Transesophageal Echocardiography Imaging

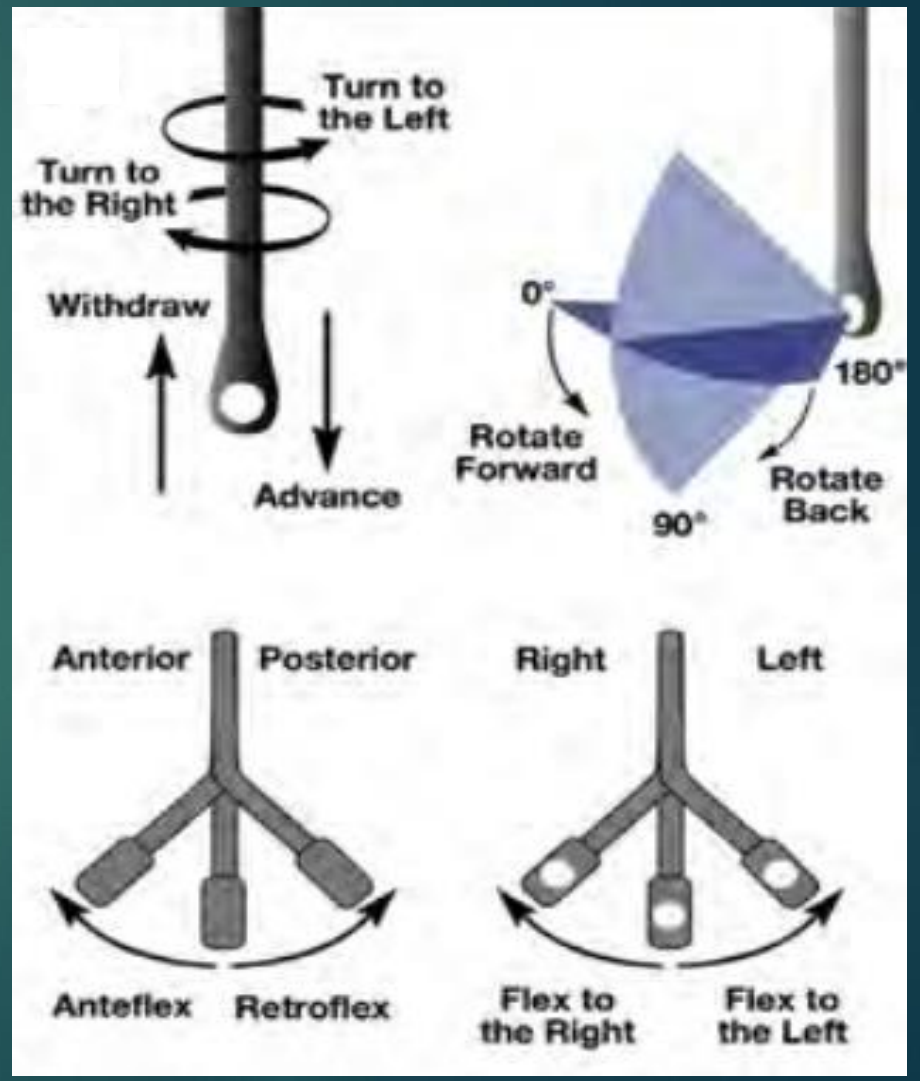
BASIC AND ADVANCED TEE WINDOWS

Objectives

- Describe the use of perioperative TEE (PTE) as an advanced cardiac monitor
- Identify eleven windows used for hemodynamic monitoring and cardiopulmonary instability
- List six advanced uses of advanced perioperative TEE
- Identify additional ultrasound windows used with advanced perioperative TEE

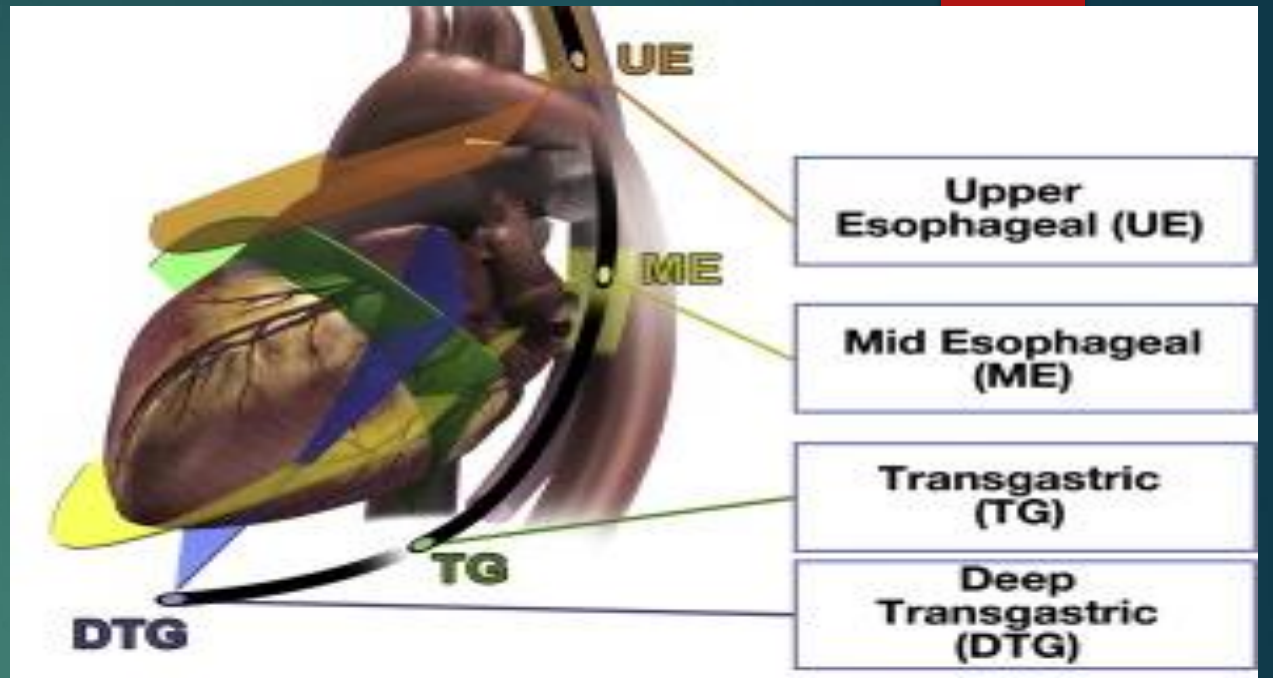
Ultrasound and Transesophageal Echo

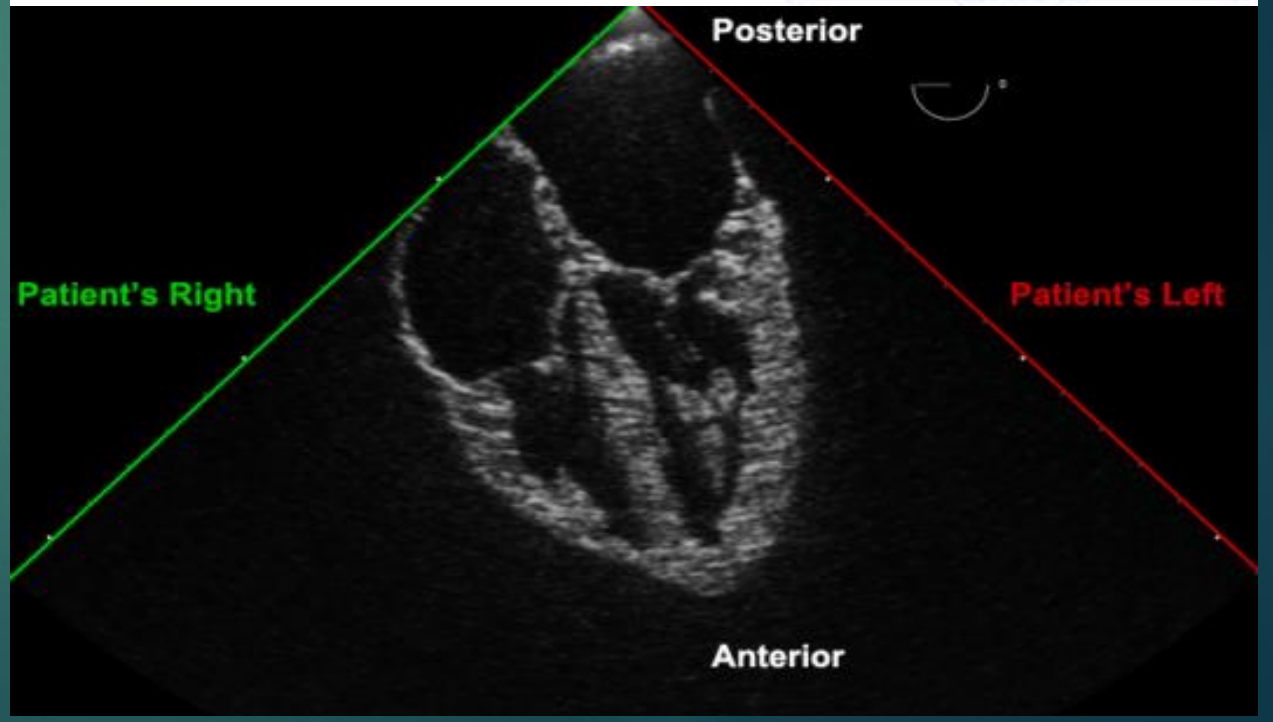
- Probe passes sound waves through a medium or tissue
  - Transducer emits brief pulses of sound by converting electrical energy into sound
  - Returning sound waves are converted into energy which generates an image
- Best image is generated when the beam is perpendicular to the structure
- Ultrasound beam is manipulated by advancing, tilting, anteflex/retroflex of the TEE probe
- Omniplane is used to rotate the ultrasound beam



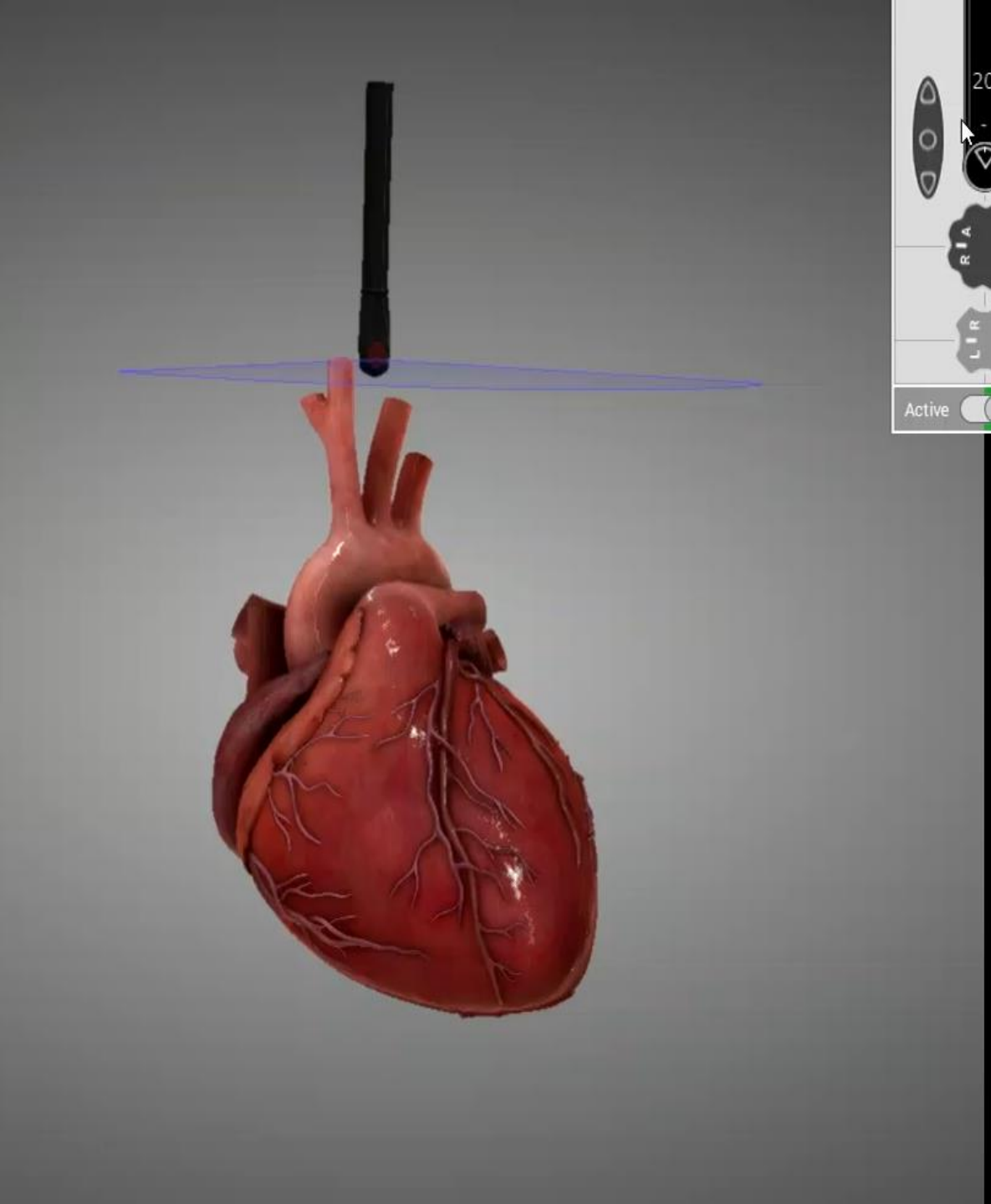
Probe Position and Imaging

- Probe is placed in the esophagus in one of four positions and US beam generated
- Reflected signals are collated to produce an image
- A two-dimensional (2-D) or 3-D image is generated of the structures

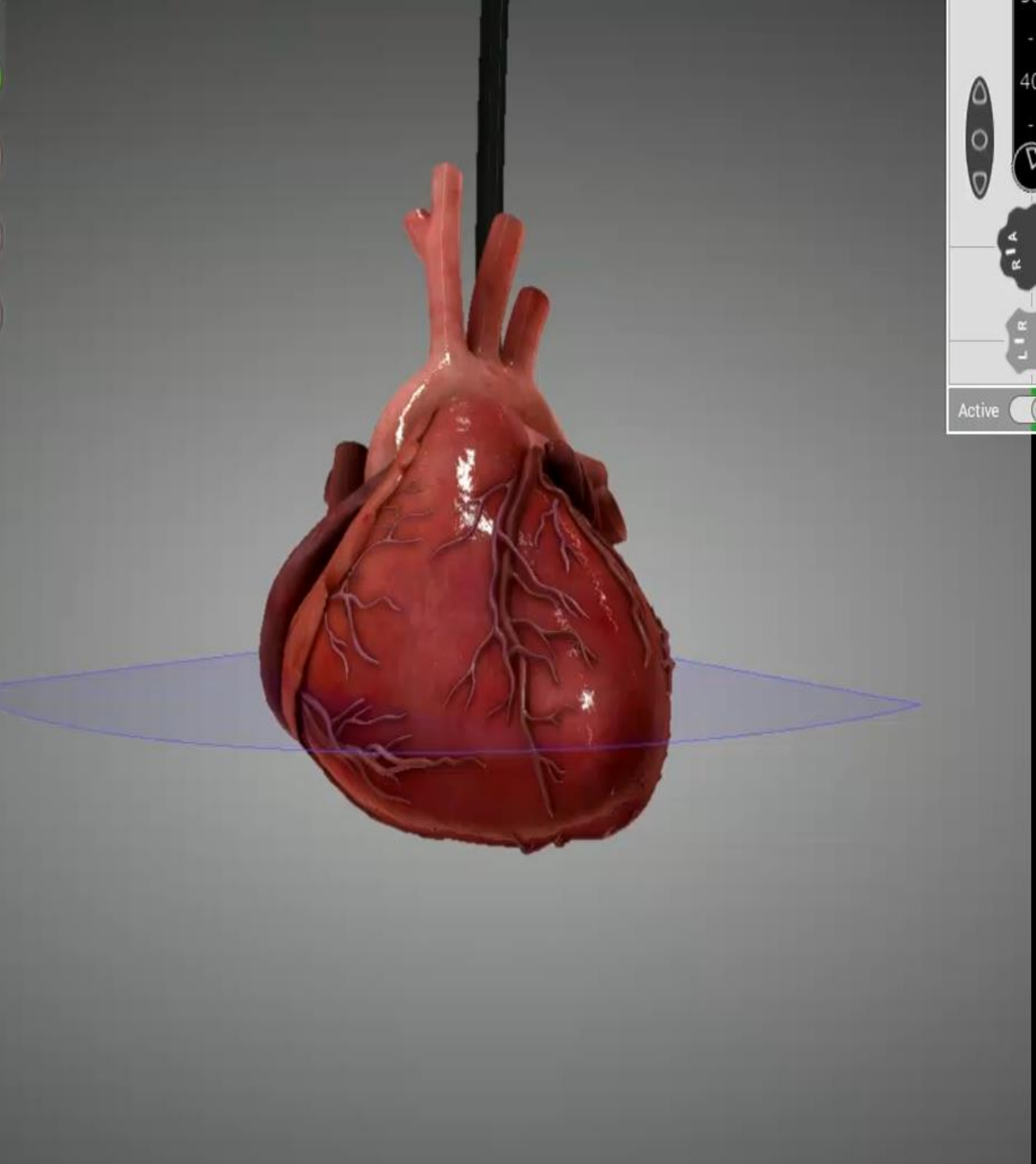


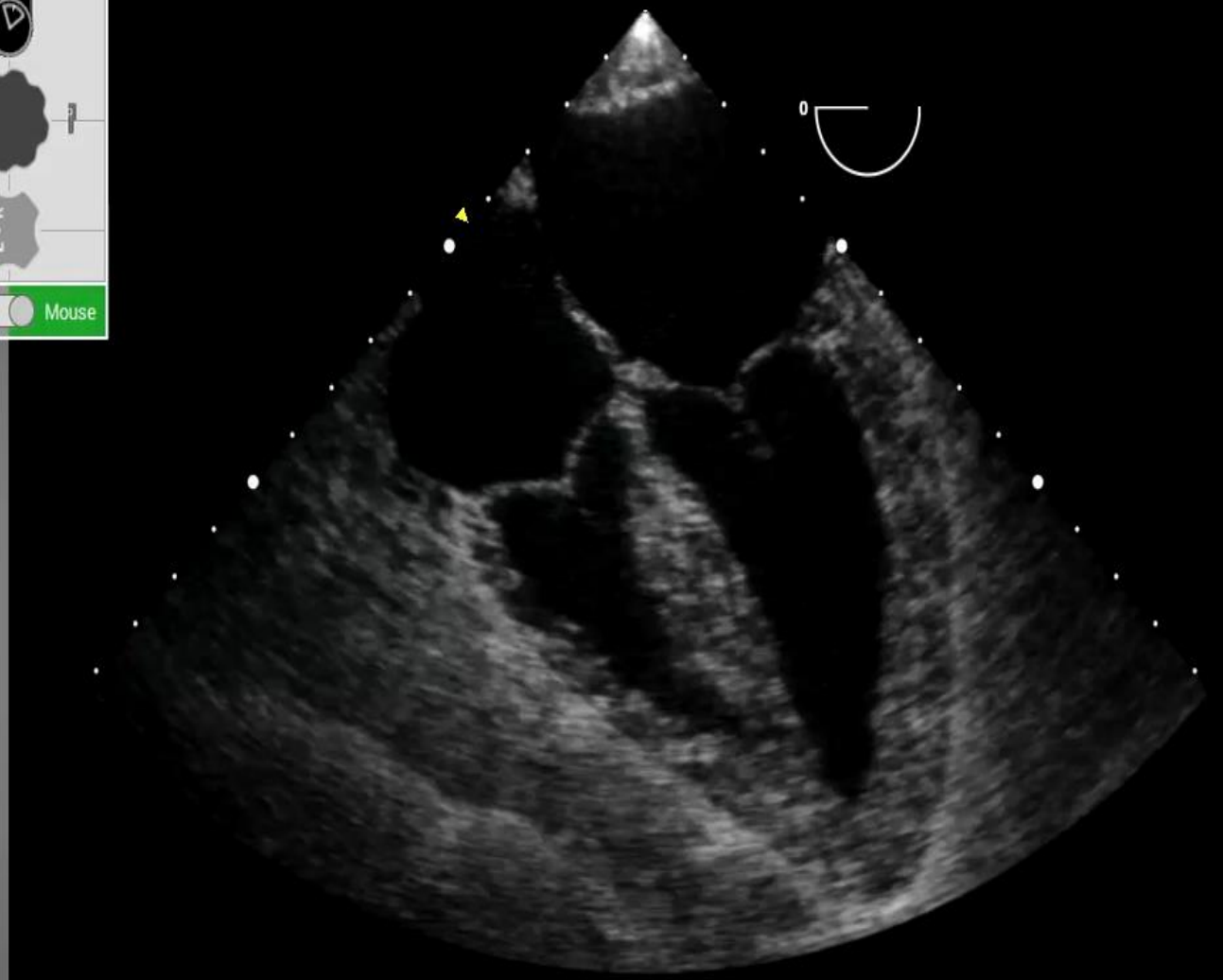


TEE Probe Manipulation and Imaging



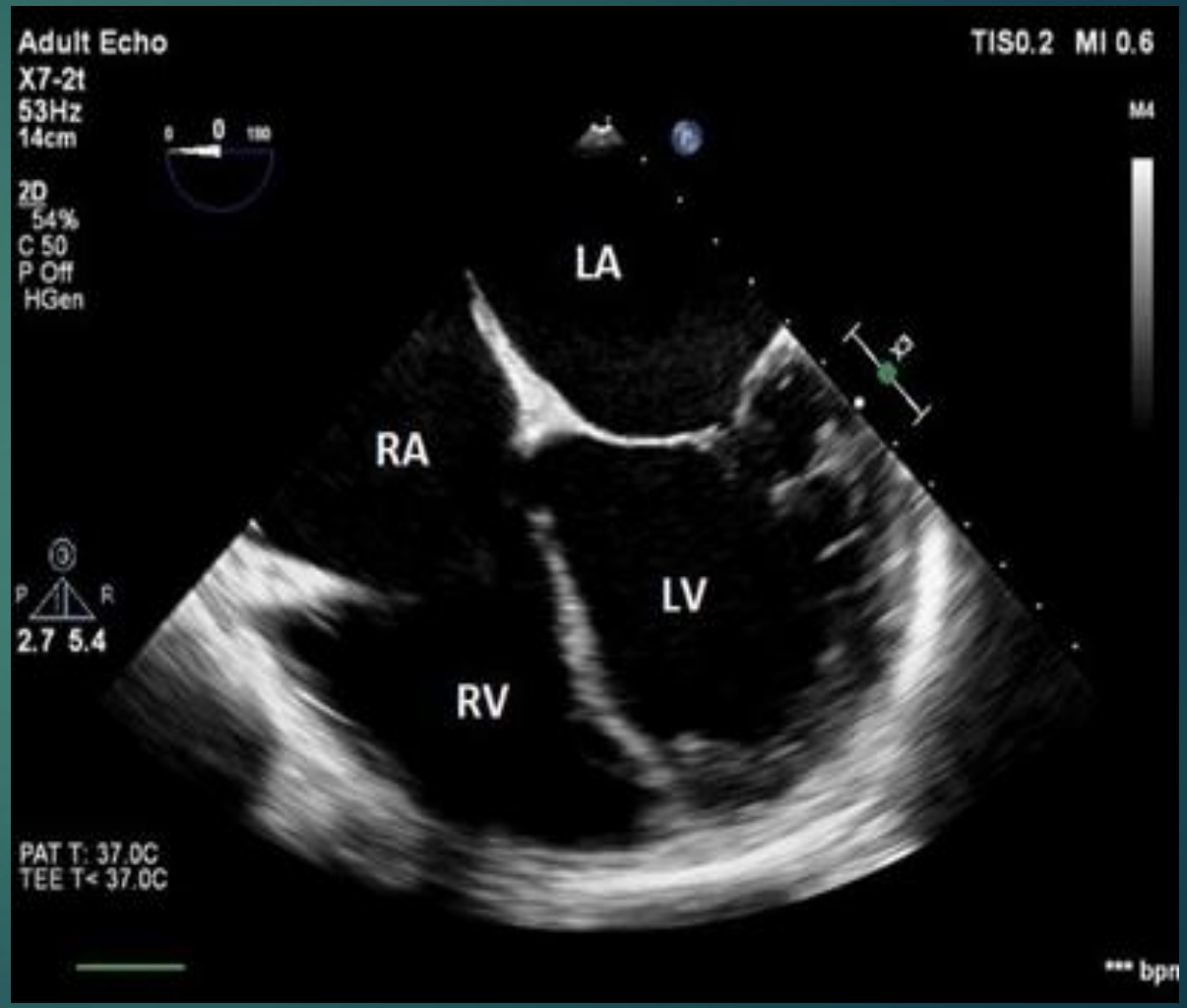
TEE Probe and the ME Four Chamber





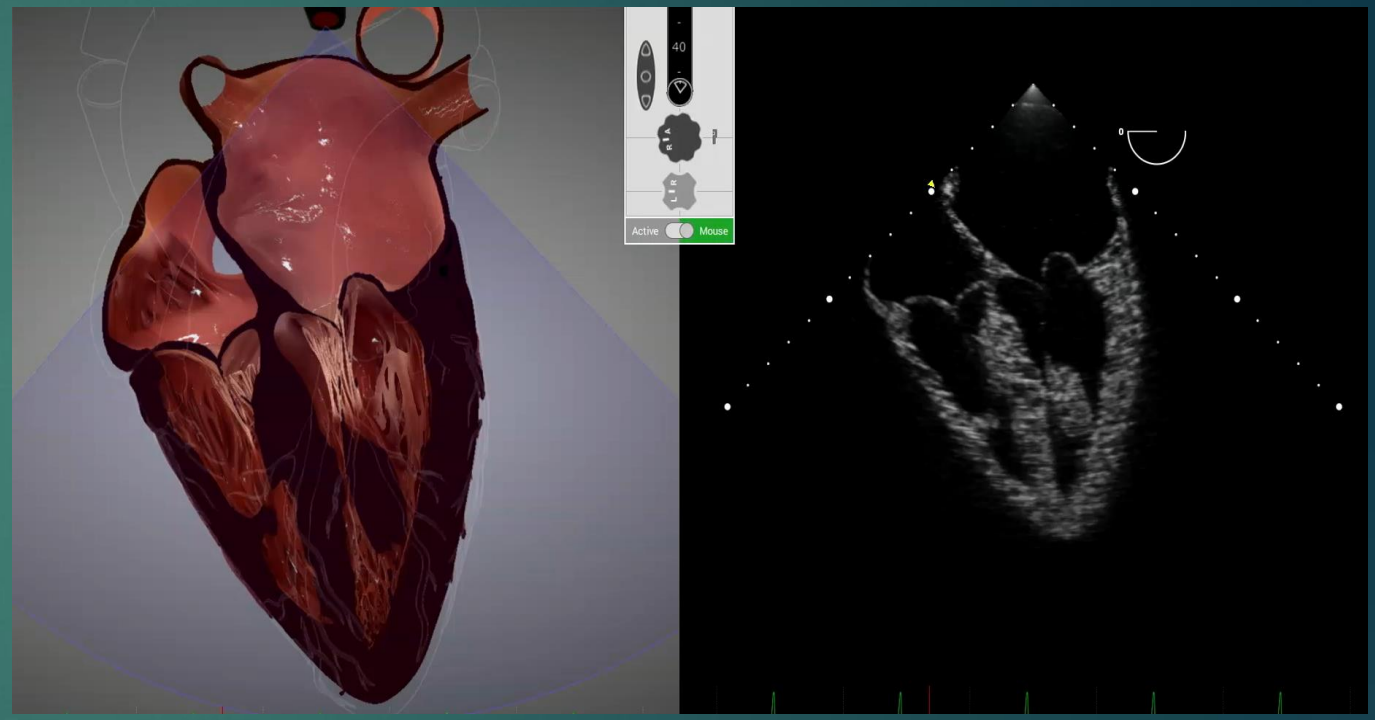
Information Available by Basic TEE

- Left and right ventricular function
- Heart wall motion
- Heart chamber volume
- Vessel integrity
- Valve function and integrity
- Heart tumors
- Pericardial effusion



Utility of Basic Perioperative TEE

- Entire perioperative pathway
  - Preoperative for EF and murmur
  - Intraoperative hemodynamic monitoring
  - Postop for effusion and volume status
- Subspecialties already utilizing TEE
  - Liver transplant
  - Vascular/neuroanesthesia
  - Intensive care/ER
  - Cardiac anesthesia
  - Obstetrics



Absolute and Relative Contraindications to TEE

Absolute

- Perforated viscous
- Esophageal stricture/tumor
- Esophageal perforation/laceration
- Esophageal diverticulum
- Active upper GI bleed

Relative

- Radiation to neck/mediastinum
- GI surgery/upper GI bleed
- Barrett's esophagus
- Dysphagia/hiatal hernia
- Neck immobility/cervical disc disease
- Symptomatic hiatal hernia
- Esophageal varices
- Coagulopathy

Hahn et al. Guidelines for performing a comprehensive transesophageal echocardiographic examination: Recommendations from the American Society of Echocardiography and Society of Cardiovascular Anesthesiologists. J Am Soc Echocardiogr 2013; 26: 921-964

Probe/Equipment Considerations

Probe Insertion

- Bite block used
- Generous lubrication
- Jaw thrust may be utilized
- Insert to 30-35 cm
- Contraindications include esophageal and gastric pathology

Intraoperative Complications

- Esophageal perforation (<0.01%)
- Gastrointestinal/pharyngeal hemorrhage (0.03-0.8%)
- Dental damage (0.03%)
- Oral/lip damage (most common, 13% with cardiology)
- Airway compromise (0.03%)
- Distraction from patient
- Misinterpretation

Basic vs. Comprehensive TEE

Basic Perioperative TEE

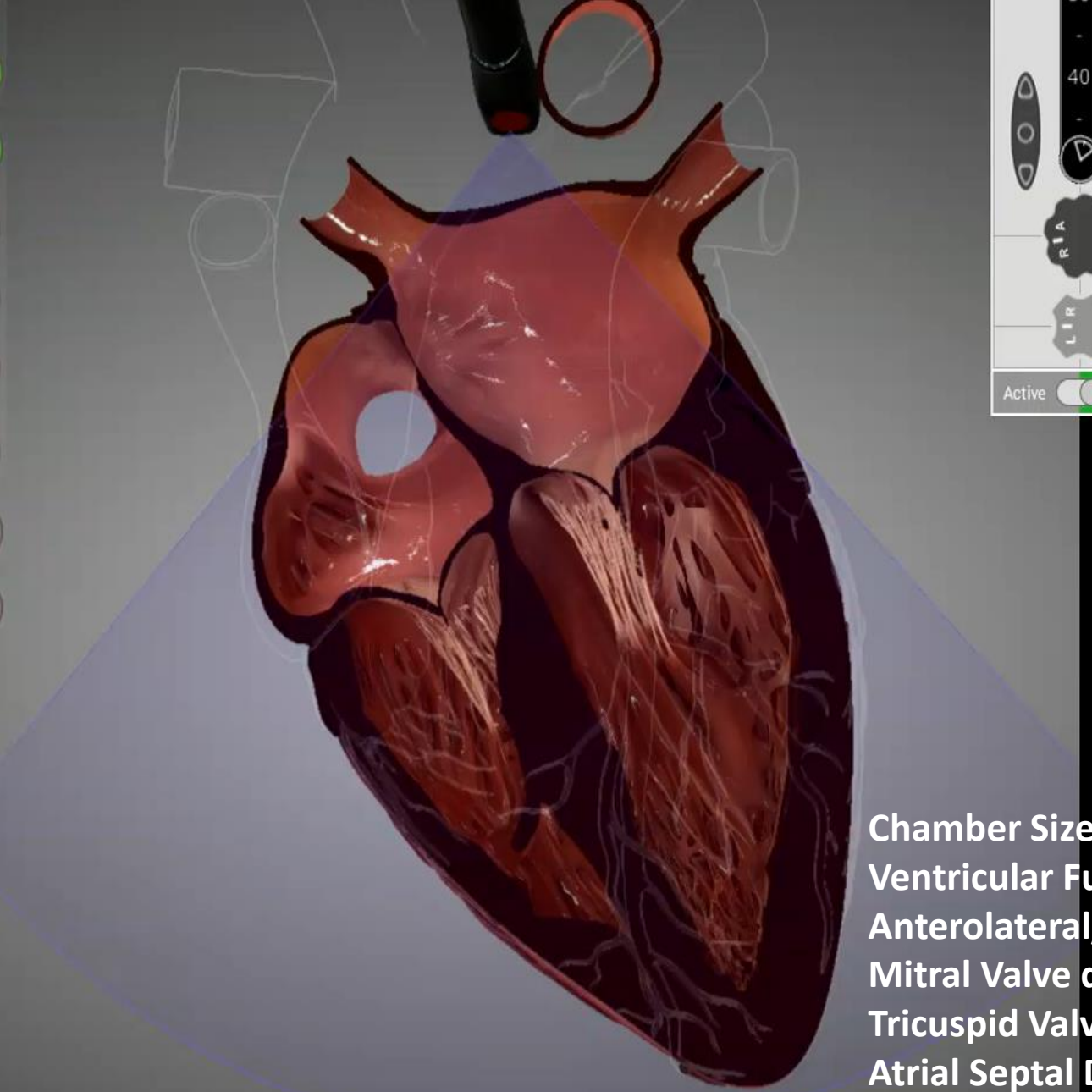
- Use of TEE as advanced hemodynamic monitor using 11 views
- Diagnose general etiology of cardiopulmonary instability
  - Gross valve pathology
  - Biventricular function
  - Filling status
  - Simple congenital defects
  - Obstructive pathology
- If complex pathology present refer to advanced echocardiographer

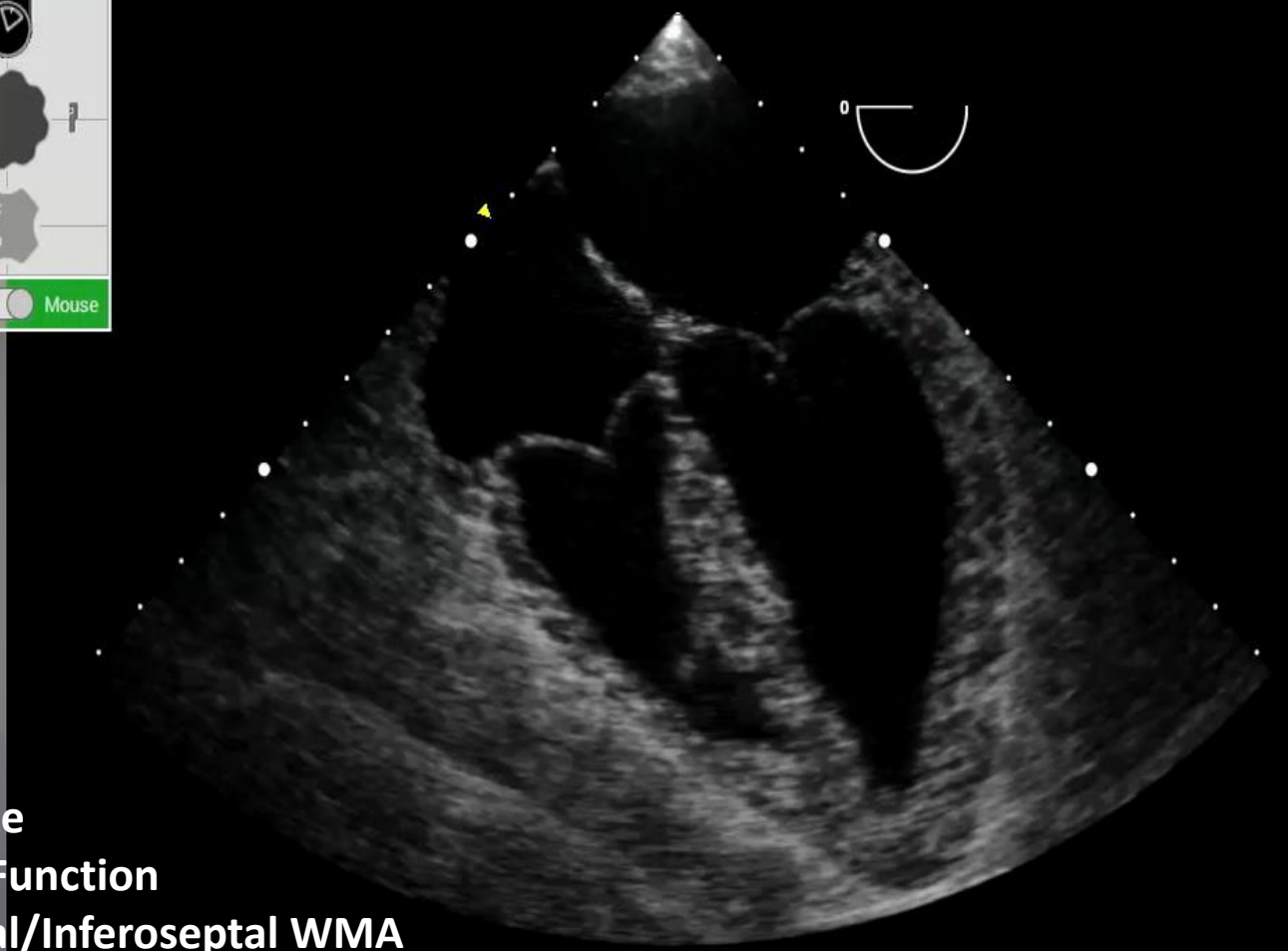
Comprehensive TEE

- Use of TEE as advanced hemodynamic monitor using up to 28 views
- Diagnose specific pathology and sources of cardiopulmonary instability
- Use of Doppler for assessment of degree of valve stenosis, regurgitation and area
- Use of Doppler to assess surgical intervention
- Use or knowledge of 3D imaging

Reeves et al-Basic perioperative transesophageal echocardiography examination: A consensus statement of the American Society of Echocardiography and the Society of Cardiovascular Anesthesiologists. *J Am Soc Echocardiogr*, 2013, 26:443-456
Hahn RT et al: Guidelines for performing a comprehensive transesophageal echocardiographic examination: Recommendations for the American Society of Echocardiography and the Society of Cardiovascular Anesthesiologists. *J Am Soc Echocardiogr* 26:931-964, 2013

