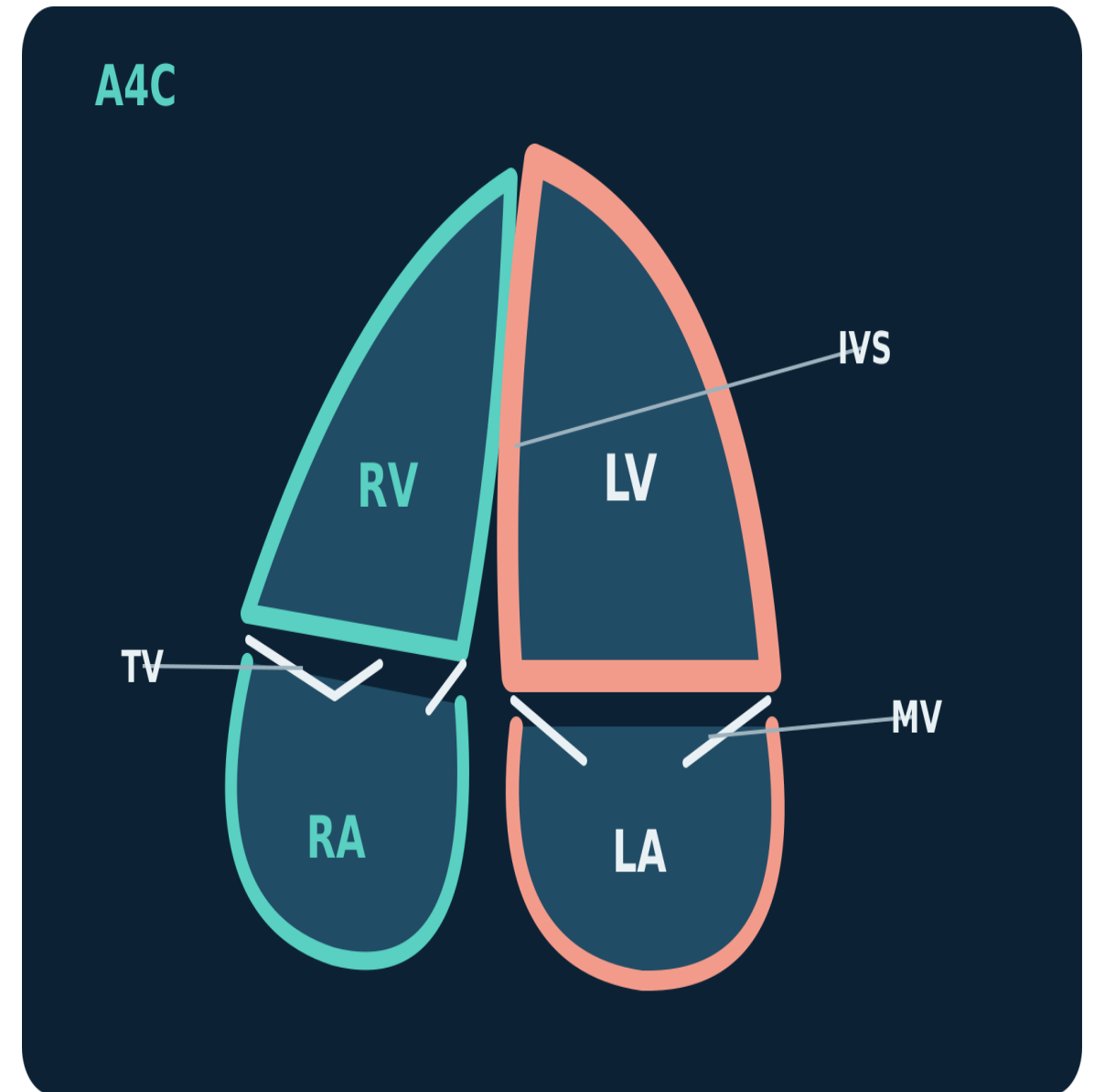


ΠΡΟΣΕΓΓΙΣΗ ΚΑΡΔΙΑΚΩΝ ΔΟΜΩΝ

ΚΟΥΛΑΟΥΖΙΔΗΣ ΓΕΩΡΓΙΟΣ MD, MSc, PhD

ΕΙΔΙΚΟΣ ΚΑΡΔΙΟΛΟΓΟΣ

ΕΠΙΜΕΛΗΤΗΣ Α' Γ.Ν.Θ Γ.ΠΑΠΑΝΙΚΟΛΑΟΥ



Why the heart matters in respiratory practice

Dyspnoea may have pulmonary, cardiac or mixed causes.

