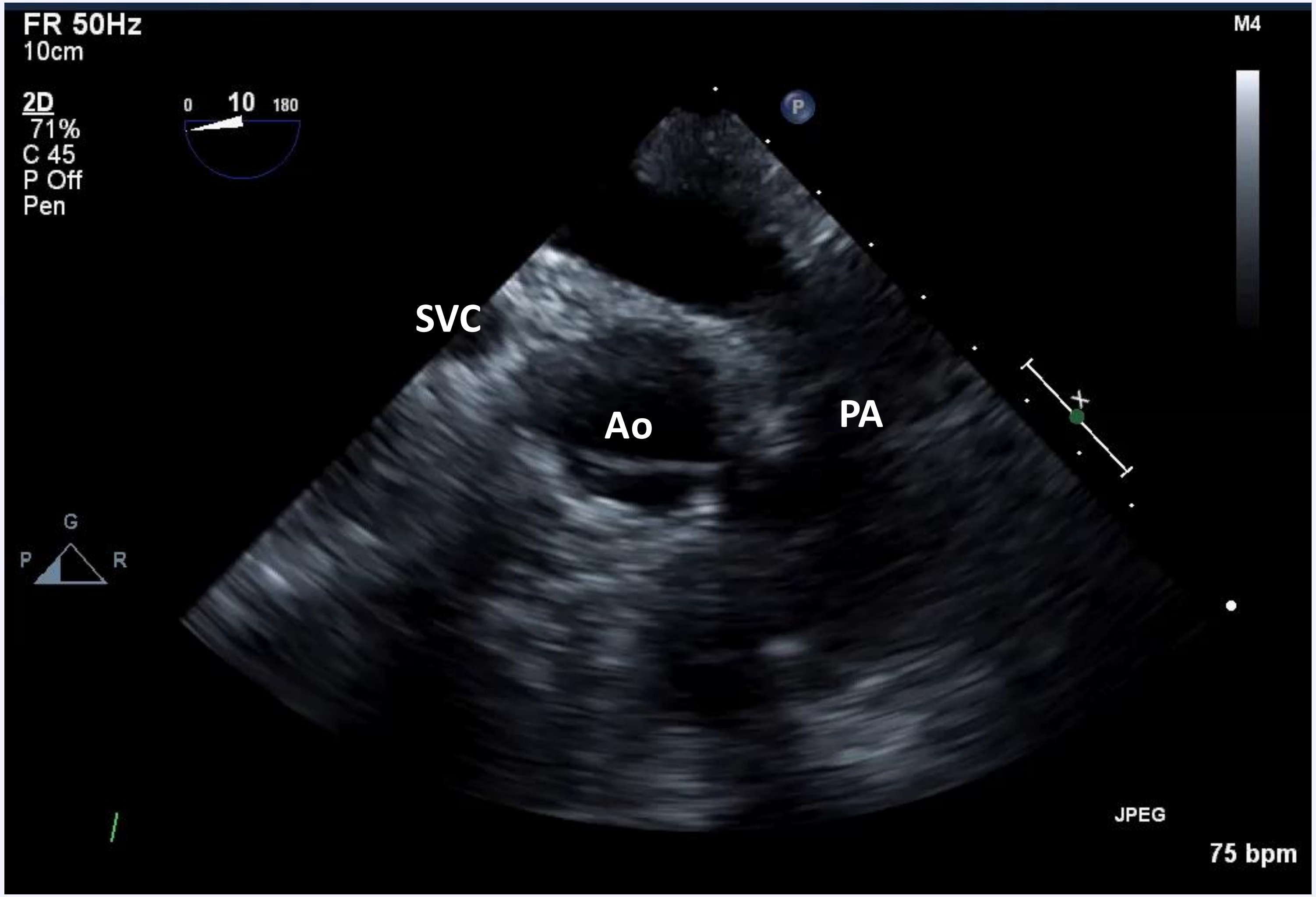


Figure 8 ME ascending aortic SAX view. *Ao*, Aorta; *SVC*, superior vena cava.