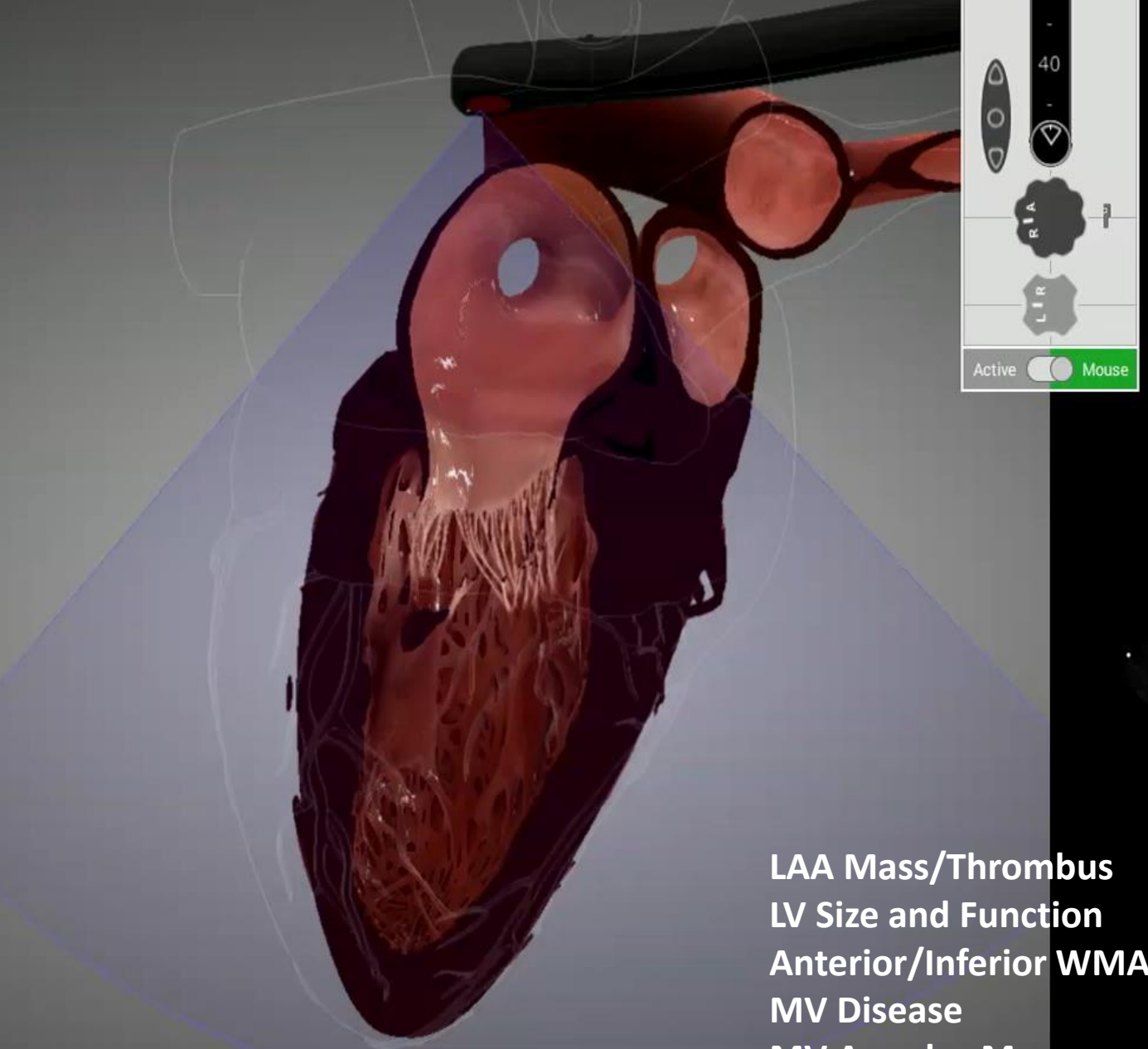
ME Four Chamber

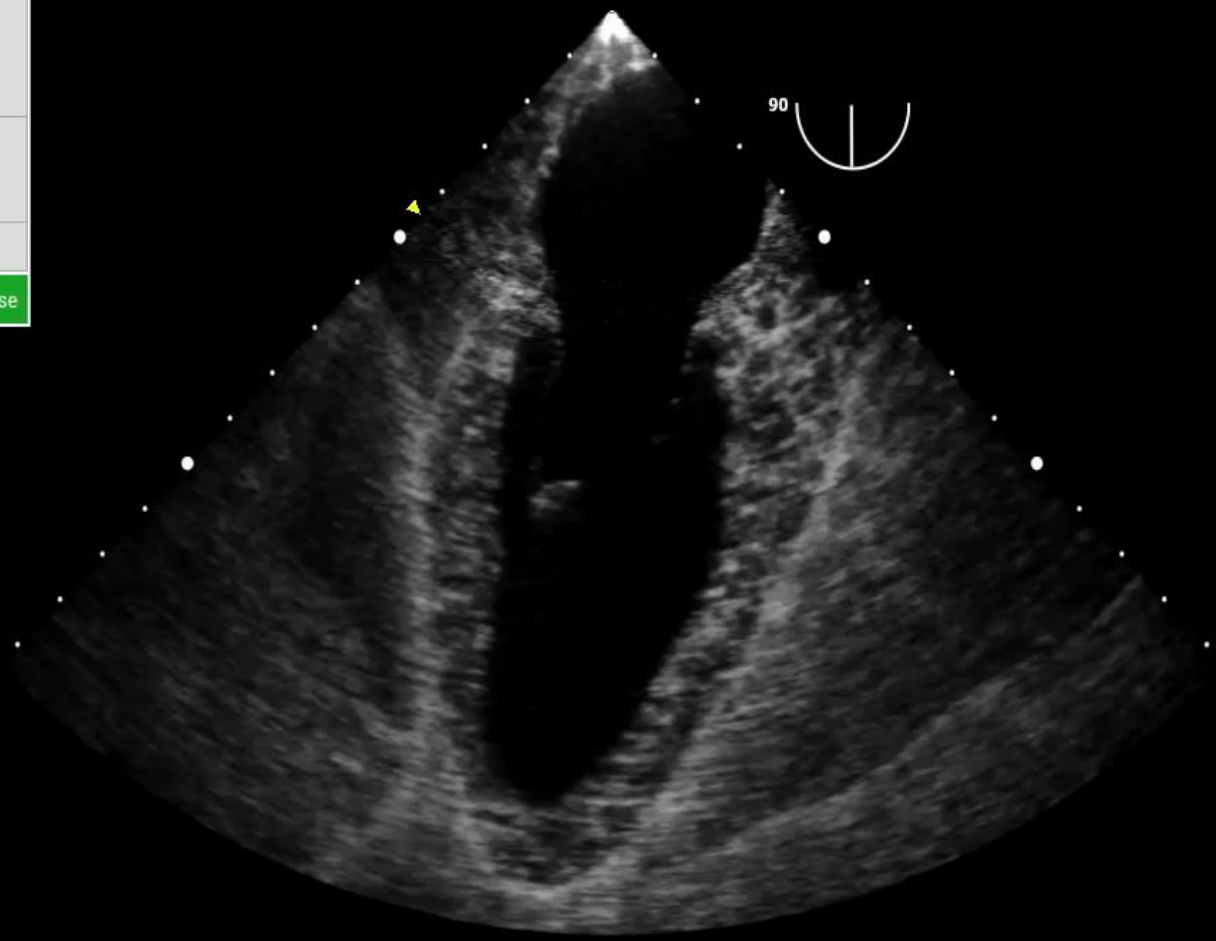




Chamber Size
Ventricular Function
Anterolateral/Inferoseptal WMA
Mitral Valve disease
Tricuspid Valve Disease
Atrial Septal Defect
Pericardial Effusion

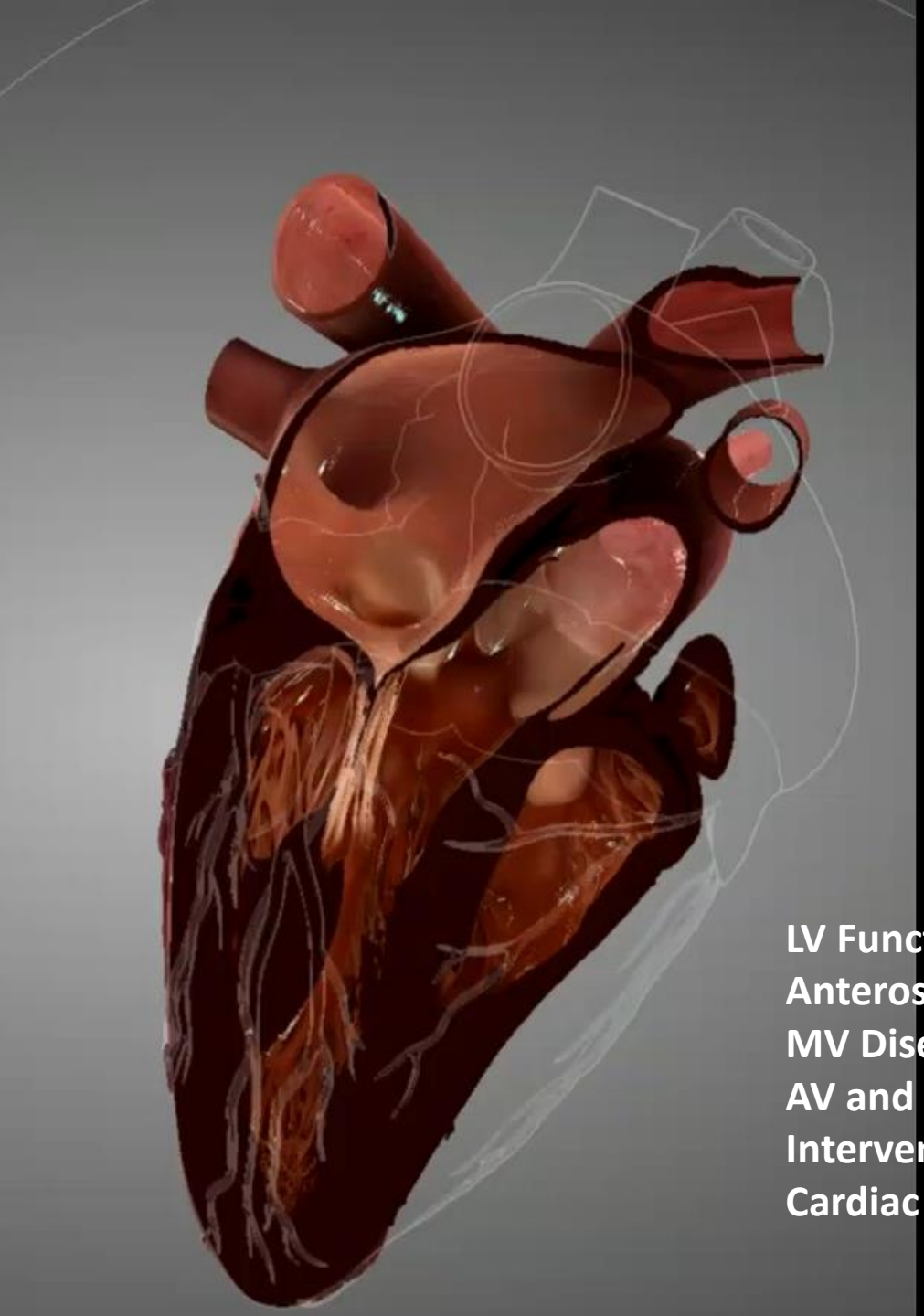
ME Two Chamber

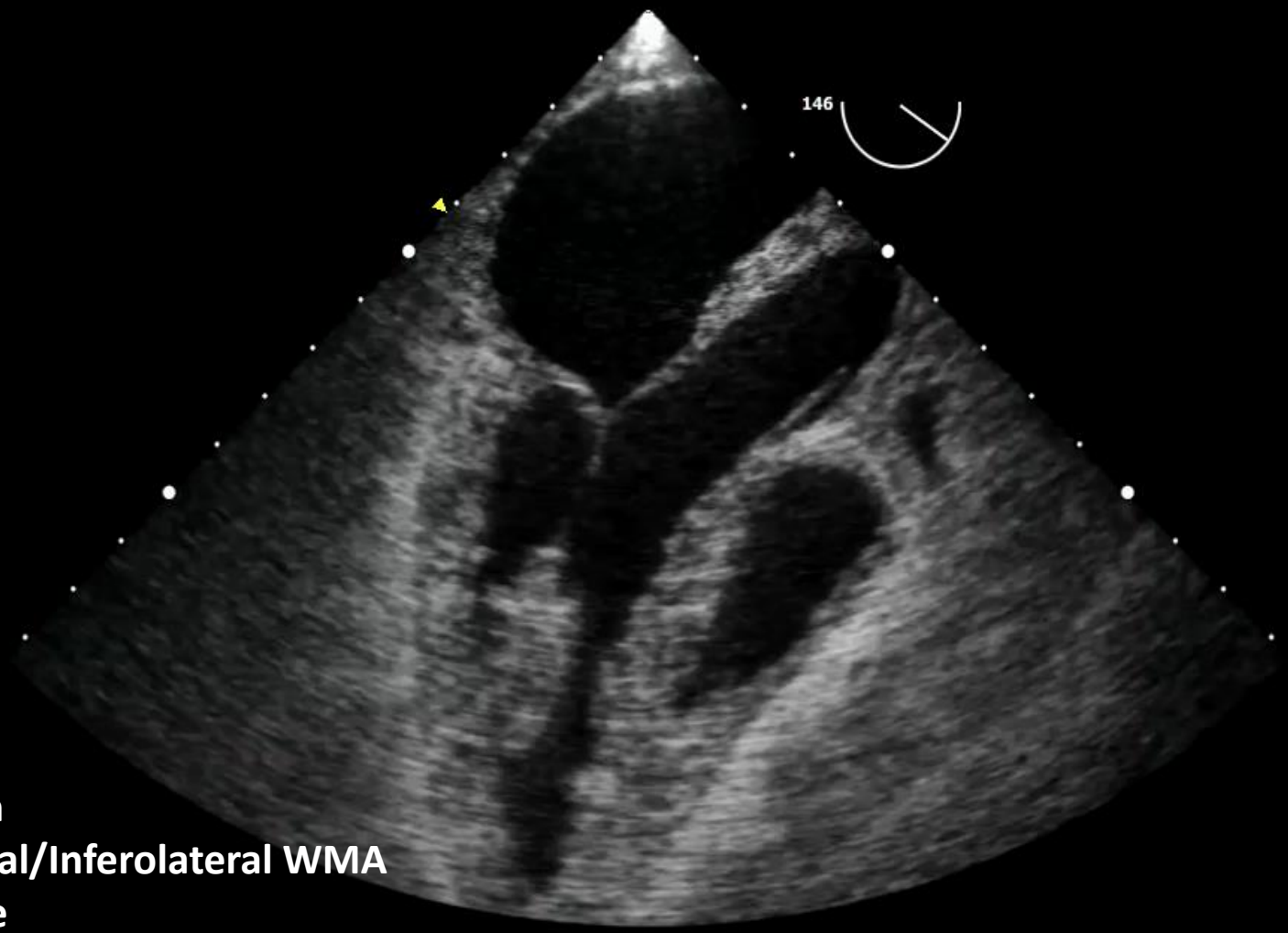




LAA Mass/Thrombus
LV Size and Function
Anterior/Inferior WMA
MV Disease
MV Annulus Measurement

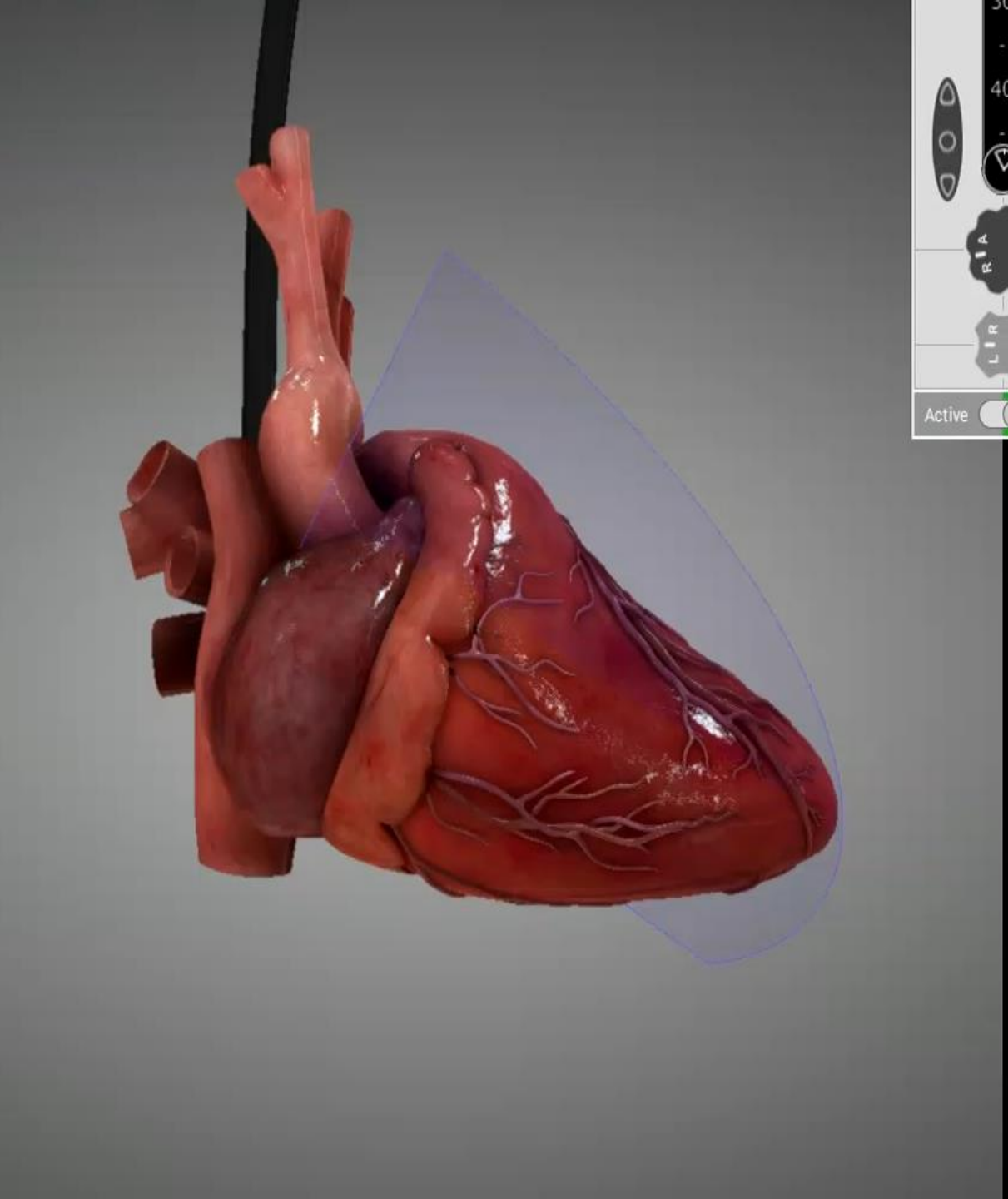
ME Long Axis



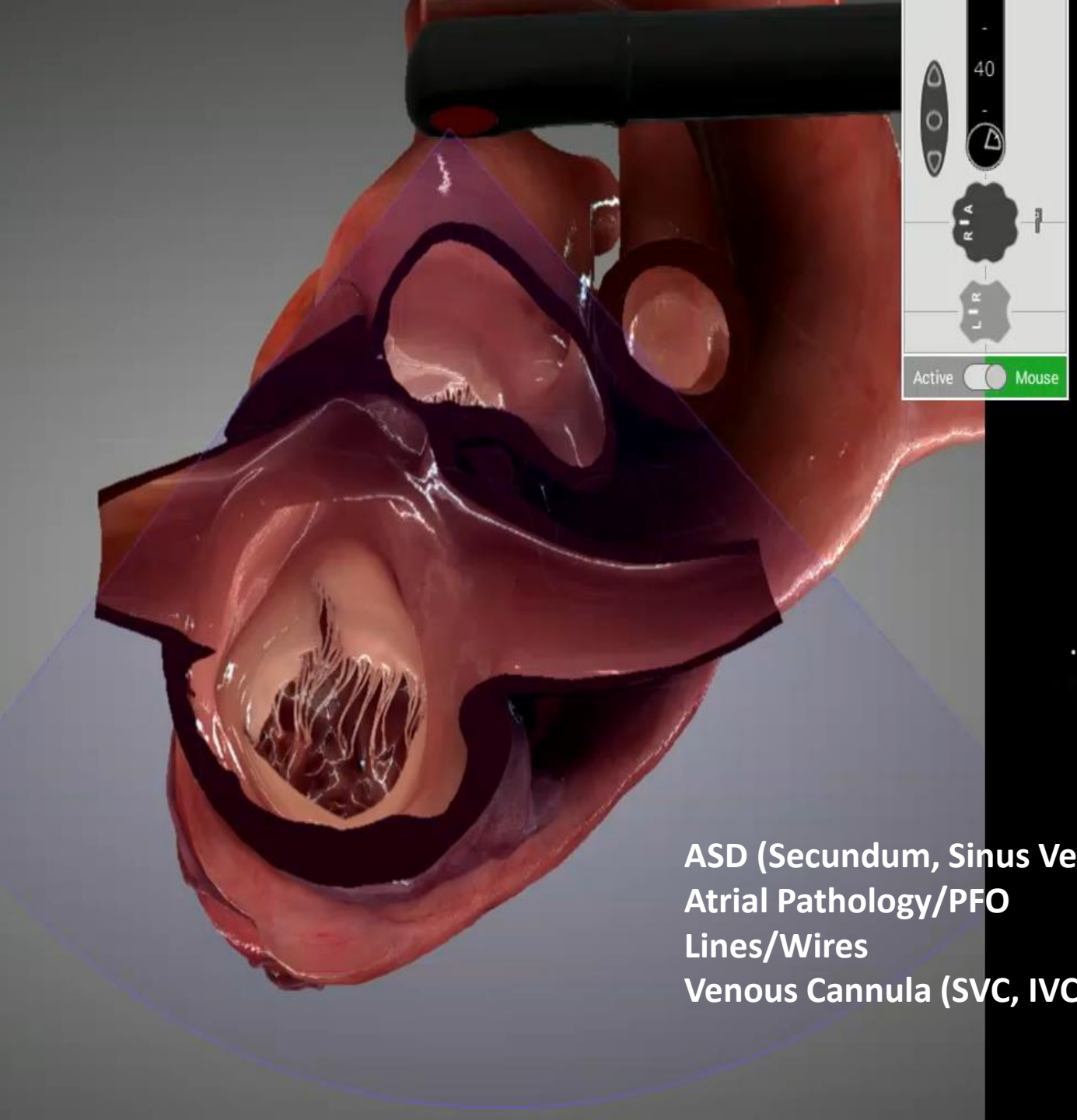


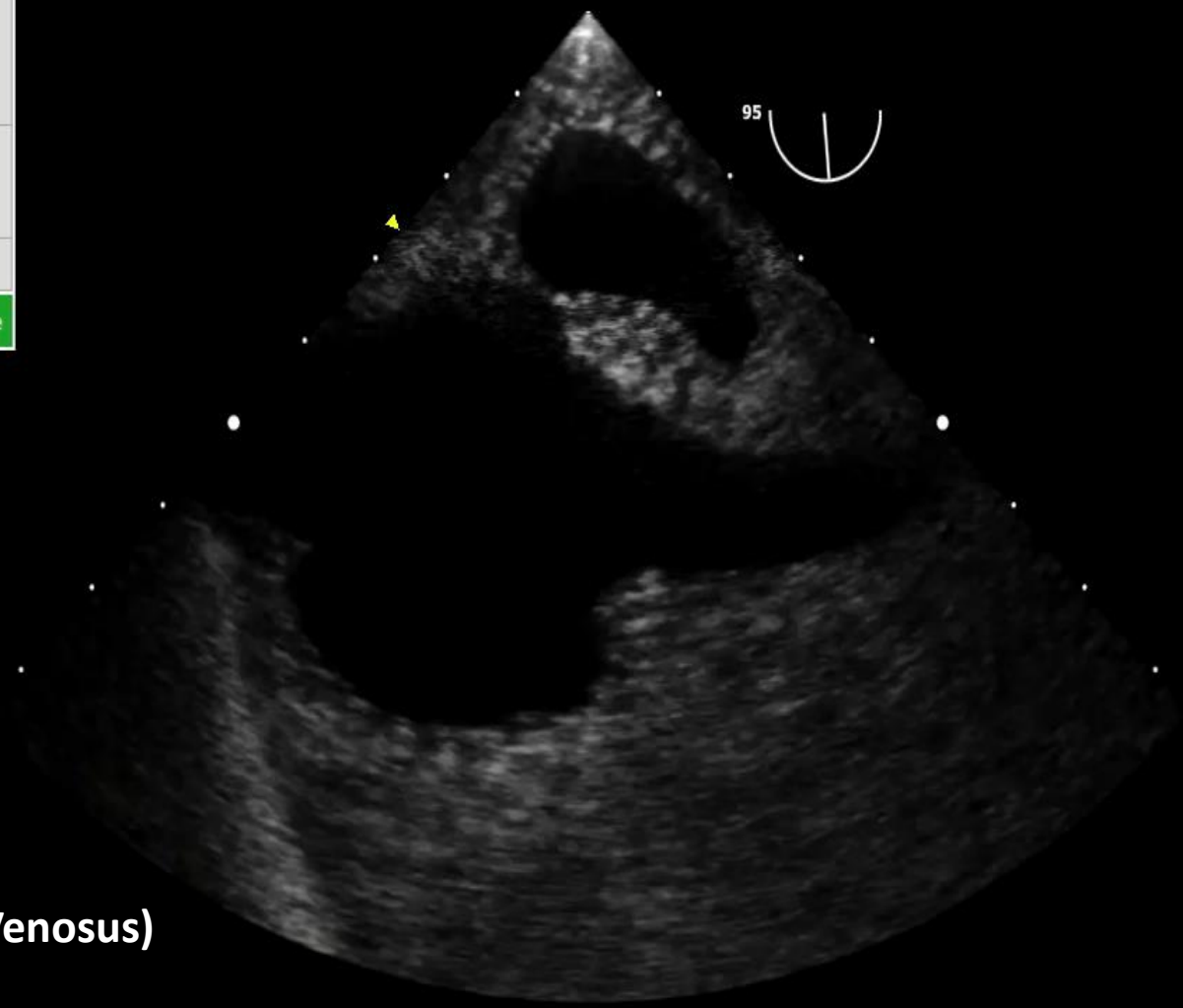
LV Function
Anteroseptal/Inferolateral WMA
MV Disease
AV and Aortic Root Disease
Interventricular Septum Pathology
Cardiac Air

Role of Omniplane in Window Acquisition



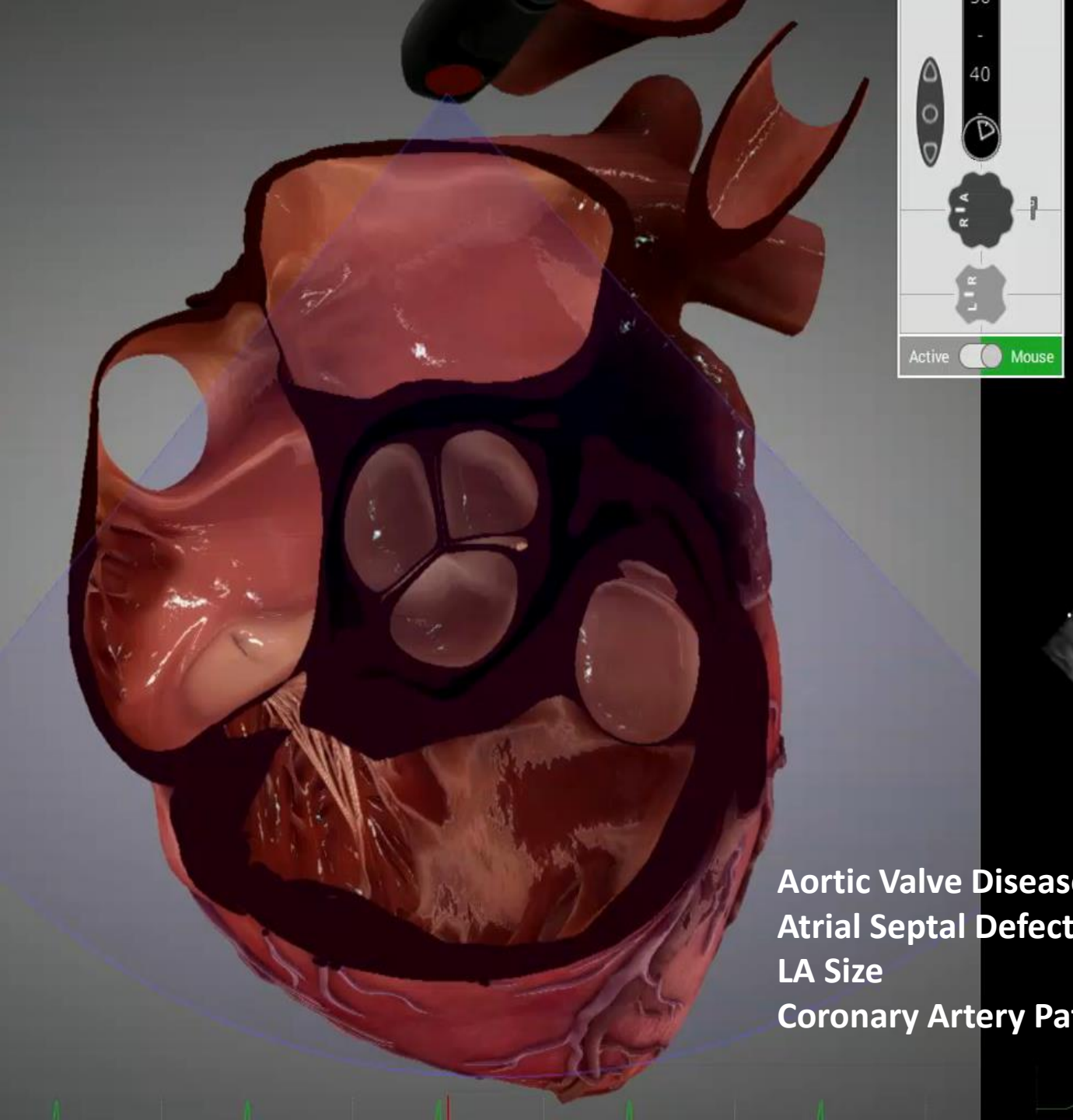
ME Bicaval

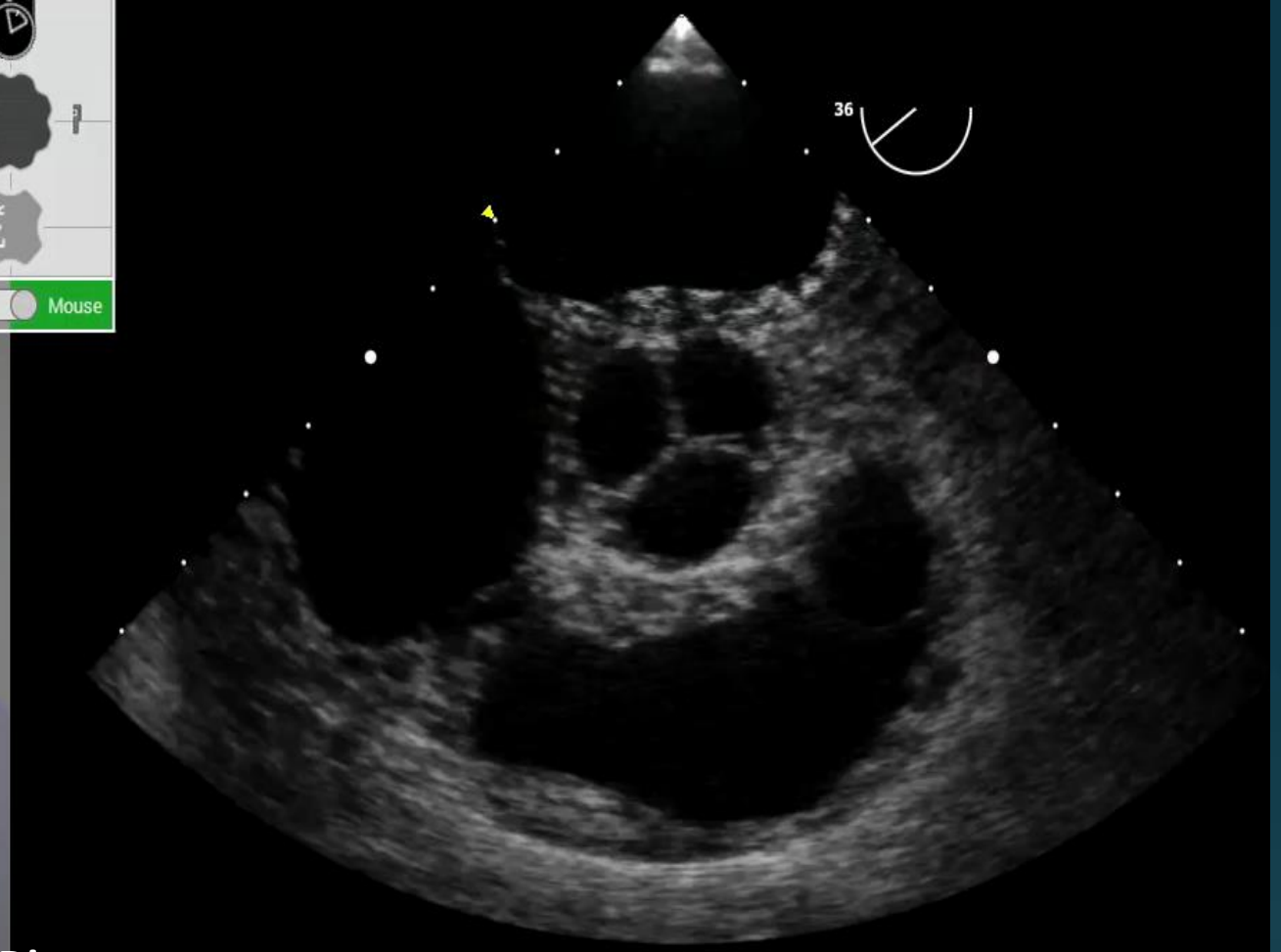




ASD (Secundum, Sinus Venosus)
Atrial Pathology/PFO
Lines/Wires
Venous Cannula (SVC, IVC)

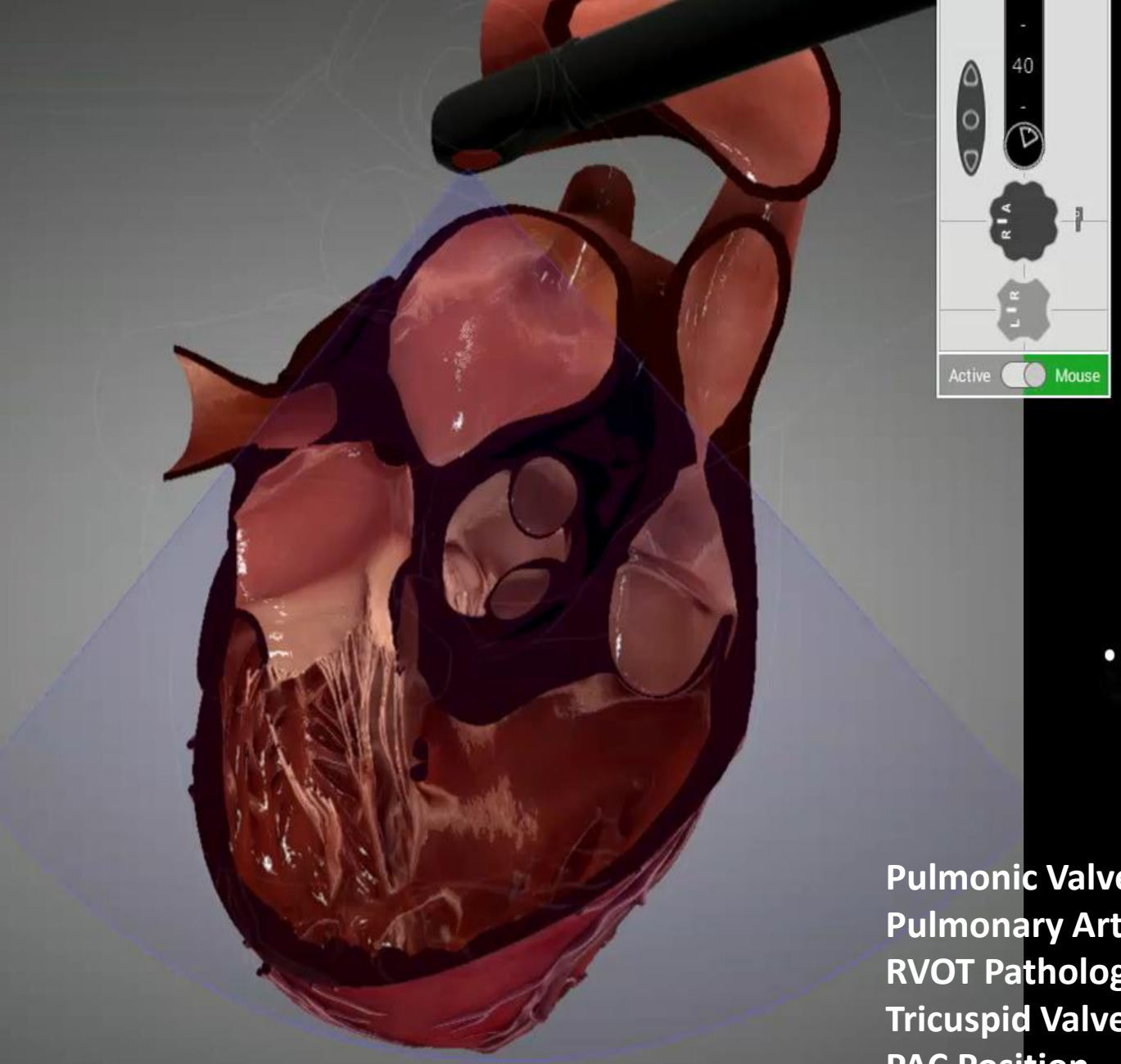
ME Aortic Valve Short Axis

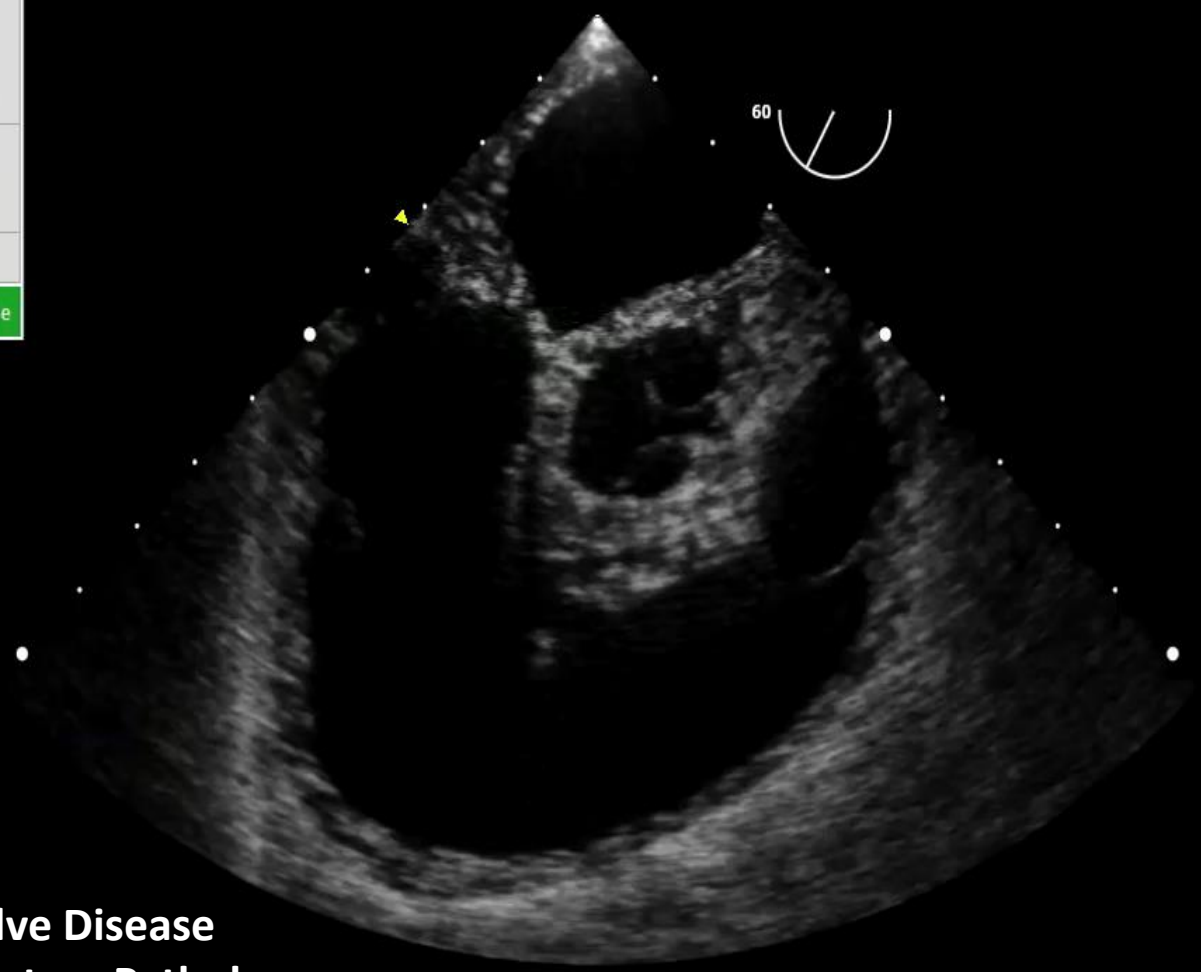




Aortic Valve Disease
Atrial Septal Defect (ASD secundum)
LA Size
Coronary Artery Pathology?