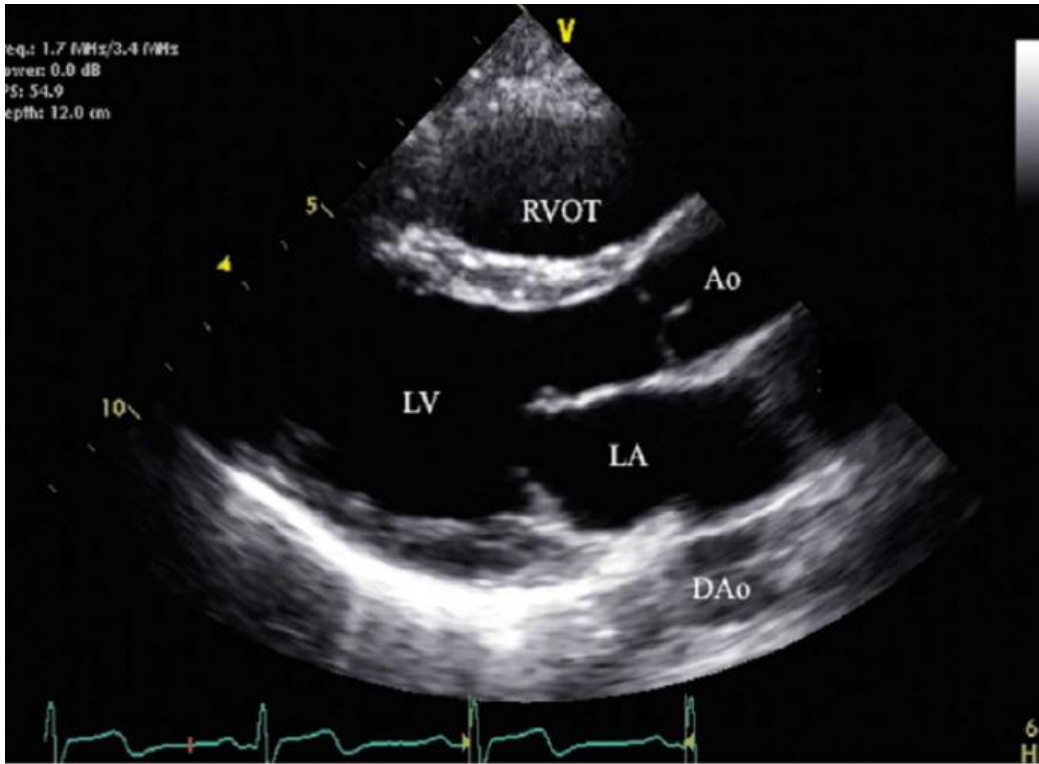
- Left-heart dysfunction can contribute to breathlessness.
- Pulmonary vascular disease can affect the right heart.
- Valve disease and pericardial fluid may change the clinical picture.

Clinical question: which cardiac finding could explain this patient's symptoms?

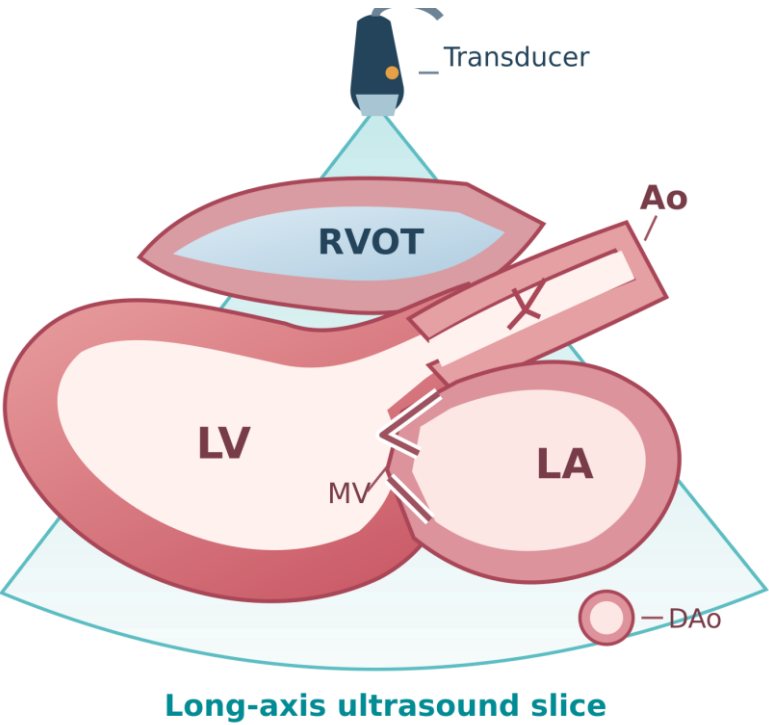
Parasternal long-axis view (PLAX)

The echo image, the ultrasound slice through the heart, and the probe position that produces it.