ME ascending aortic SAX view

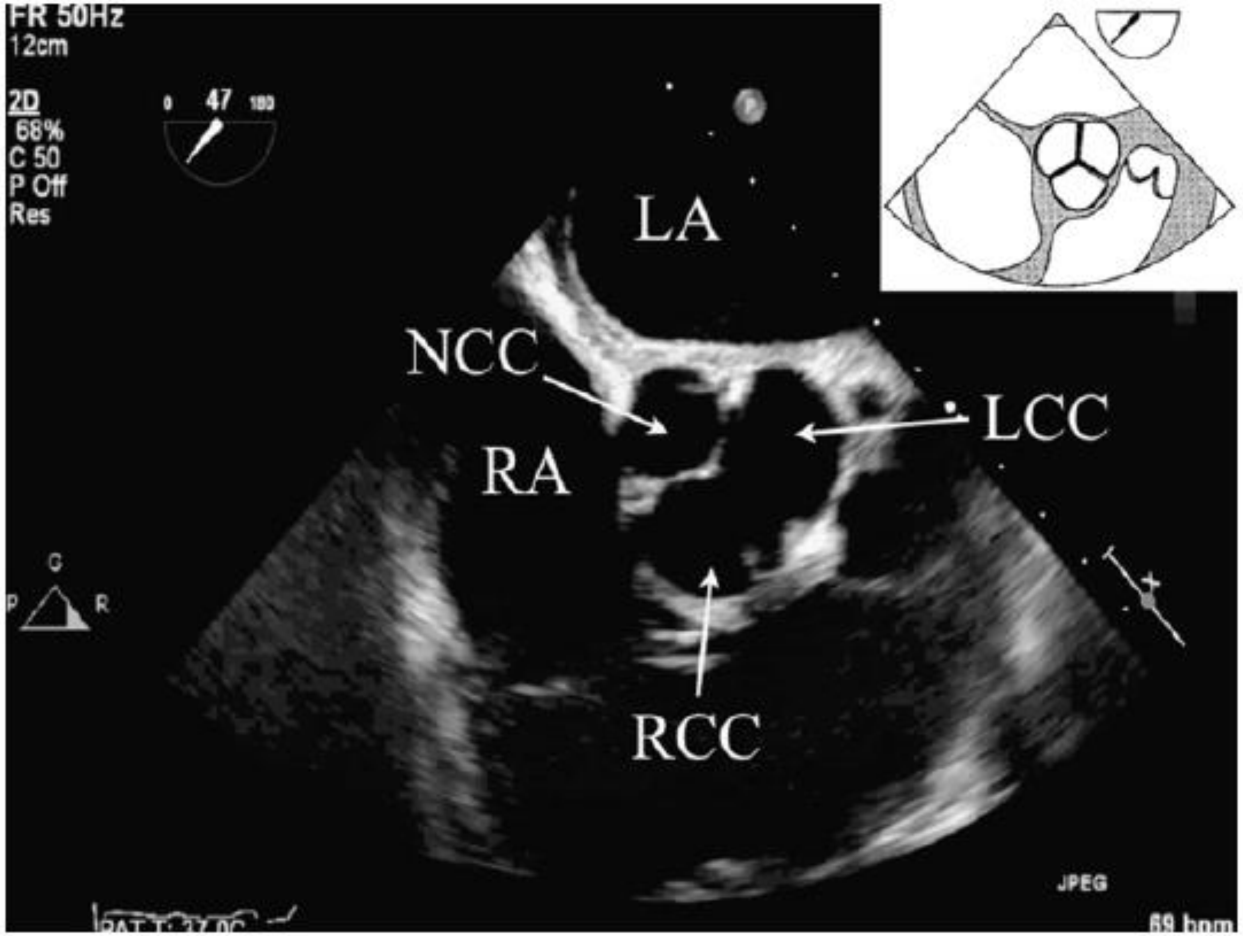
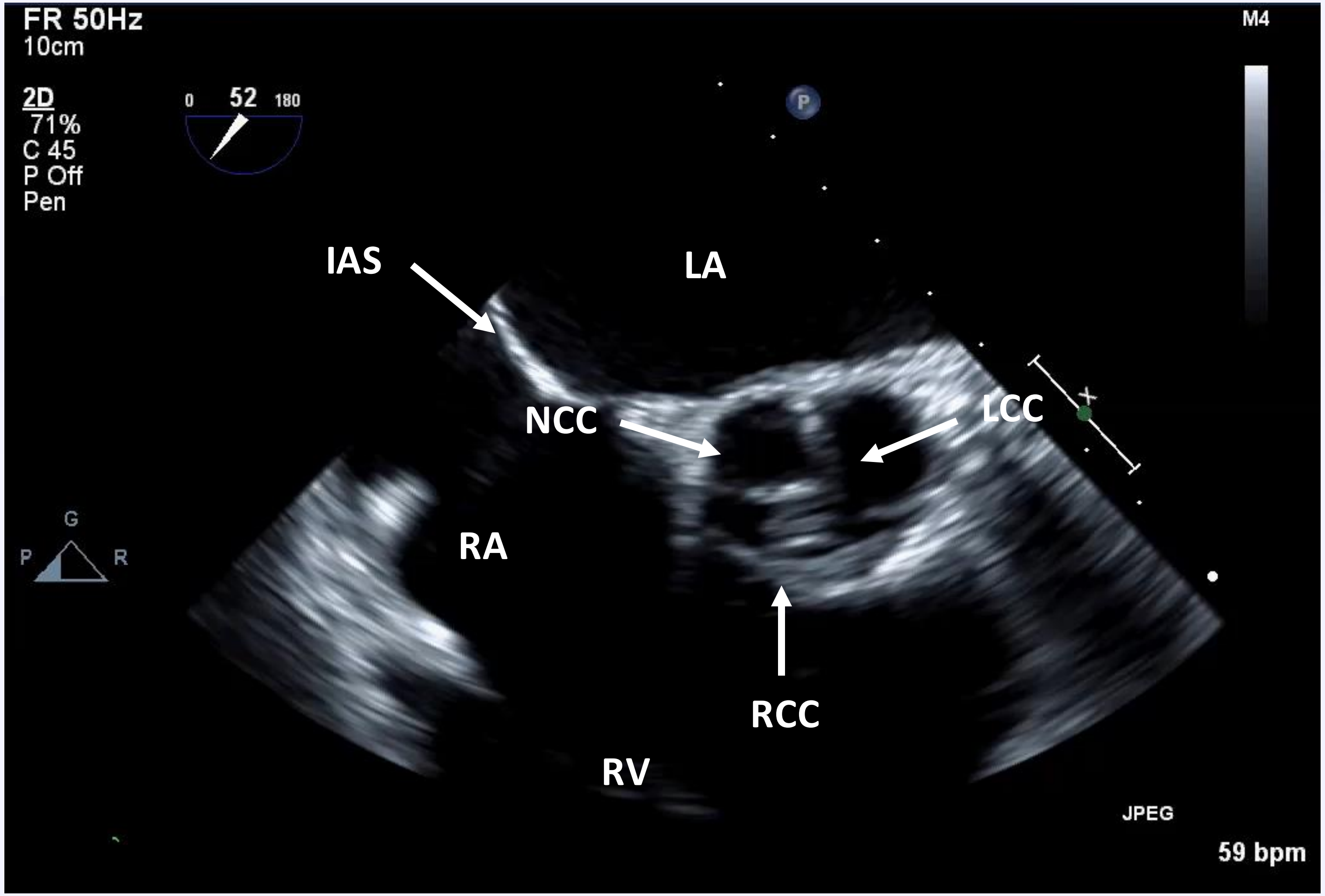


Figure 9 ME AV SAX view. *LA*, Left atrium; *LCC*, left coronary cusp; *NCC*, noncoronary cusp; *RA*, right atrium; *RCC*, right coronary cusp.