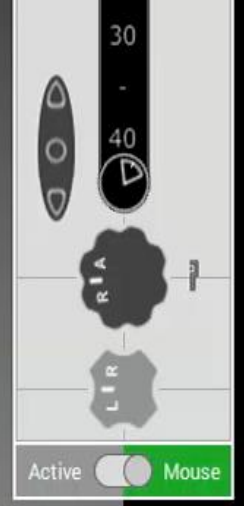
ME Right Ventricular-IF-OF

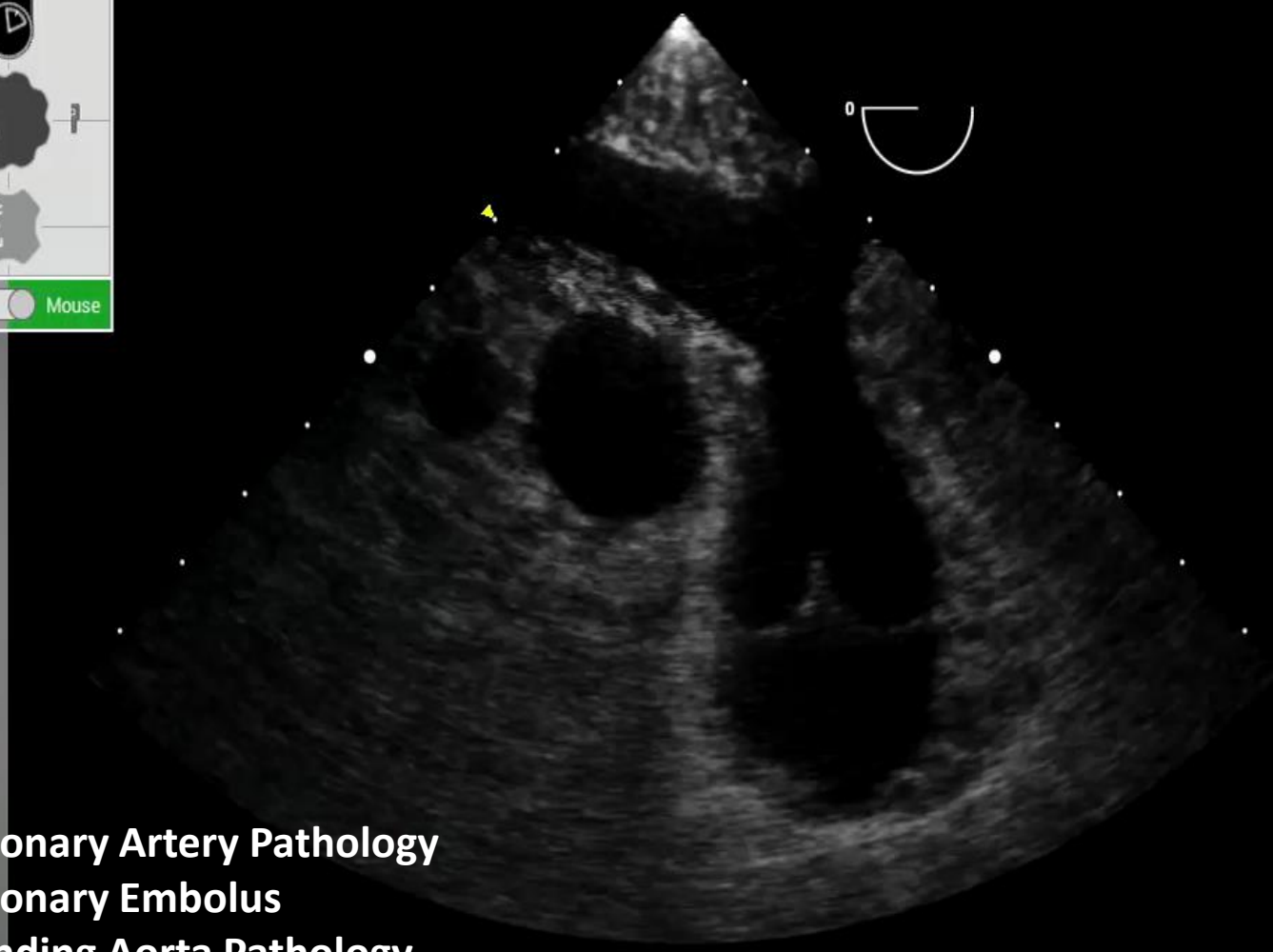




Pulmonic Valve Disease
Pulmonary Artery Pathology
RVOT Pathology
Tricuspid Valve Disease
PAC Position

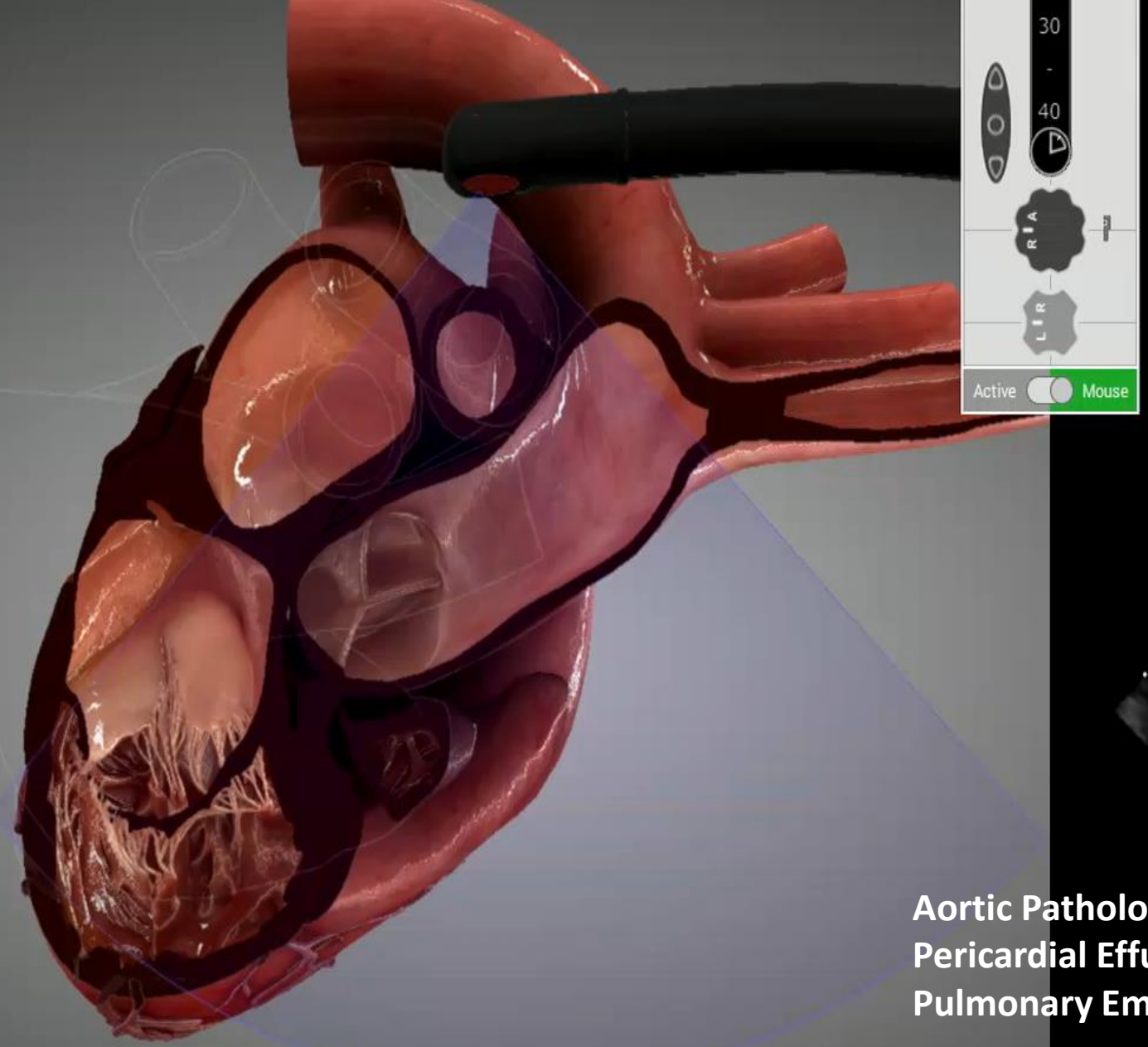
ME Ascending Aorta SAX

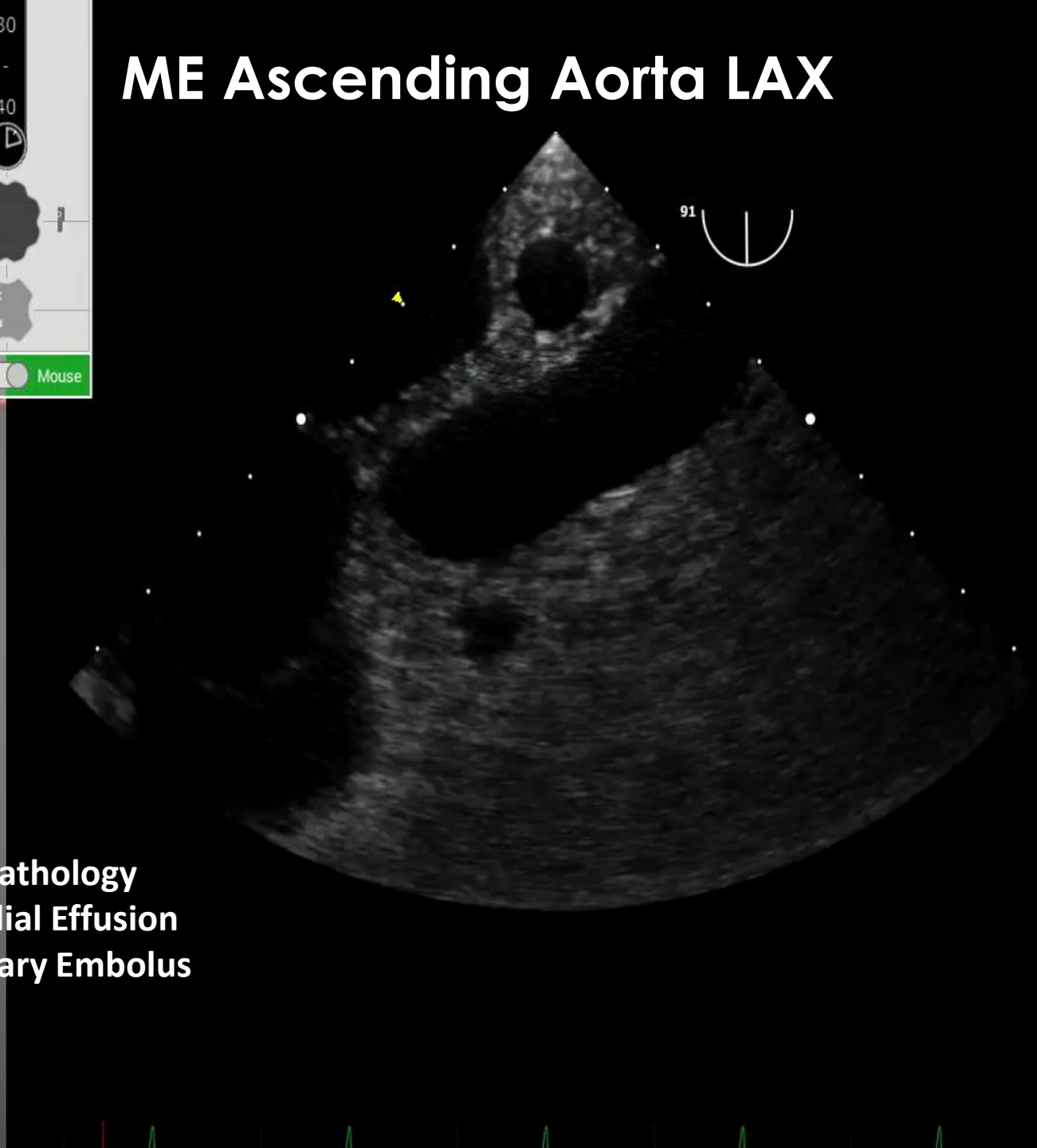




Pulmonary Artery Pathology
Pulmonary Embolus
Ascending Aorta Pathology
Patent Ductus Arteriosus (PDA)
PAC Position
Atherosclerotic Disease

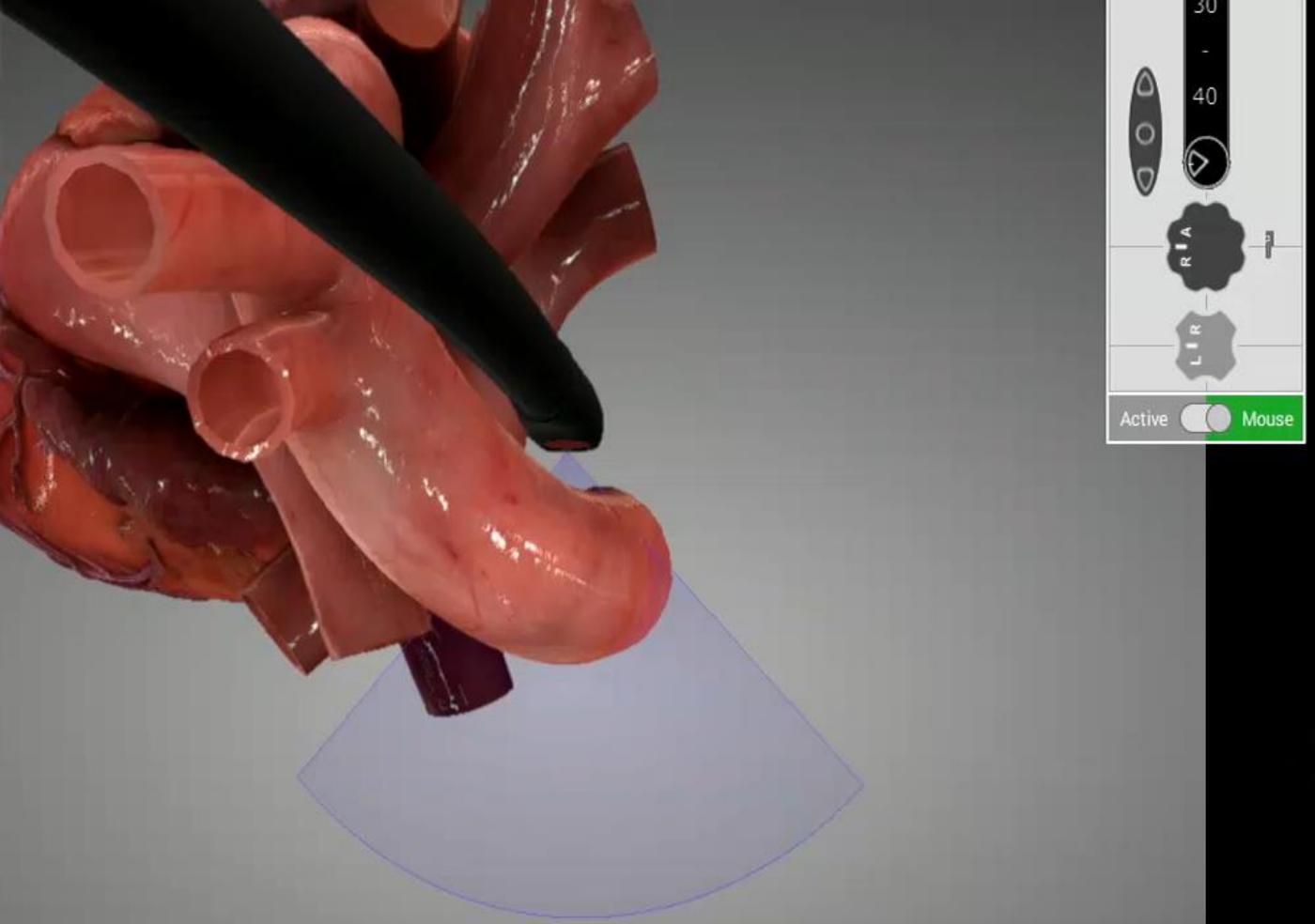
ME Ascending Aorta LAX





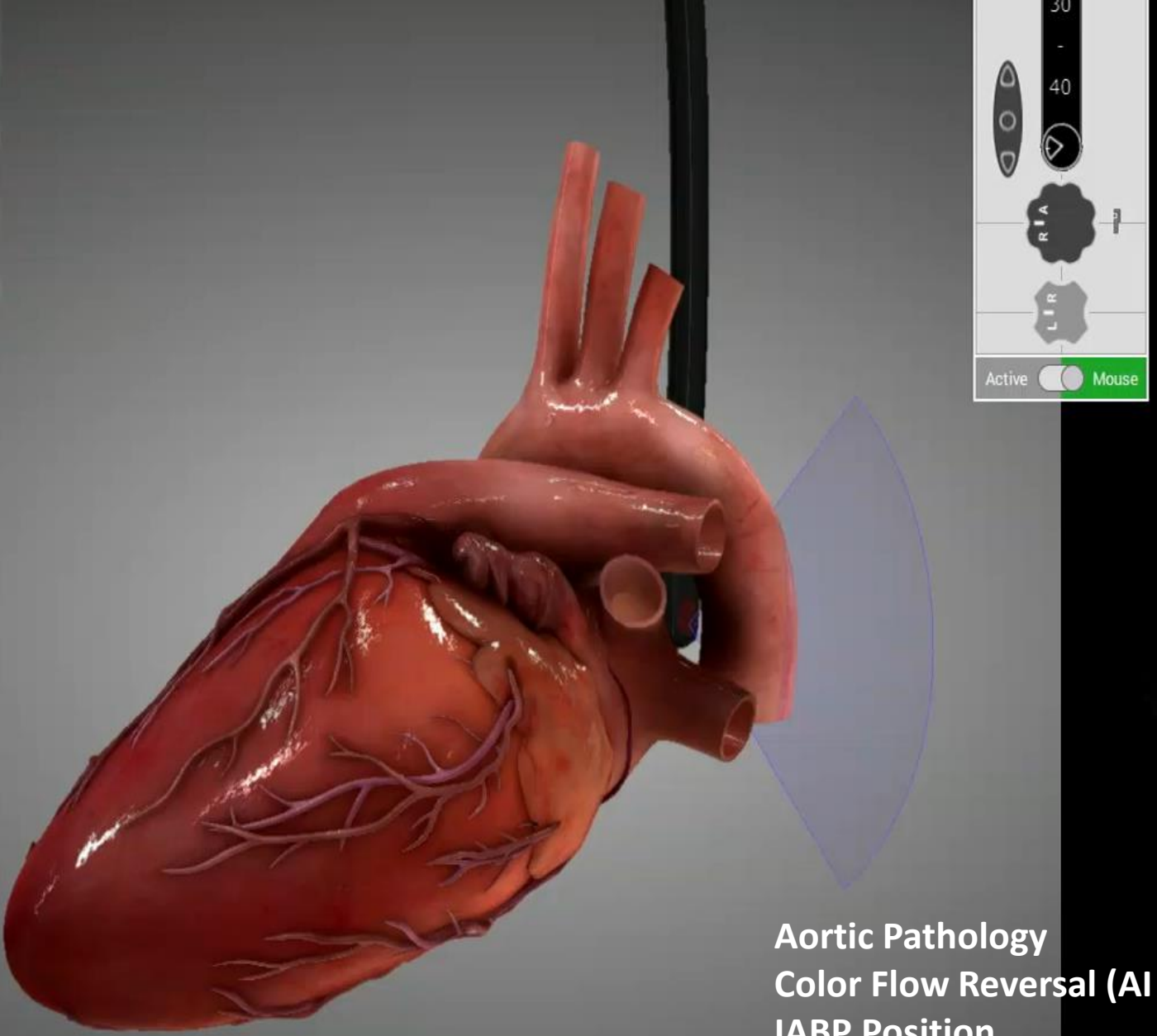
Aortic Pathology
Pericardial Effusion
Pulmonary Embolus

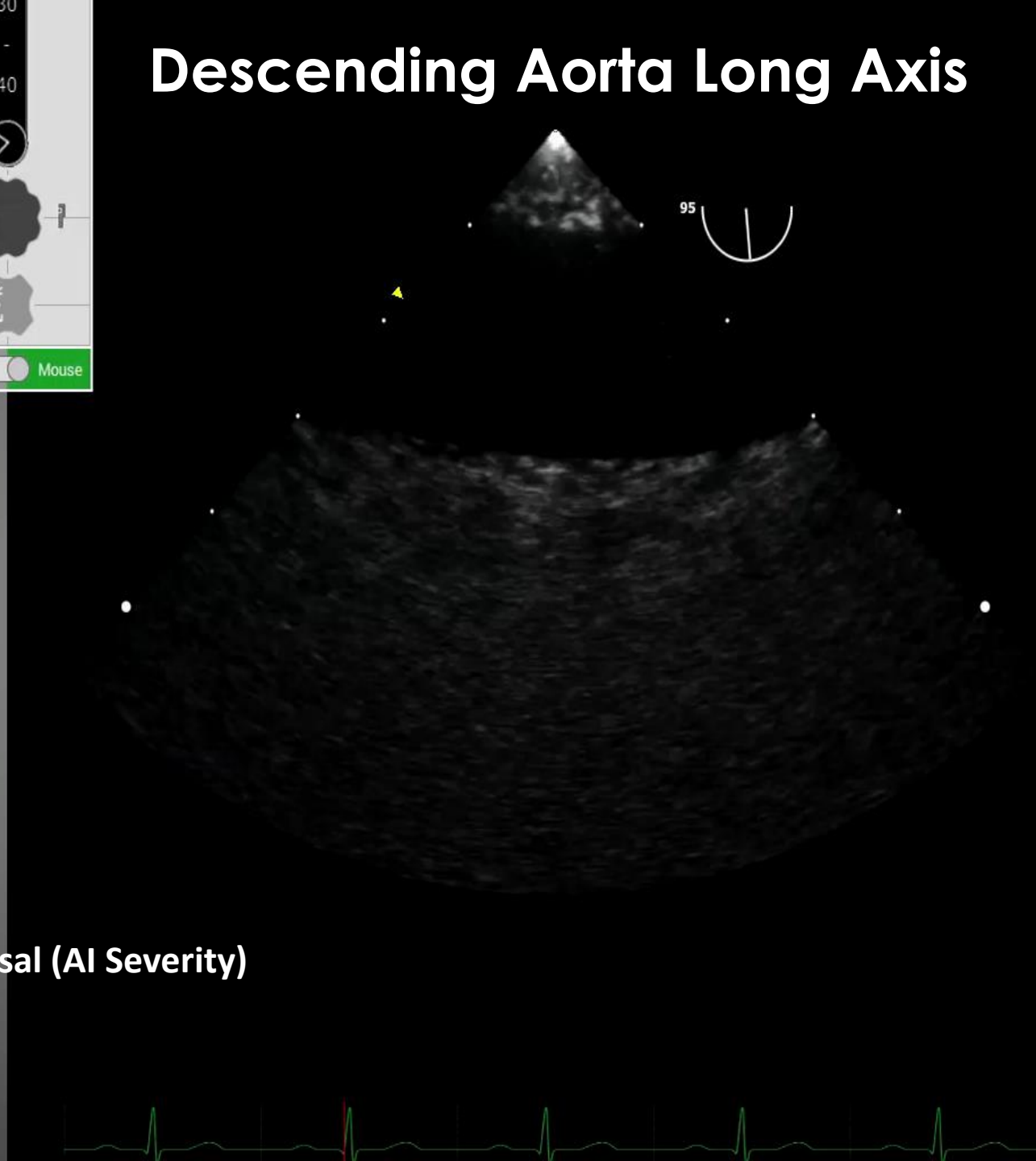
Descending Aorta Short Axis



Aortic Pathology
Color Flow Reversal (AI Severity)
IABP/Percutaneous Bypass wire Position
Left Pleural Effusion
Atherosclerotic Disease

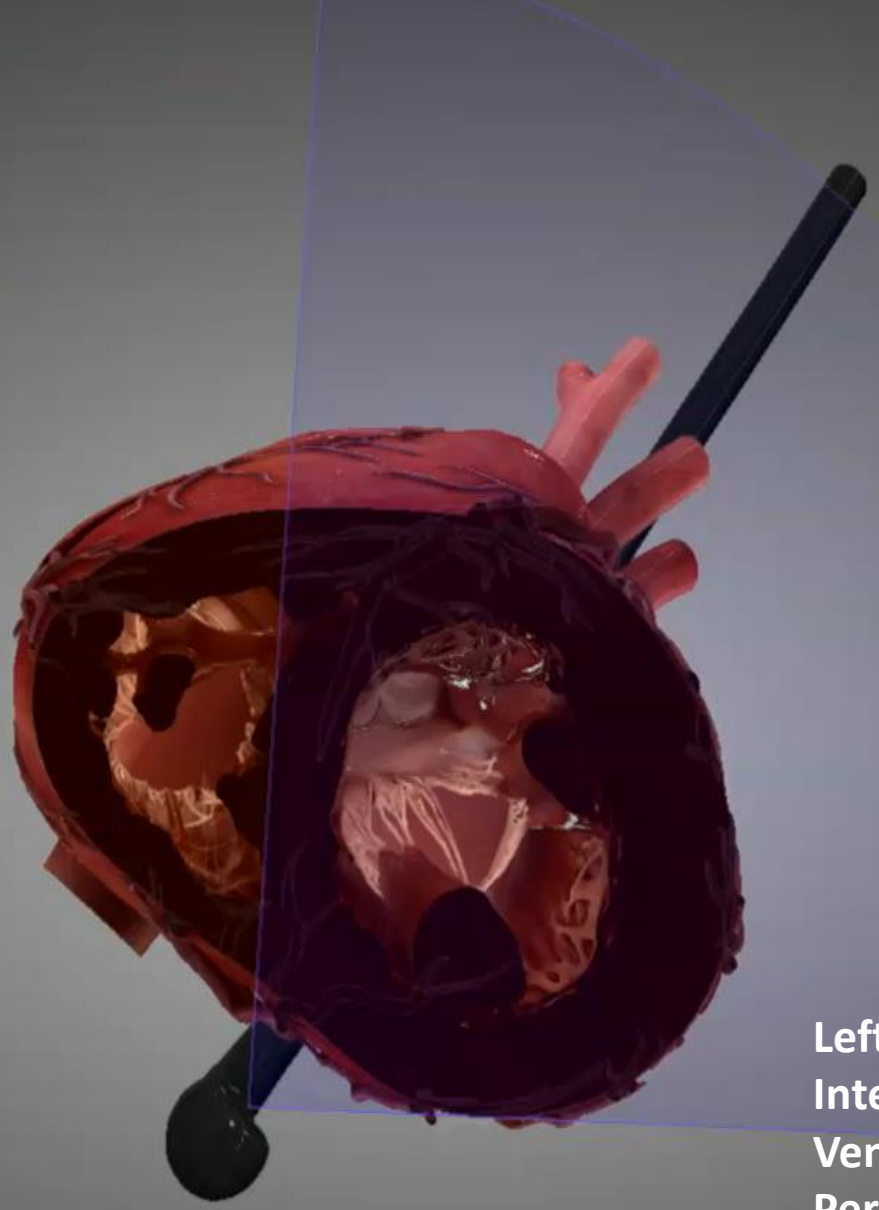
Descending Aorta Long Axis

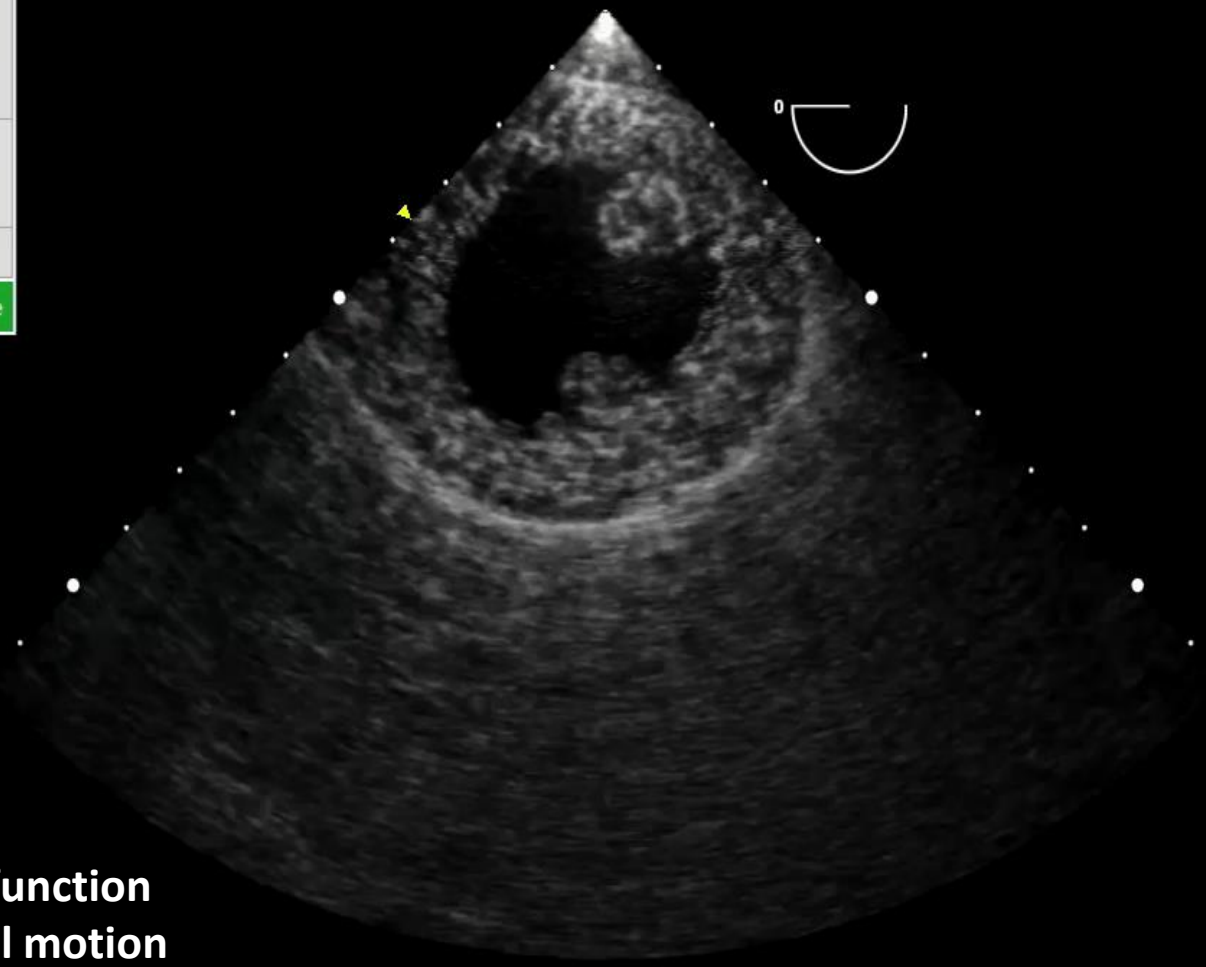




Aortic Pathology
Color Flow Reversal (AI Severity)
IABP Position

Transgastric SAX

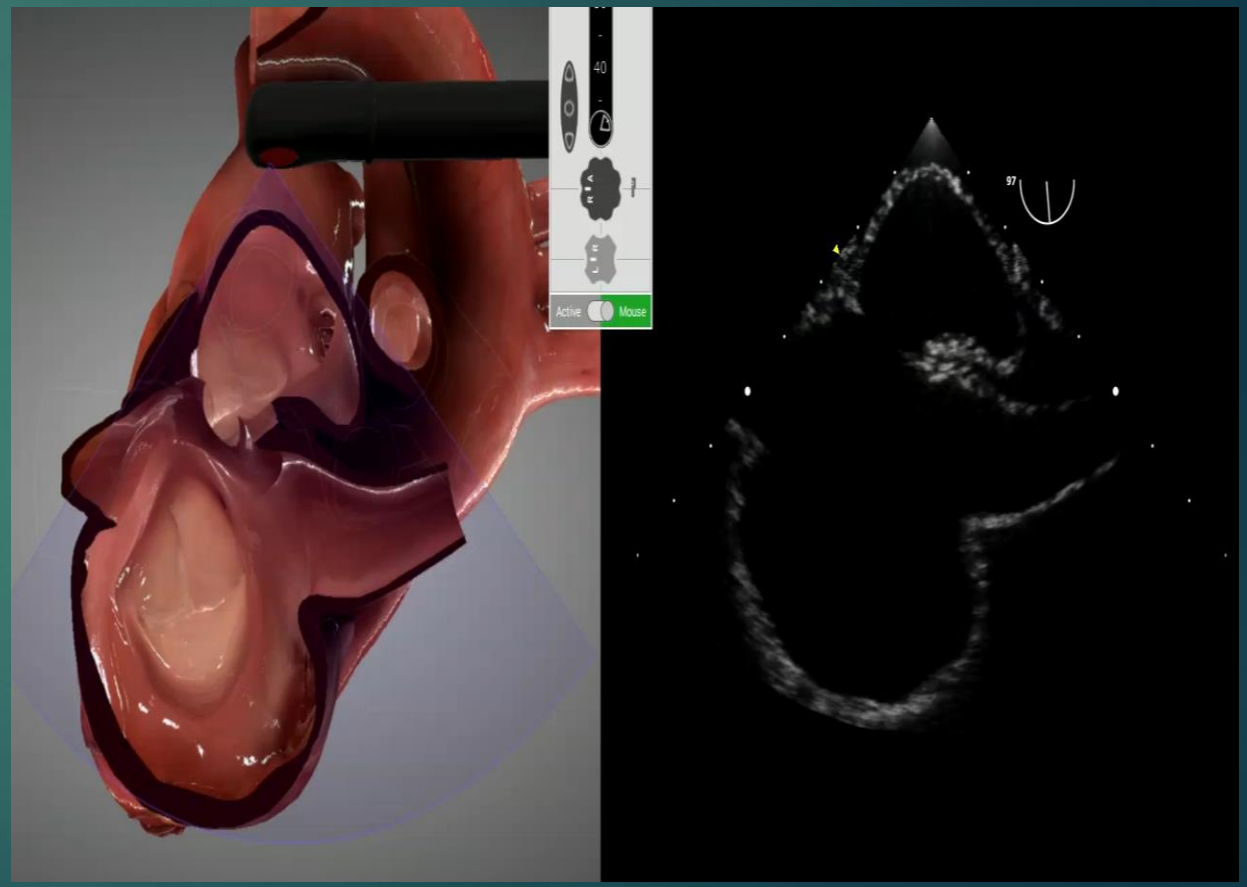




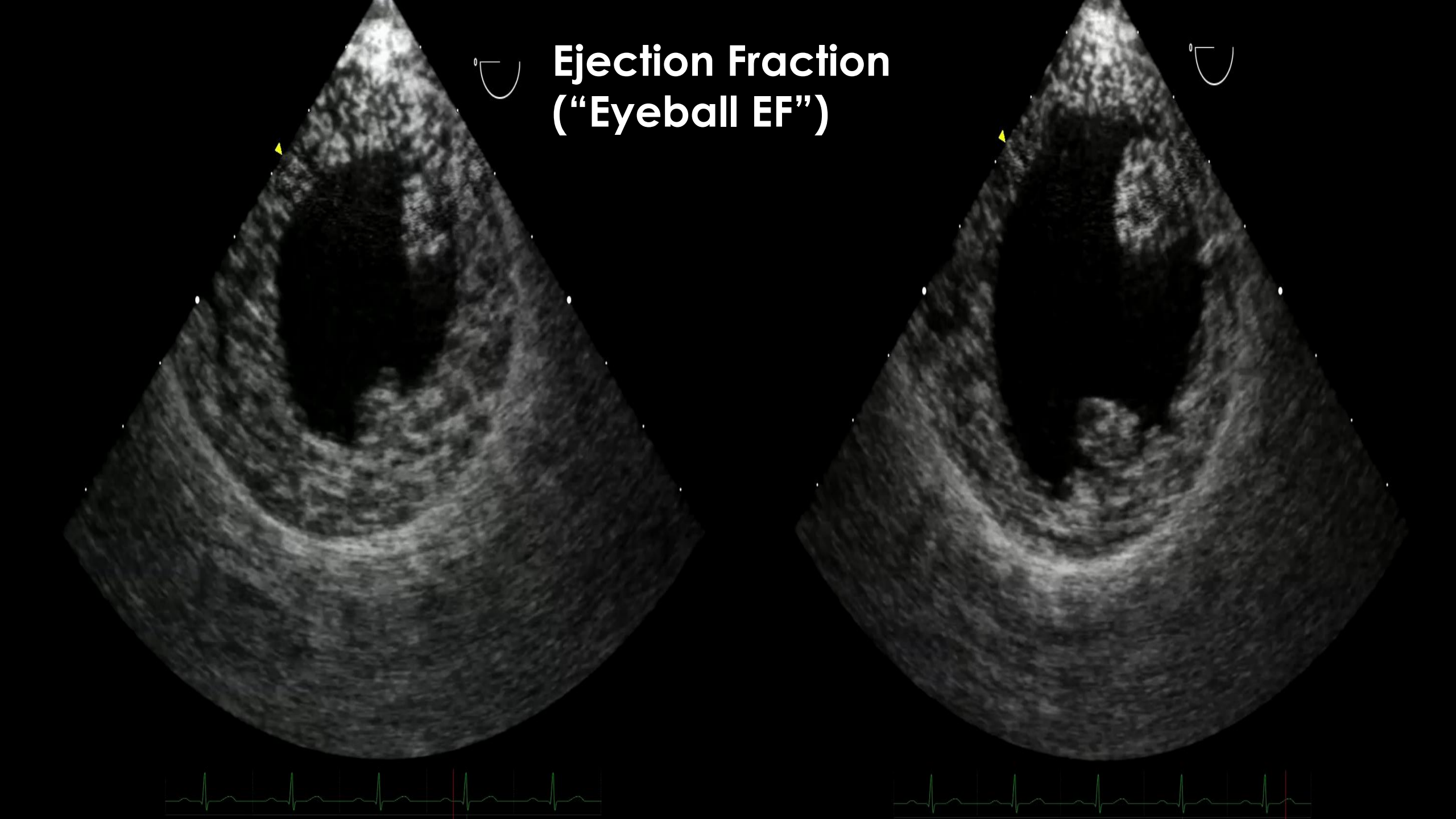
Left Ventricular Size/function
Interventricular septal motion
Ventricular Septal Defect
Pericardial Effusion
Volume Status