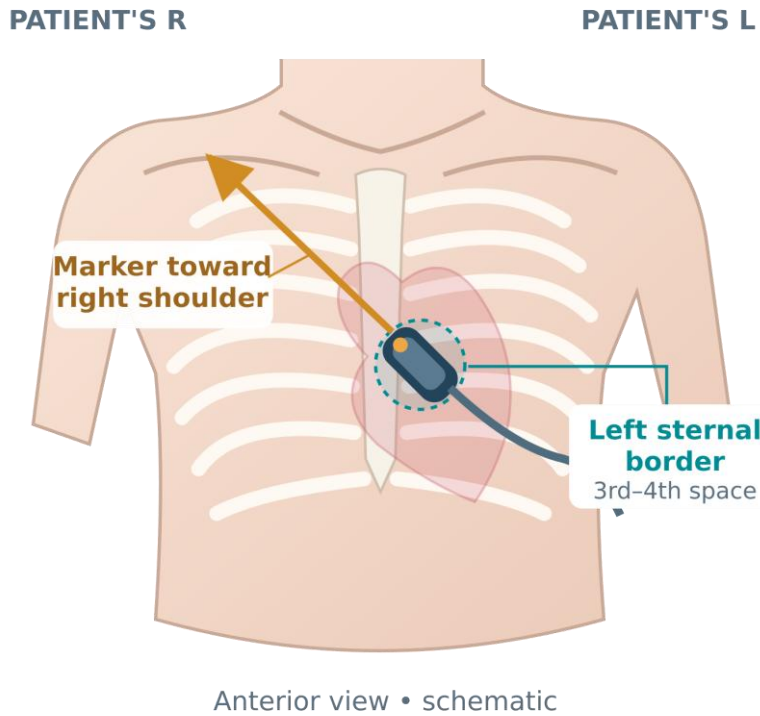
01 Echo view



02 Heart in the imaging plane



03 Probe on the chest



PATIENT Left lateral decubitus

PLANE Through LV, mitral valve and aortic root

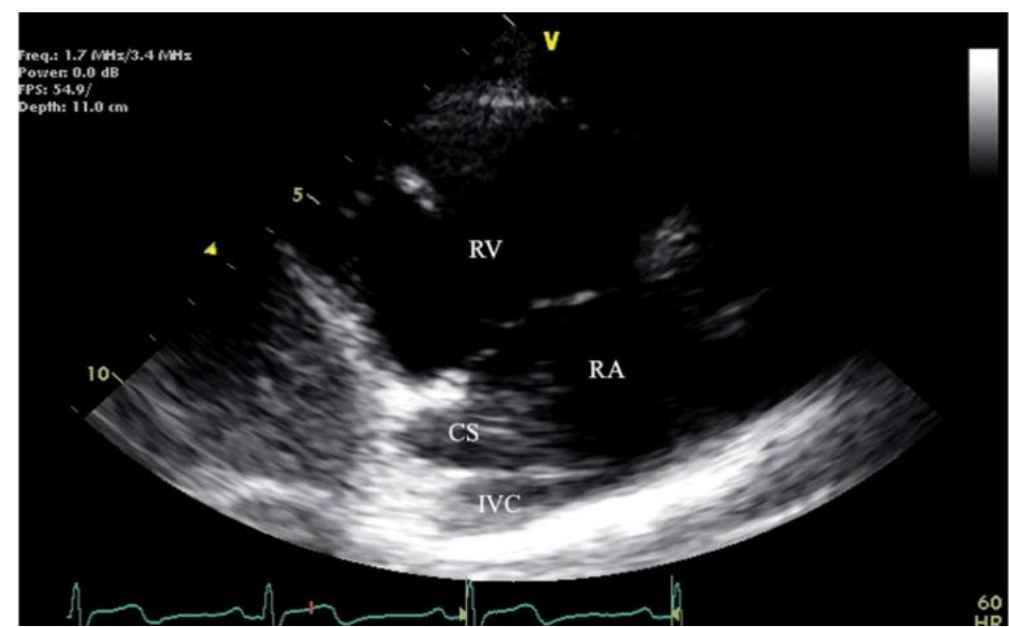
Phased-array transducer

LV: left ventricle • LA: left atrium • RVOT: right ventricular outflow tract • Ao: aorta • DAo: descending aorta • MV: mitral valve

Parasternal right ventricular inflow view

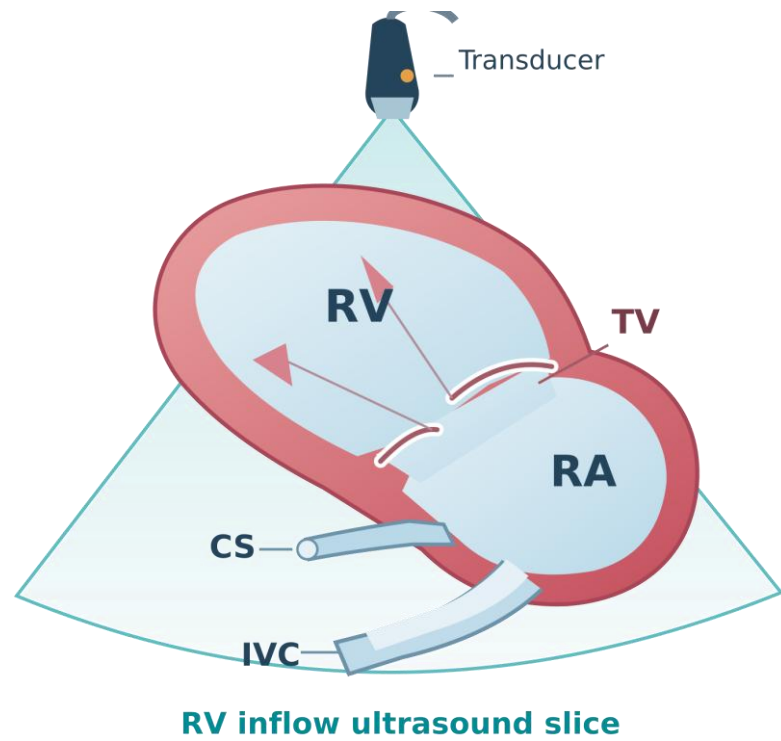
From the PLAX window, tilt the ultrasound beam inferiorly toward the patient’s right hip.