ME AoV SAX view

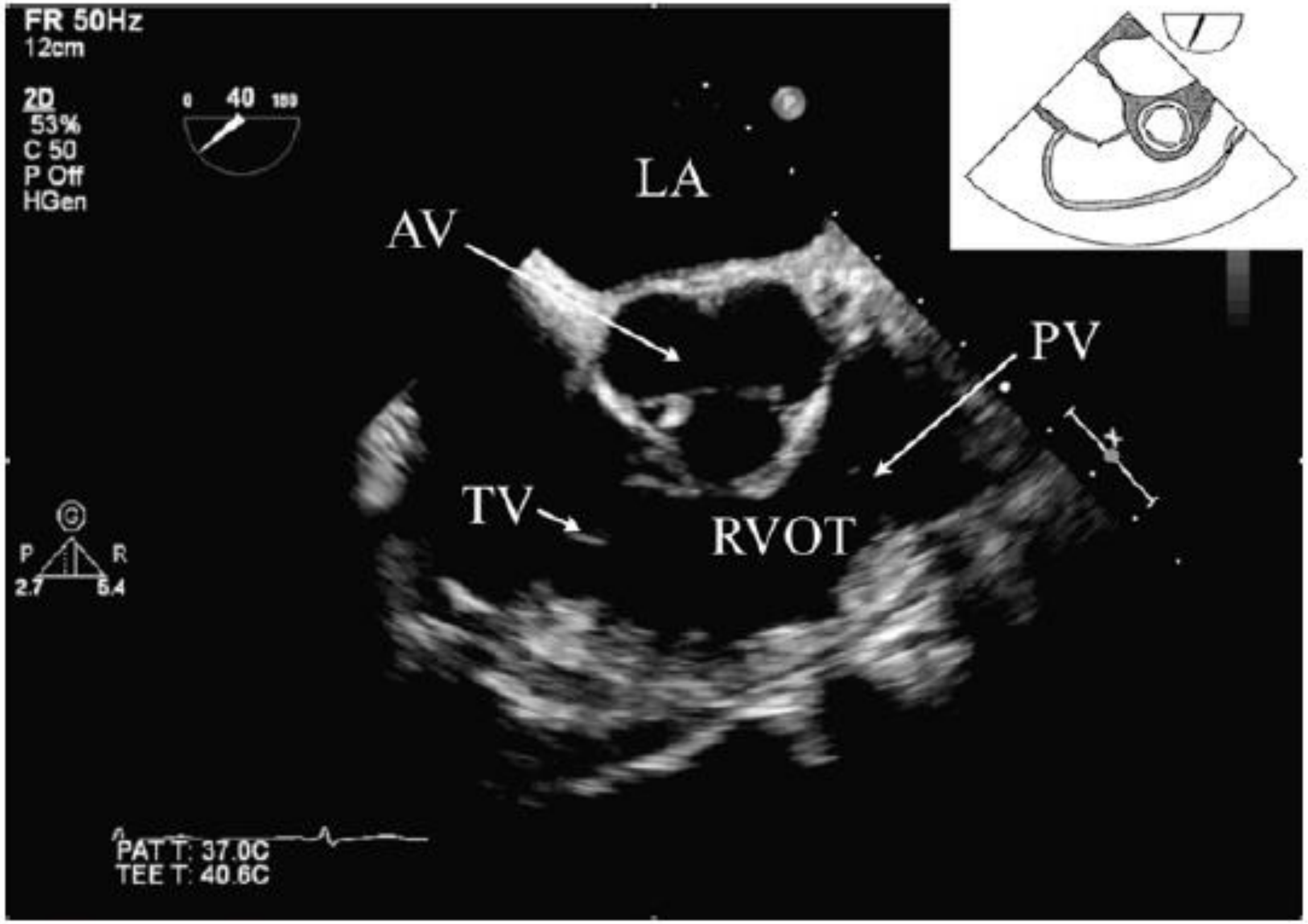
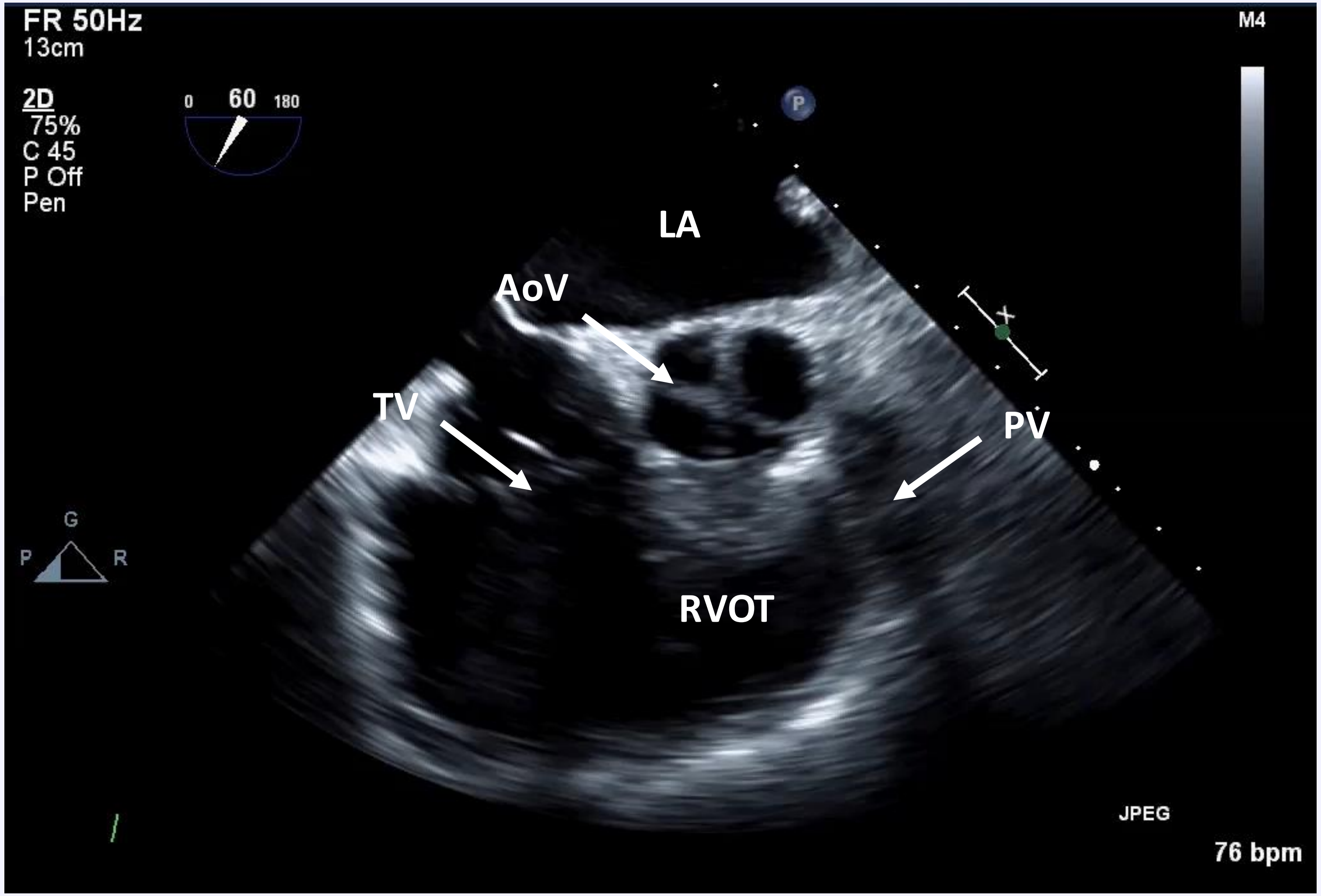


Figure 10 ME RV inflow-outflow view. *LA*, Left atrium.