Color Doppler and Color Flow Mapping

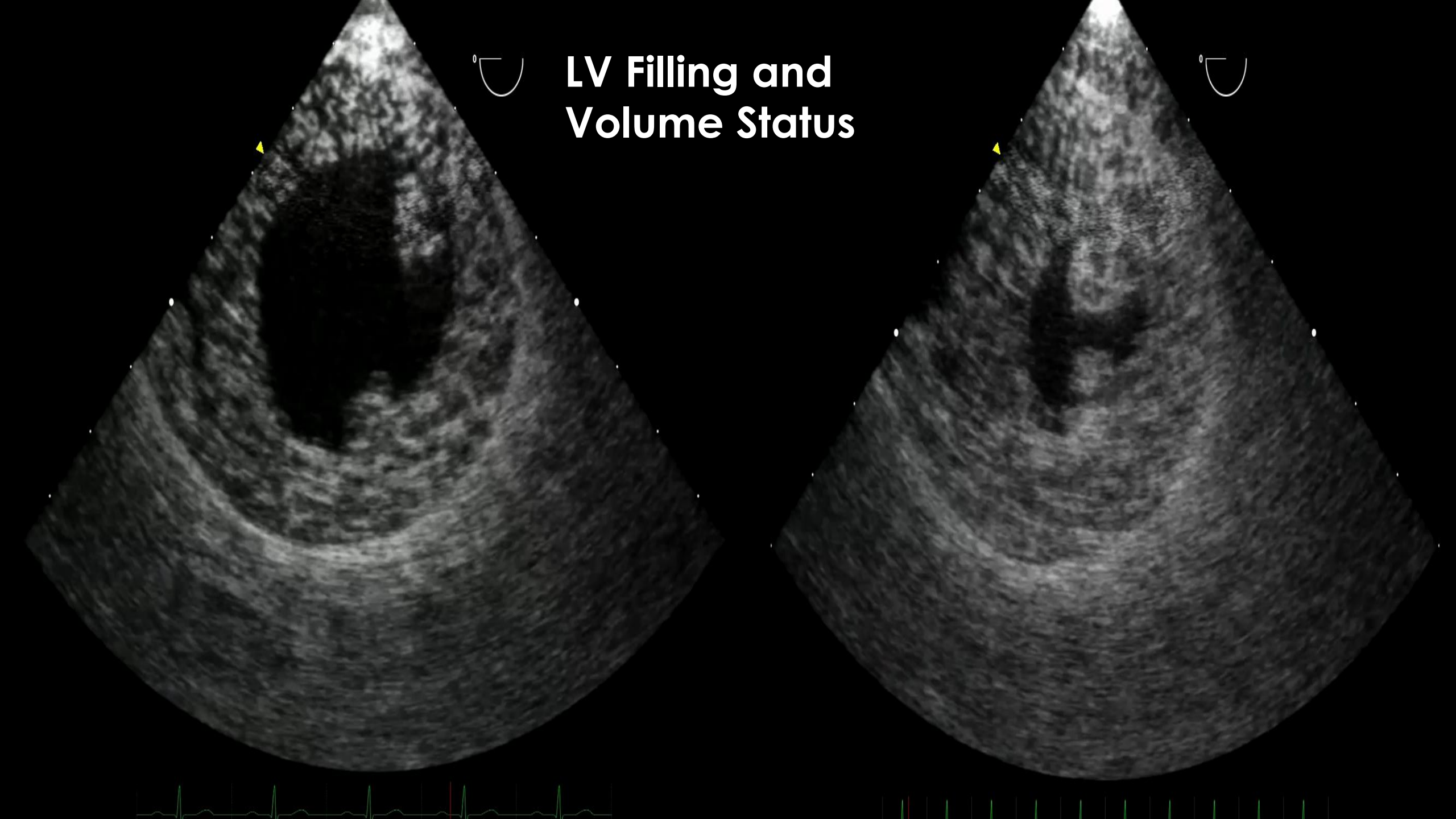
- Doppler ultrasound provides **direction** and **velocity** of flow
- Direction and velocity of blood is depicted as:
  - Red-towards the transducer
  - Blue-away from the transducer
- "BART"
- Higher velocities assigned a more intense degree of color

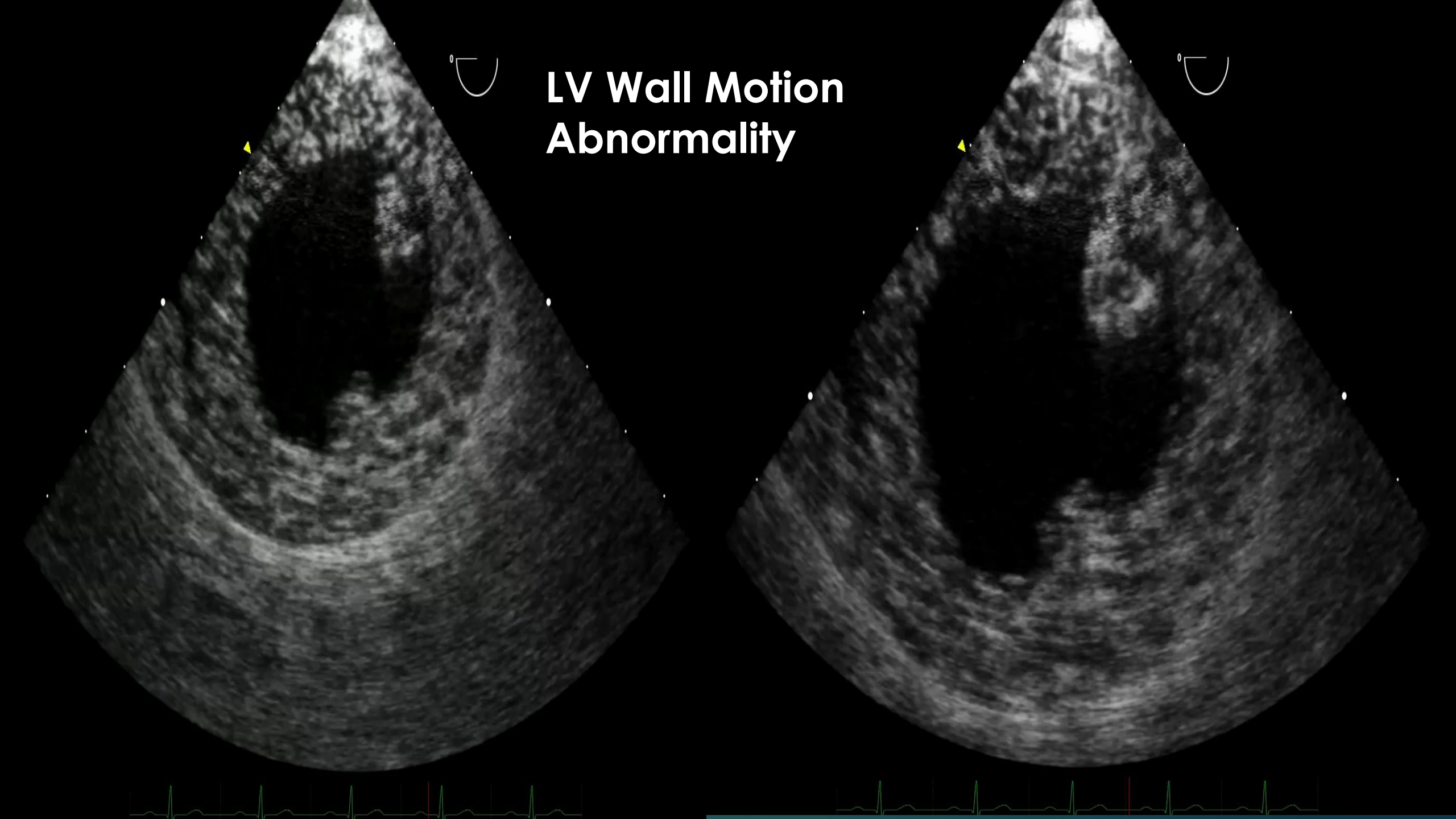


Ejection Fraction ("Eyeball EF")



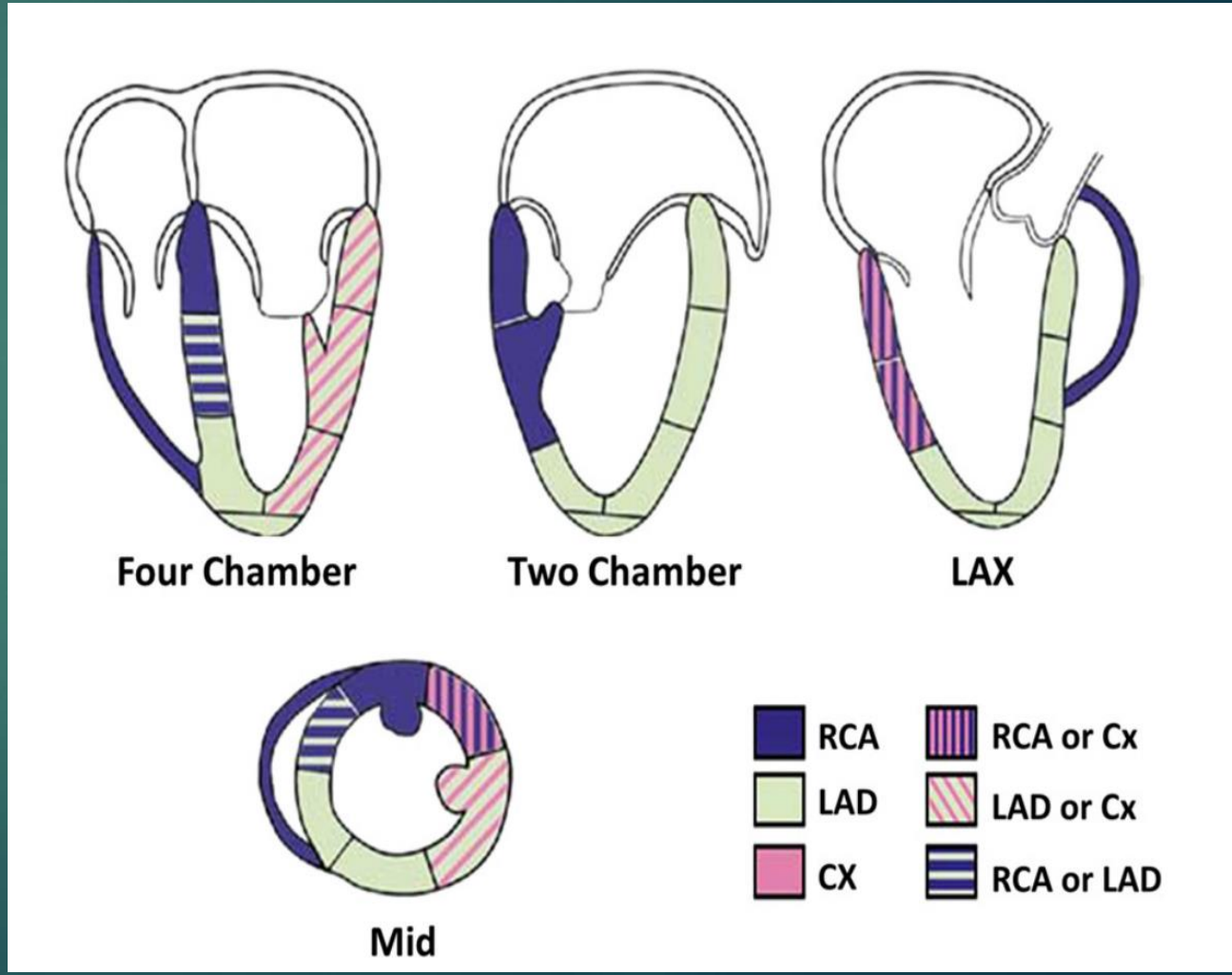
LV Filling and Volume Status




LV Wall Motion
Abnormality

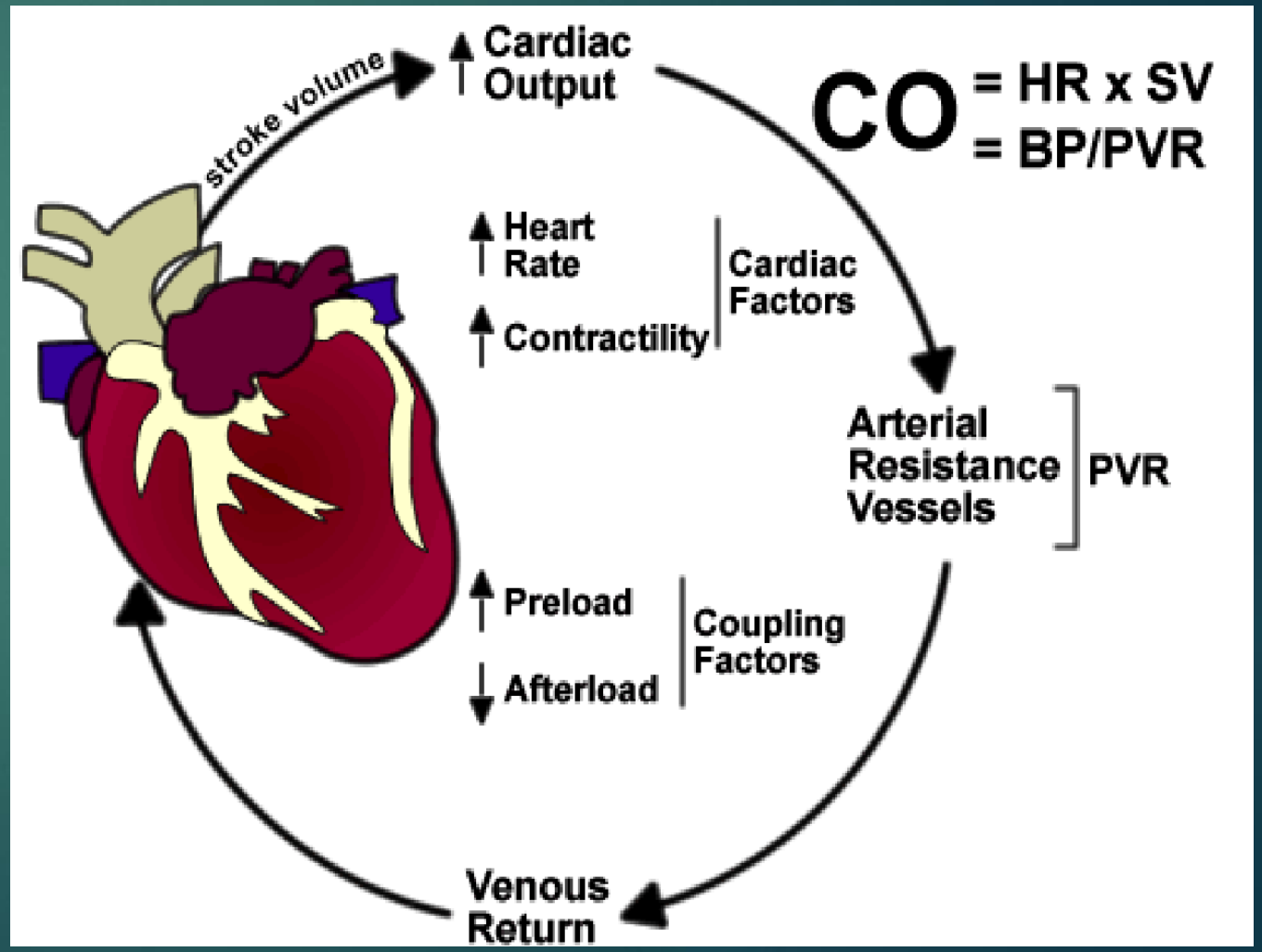
Myocardial Ischemia and Wall Motion

- ECG continues to be more sensitive
- TEE confirms or "rules in" ischemia through wall motion assessment
- 17 segments required for full assessment
- Wall motion assessed by thickening and inward movement

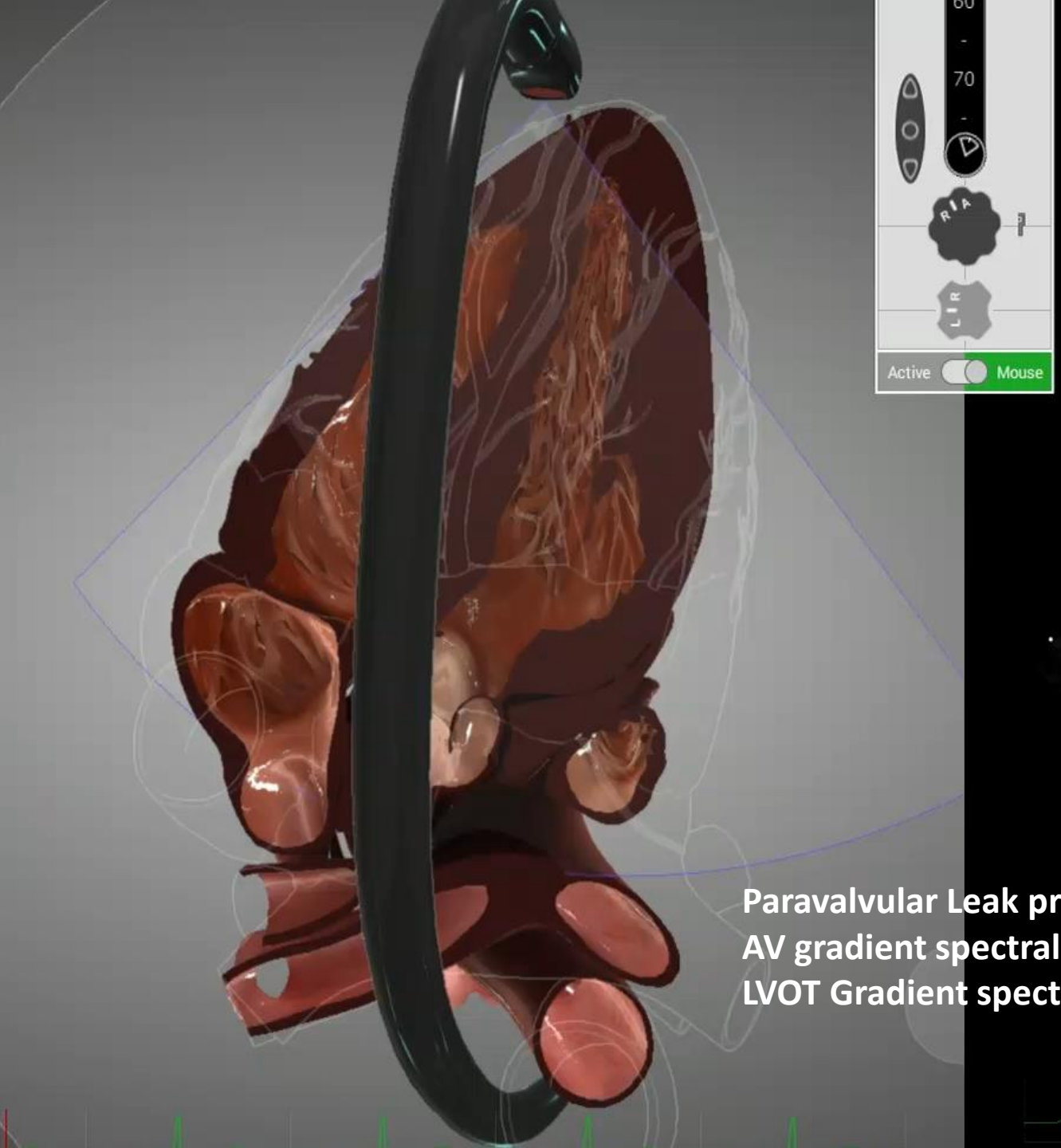


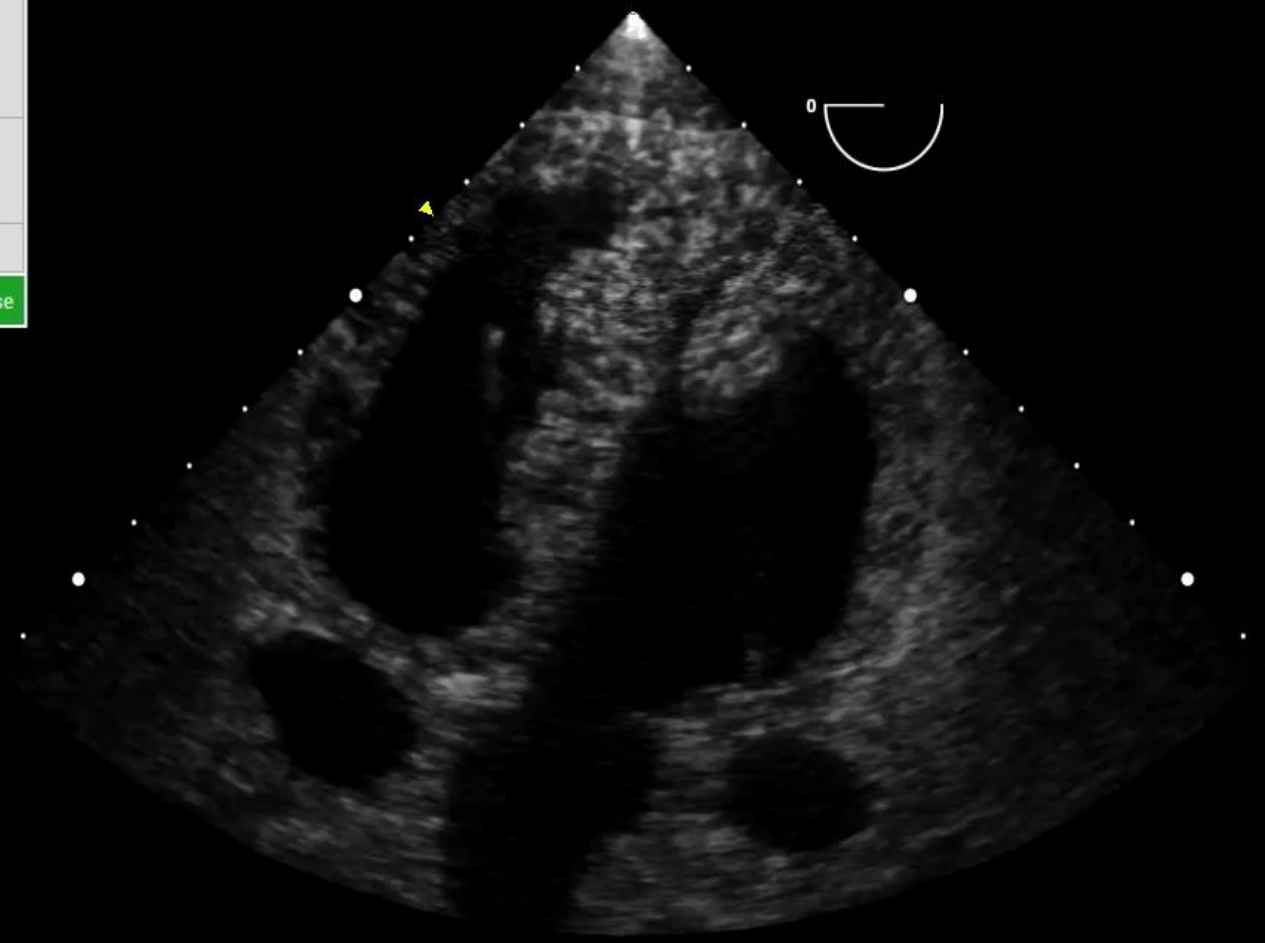
Pharmacologic Interventions Based on TEE Findings

- Pump
  - Left Ventricular Function
  - Right Ventricular Function
- Tank
  - Ventricular Filling
  - Mitral Valve Disease
- Pipes
  - Blood pressure/ejection velocity
  - Treatment of obstruction (Lytics, pericardiocentesis)



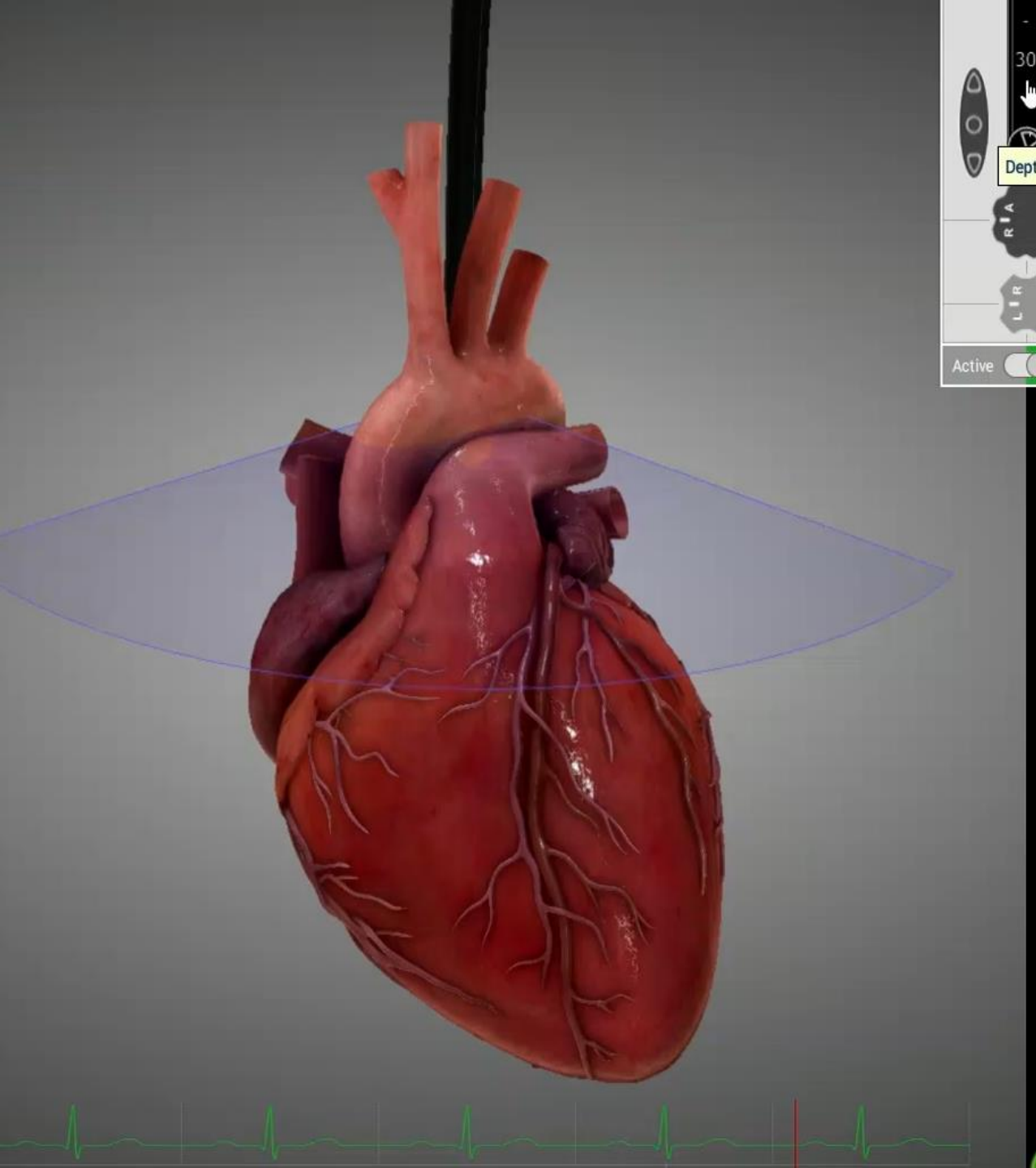
Deep Transgastric Long Axis

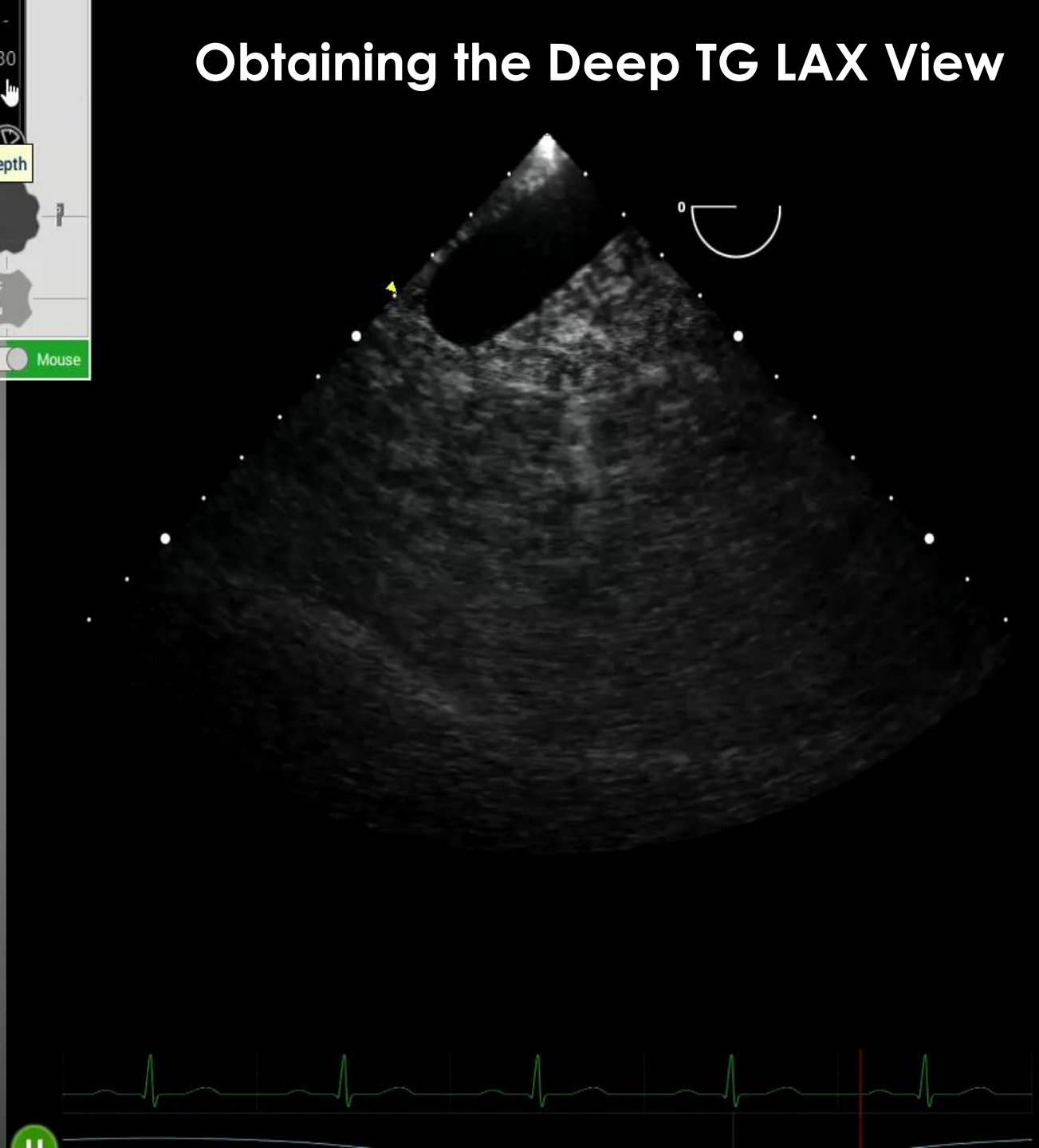




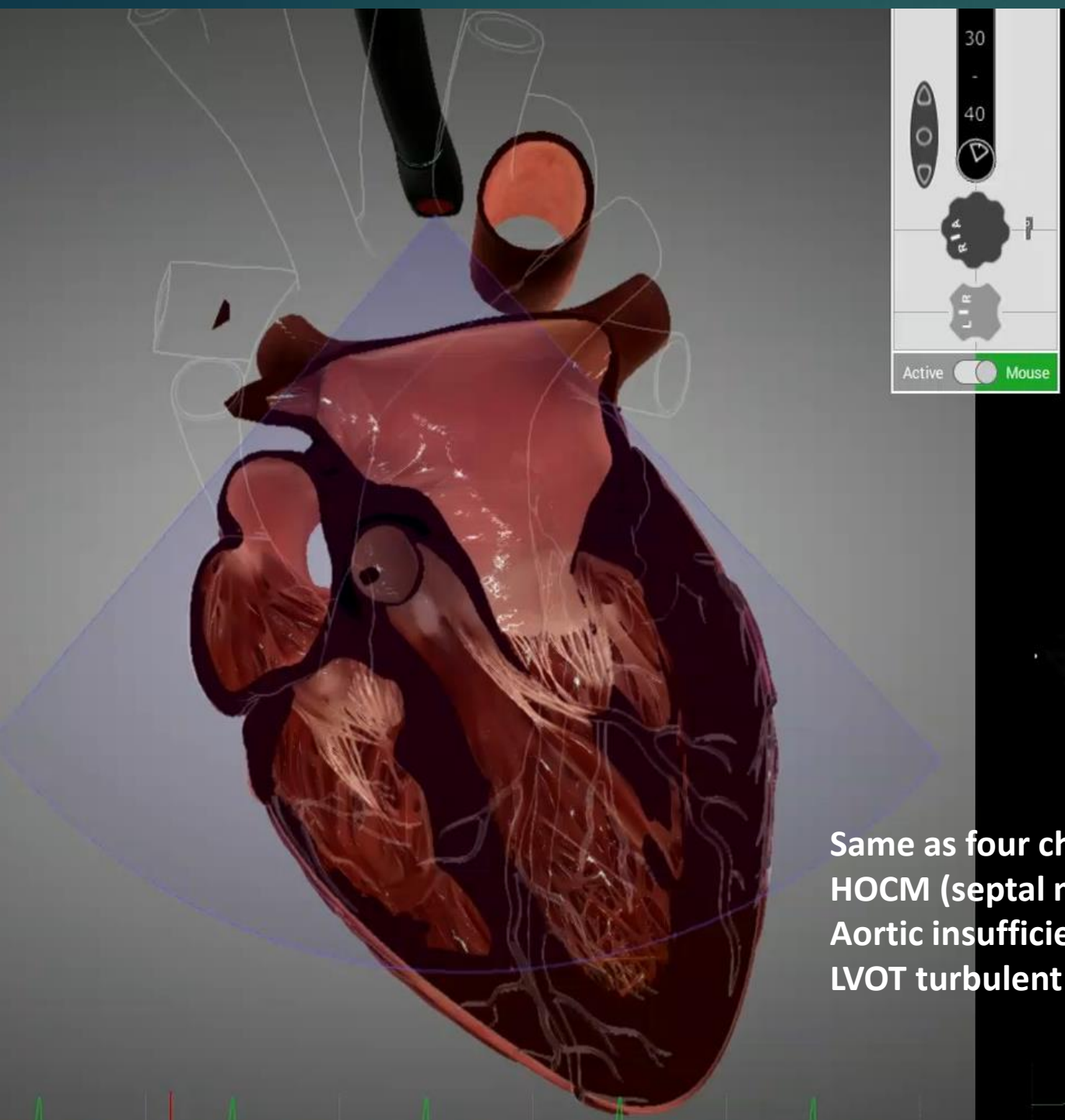
Paravalvular Leak prosthetic aortic valve
AV gradient spectral doppler
LVOT Gradient spectral doppler