01 Echo view

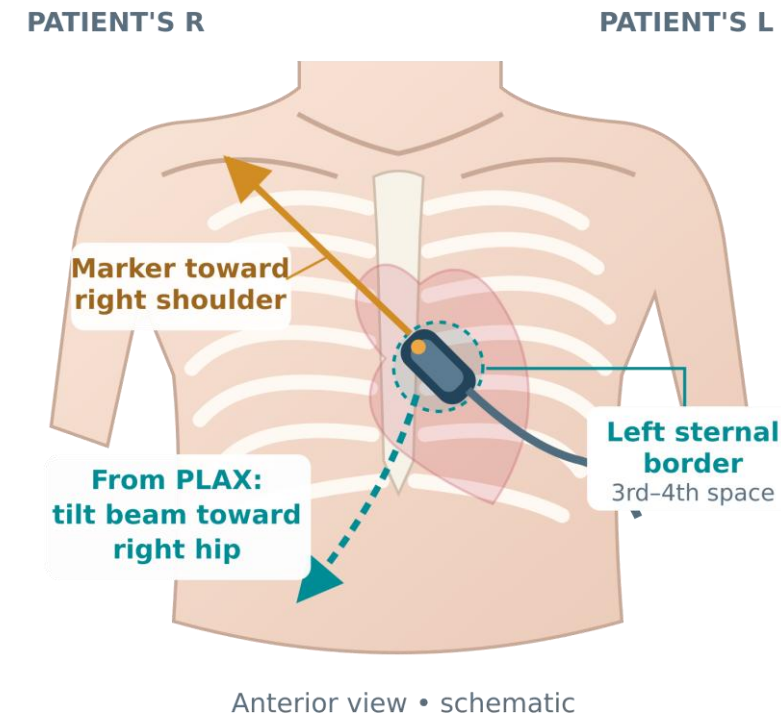


RV above the tricuspid valve • RA below

02 Heart in the imaging plane



03 Probe on the chest



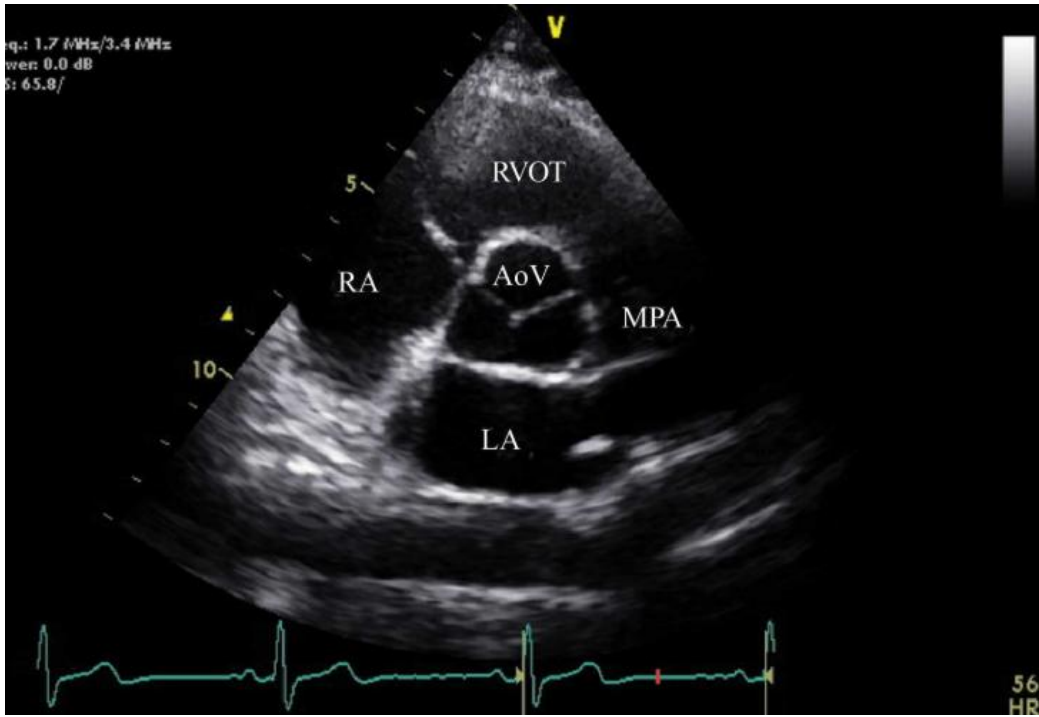
PATIENT	Left lateral decubitus	PLANE	Through RV, tricuspid valve and RA	Phased-array transducer
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RV: right ventricle • RA: right atrium • TV: tricuspid valve • CS: coronary sinus • IVC: inferior vena cava