ME RV inflow-outflow view

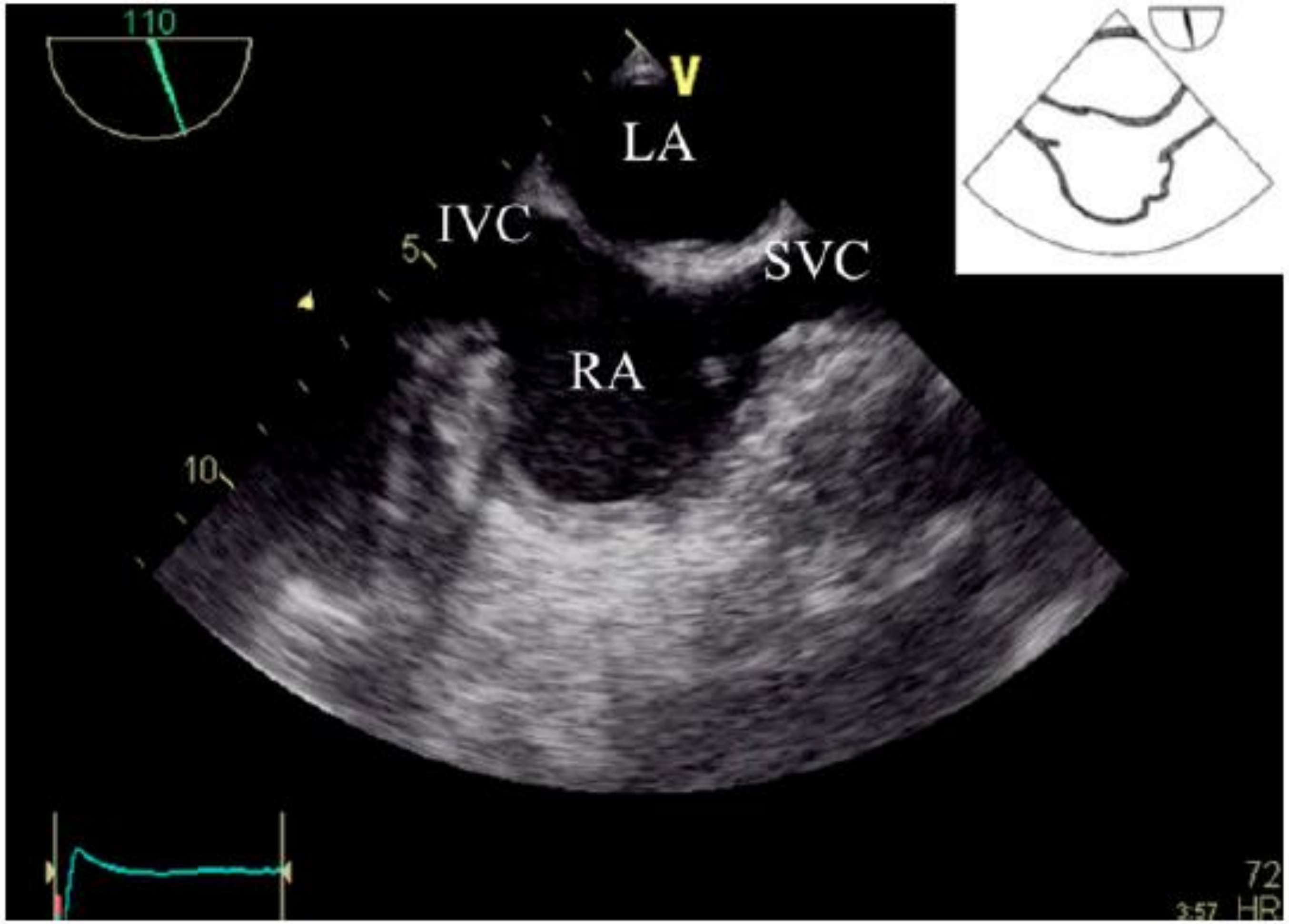
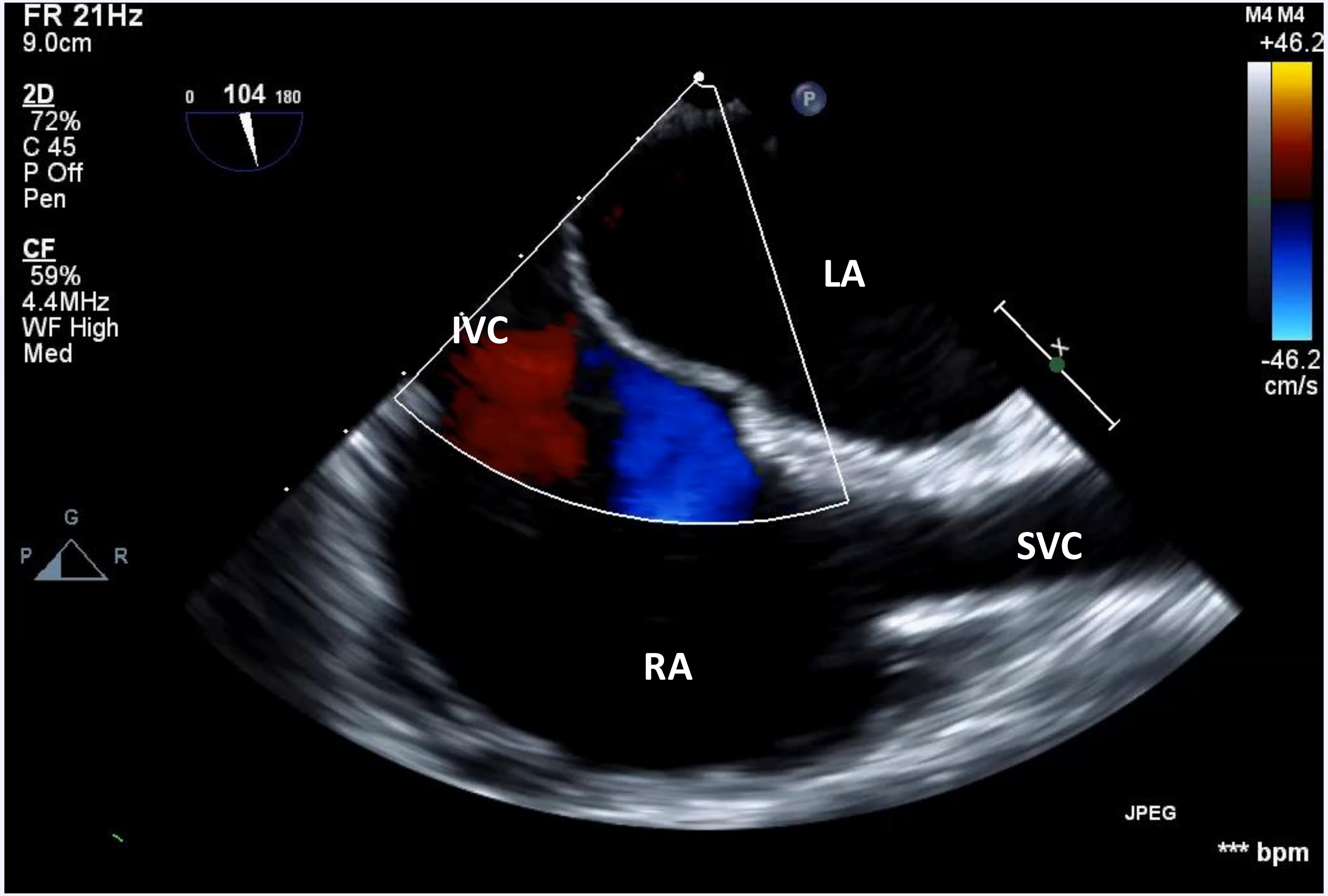


Figure 11 ME bicaval view. *IVC*, Inferior vena cava; *LA*, left atrium; *SVC*, superior vena cava; *RA*, right atrium.