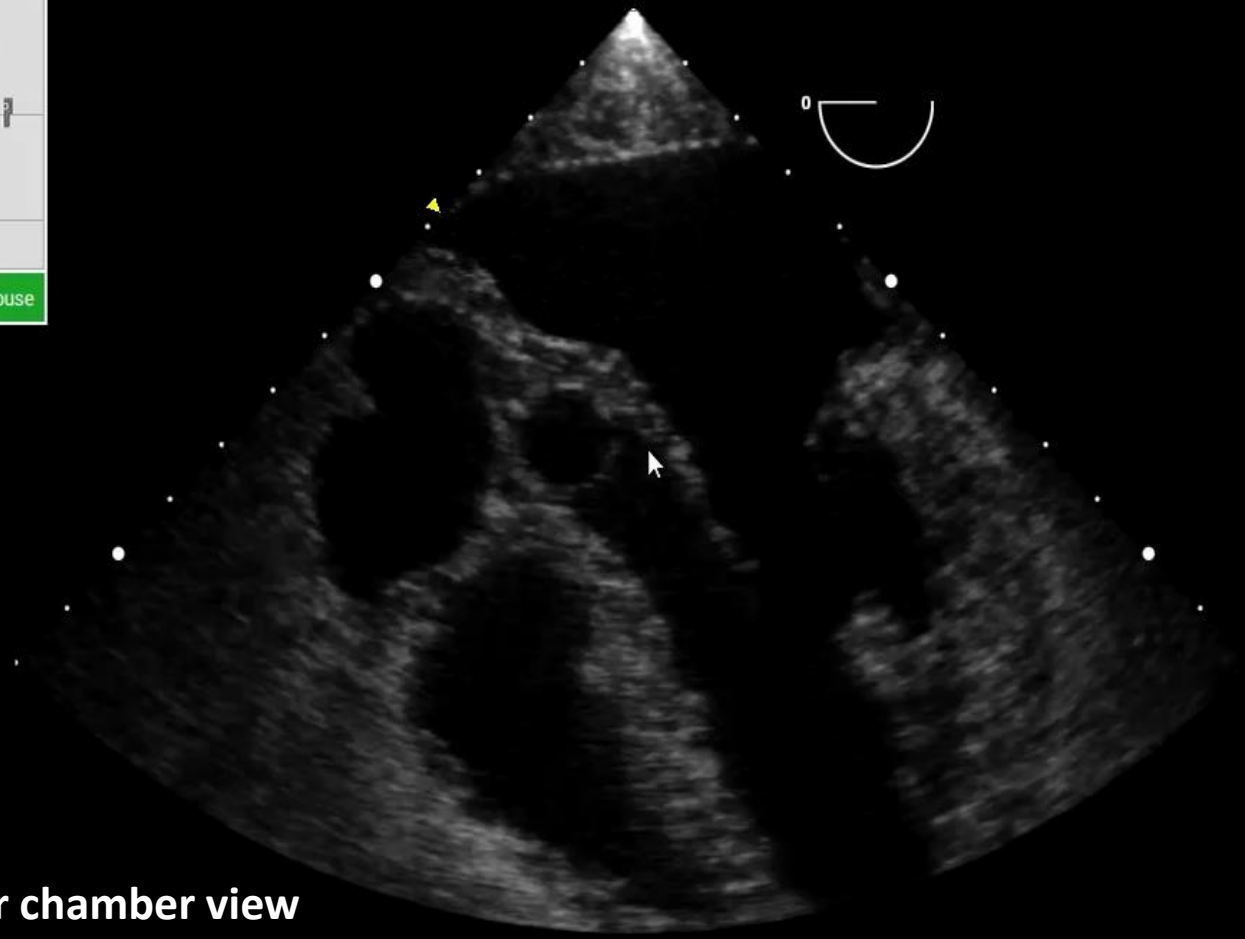
Obtaining the Deep TG LAX View





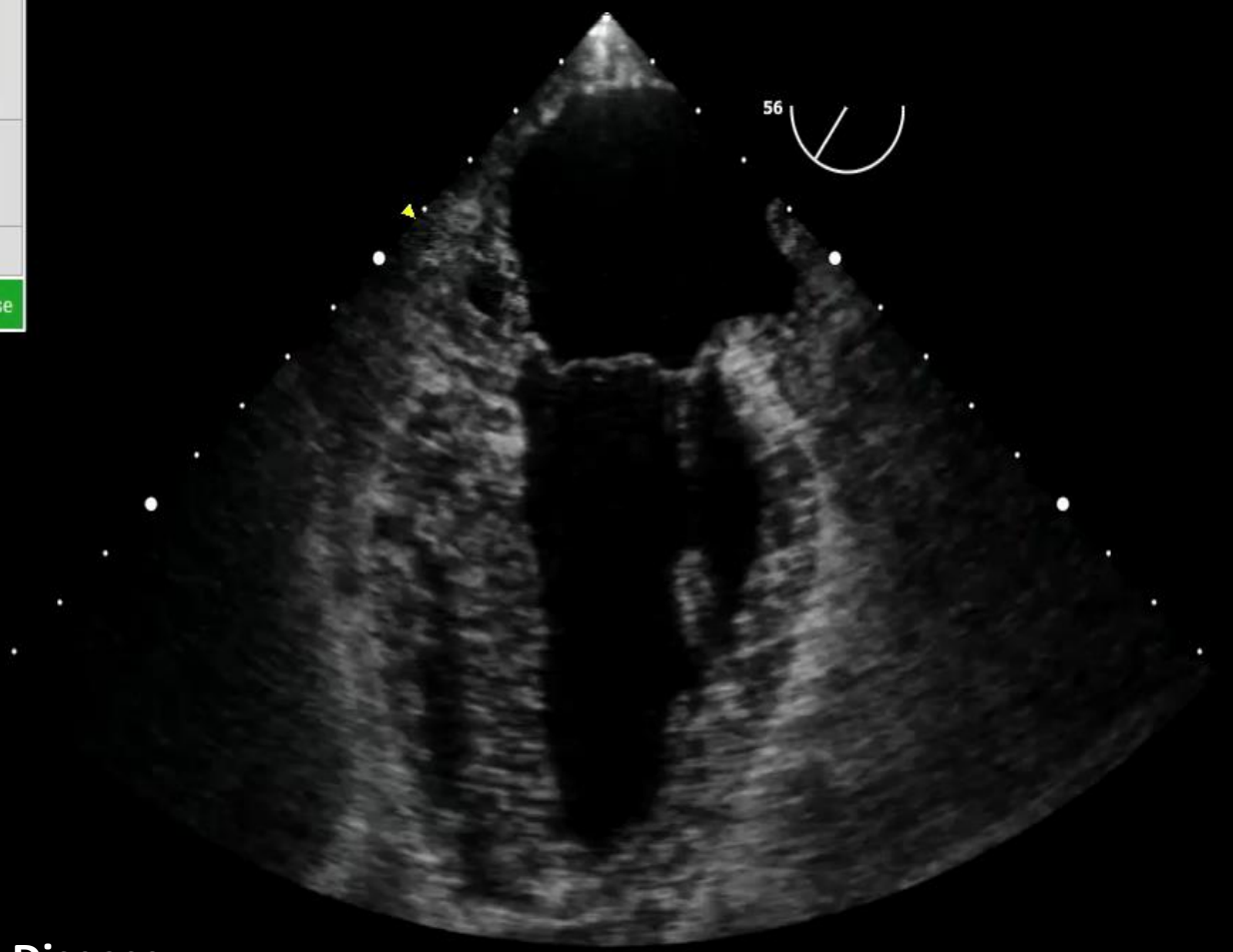
ME 5 Chamber





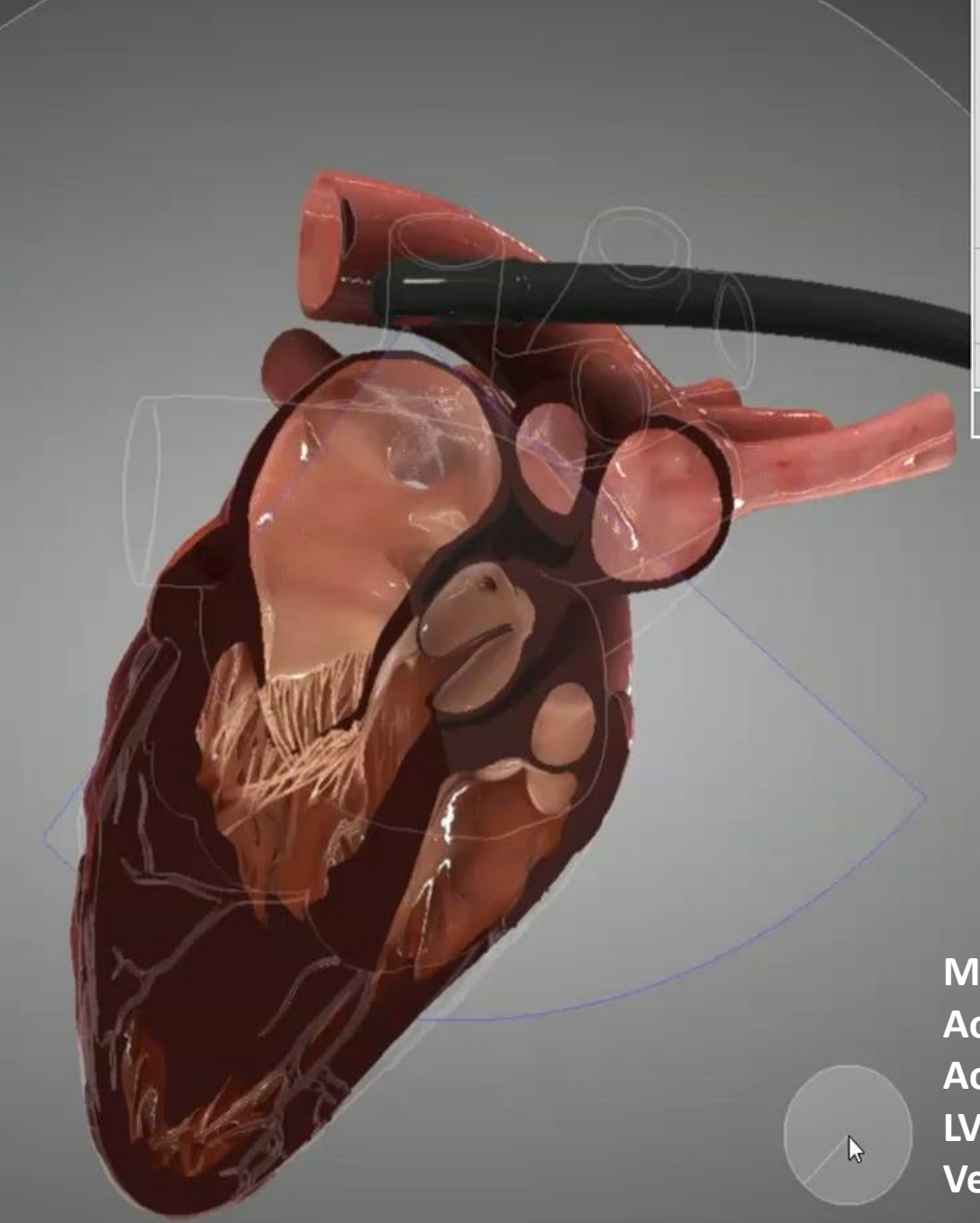
Same as four chamber view
HOCM (septal measurements)
Aortic insufficiency
LVOT turbulent flow

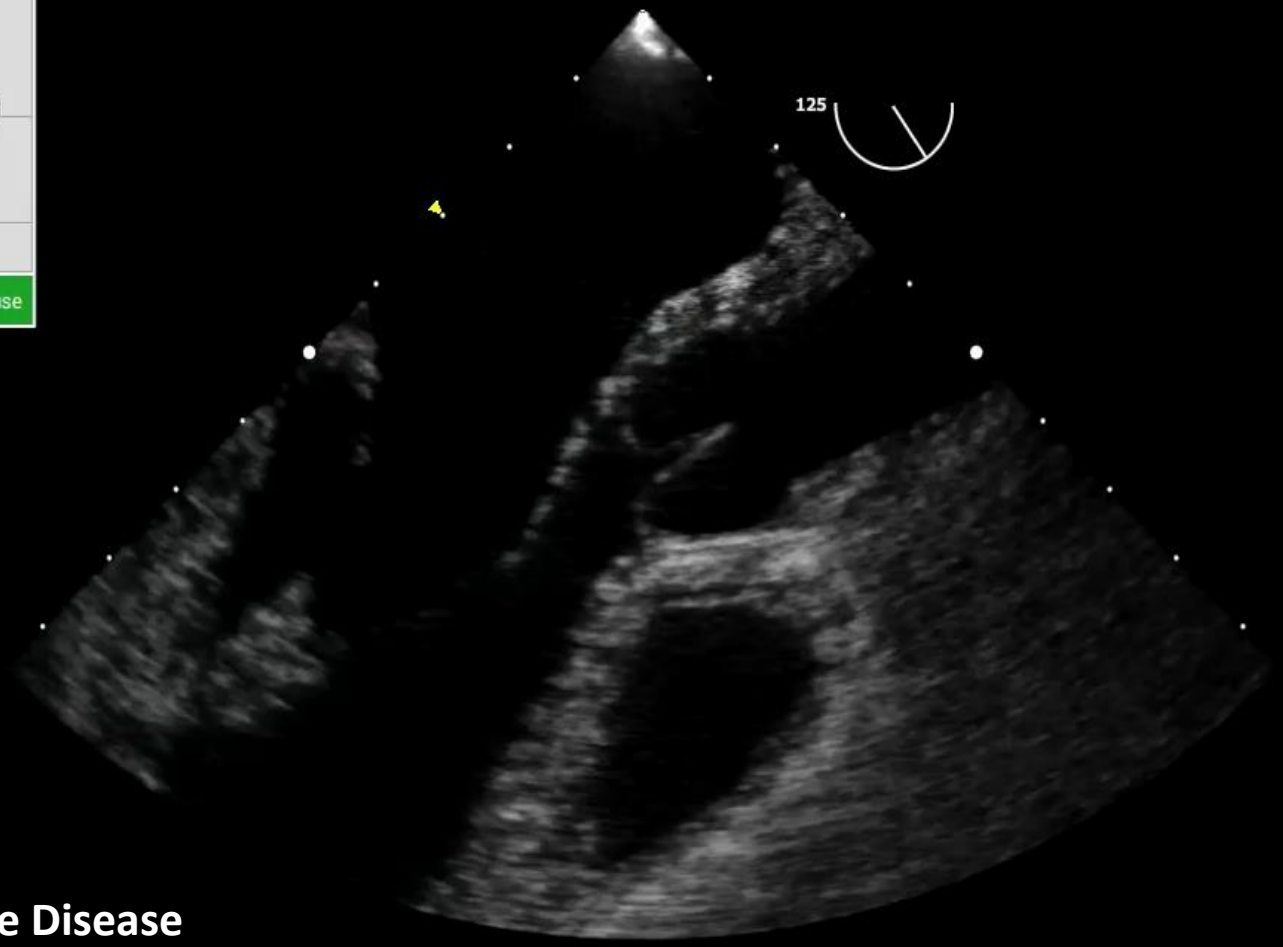
ME Commissural View



Mitral Valve Disease
LV Function
LA Pathology

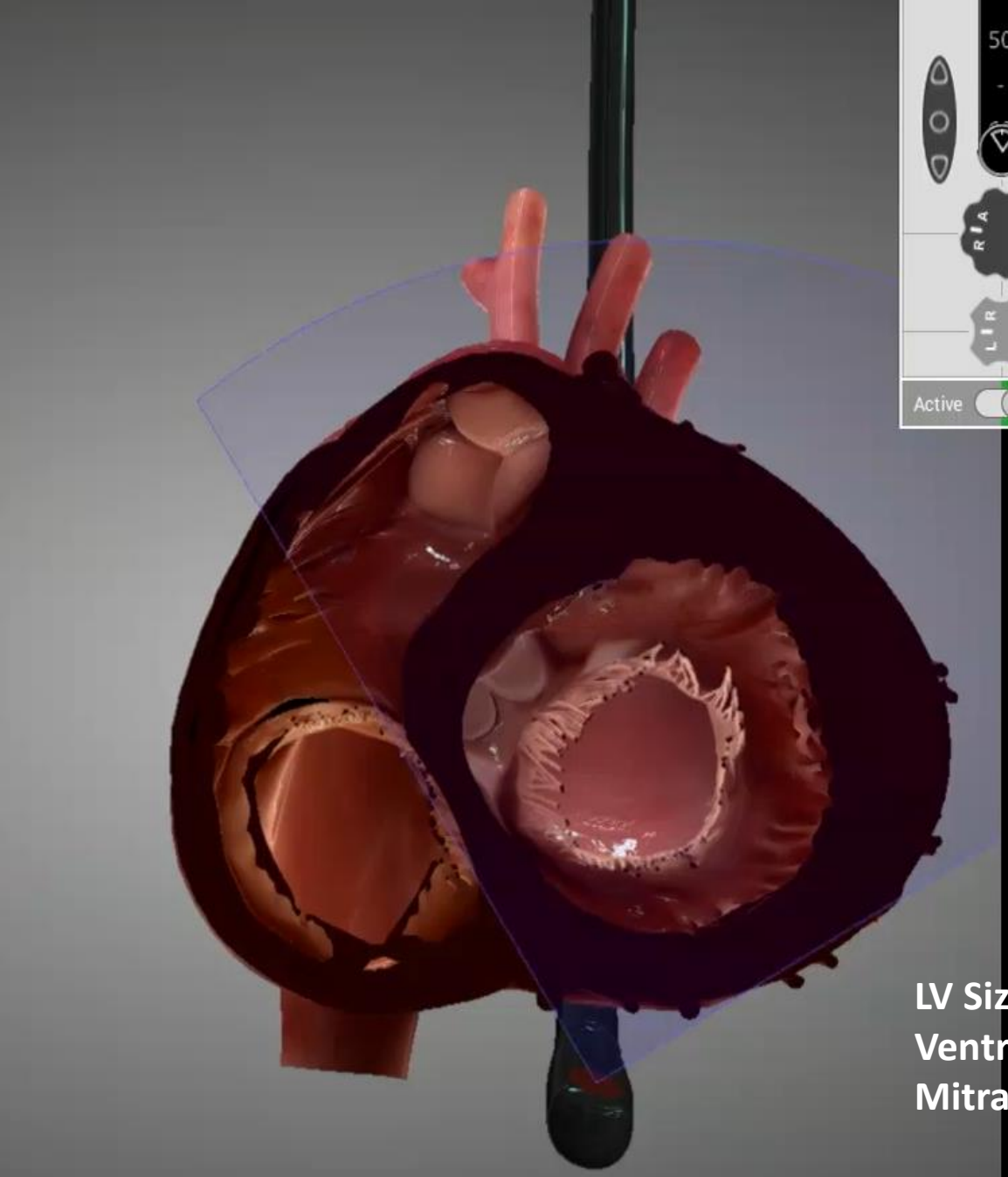
ME AV LAX

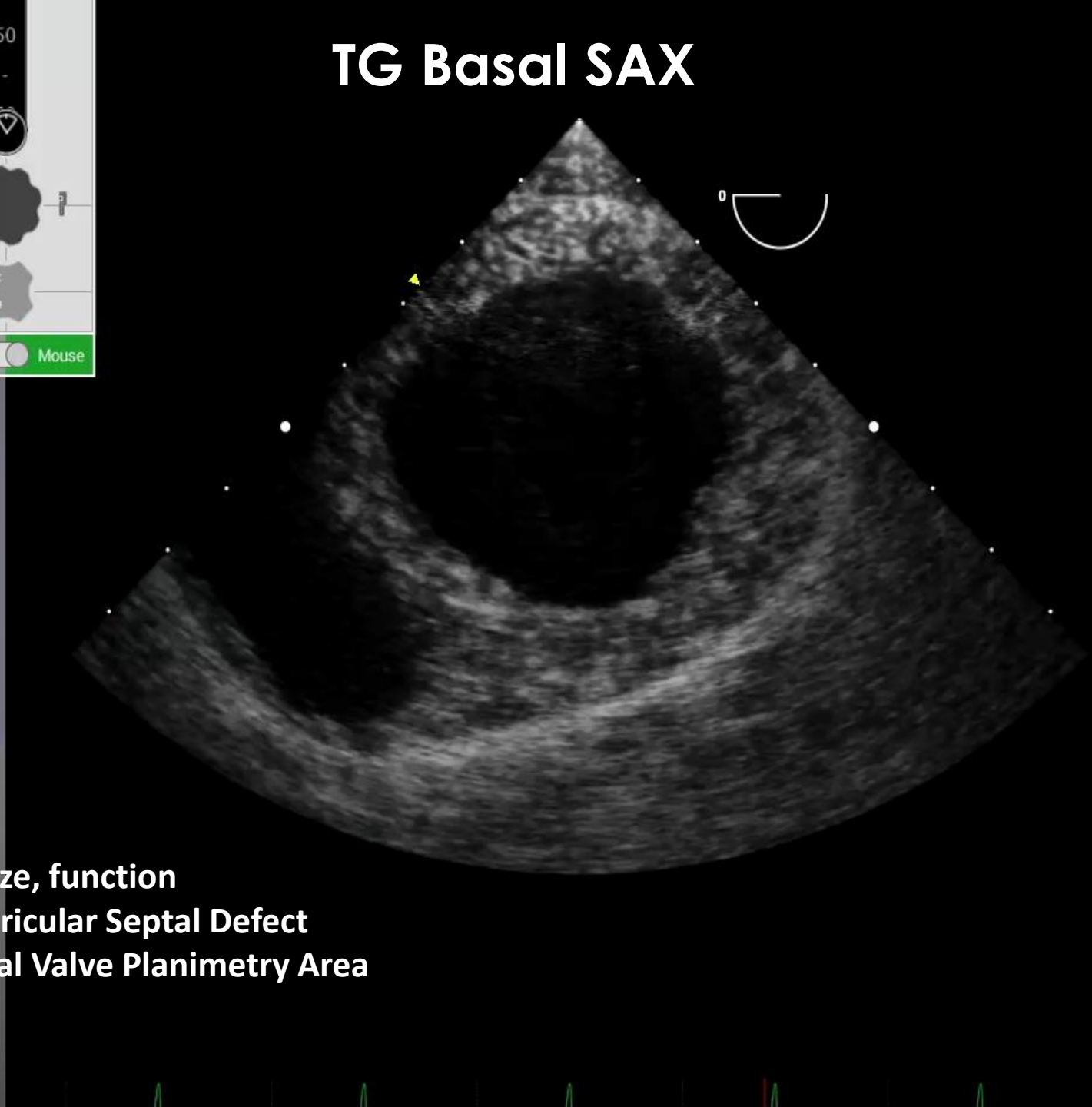




Mitral Valve Disease
Aortic Valve Disease
Aortic Root Dimensions and Pathology
LVOT Pathology
Ventricular Septal Defect