Parasternal short-axis view: aortic valve level

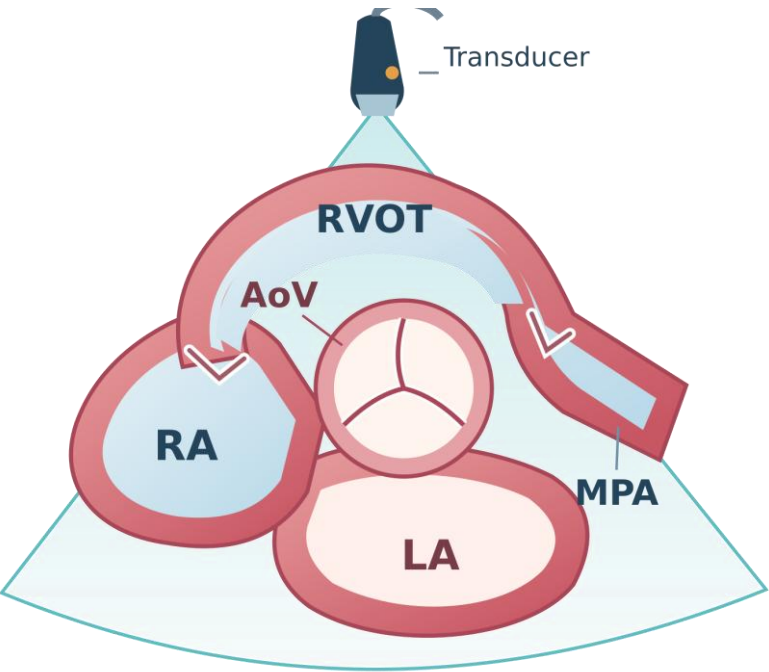
Rotate 90° clockwise from PLAX, then adjust the tilt to center the aortic valve.

01 Echo view



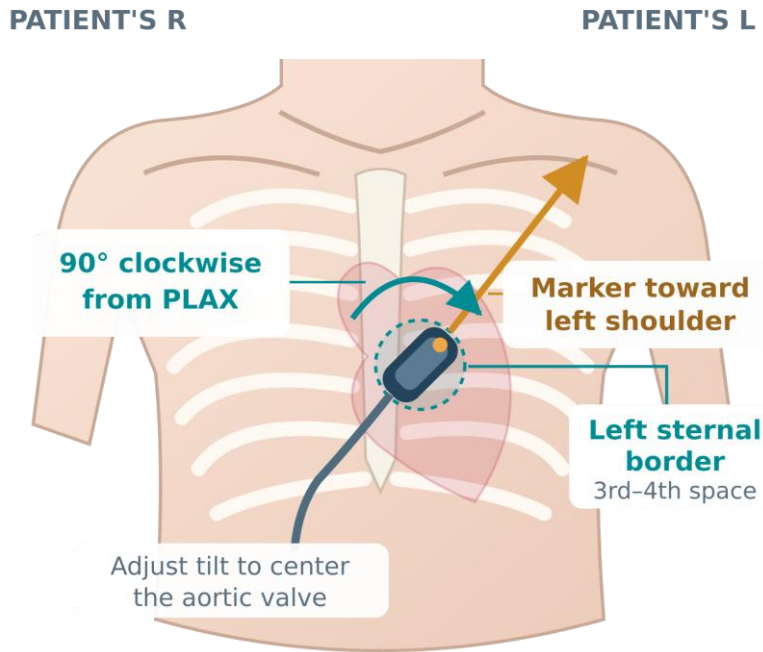
Aortic valve centrally • RVOT anteriorly • LA posteriorly