ME Bicaval view

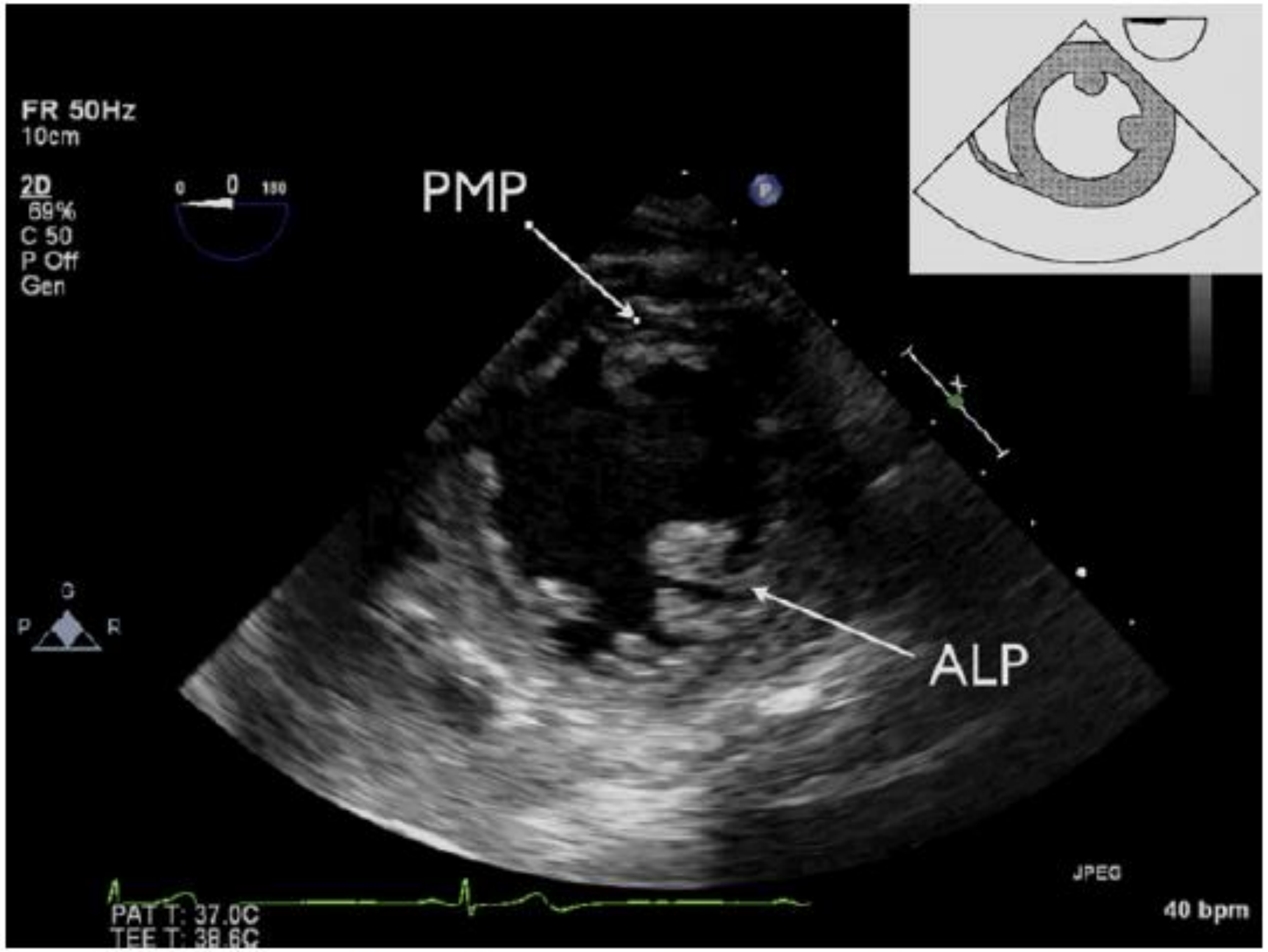
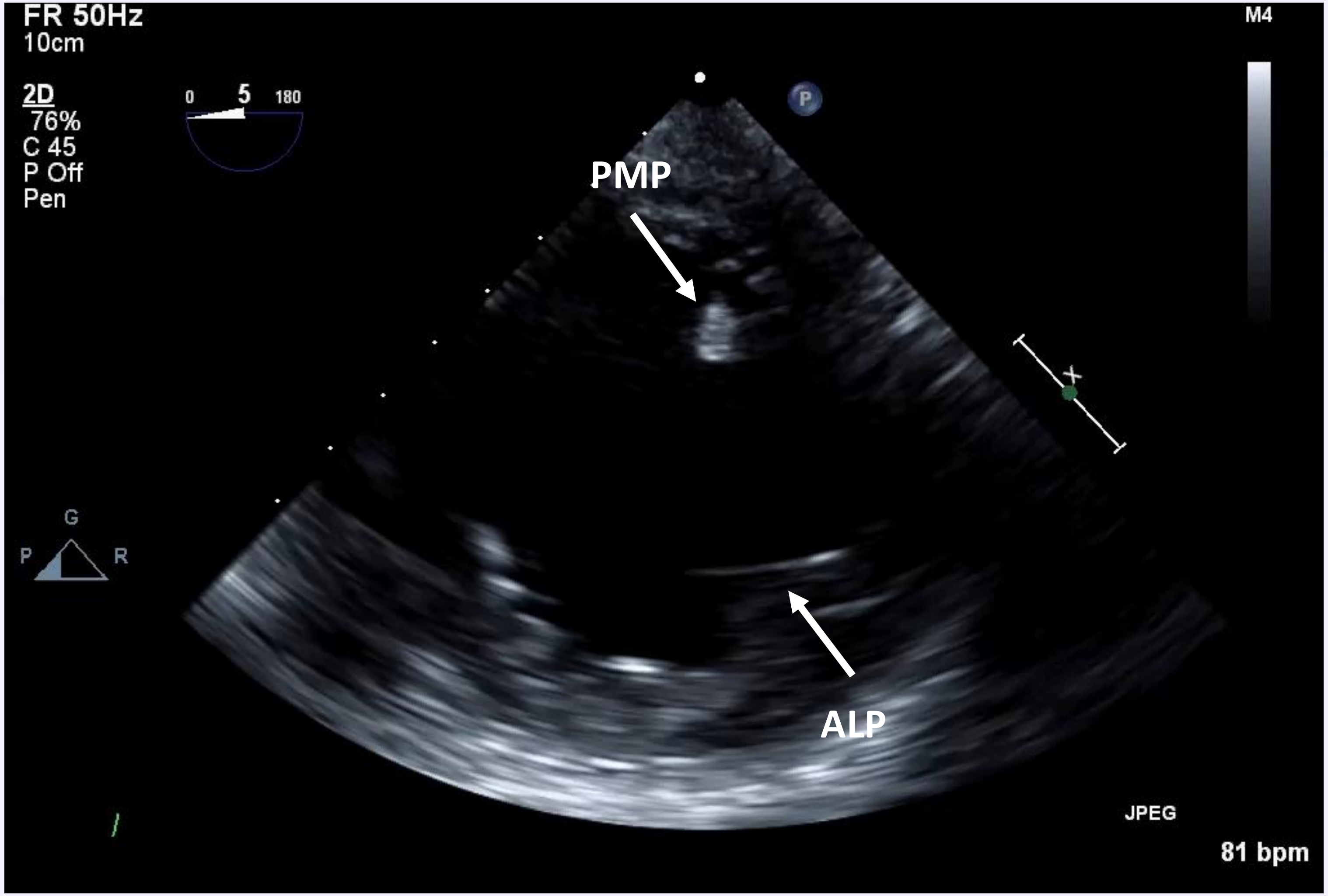


Figure 12 TG midpapillary SAX view. *ALP*, Anterior lateral papillary muscle; *PMP*, posterior medial papillary muscle.