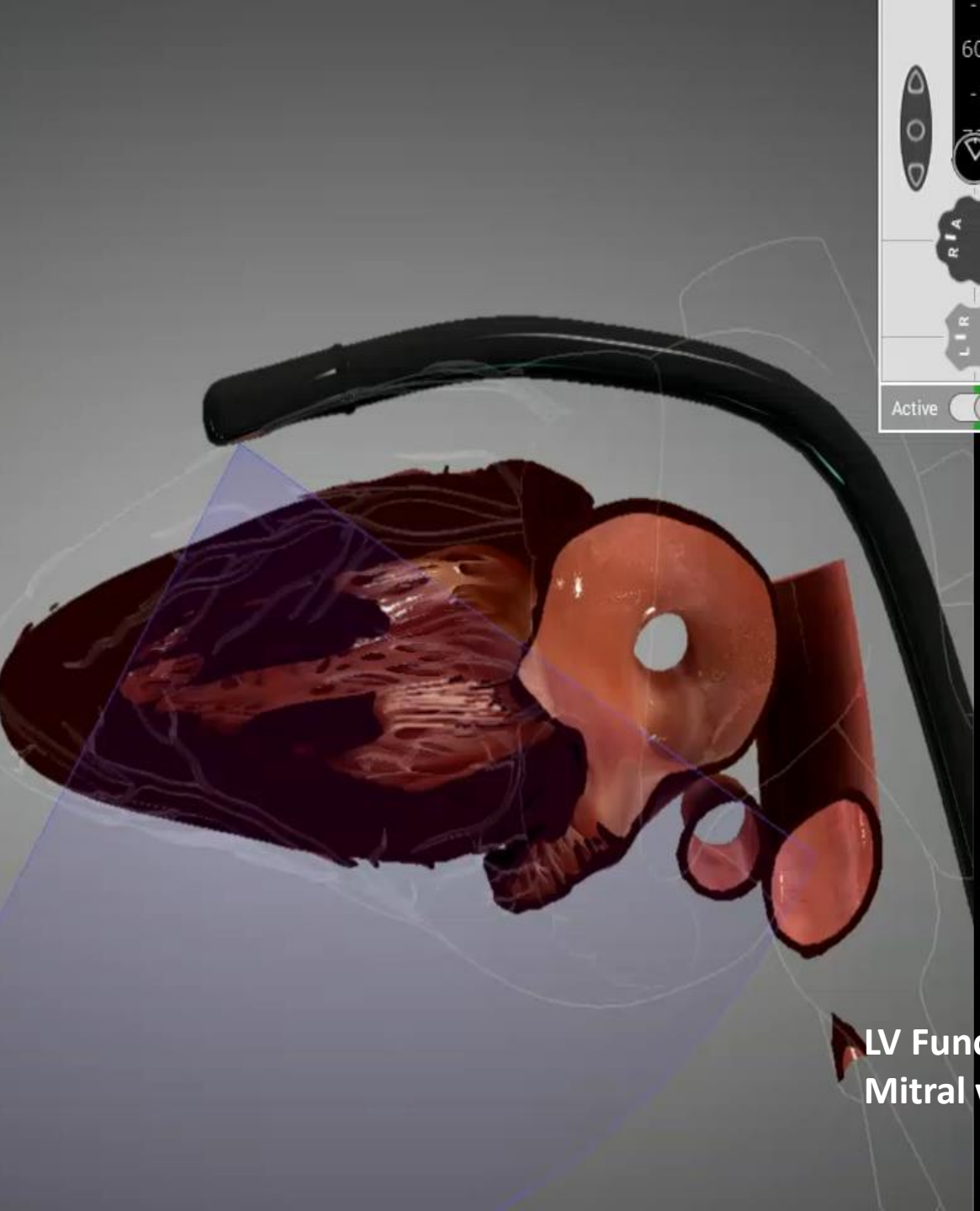
TG Basal SAX

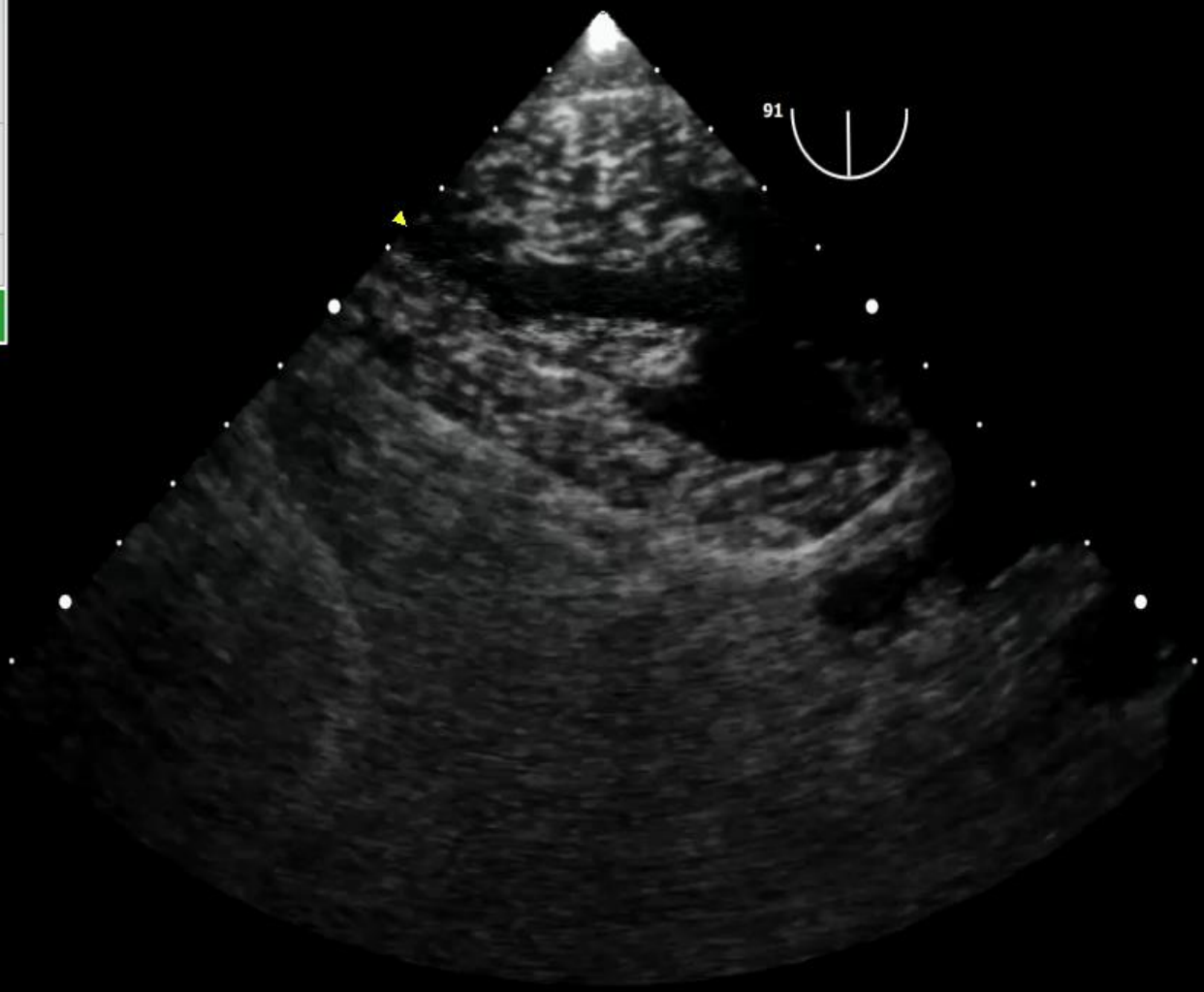




LV Size, function
Ventricular Septal Defect
Mitral Valve Planimetry Area

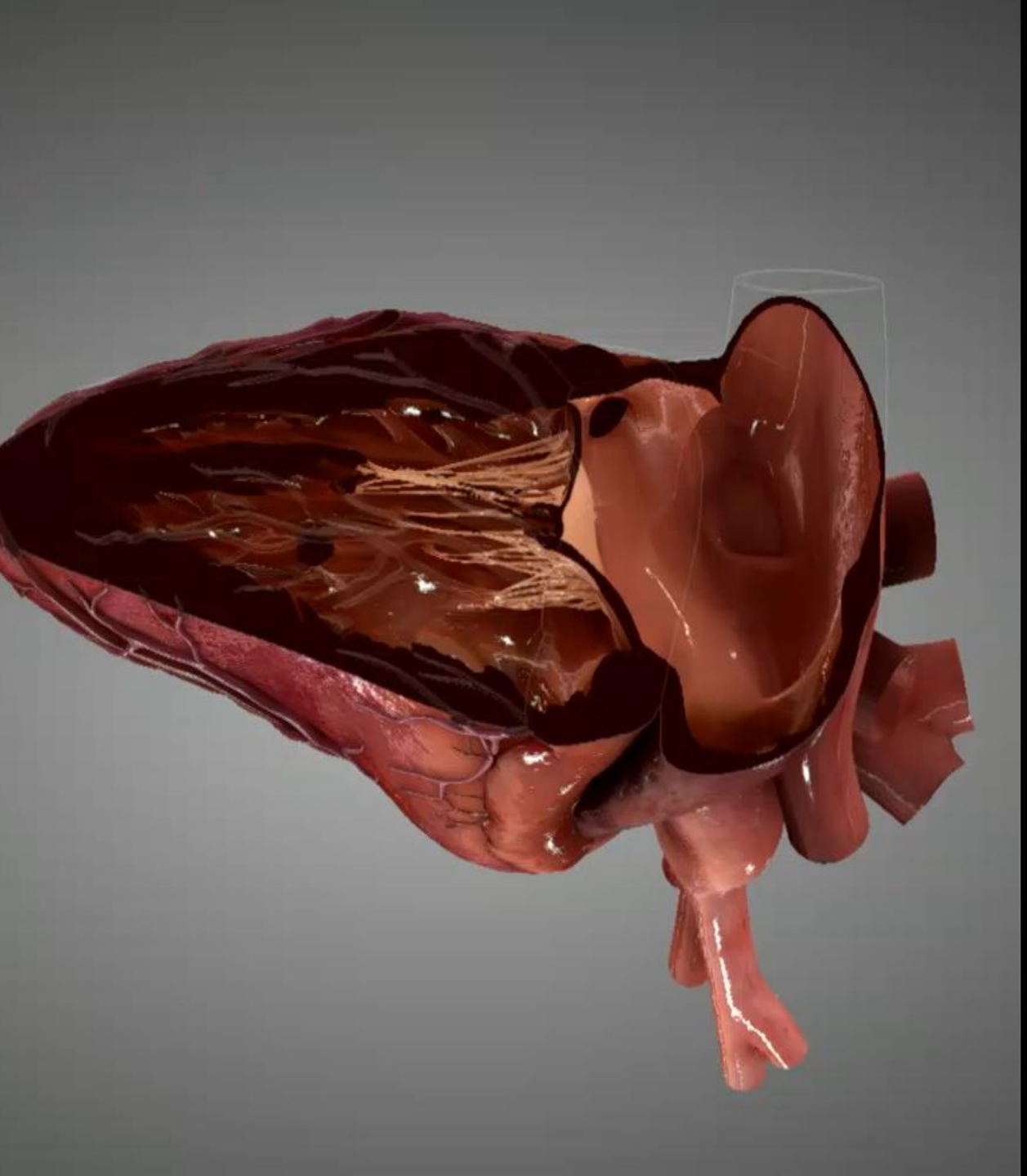
TG 2 Chamber View

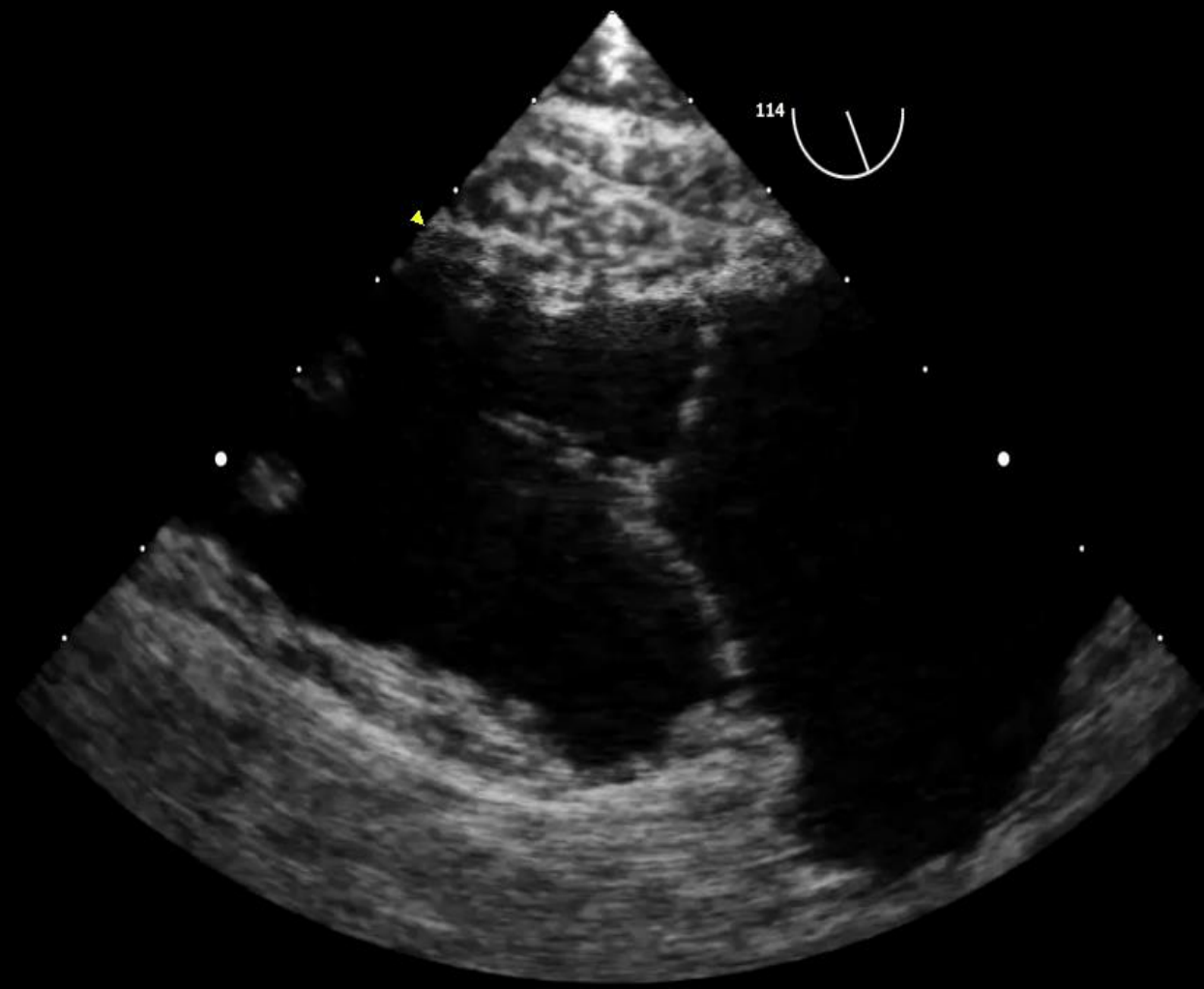




LV Function
Mitral valve Subvalvular Pathology

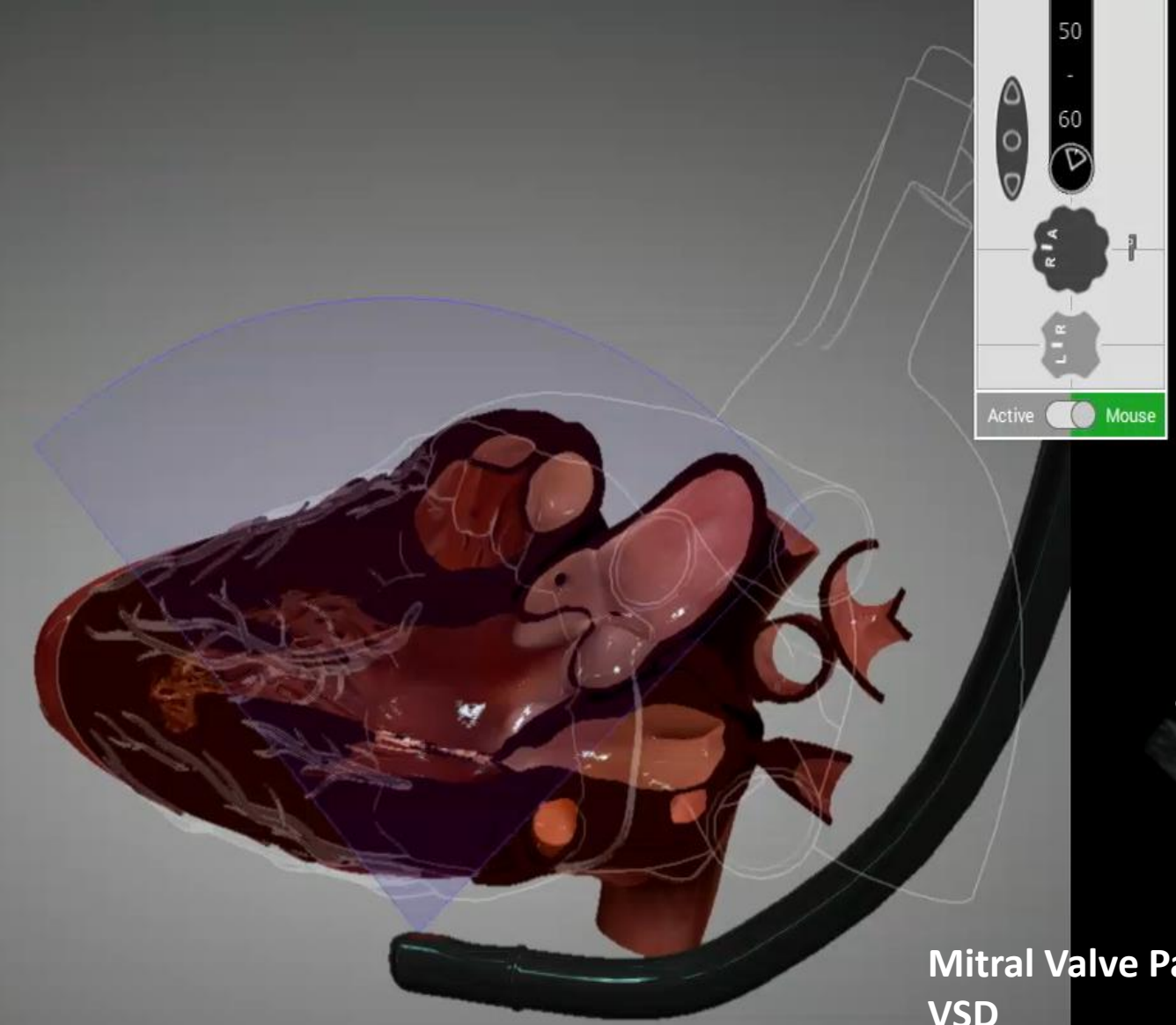
TG RV Inflow View

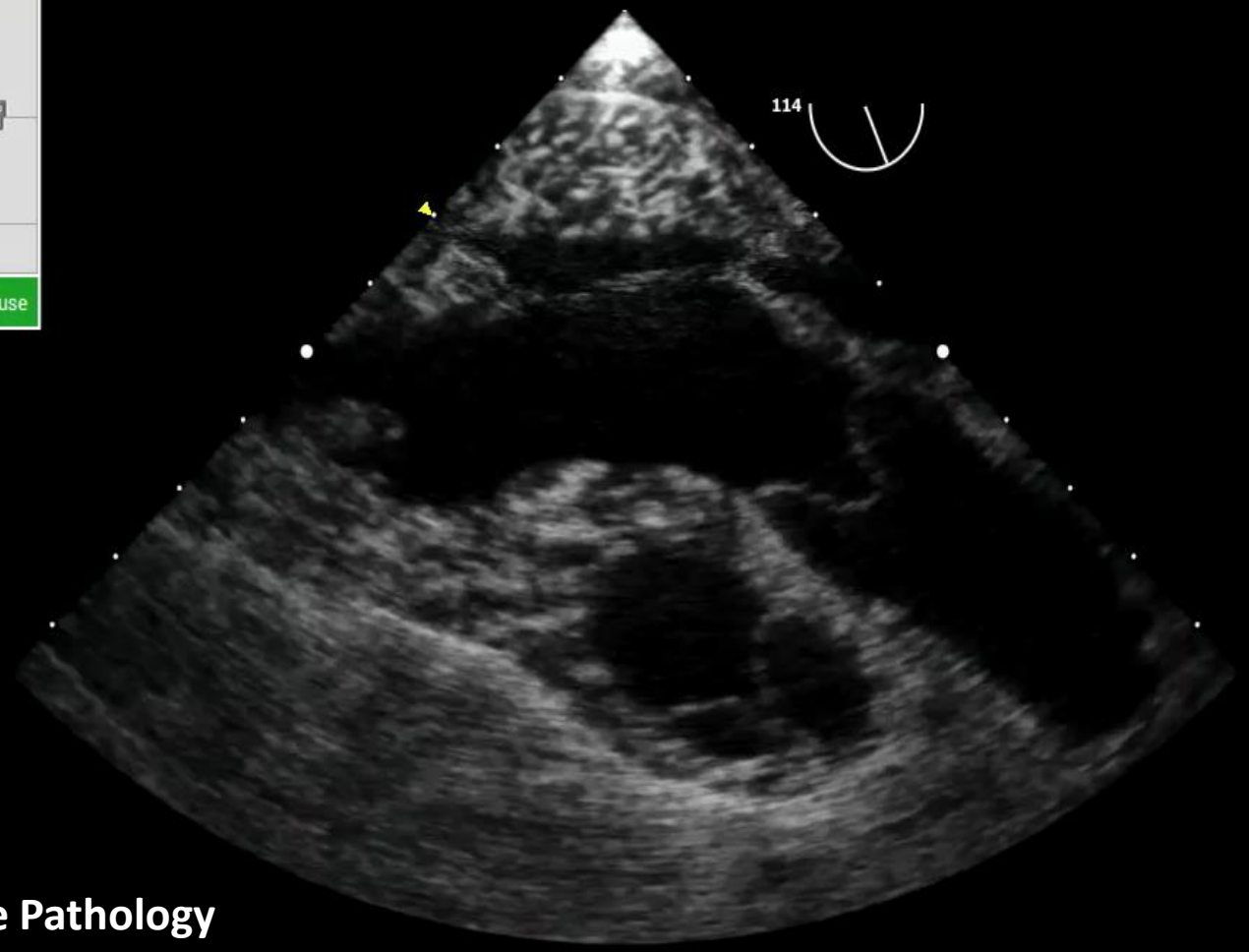




RV Function
Tricuspid Subvalvular apparatus pathology
Tricuspid Valve Pathology

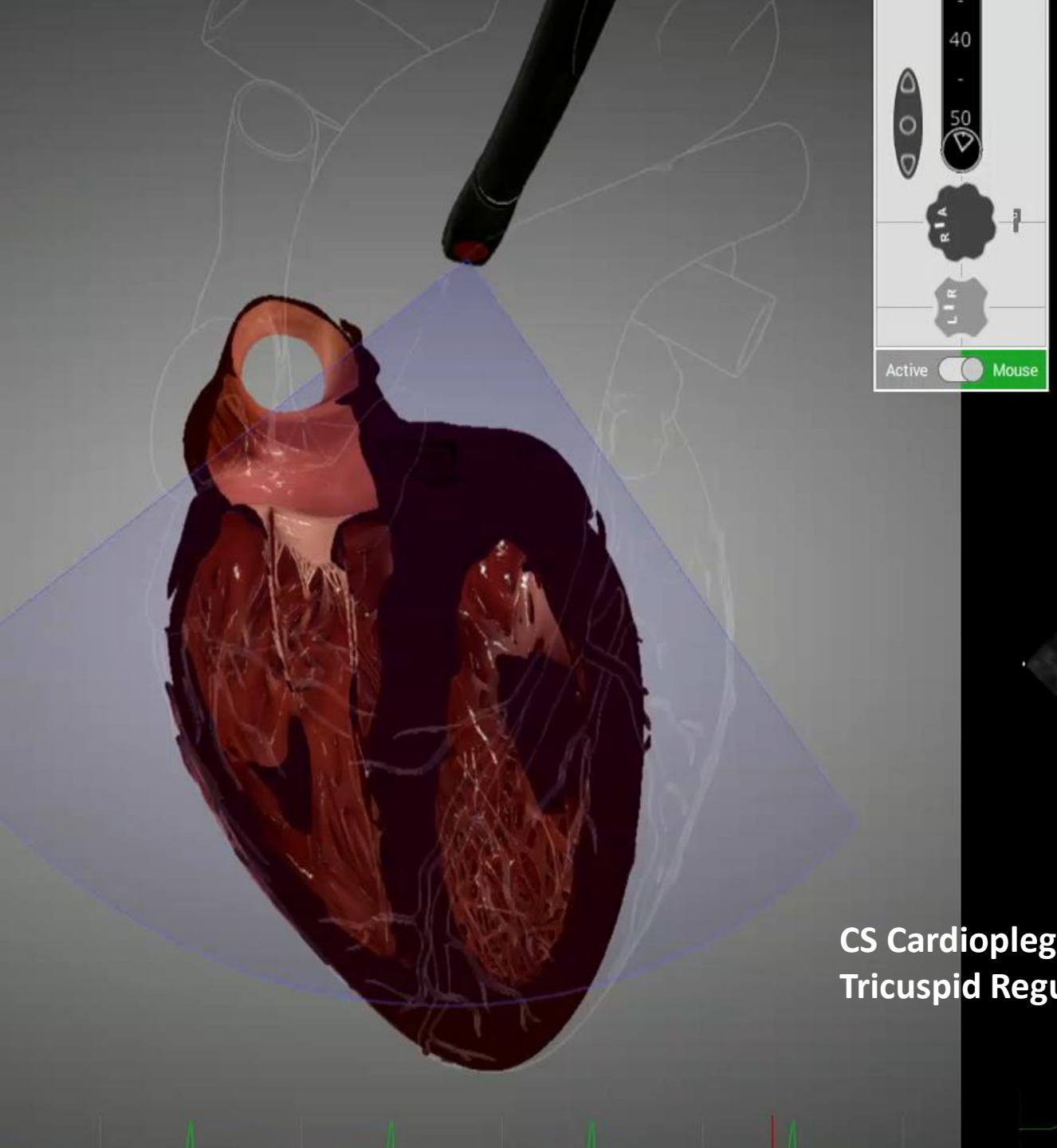
Transgastric Long Axis

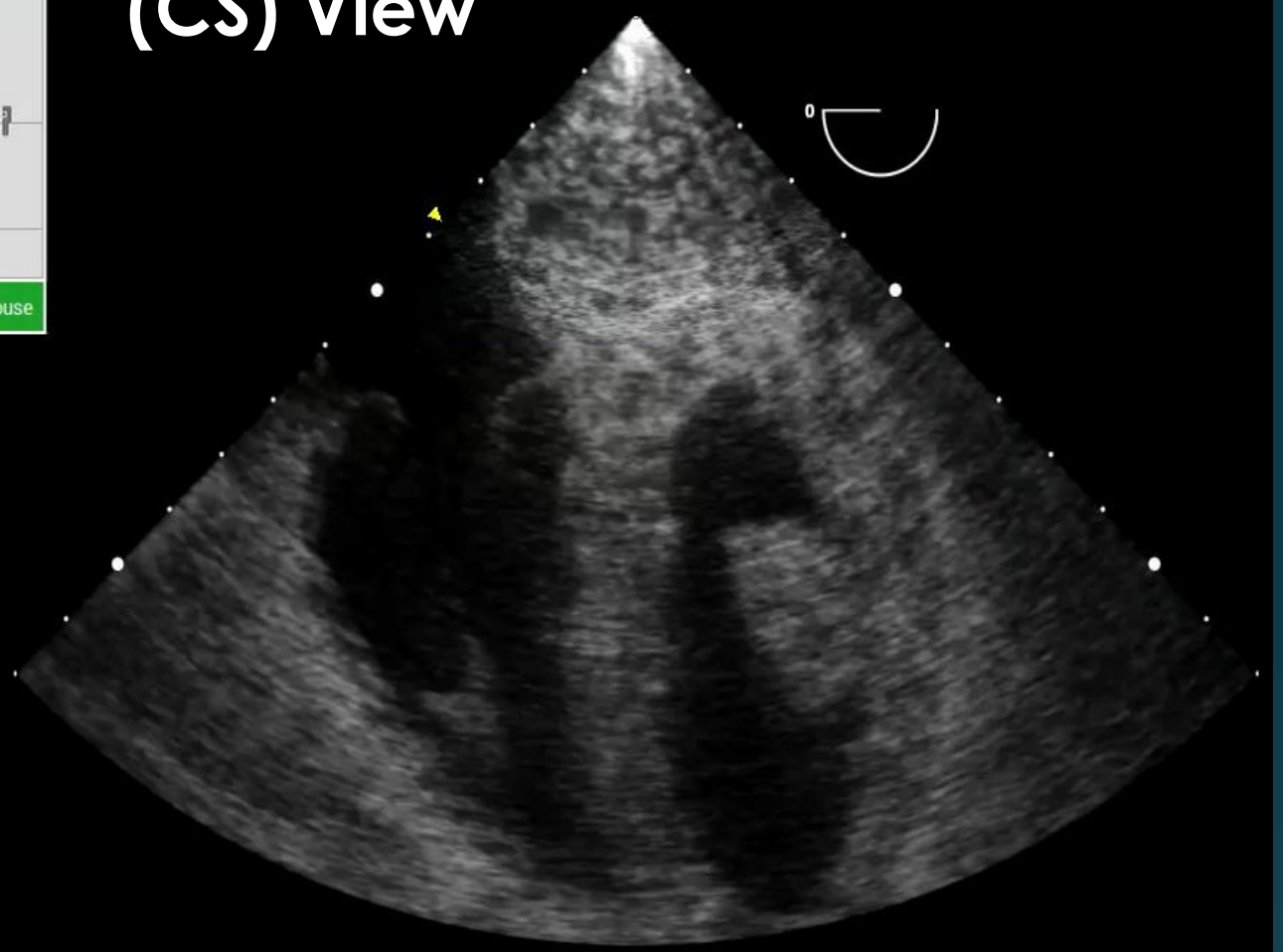




Mitral Valve Pathology
VSD
LV Systolic Function
Aortic Valve: Spectral and Color Doppler
LVOT: Spectral and Color Doppler

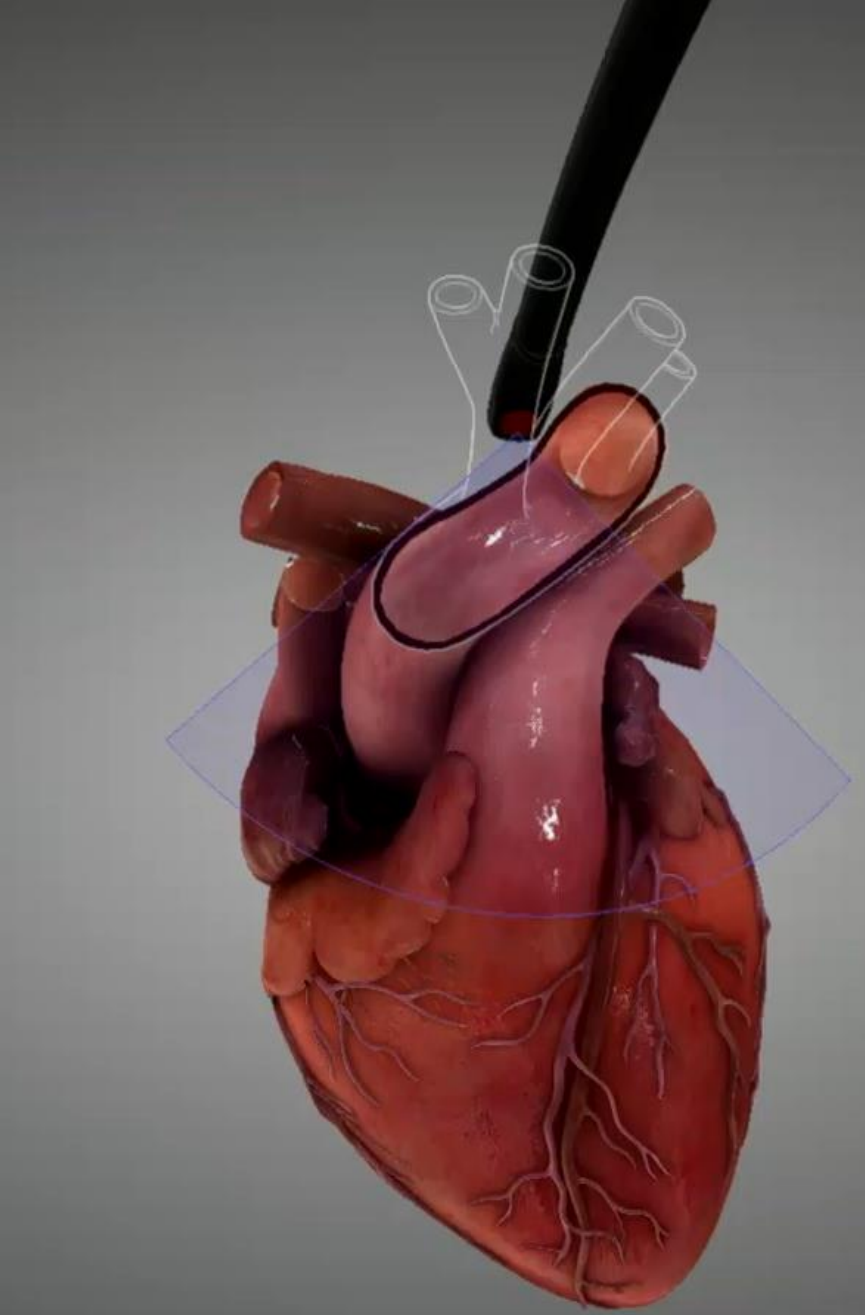
Modified ME 4 Chamber (CS) View

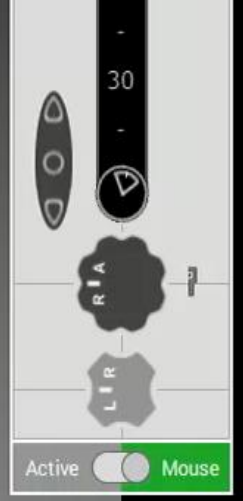


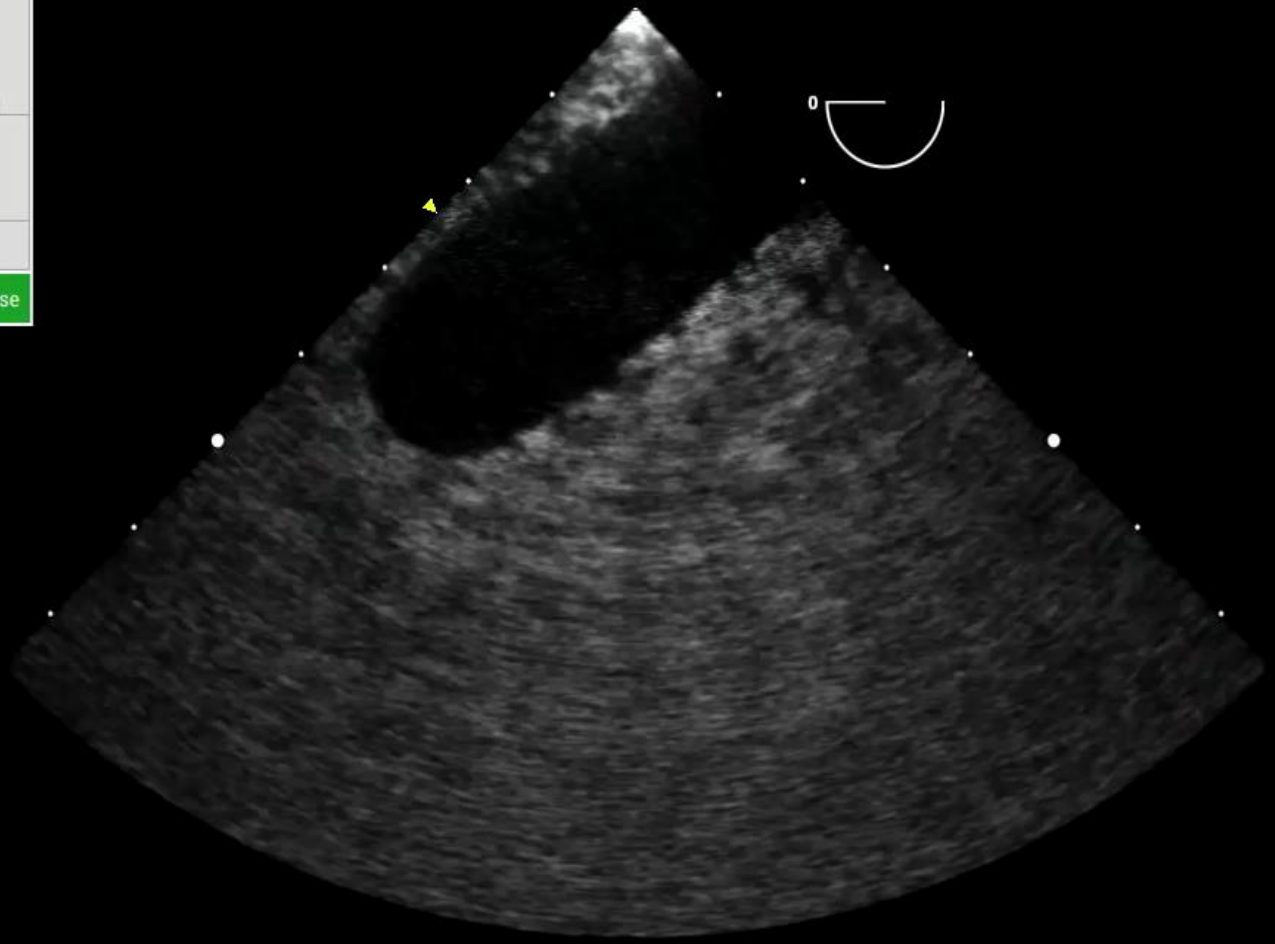


CS Cardioplegia Catheter
Tricuspid Regurgitation Severity (CS Flow Reversal)