02 Heart in the imaging plane



Short-axis slice • aortic valve level

03 Probe on the chest



Anterior view • schematic

PATIENT Left lateral decubitus

PLANE Short-axis section through the aortic valve

Phased-array transducer

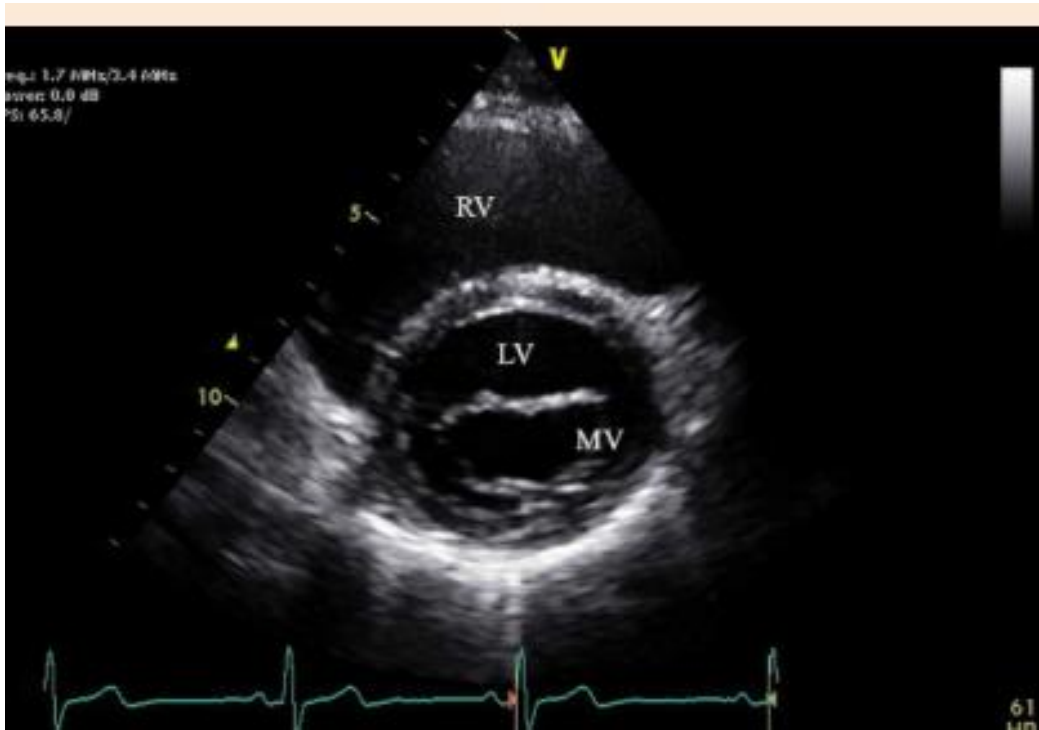
AoV: aortic valve • RVOT: right ventricular outflow tract • MPA: main pulmonary artery • RA: right atrium • LA: left atrium

Source: ASE comprehensive TTE recommendations (Mitchell et al., 2018), §IV.B, Tables 2.8–2.9. Echo image supplied by user. Diagrams are schematic.

Parasternal short-axis view: mitral valve level

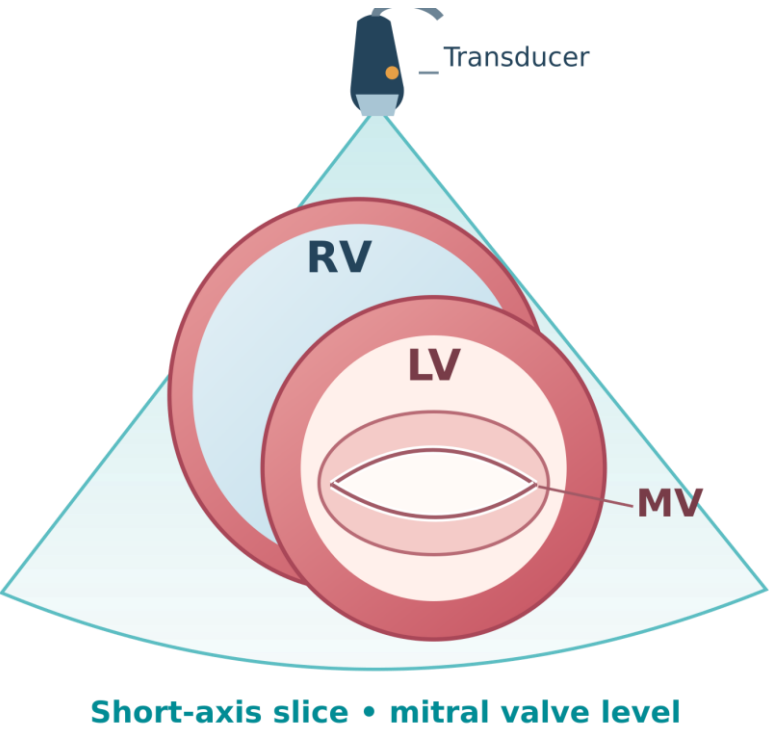
From the PSAX aortic level, tilt inferiorly toward the apex until the mitral valve is seen.