TG midpapillary SAX view

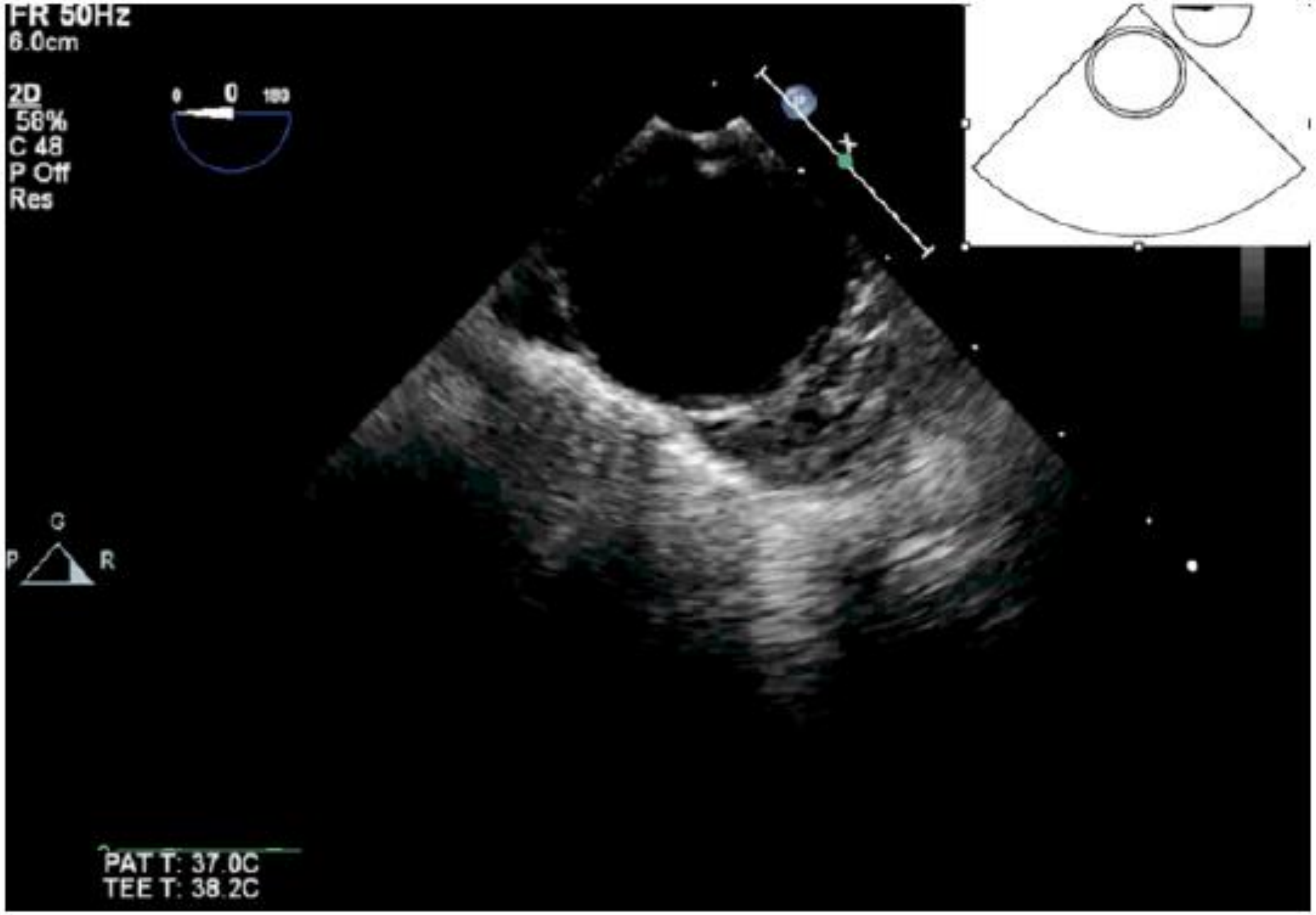
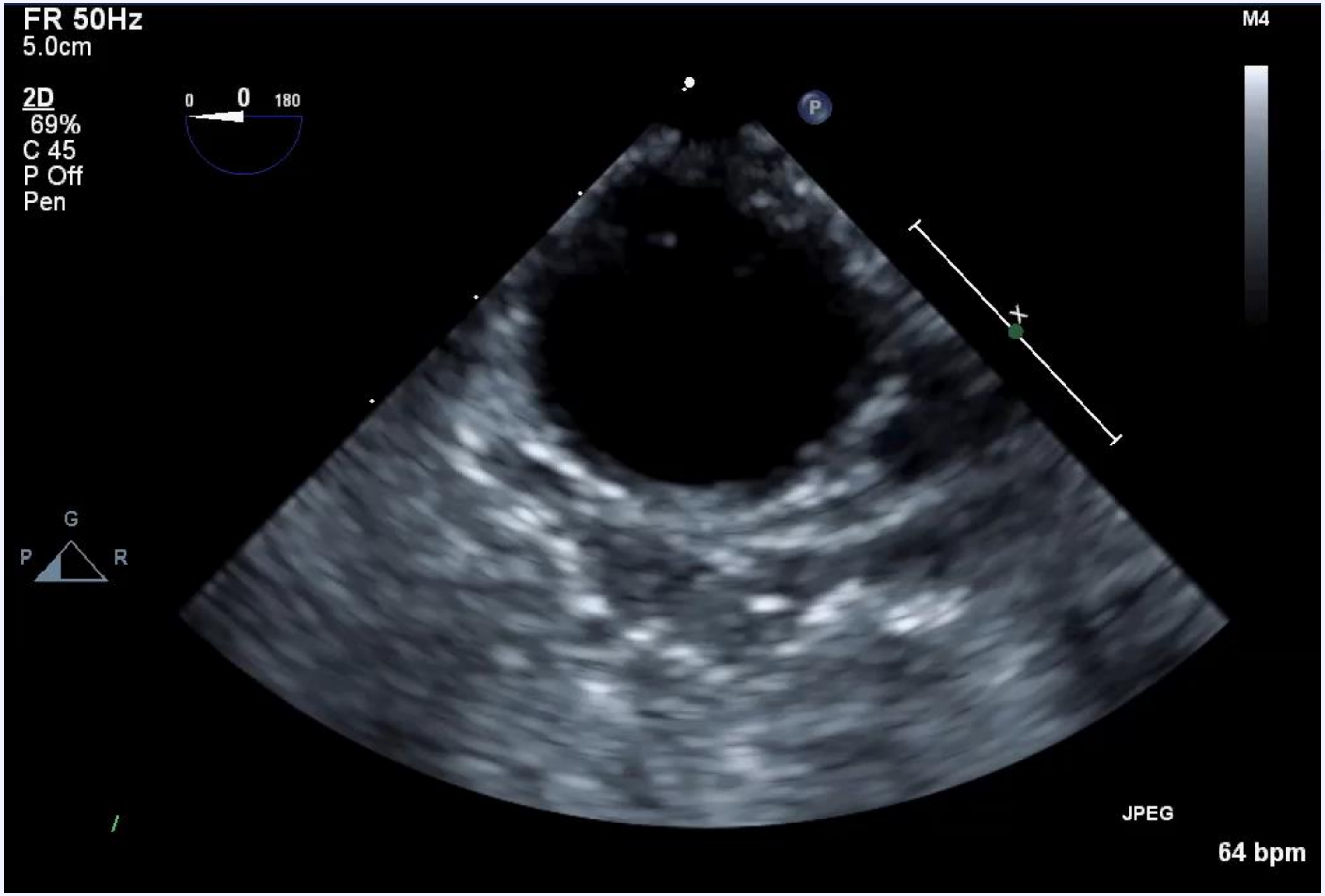


Figure 13 Descending aortic SAX view.