UE Aortic Arch LAX

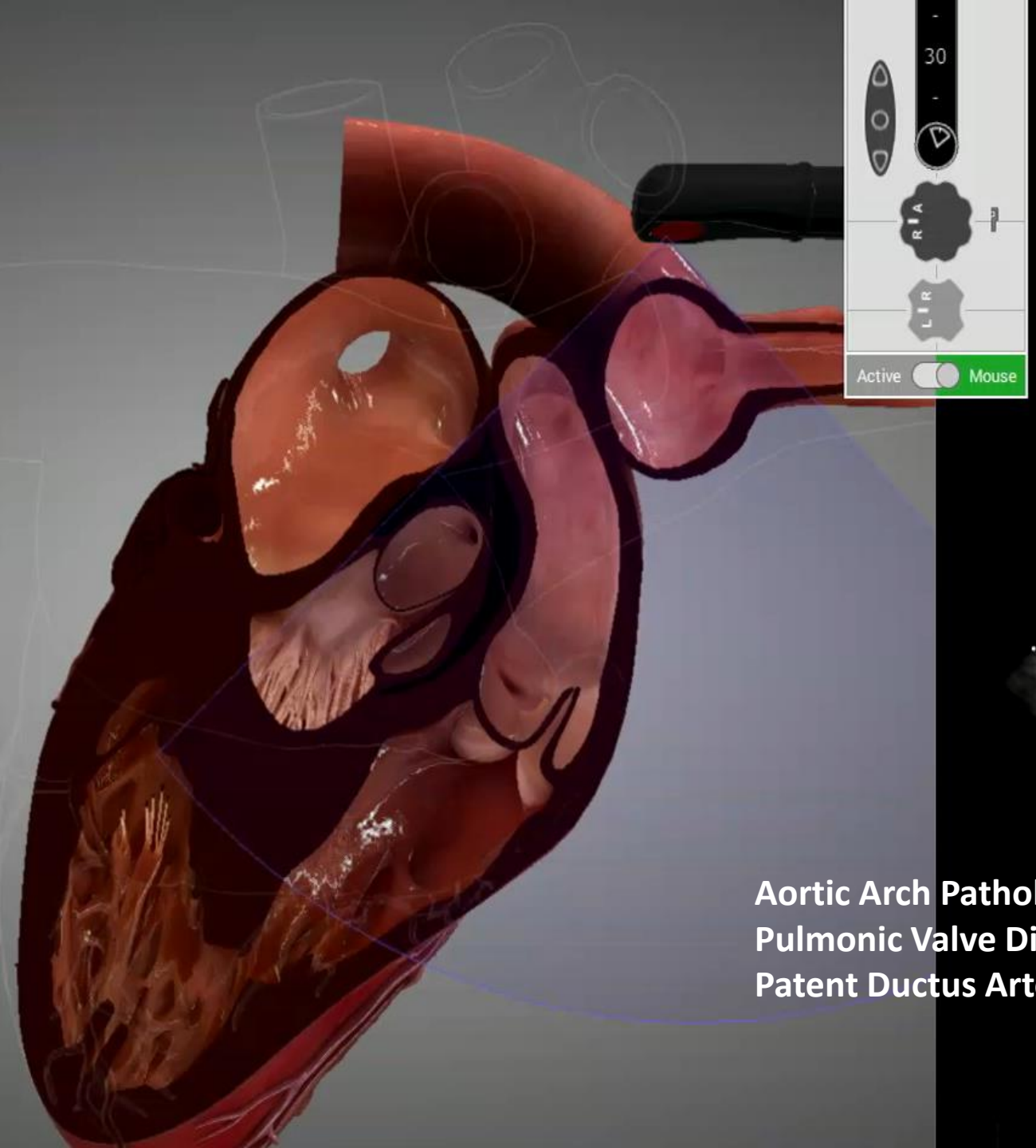


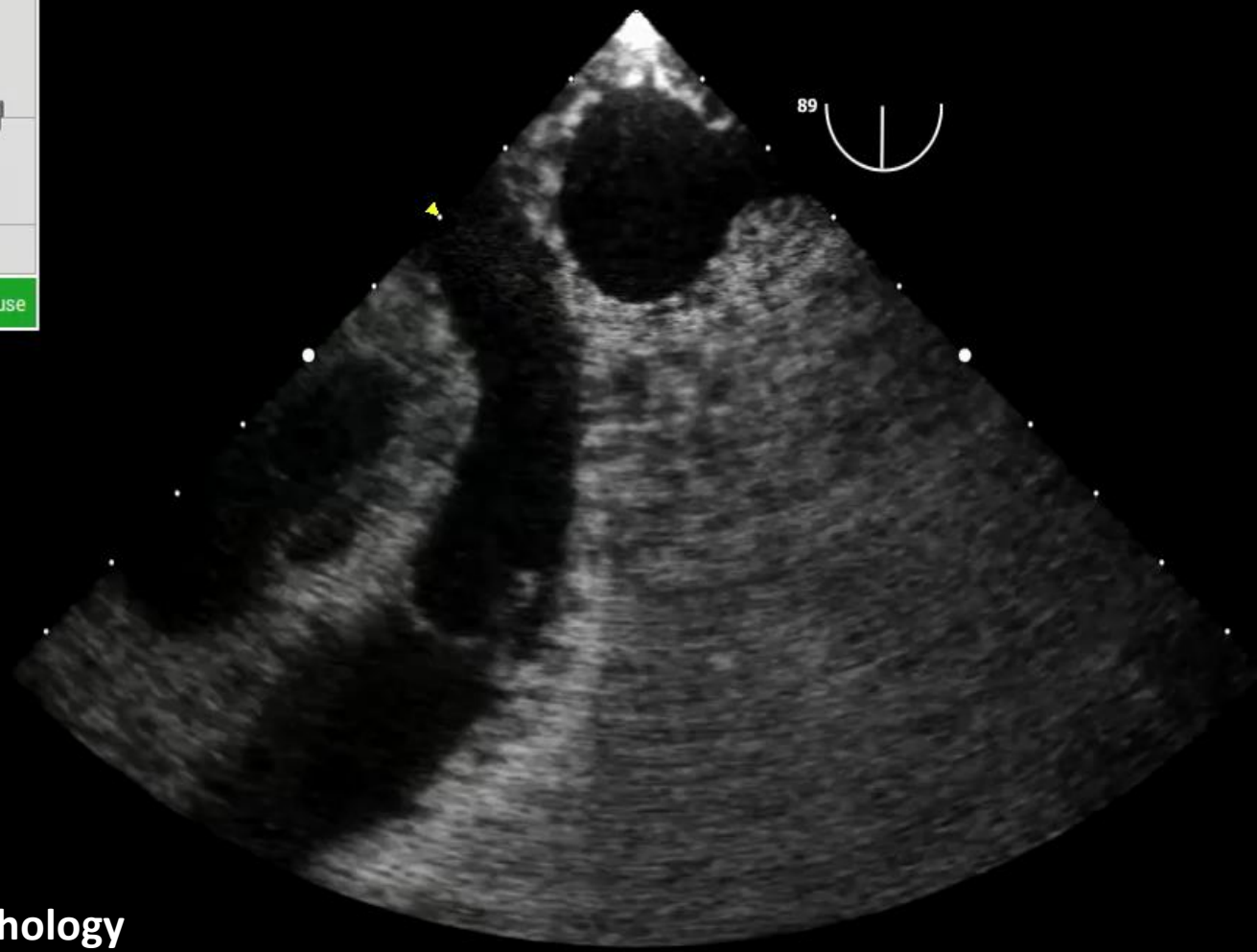




Aortic Pathology
Color Flow Reversal in Aortic Insufficiency

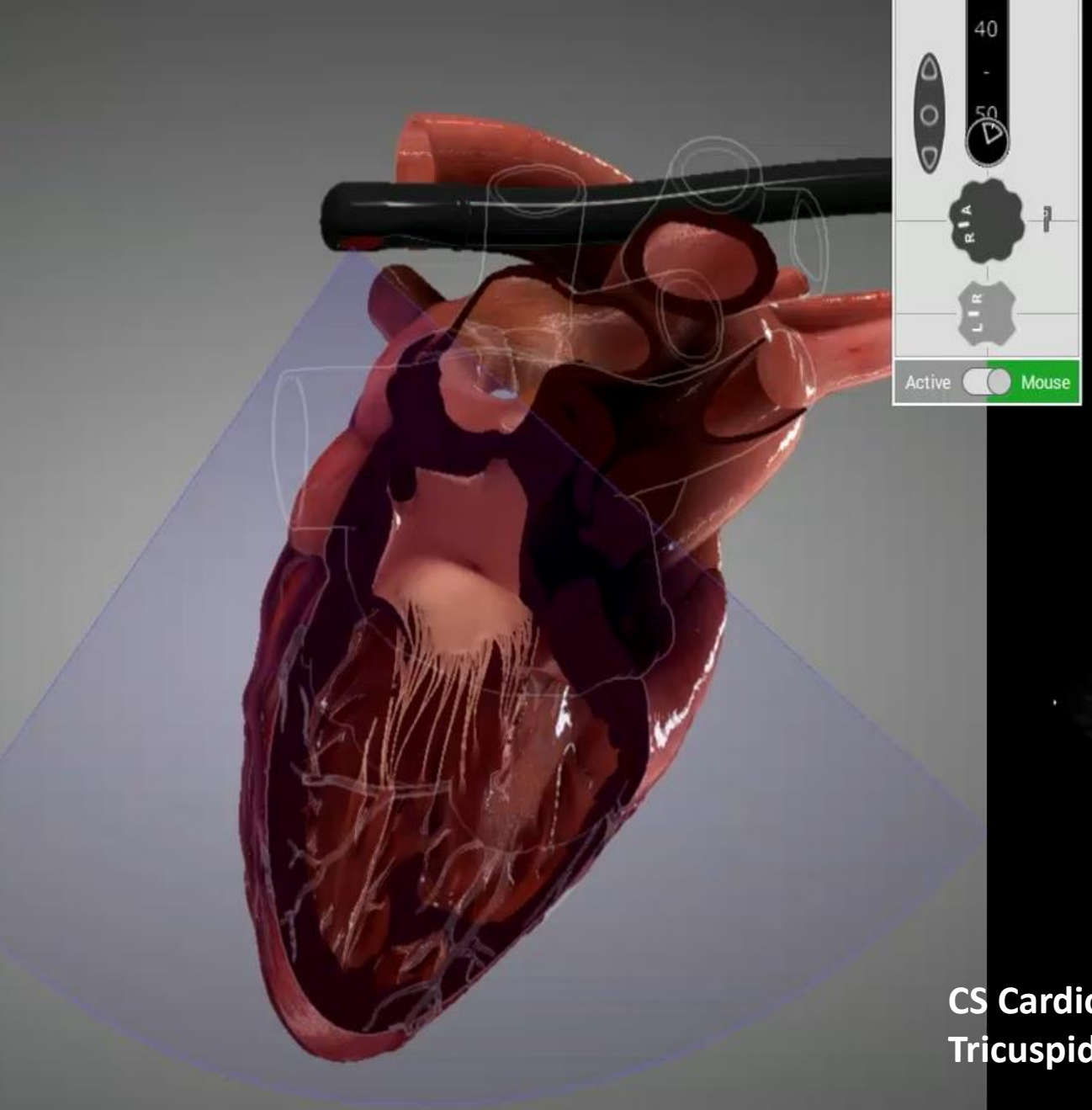
UE Aortic Arch SAX

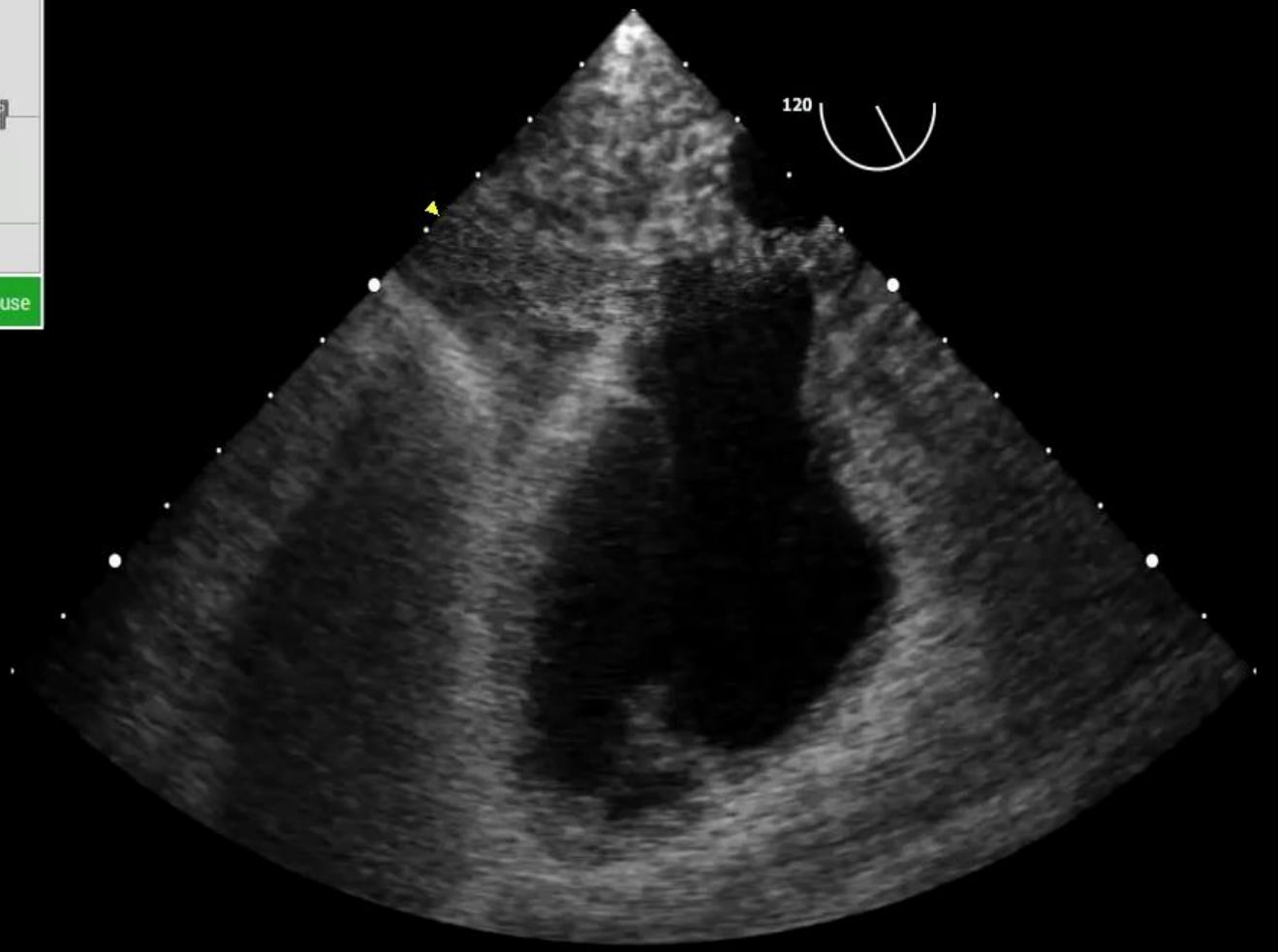




Aortic Arch Pathology
Pulmonic Valve Disease
Patent Ductus Arteriosus

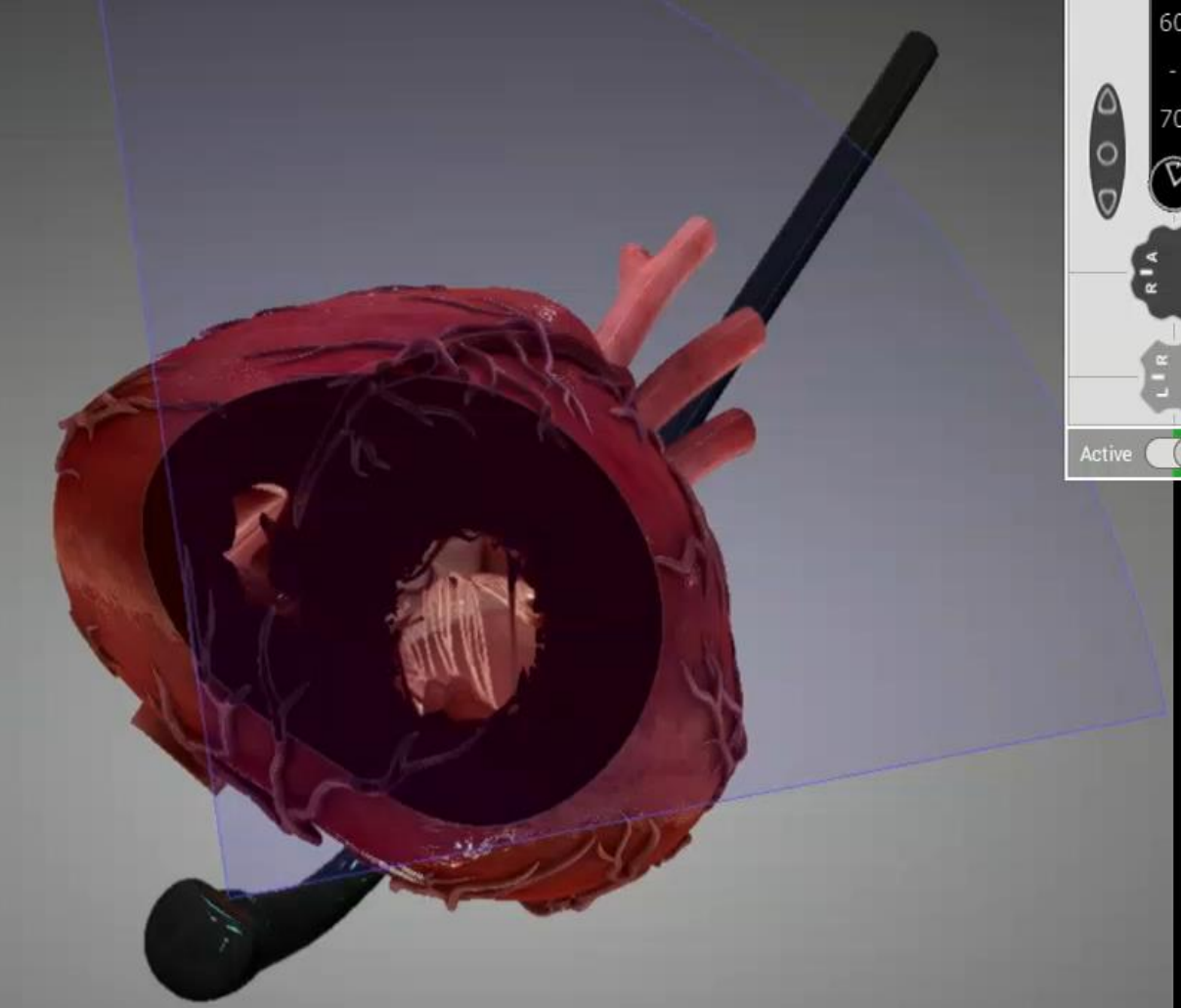
ME Modified Bicaval (CS) View

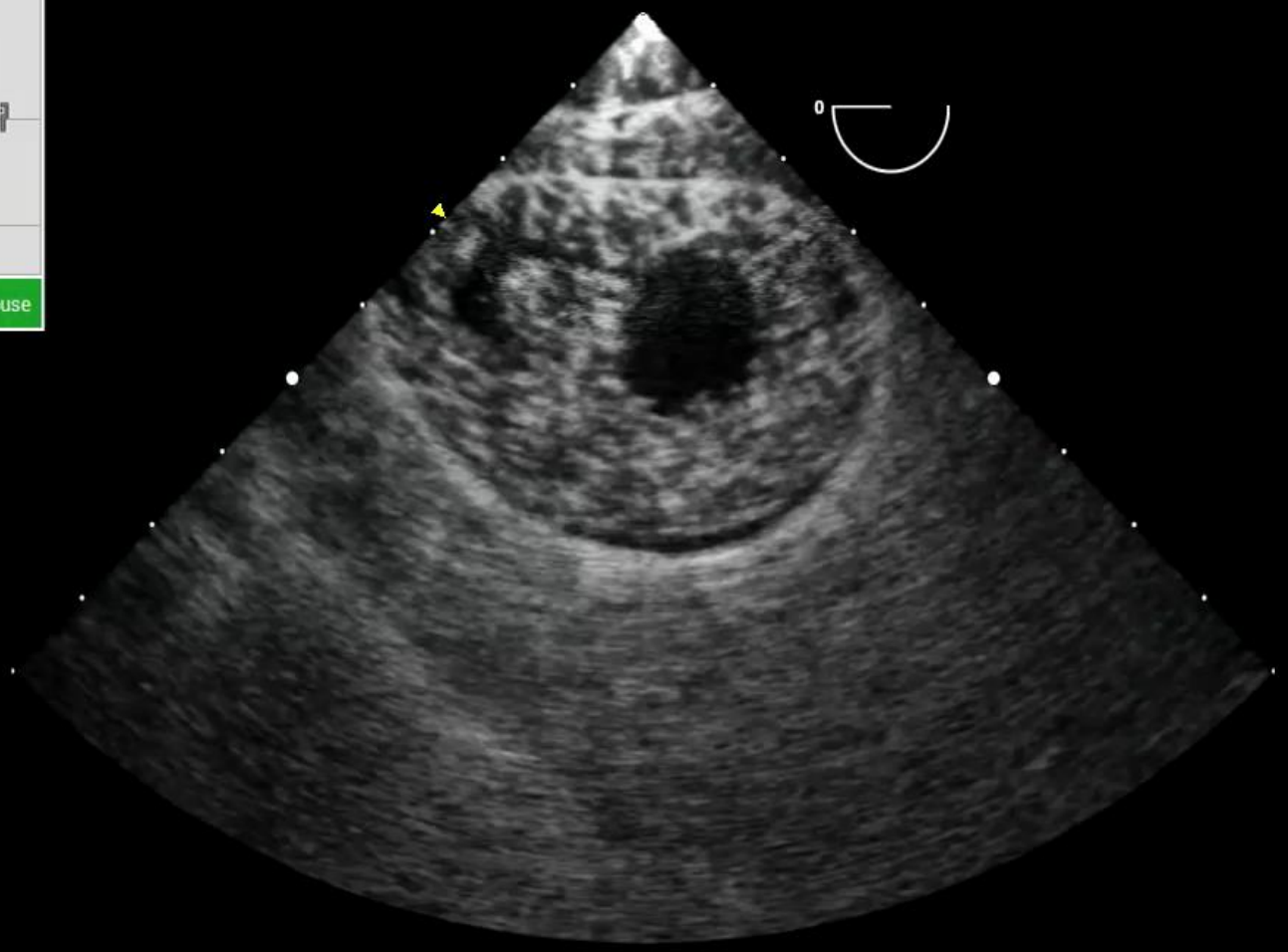




CS Cardioplegia Catheter
Tricuspid Regurgitation

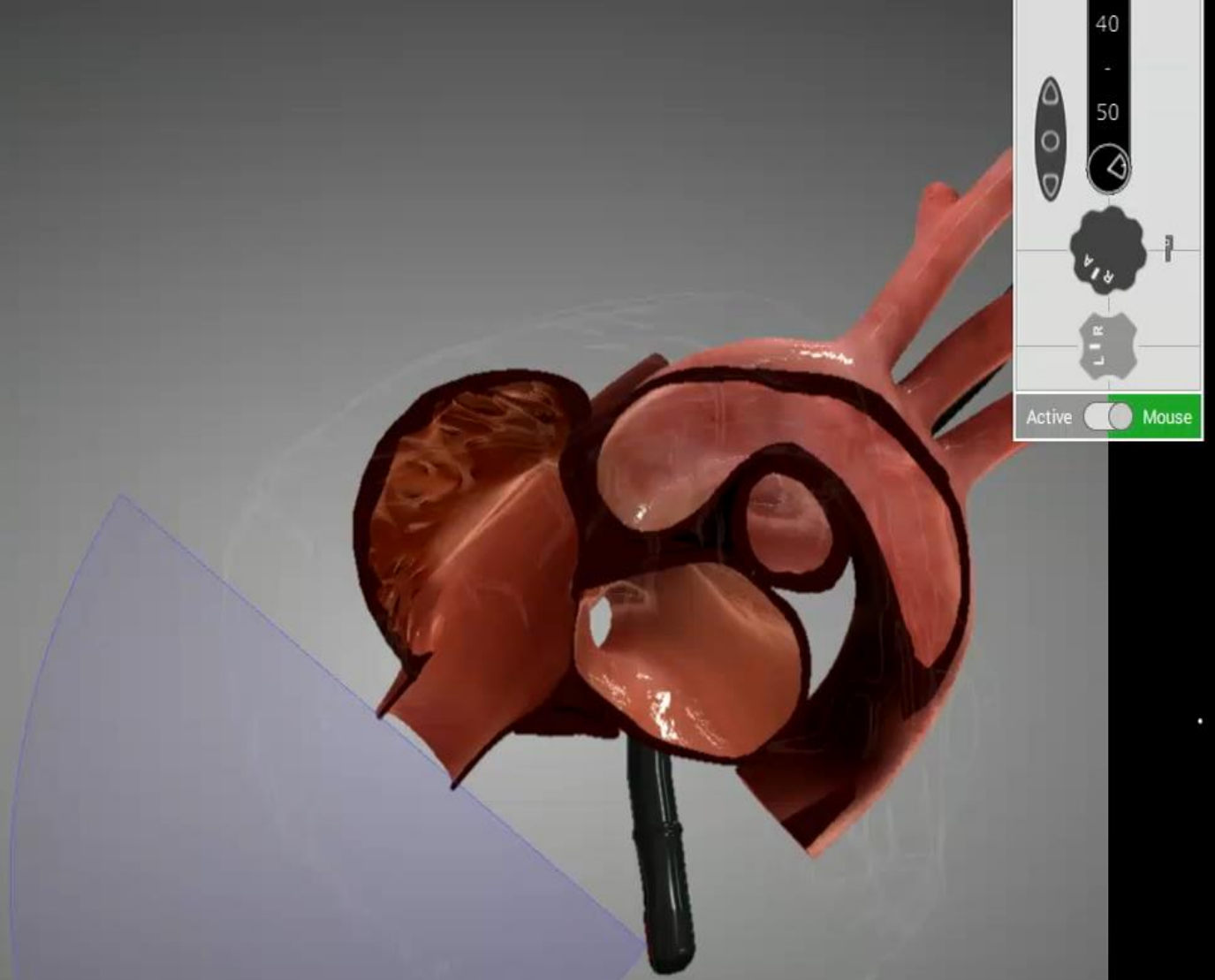
TG Apical SAX

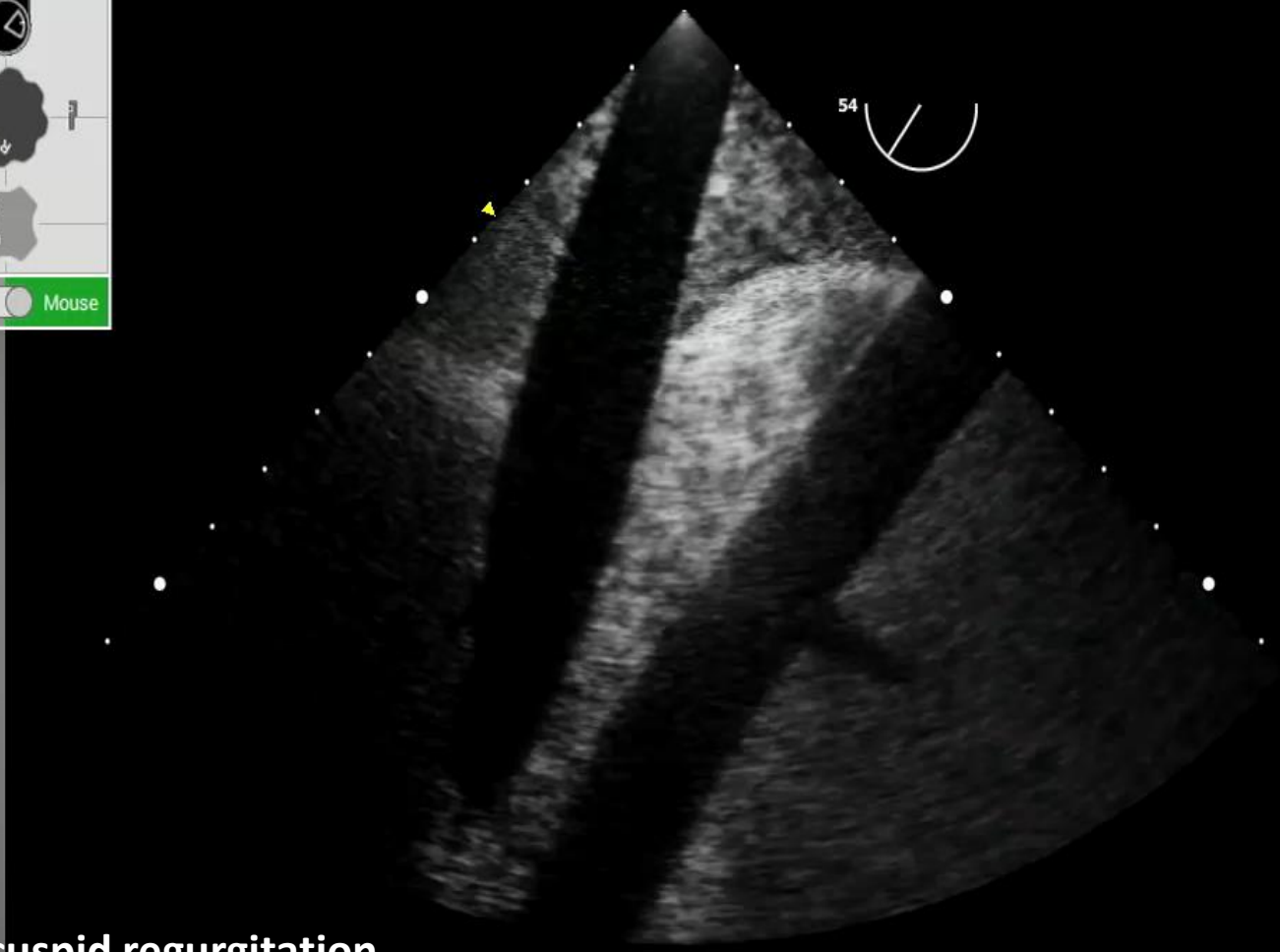




Interventricular septal motion
Aneurysmal Apex

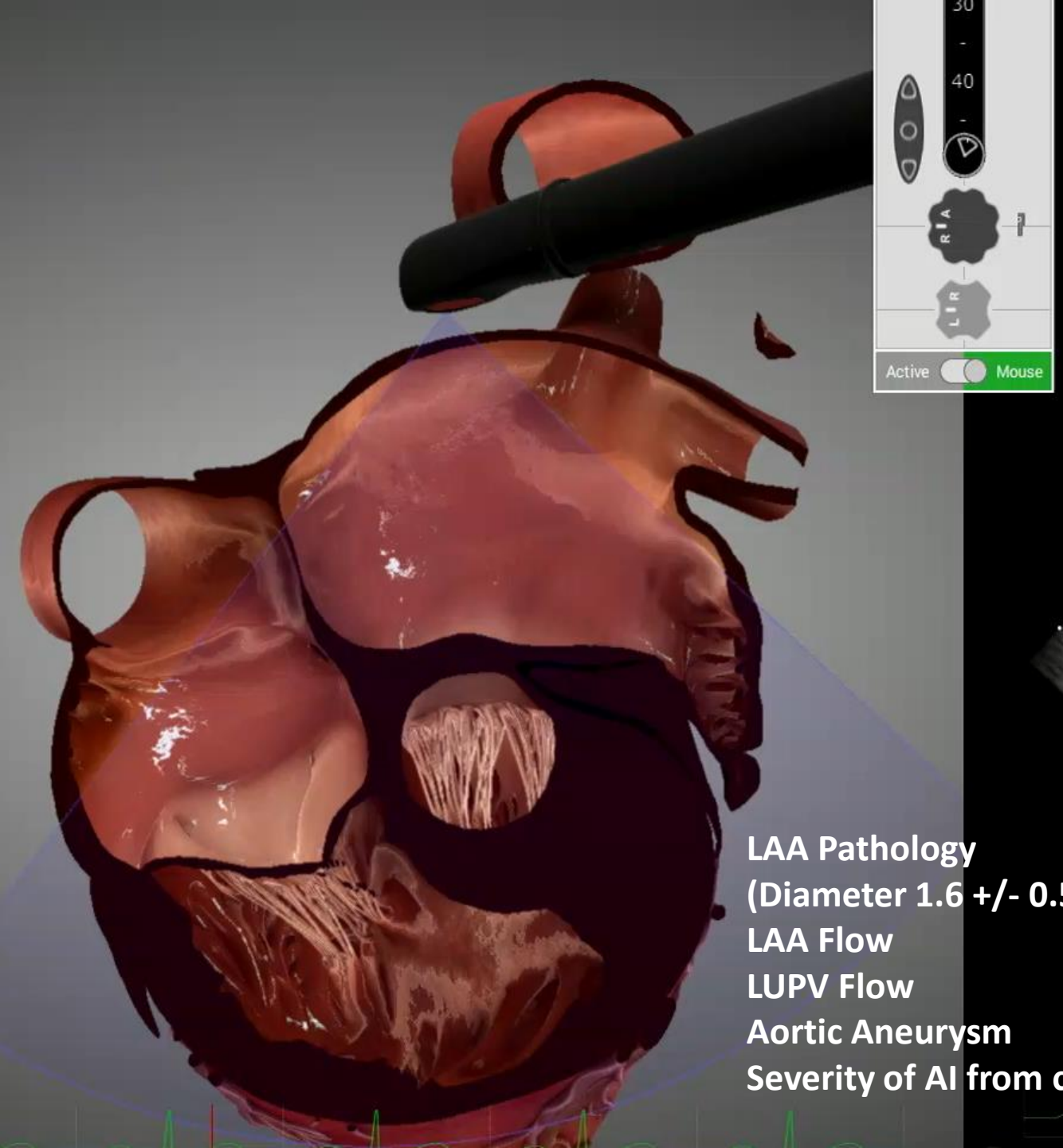
Deep IVC View

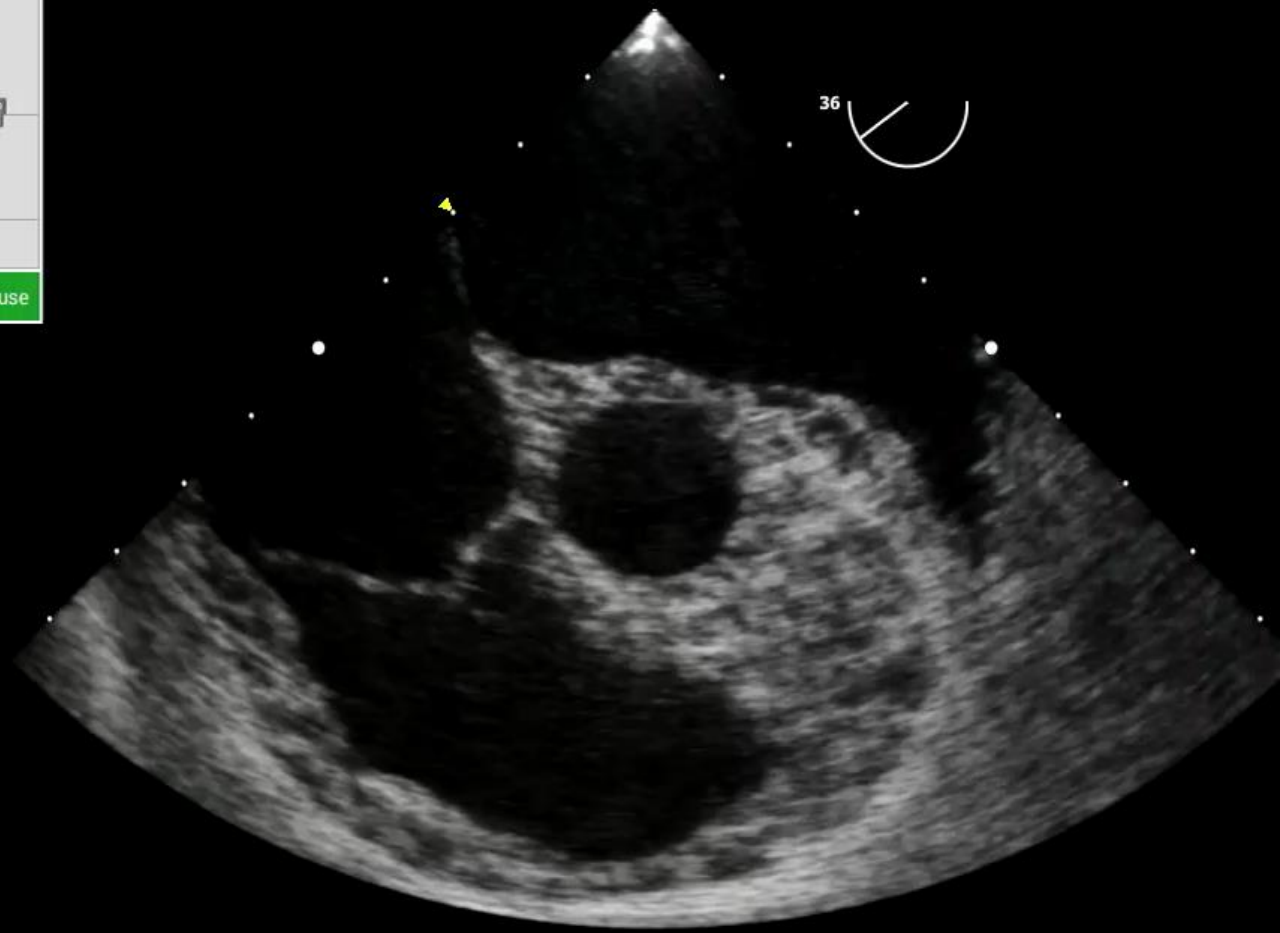




Tricuspid regurgitation
Mass (tumor, thrombus)
IVC wire/cannula
IVC respiratory variation

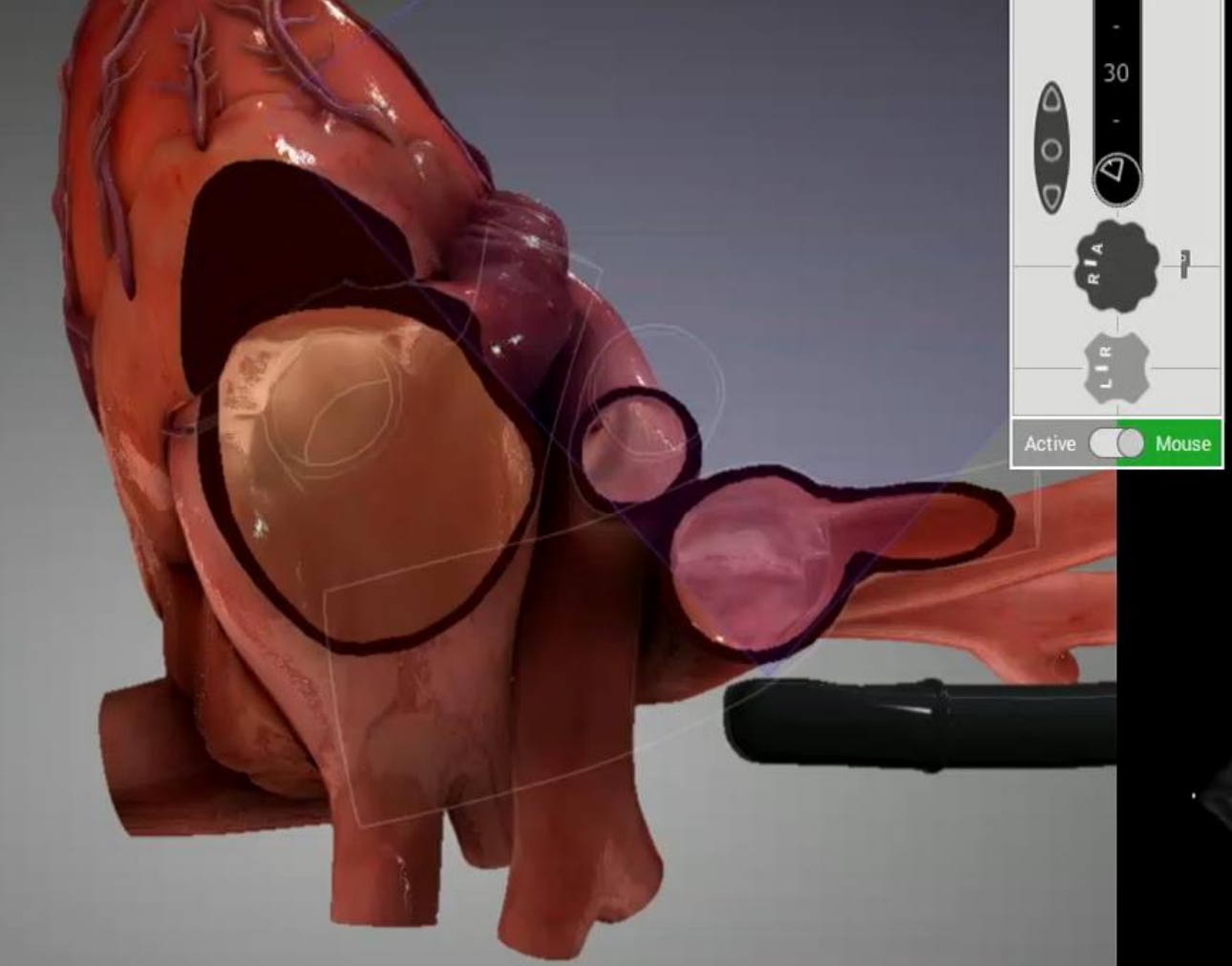
Left Atrial Appendage View

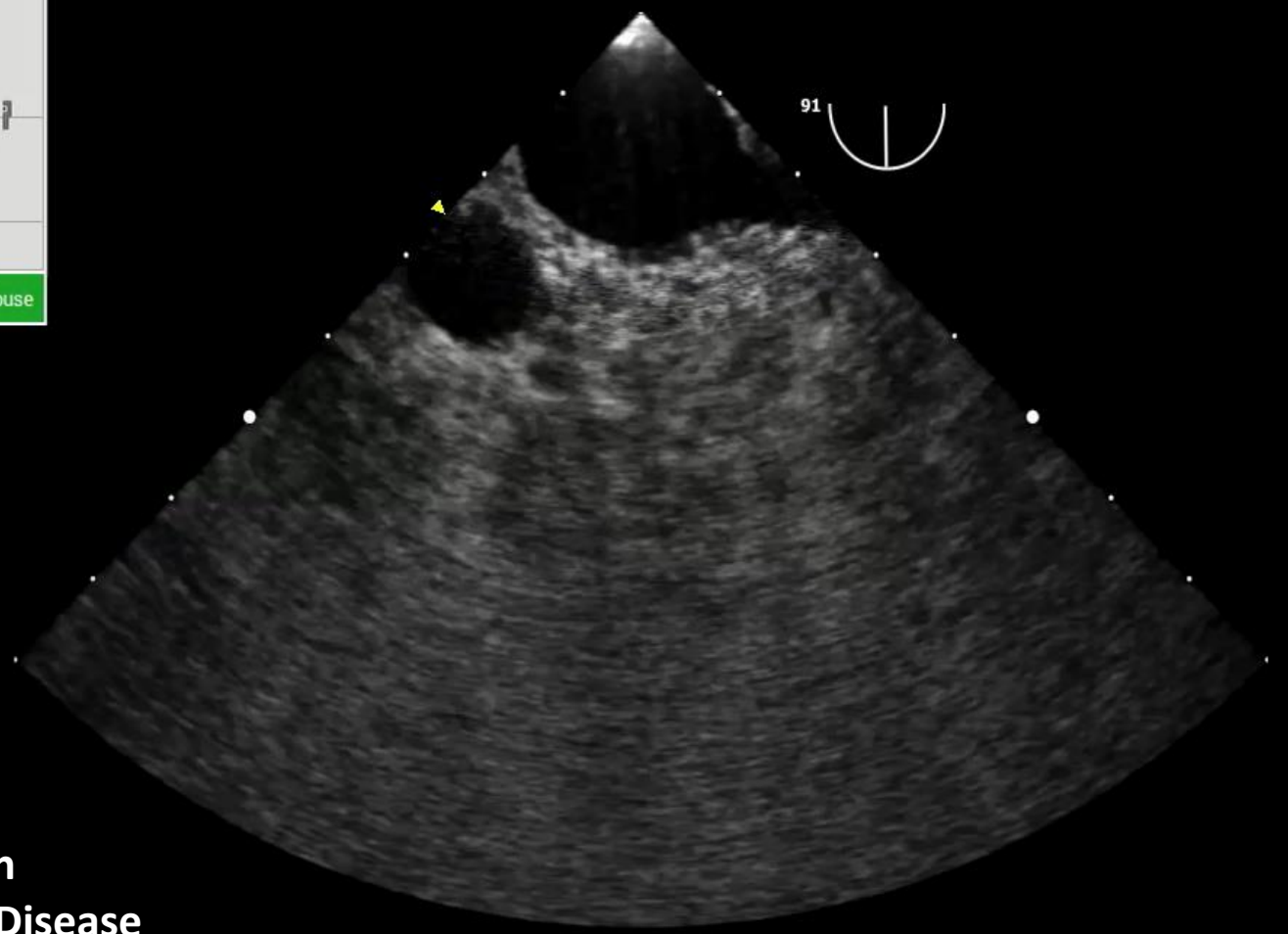




LAA Pathology
(Diameter 1.6 +/- 0.5 cm; length 2.9 =/- 0.5 cm)
LAA Flow
LUPV Flow
Aortic Aneurysm
Severity of AI from color flow reversal

Arch Subclavian View

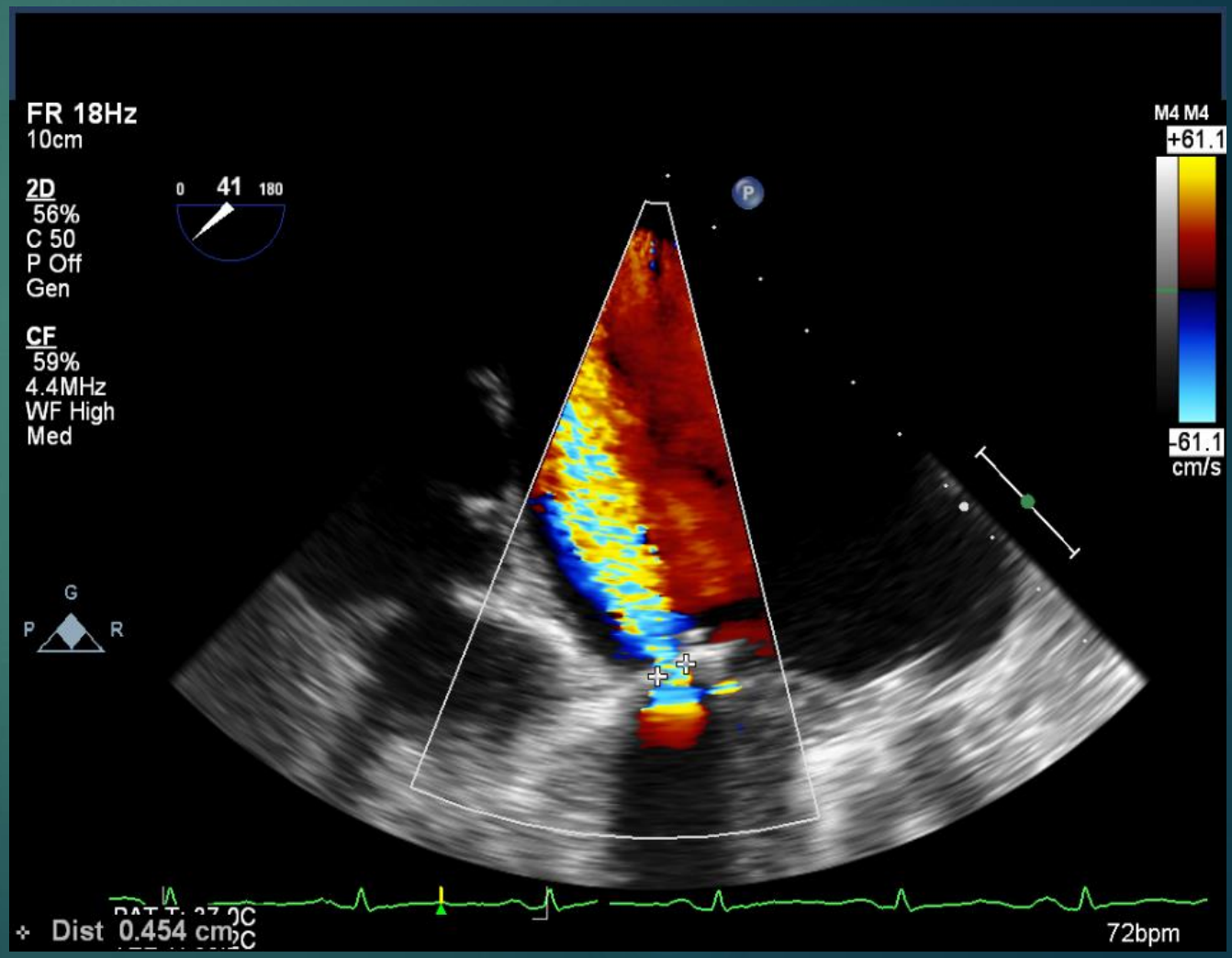




Aortic Dissection
Atherosclerotic Disease
IABP Position
Aortic stent placement
Coarctation

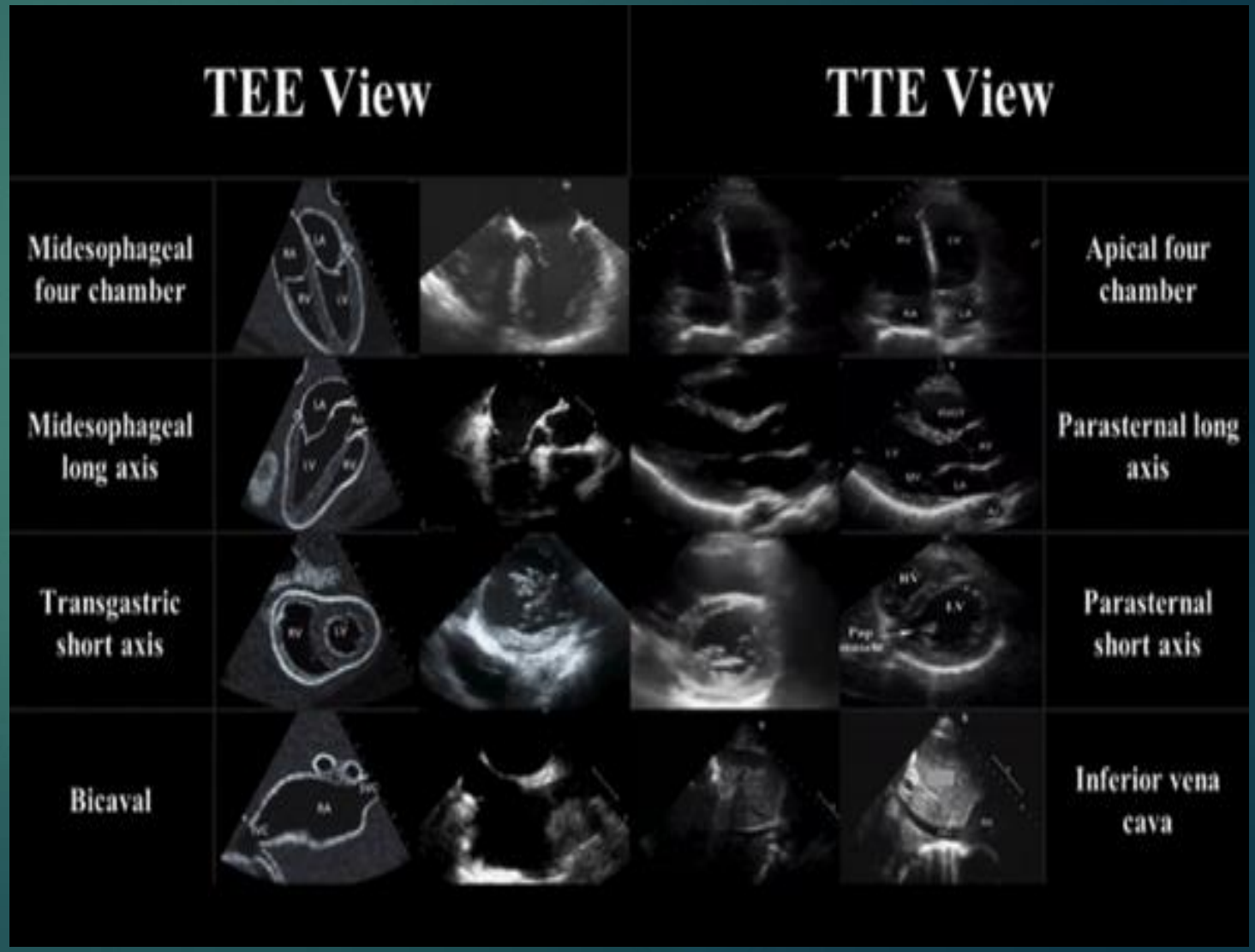
Perioperative Use of Advanced TEE

- Advanced use as monitor
- Additional views for diagnostic and interventional uses
  - Valve area
  - Advanced valve function assessment
  - Guide device deployment
  - Advanced Doppler and quantitative assessment
- Assessment of cardiac surgical intervention



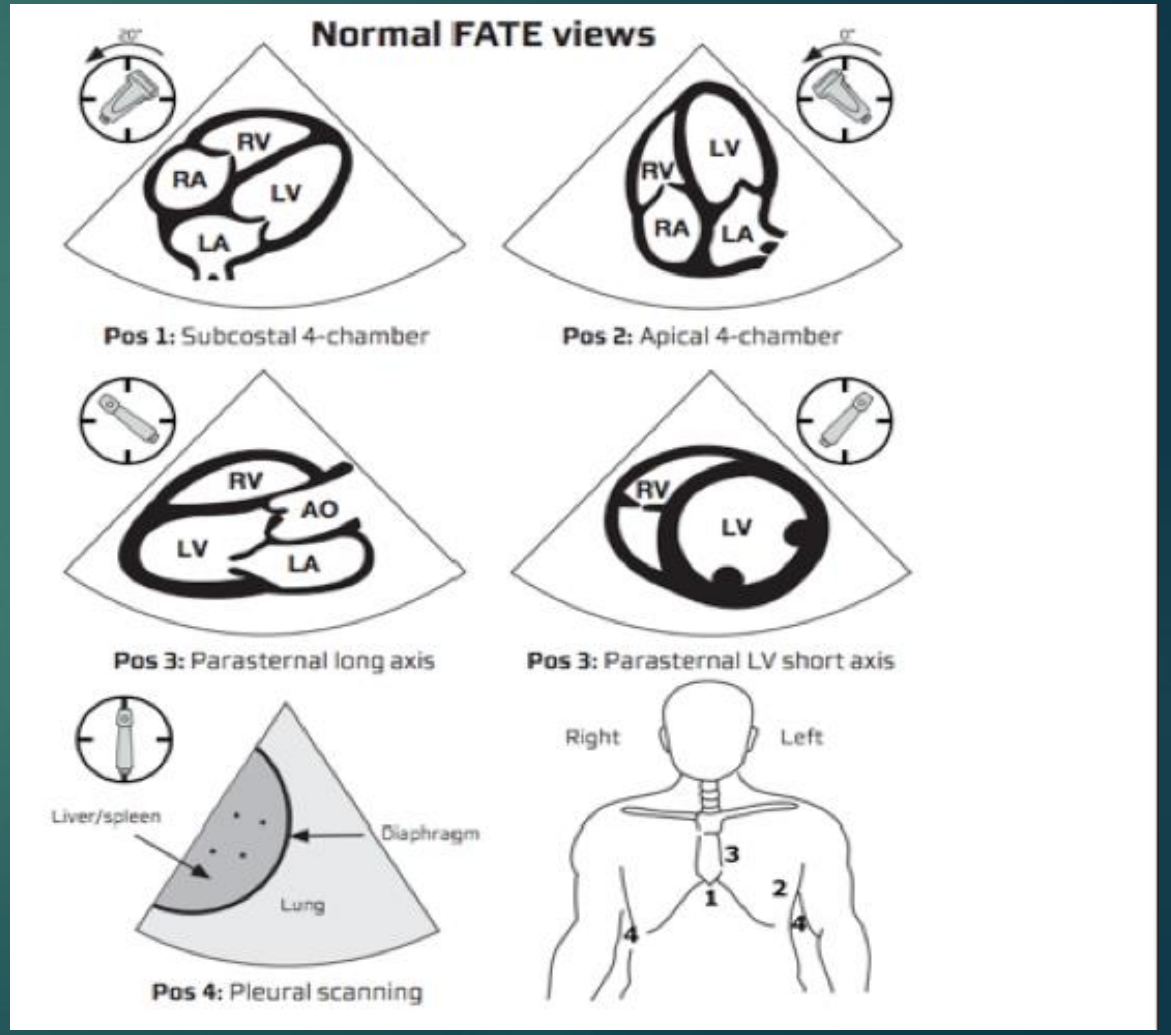
Additional Imaging Used in Advanced TEE

- Diagnostic and interventional uses of TEE require advanced skill set
- Additional views offer surgeon and interventionalist 2-D and 3-D imaging
- Full perioperative use of echocardiography is no longer limited to TEE but includes limited transthoracic echo (TTE)



Focused Assessed Transthoracic Exam (FATE)

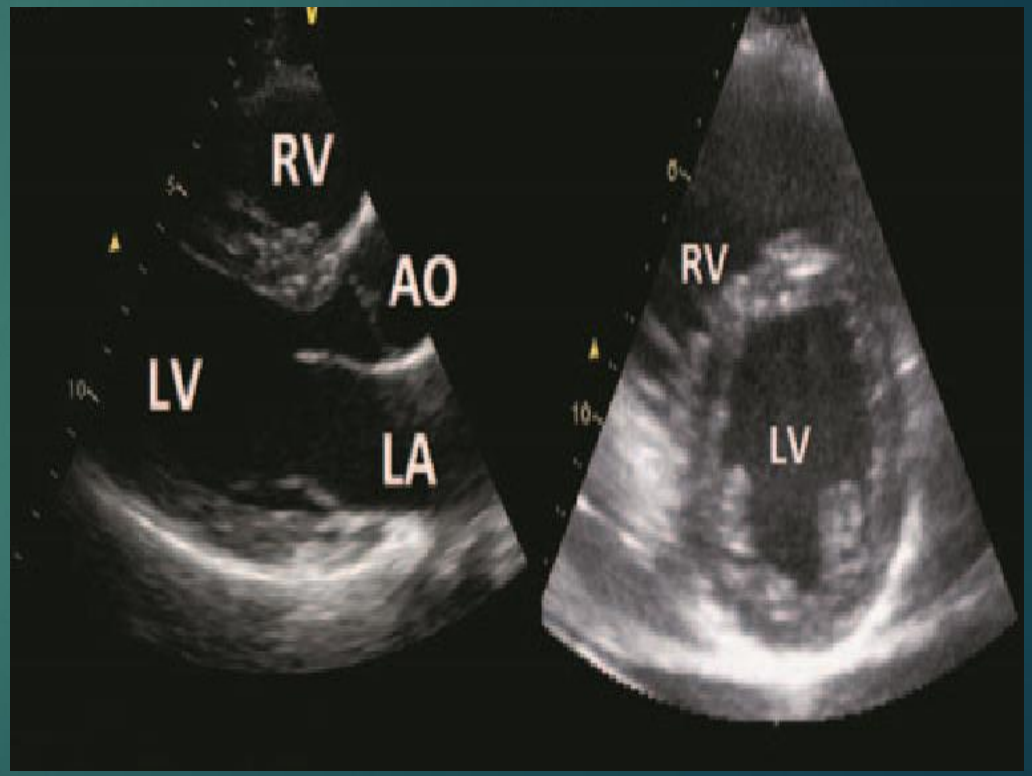
- Four ultrasound/TTE positions
- Basic anatomical and functional assessment complementing other assessments
  - Biventricular function
  - Valvular function
  - Volume status
  - Pericardial/pleural effusion
  - Exclusion of pulmonary pathology



Spencer et al. Focused cardiac ultrasound: Recommendations from the American Society of Echocardiography. J Am Soc Echocardiogr 2013:26:567-581