01 Echo view

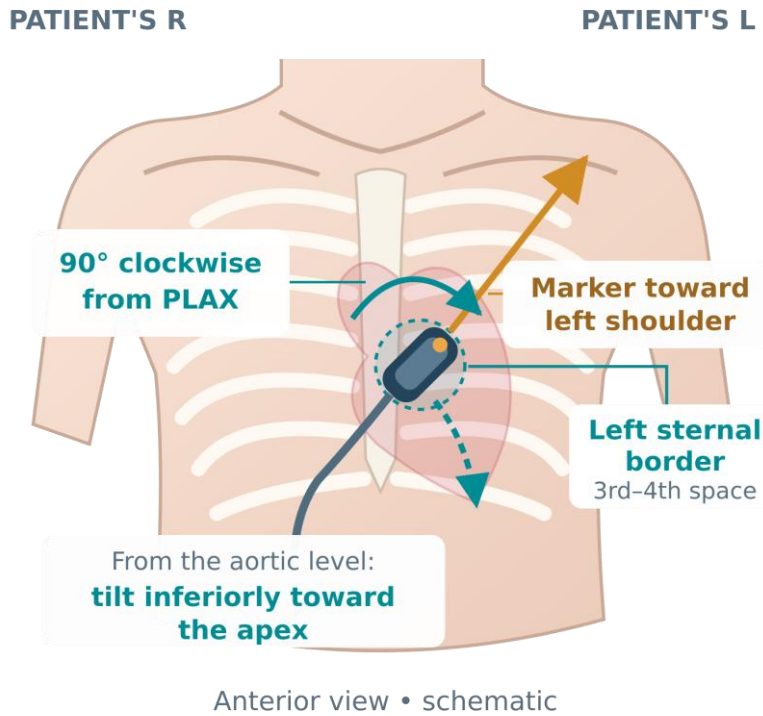


Mitral leaflets within the circular LV

02 Heart in the imaging plane



03 Probe on the chest



PATIENT Left lateral decubitus

PLANE Short-axis section at mitral valve level

Phased-array transducer

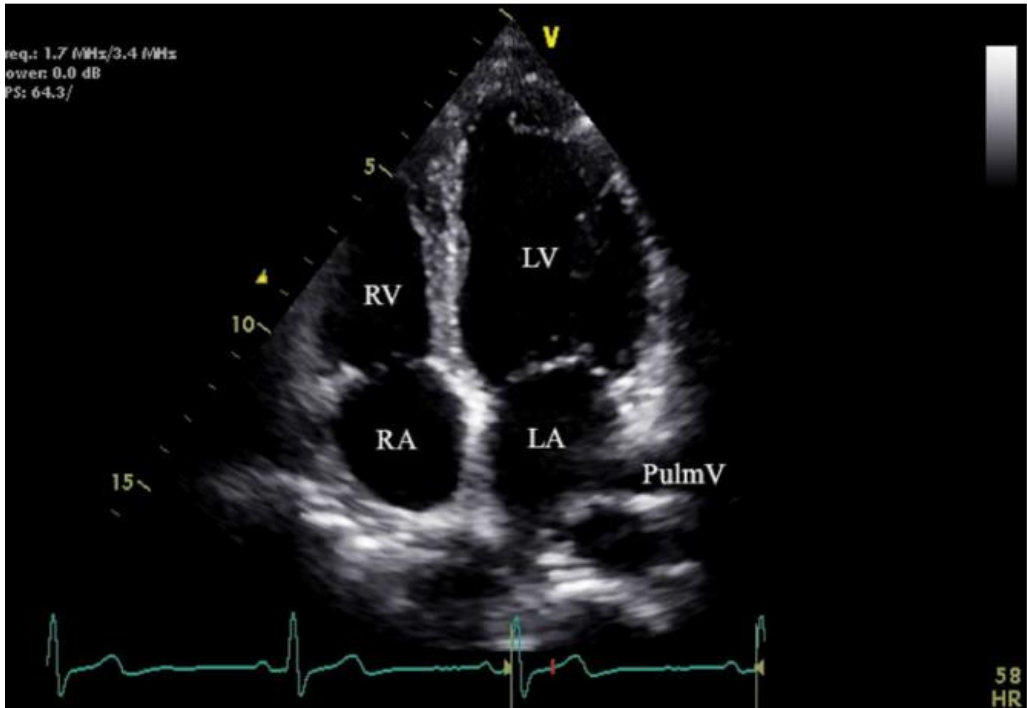
LV: left ventricle • RV: right ventricle • MV: mitral valve • PSAX: parasternal short-axis

Source: ASE comprehensive TTE recommendations (Mitchell et al., 2018), §IV.B, Table 2.11. Echo image supplied by user. Diagrams are schematic.

Apical four-chamber view (A4C)

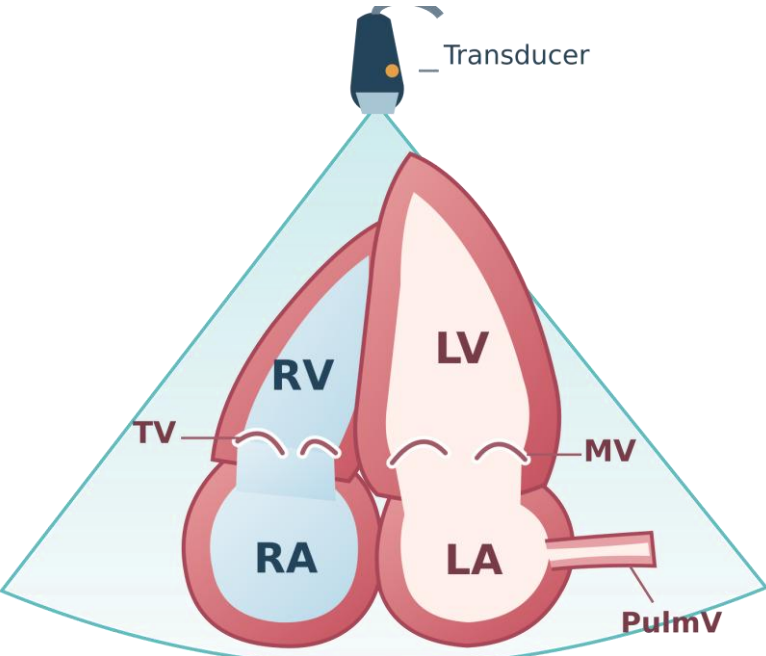
Place the probe at the apical impulse and direct the ultrasound beam toward the cardiac base.