Descending aortic SAX view

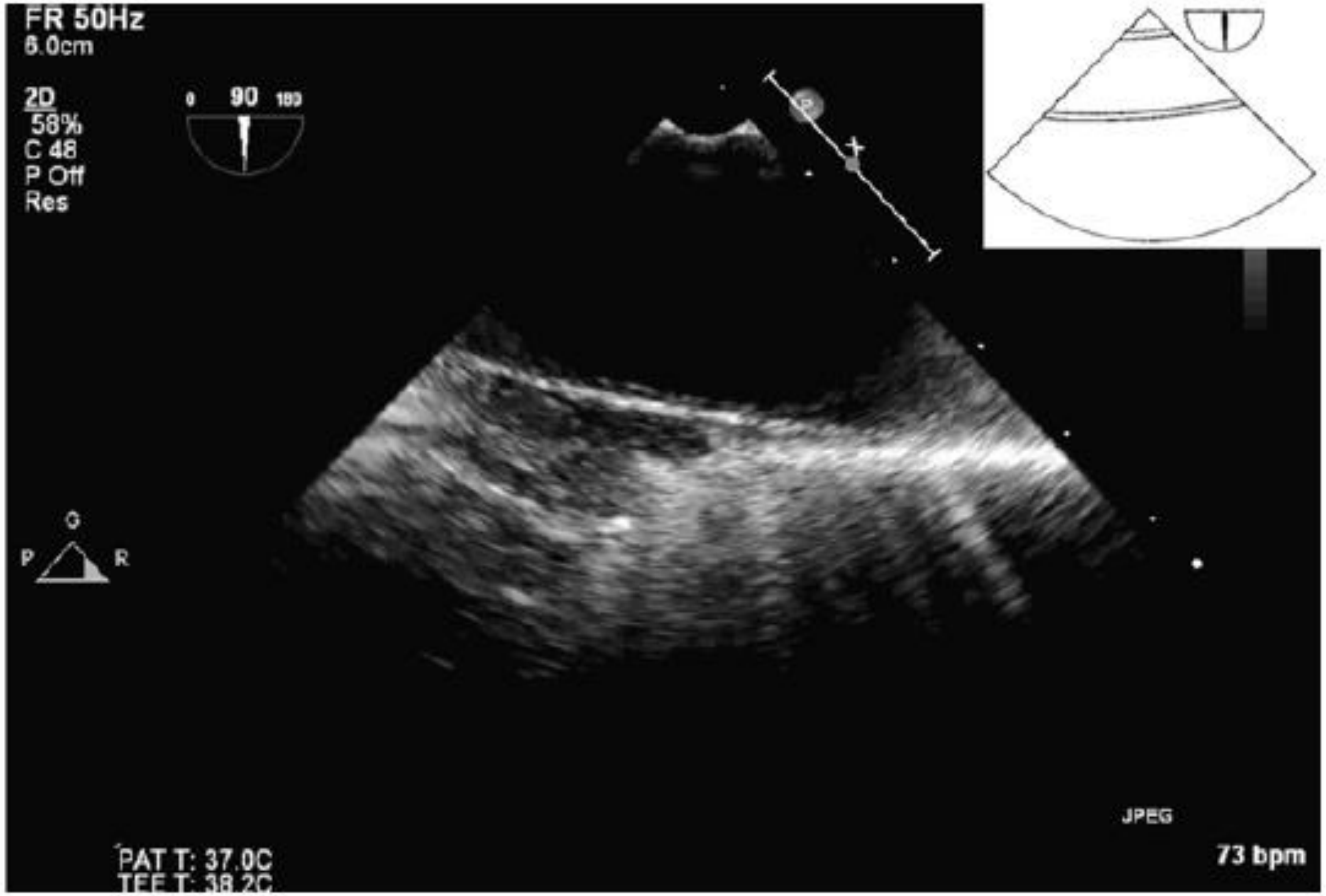
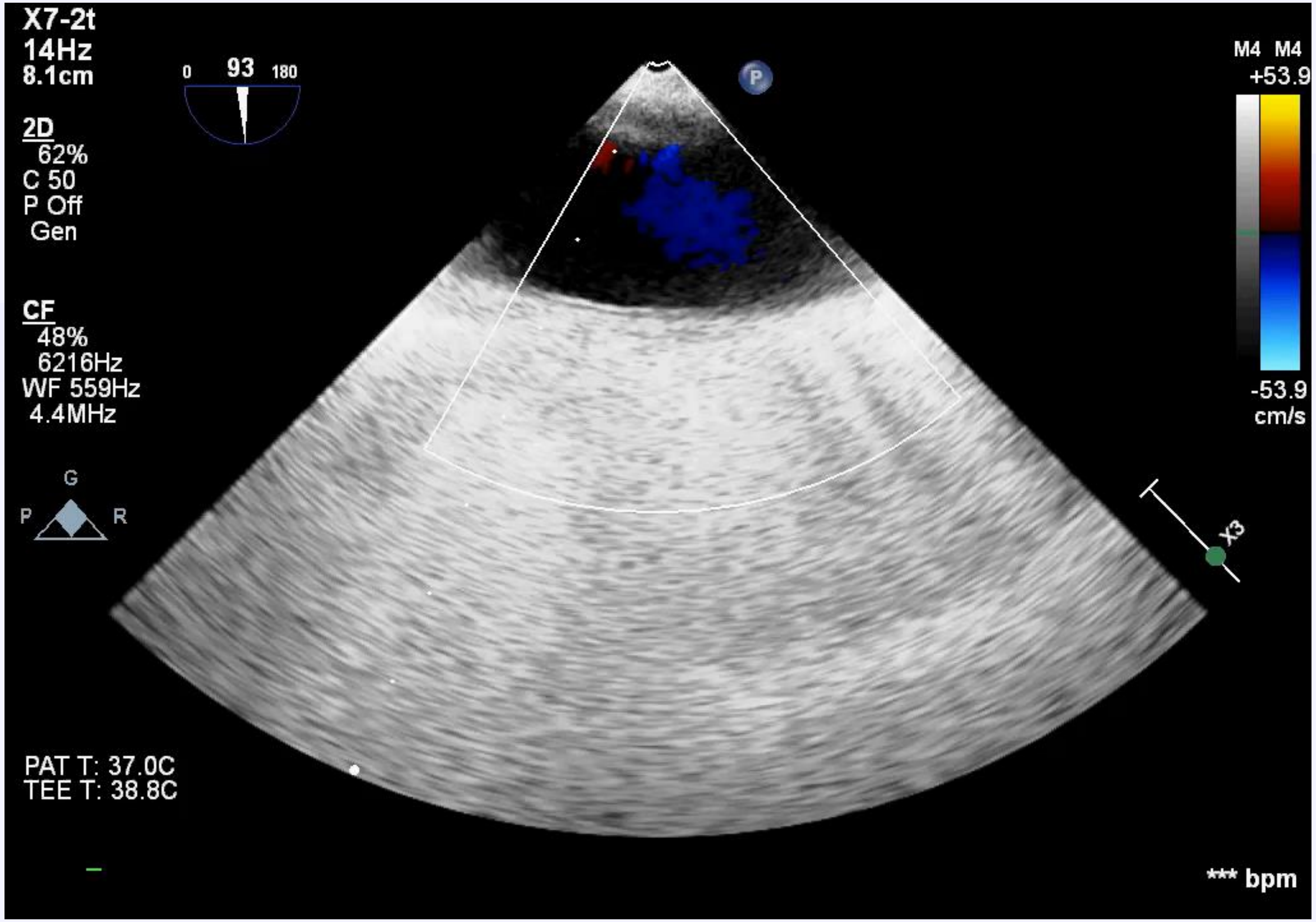


Figure 14 Descending aortic LAX view.



Descending aortic LAX view

Indications of basic and advanced PTEE

- The ASA practice guideline recommended “appropriateness” criteria for performing basic and advanced PTE echocardiography in the context of the condition of the patient, the risks of the procedure, and the specific circumstances.
- Basic PTE echocardiography is recommended when the nature of the planned surgery or the patient’s known or suspected. cardiovascular pathology might result in severe hemodynamic, pulmonary, or neurologic compromise.
- In addition, when available, basic PTE echocardiography should be used when unexplained life-threatening circulatory instability (such as hypotension) persists despite corrective therapy.

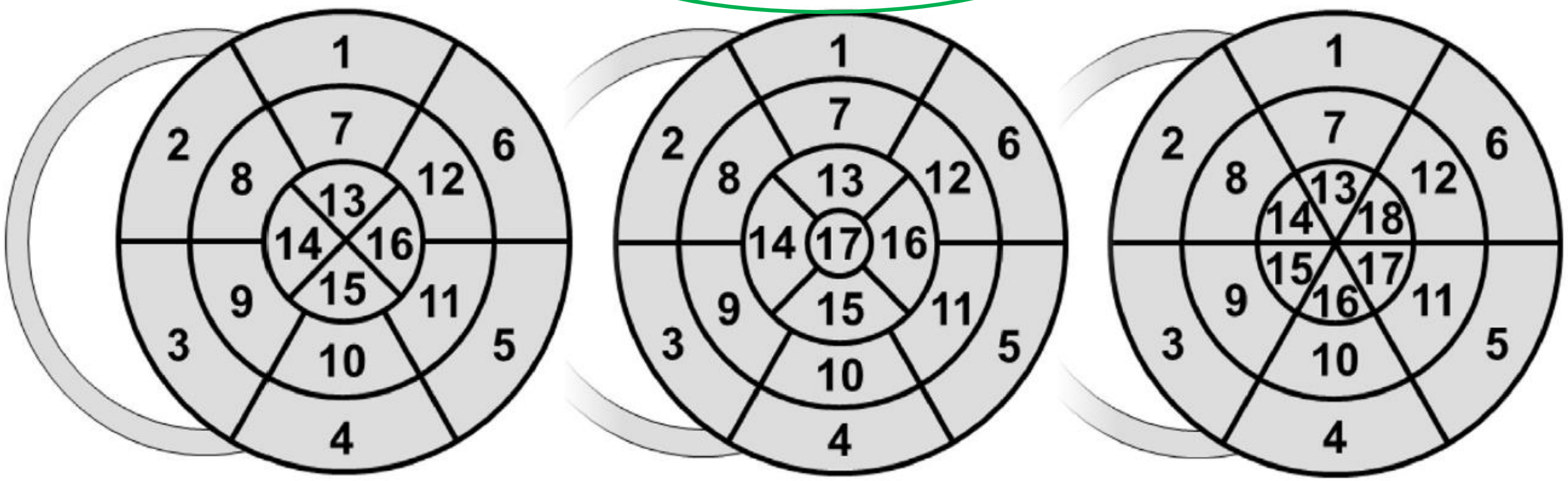
Indications of basic and advanced PTEE Cont.

1. Global and regional LV function
2. RV function
3. Hypovolemia
4. Basic valvular lesions
5. Pulmonary embolism (PE)
6. Neurosurgery: Air embolism
7. Pericardial effusion and thoracic trauma
8. Simple congenital heart disease in adults

1- Global and regional LV function

- Determination of global LV systolic function is one of the most common indications of a basic PTE examination.
- Several techniques for acquiring quantitative measures of global LV systolic function have been described and will be discussed later in our lectures.
- The most common qualitative method is visual assessment (eyeballing) which is fast and popular but is not precise.
- Regional wall motion analysis using 17-segments model can be performed using ME four and two chamber views and ME LAX view.
- The TG midpapillary SAX view provides significant diagnostic information pertaining regional and global ventricular function.