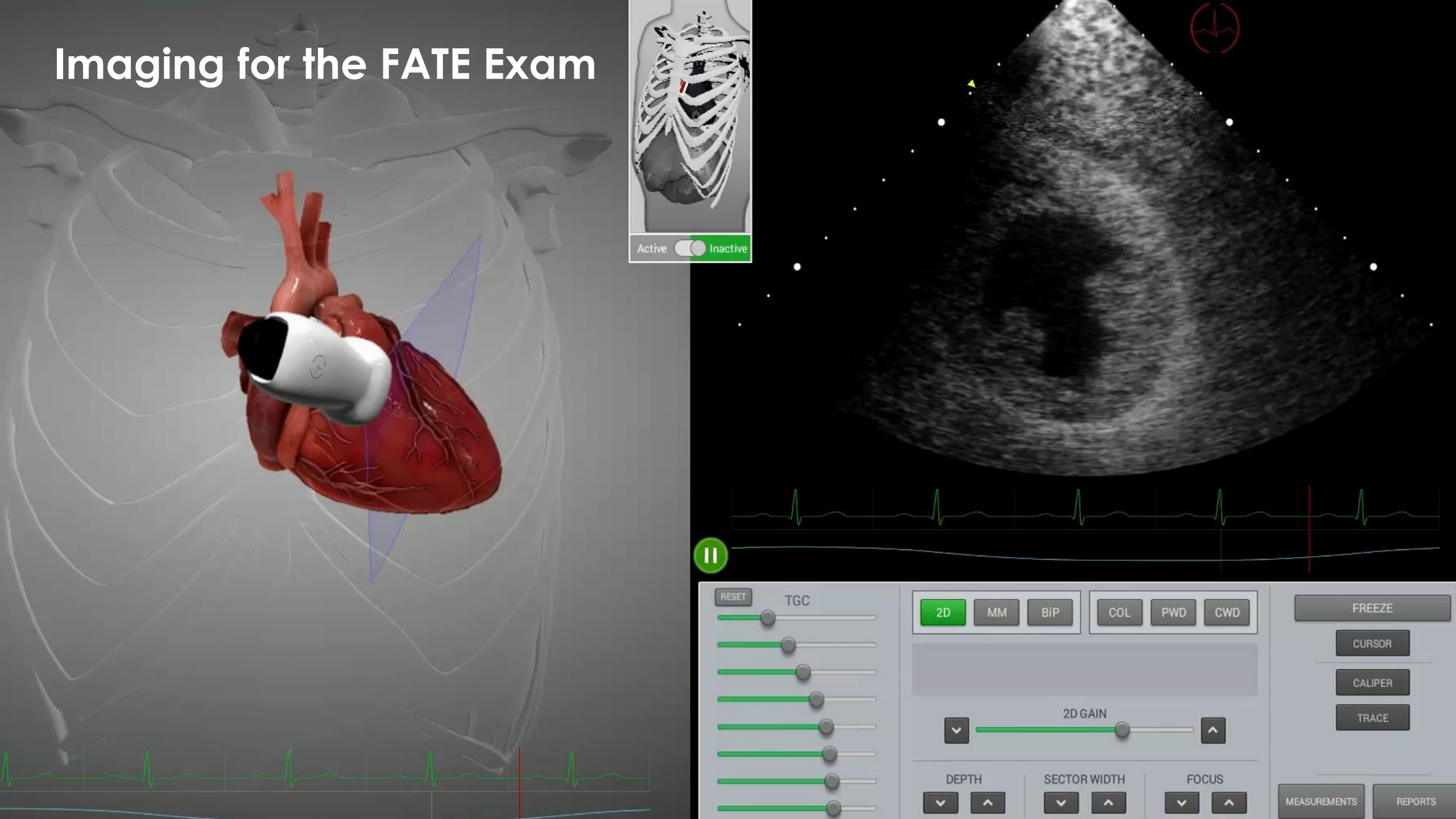
Perioperative Use of the FATE Exam

- Monitoring and treatment of the unstable patient involves
  - Estimation of preload
  - Estimation of contractility
  - Estimation of heart chamber and wall dimensions
- An abbreviated two dimensional cardiac ultrasound offers these assessments
- The FATE protocol offers useful information in 97% of ICU patients

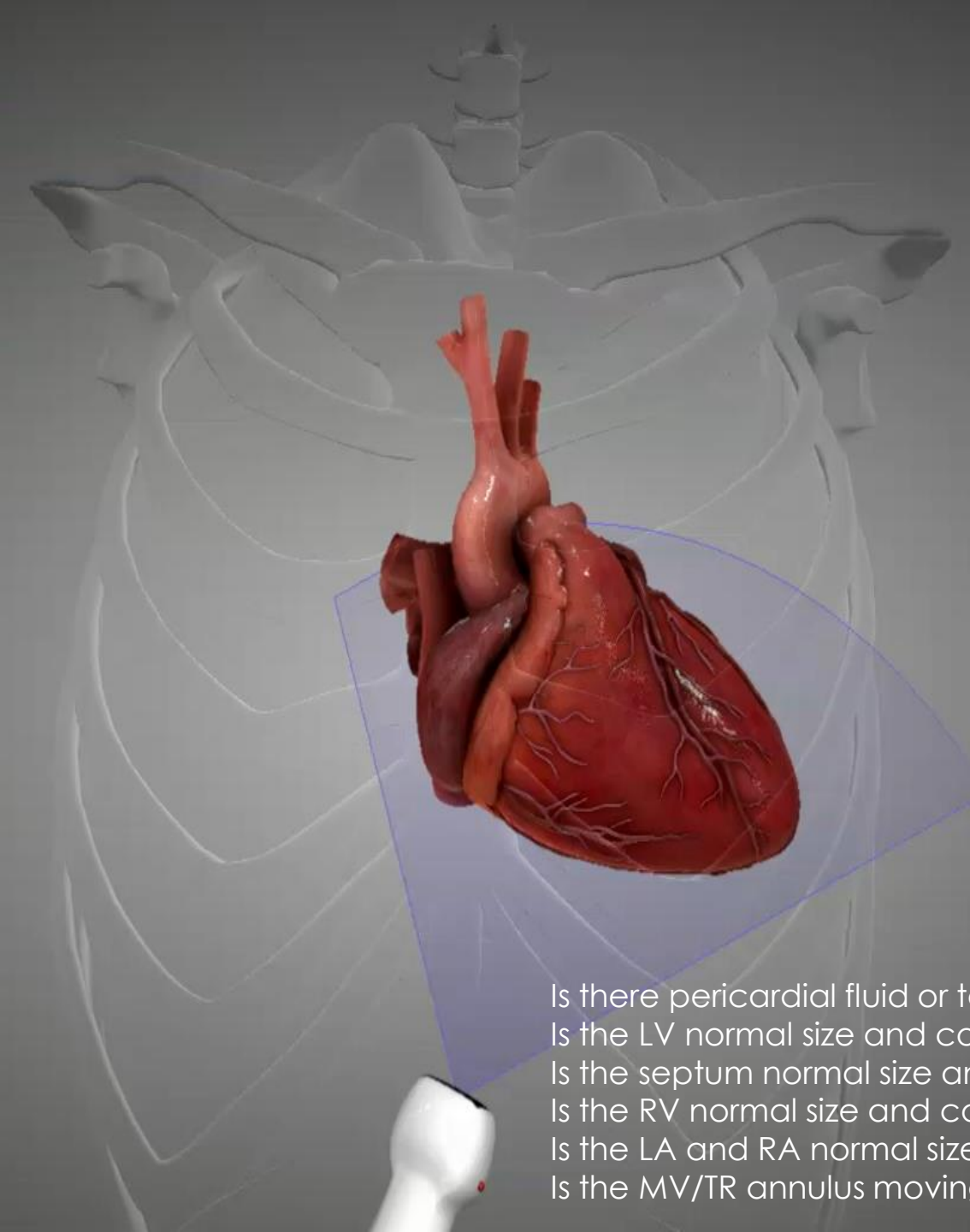


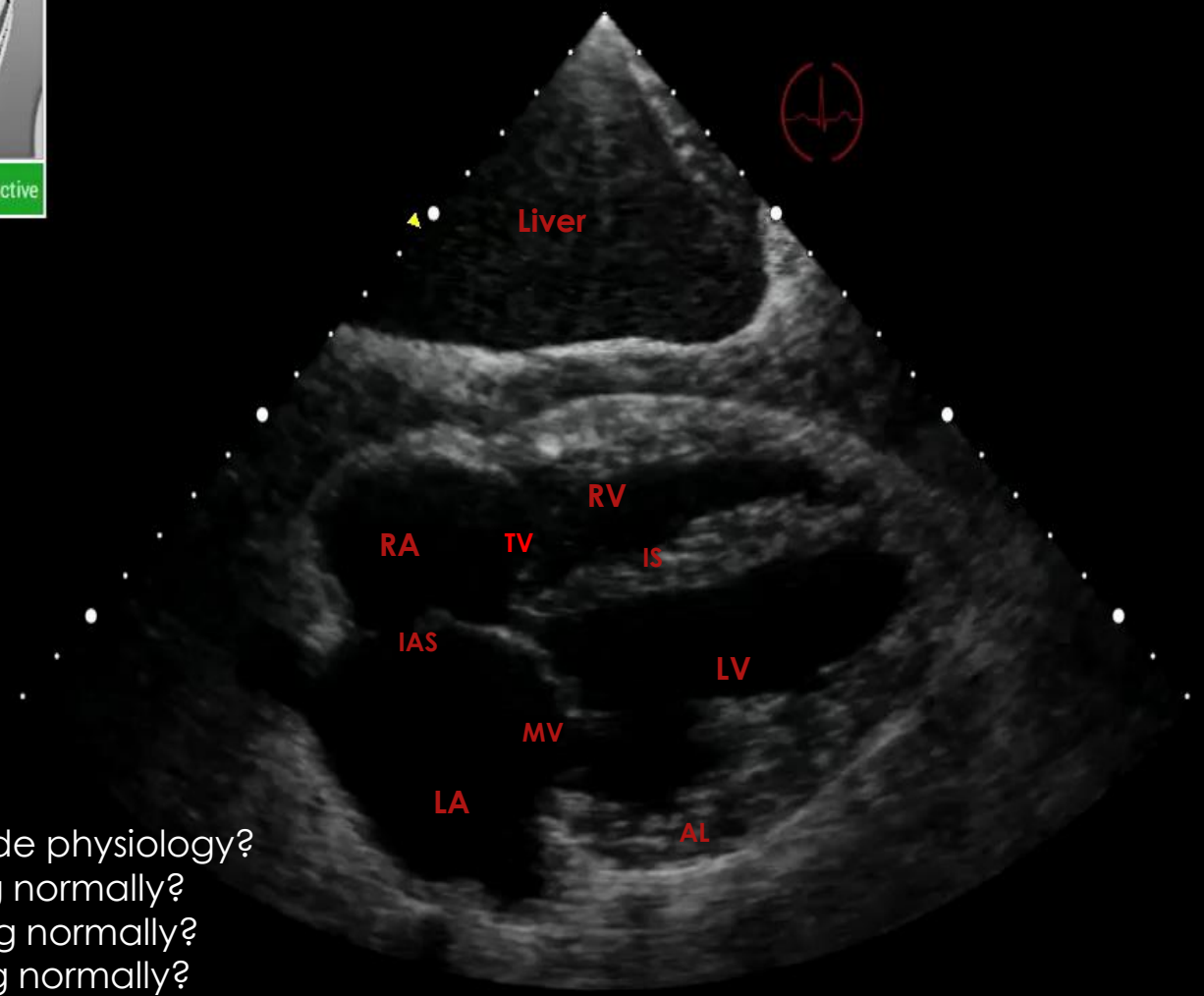
Holm et al. Perioperative use of Focus Assessed Transthoracic Echocardiography (FATE). Anesth Analg 2012, 115: 1029-1032

Imaging for the FATE Exam



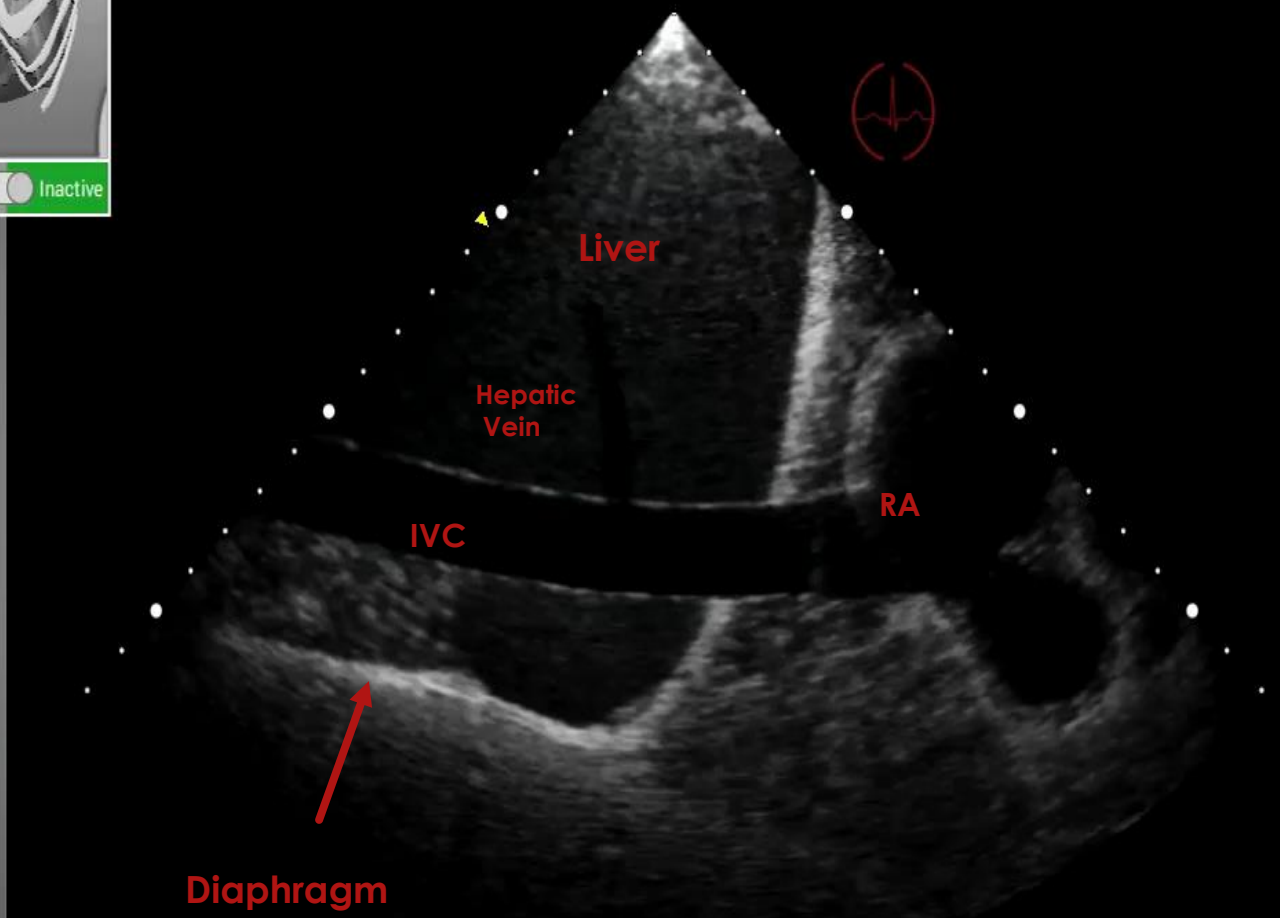
Subcostal Four Chamber





Is there pericardial fluid or tamponade physiology?
Is the LV normal size and contracting normally?
Is the septum normal size and moving normally?
Is the RV normal size and contracting normally?
Is the LA and RA normal size and interatrial septum normal?
Is the MV/TR annulus moving up and down (good LV/RV function)?

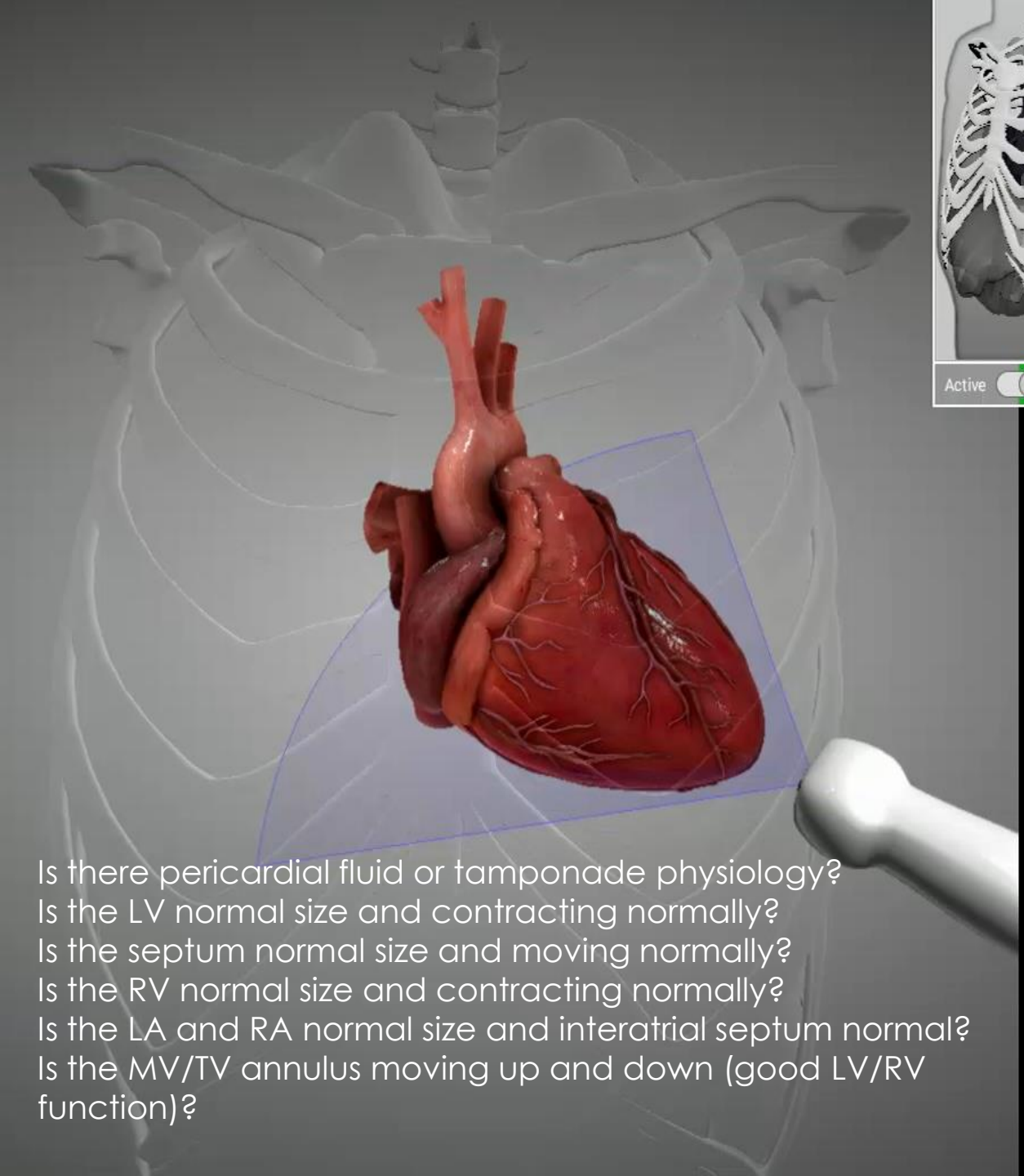
Subcostal Inferior Vena Cava

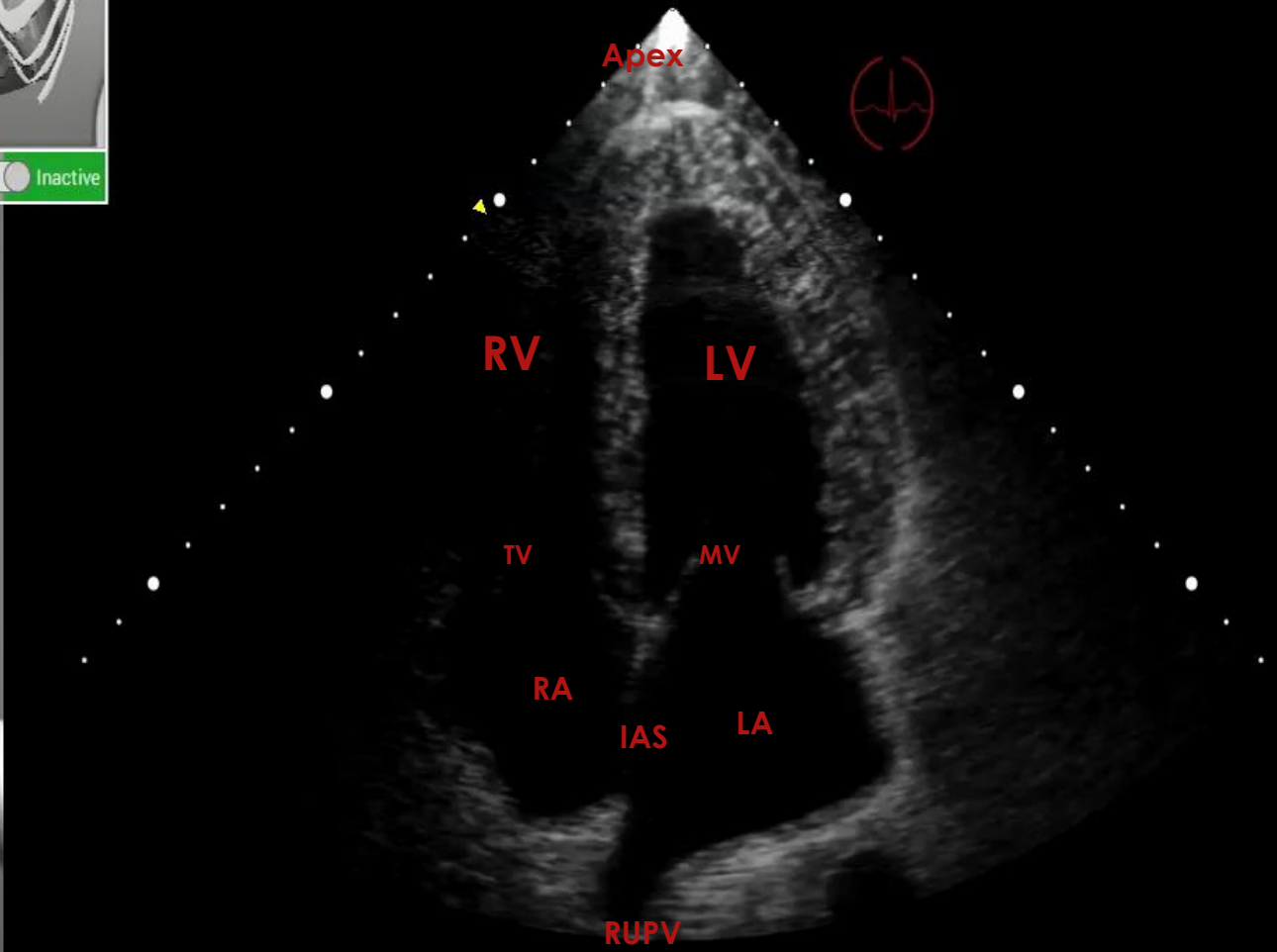


IVC Diameter	%collapse	CVP
< 2 cm	> 50%	0-5
> 2 cm	> 50%	5-10
> 2 cm	minimal	15-20
> 2 cm	none	> 20

Measure the IVC
Assess IVC collapsibility
Compare to LV size, obliteration of chamber during systole
Responsiveness to volume administration

Apical Four Chamber





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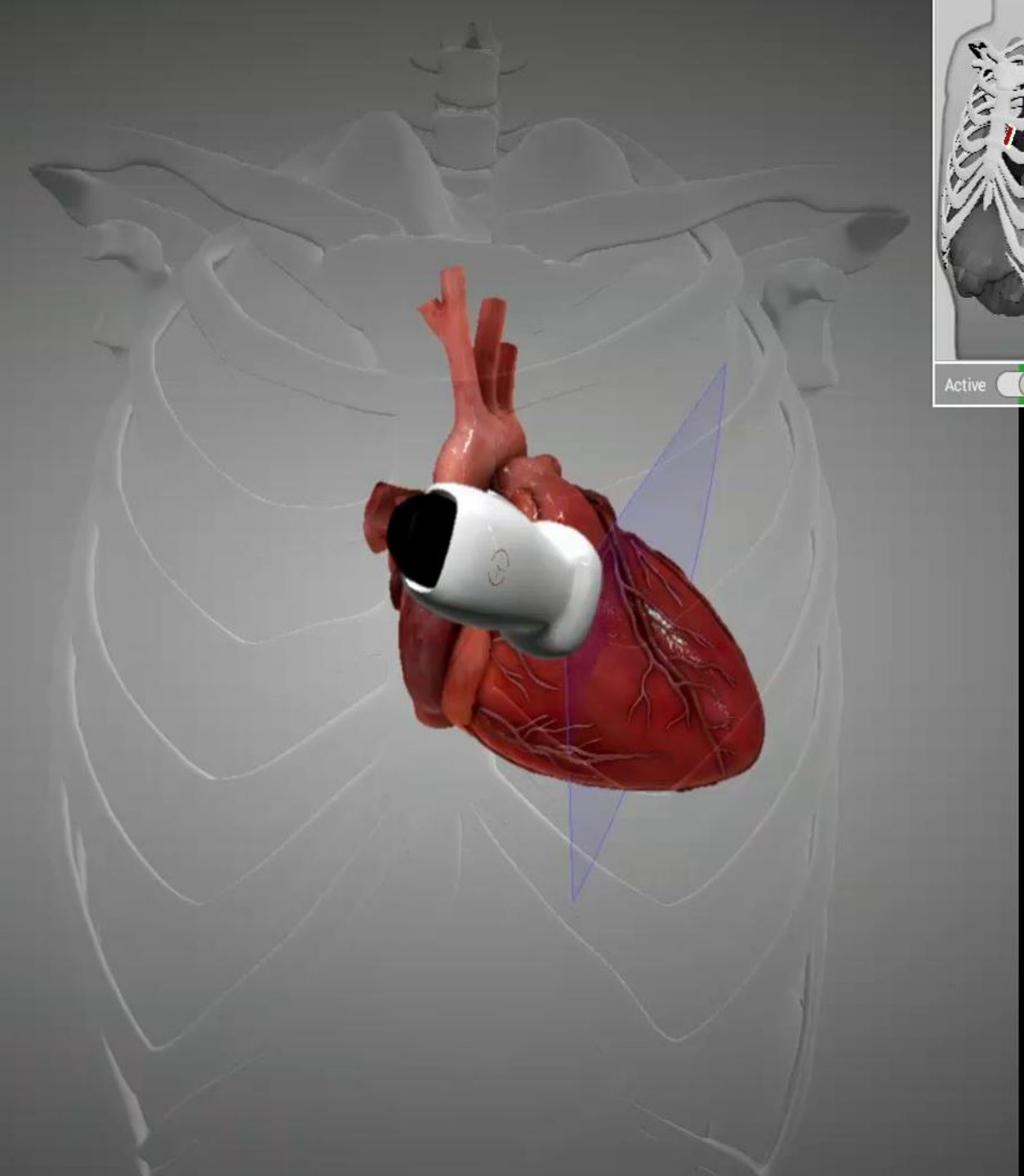
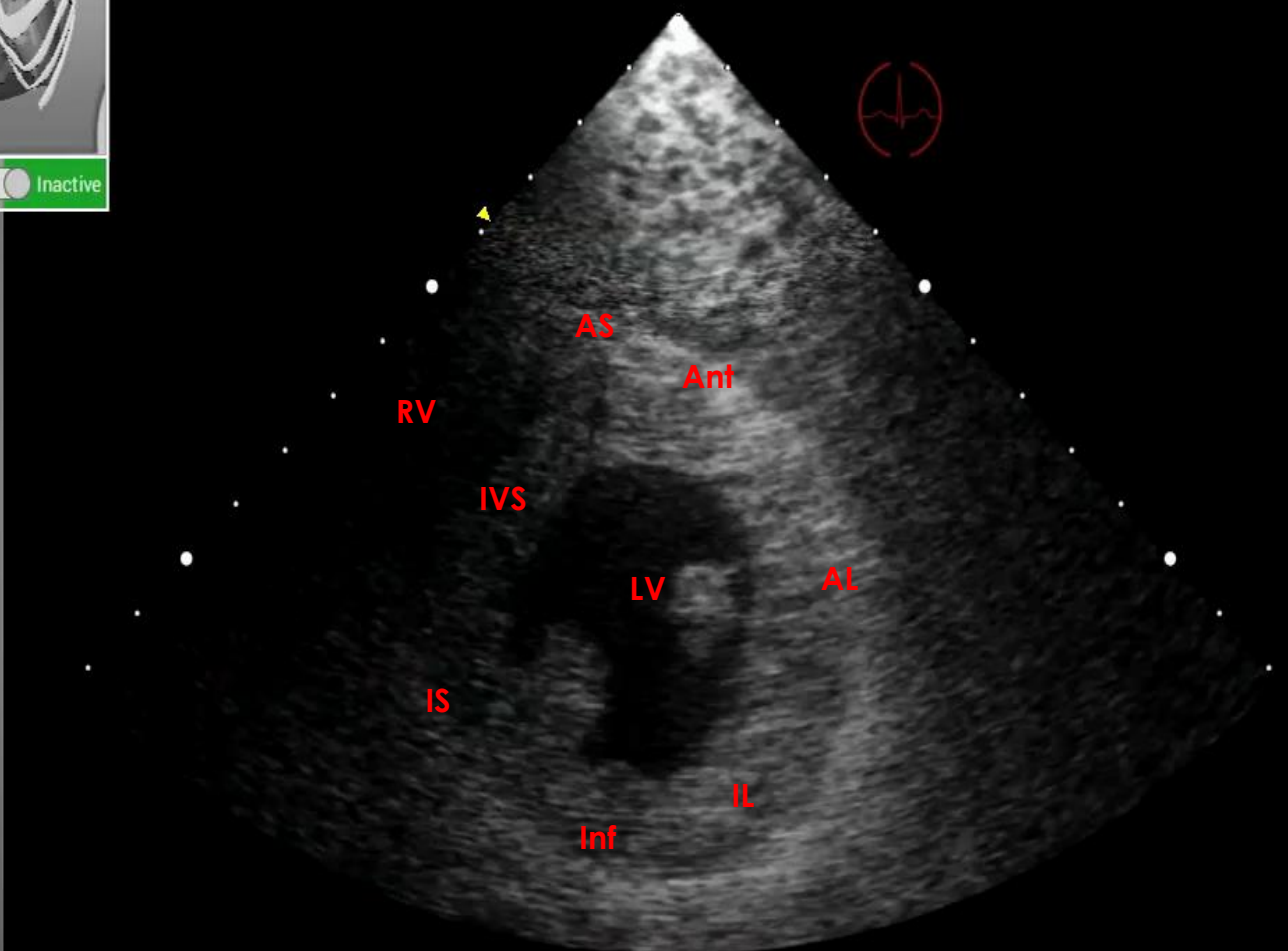
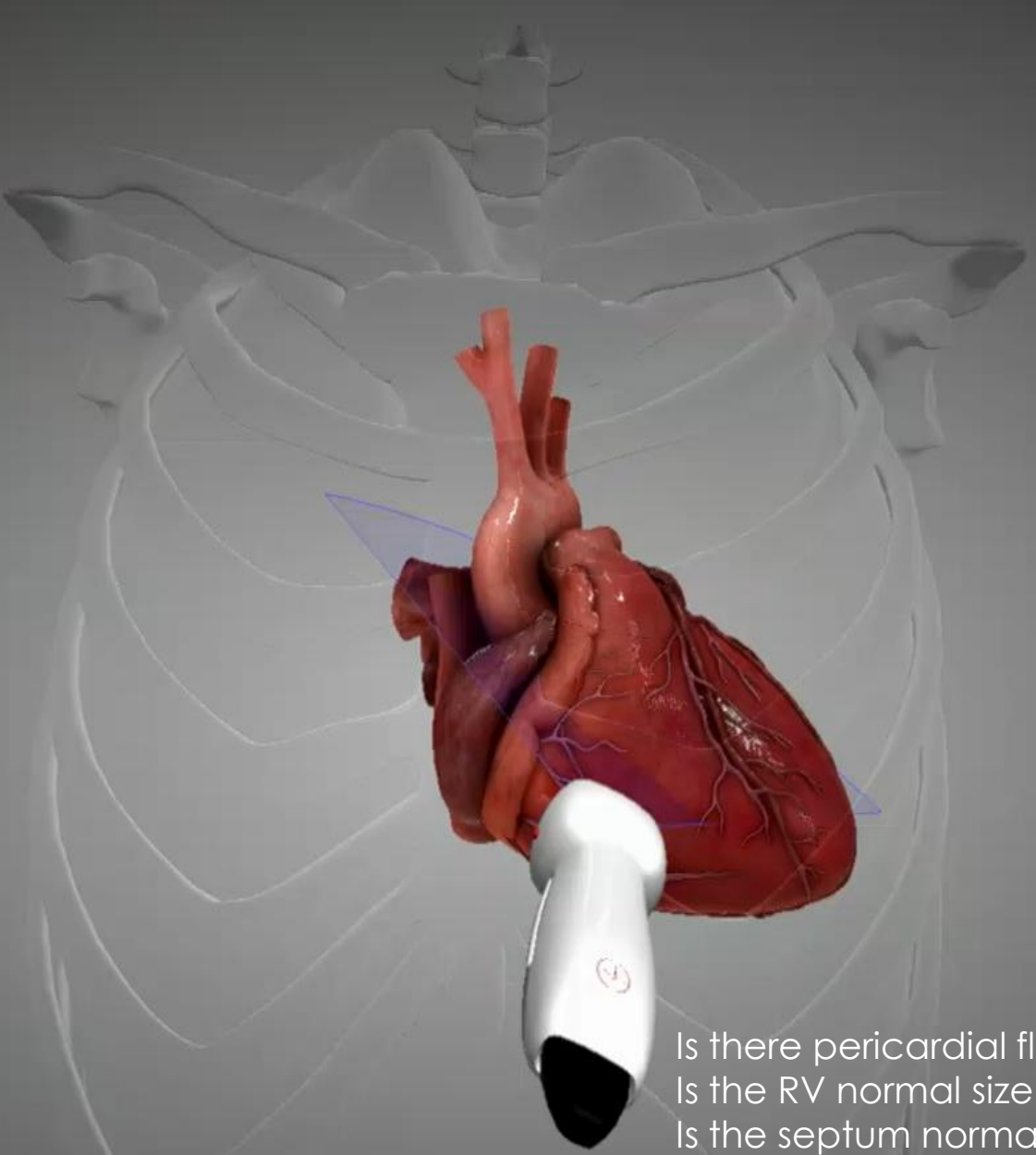


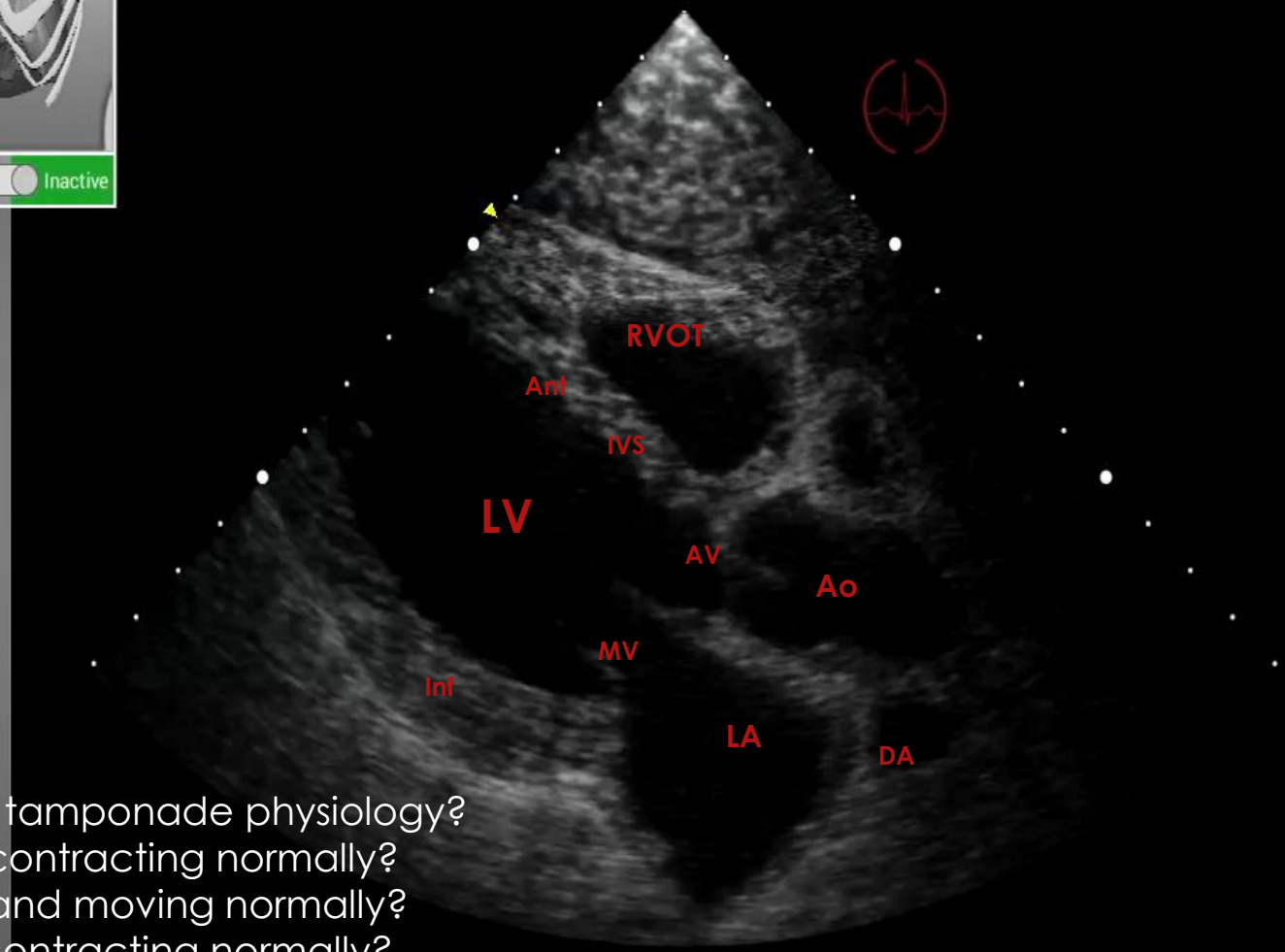
Parasternal Short Axis



Is LV contracting normally, euvolemic without regional WMA?
Is RV smaller than LV (60%) and D-shaped?
Is there any pericardial fluid/tamponade?

Parasternal Long Axis





Is there pericardial fluid or tamponade physiology?
Is the RV normal size and contracting normally?
Is the septum normal size and moving normally?
Is the LV normal size and contracting normally?
Does the anterior MV leaflet approximate the septum (normal EF)?
Is the aortic root normal size; is there a dissection flap?
Is the LA normal size?

Summary

- Basic perioperative TEE offers full assessment of the etiology of cardiopulmonary instability using only 11 windows
- Advanced TEE incorporates up to 28 windows and 3-D to offer more precise diagnostic information
- Use of basic TTE extends the use of echocardiography throughout the entire perioperative period