16 segment model, 1995 | 17 segment, 2005 | 18 segment, 2015



all models

1. basal anterior
2. basal anteroseptal
3. basal inferoseptal
4. basal inferior
5. basal inferolateral
6. basal anterolateral
7. mid anterior
8. mid anteroseptal
9. mid inferoseptal
10. mid inferior
11. mid inferolateral
12. mid anterolateral

16 and 17 segment model

13. apical anterior
14. apical septal
15. apical inferior
16. apical lateral

17 segment model only

17. apex

18 segment model only

13. apical anterior
14. apical anteroseptal
15. apical inferoseptal
16. apical inferior
17. apical inferolateral
18. apical anterolateral

Figure 3 Schematic diagram of the different LV segmentation models: 16-segment model (*left*),[36] 17-segment model (*center*),[35] and 18-segment model (*right*). In all diagrams, the outer ring represents the basal segments, the middle ring represents the segments at mid-papillary muscle level, and the inner ring represents the distal level. The anterior insertion of the right ventricular wall into the left ventricle defines the border between the anteroseptal and anterior segments. Starting from this point, the myocardium is subdivided into six equal segments of 60°. The apical myocardium in the 16- and 17-segment models is divided instead into four equal segments of 90°. In the 17-segment model an additional segment (*apical cap*) is added in the center of the bull's-eye. (modified from Voigt *et al*.[24]).

2- RV function

- Several techniques for acquiring quantitative measures of global RV systolic function have been well described.
- Most basic echocardiographers rely on a qualitative, visual estimation of RV systolic function.
- Evaluation of RV function should be routinely performed when assessing hypotensive patients.
- Patients undergoing liver transplant are at increased risk for hypotension secondary to RV failure due to volume shift. This risk is even higher in patients with pre-existing pulmonary hypertension.
- Routine assessment of RV function is indicated in pre and post intraoperative TEE for cardiac surgery.

3- Hypovolemia

- Hypovolemia is the common cause of hemodynamic instability.
- The most common echocardiographic parameters used to diagnose hypovolemia are LV end-diastolic diameter and LV end-diastolic area obtained in the TG midpapillary SAX view. Compared with baseline imaging, these measurements can be used as an indirect measurement of LV preload and can be used to monitor response to fluid therapy.
- More advanced Doppler-derived data can also be obtained to assess acute changes in LV preload and will be discussed in future.
- It is the recommendation of the writing committee that a physician trained in basic PTE echo use the TG midpapillary SAX view to monitor and guide the therapy in a hypovolemic patient.

4- Basic valvular lesions

- Practitioners of basic PTE echocardiography need familiarity with basic valvular lesions. This includes knowledge of color flow Doppler assessment of valvular regurgitation and stenosis for the AoV, MV, TV, and PV.
- It is the recommendation of the writing committee that a physician trained in basic PTE echocardiography use the complete basic examination to qualitatively delineate valvular regurgitation and/or stenosis. However if the valve lesion is considered severe, or if comprehensive quantification is required to ultimately determine the need for intervention, a consultation with an advanced PTE echocardiographers is necessary to confirm the severity and etiology of the valve pathology.

5- Pulmonary embolism (PE)

- Both surgery and trauma pose an increased risk for PE. Thus , anesthesiologists may be responsible for both PE diagnosis and treatment. Although TEE is not the gold standard for PE diagnosis, it compares well with CT when the PE is acute and central. The sensitivity of 2D TEE to diagnose a PE by direct visualization of a thrombus in the PA is actually quit low, but studies using TEE to diagnose hemodynamically significant PEs have shown far better diagnostic sensitivity especially if is performed by a physician with advanced PTE skills.
- A physician with basic PTE skill should be able to identify indirect signs of a PE, such as the presence of clot in right heart and /or signs of RV dysfunction , before the initiation of the treatment.

6- Neurosurgery: Air embolism

- Venous air embolism (VAE) is a common occurrence during craniotomies in the sitting position and has an incident as high as 76%. Although the vast majority of VAE are small with little clinical significance, the sequelae of massive VAE and paradoxical embolism across a PFO can be catastrophic. Thus early detection and treatment are necessary. Basic PTE echocardiography offers the advantage of providing both real-time data and a visual quantification of a VAE. Diagnosis of a shunt may influence the operative team to avoid the sitting position in this patient population.
- It is the recommendation of this committee to use basic PTE examination to identify patients at risk for right –to-left shunt.

7- Pericardial effusion and Thoracic Trauma

- TEE offers a mobile tool that provides a rapid, accurate diagnosis of pericardial effusions, traumatic aortic injuries, and cardiac contusions. Both physical trauma (blunt or penetrating thoracic trauma) and iatrogenic trauma (during procedures) can result in the accumulation of a pericardial effusion (rapid or slow).
- Many publications support the use of TEE for traumatic aortic injury given the safety, portability and high diagnostic accuracy.
- Diagnosis of cardiac contusions may also be difficult and limited. When used in conjunction with TTE, serial ECG, and enzyme assessment, TEE provides valuable diagnostic information.
- Caution should be used with TEE probe manipulation because of potential coexisting esophageal or cervical spine injury.

8- Simple congenital heart disease in adults

- TEE assessment of adult patients with complex congenital heart disease usually requires a meticulous sequential evaluation that requires the knowledge and experience of the advanced PTE echocardiographers.
- A PFO or small secundum ASD in a patient with unexplained hypoxia is easy to recognize but if the question is larger secundum ASD which needs intervention or other type of ASDs like primum or sinus venosus ASD, an advanced PTE echocardiographers should be consulted.
- It is the recommendation of the writing committee that a physician trained in advanced PTE be consultant if patient is suspicious for VSD or other complex congenital heart disease.

Suggested reading materials

1. Basic perioperative TEE examination: ASE/ SCA Consensus statement. JASE May 2013.
2. Guidelines for performing a comprehensive TEE examination: ASE/SCA . JASE September 2013.
3. Guidelines for performing a comprehensive TEE examination in children and all patients with congenital heart disease. JASE February 2019

Questions

Question 1

In which of the following TEE views, interatrial septum can be visualized better?

A. Transgastric SAX view at the level of papillary muscles
B. Mid esophageal two-chamber view
C. Mid esophageal Bicaval view
D. Mid esophageal LAX view

Question 2

In which of the following TEE views, left atrial appendage can be visualized better?

A. ME four-chamber view
B. ME two-chamber view
C. TG midpapillary SAX view
D. ME LAX view

Question 3

Which of the following TEE views can visualize the territories of RCA and LAD coronary arteries better?

A. ME two-chamber view
B. ME LAX view
C. ME four-chamber view
D. ME RV inflow-outflow view

Question 4

In indications of basic PTE echocardiography, which of the following statement IS CORRECT?

A. Visual assessment of the LV (eyeballing), is the most accurate method for estimation of the LVEF.
B. Patients presenting for liver transplant with pulmonary hypertension have additional risk for RV dysfunction.
C. A normal RV function by TEE can exclude pulmonary embolism.
D. In a patient suspicious for PFO and undergoing craniotomy, sitting position is the safest for preventing right to left shunt.

Question 5

In indications of basic PTE echocardiography, all of the following statements are correct EXCEPT

A. TG midpapillary muscle SAX is the best view to assess LV hypovolemia.
B. Diagnosis of cardiac contusion by TEE is often difficult and limited.
C. In assessment of patients suspicious for post MI septal rupture, an advanced skill in TEE is required.
D. Accuracy of diagnosis of traumatic aortic injury by TEE is very low and cardiac MRI should be the first step.

Correct Answers

1- C
2- B
3- A
4- B
5- D


Toronto
Thank you.