01 Echo view



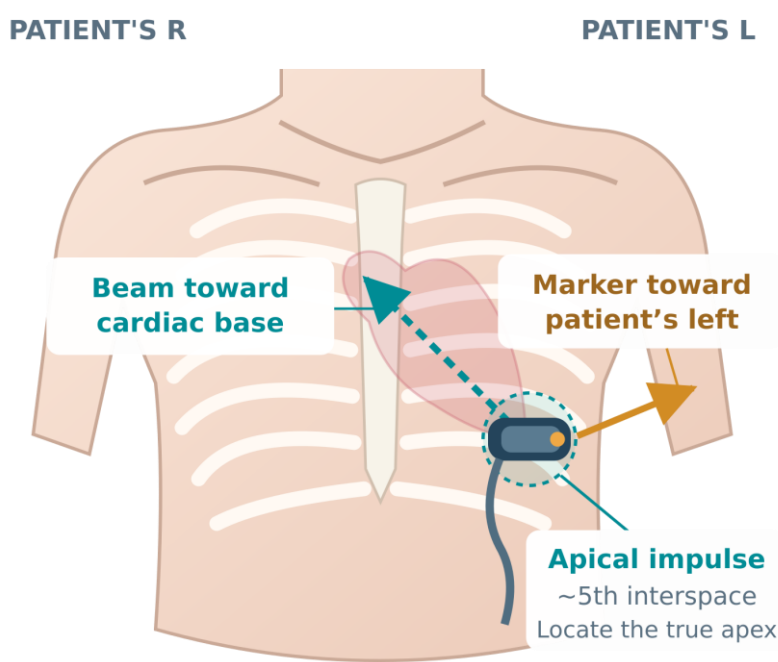
Apex in the near field • ventricles above the atria

02 Heart in the imaging plane



Four-chamber slice • apex to base

03 Probe on the chest



Anterior view • schematic

PATIENT Left lateral decubitus

PLANE Through both ventricles and both atria

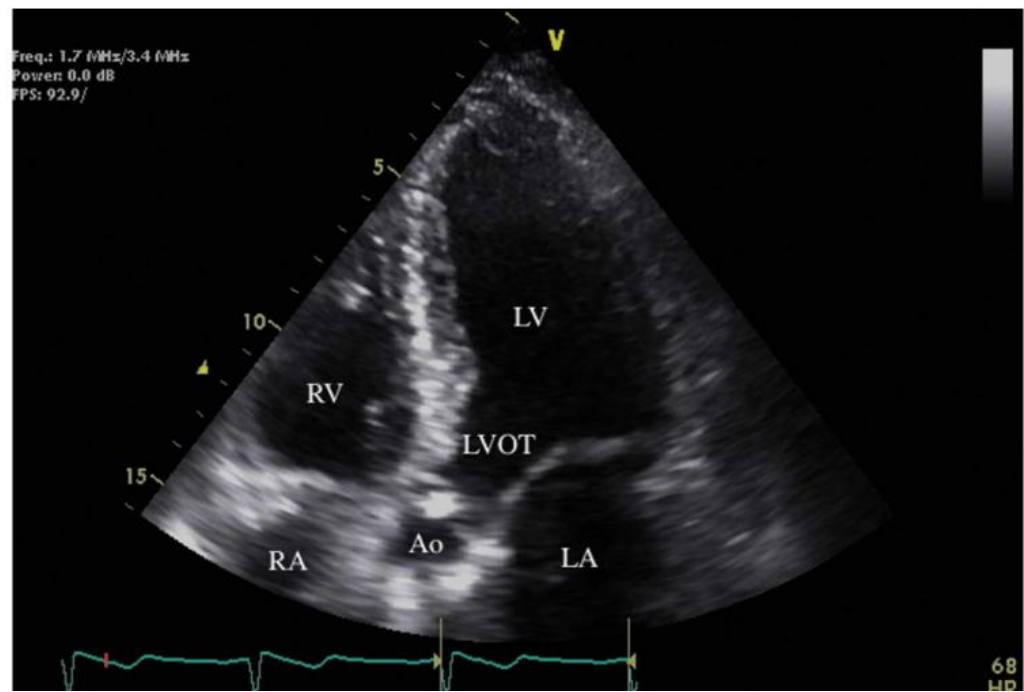
Phased-array transducer

LV / RV: left / right ventricle • LA / RA: left / right atrium • MV: mitral valve • TV: tricuspid valve • PulmV: pulmonary vein

Apical five-chamber view (A5C)

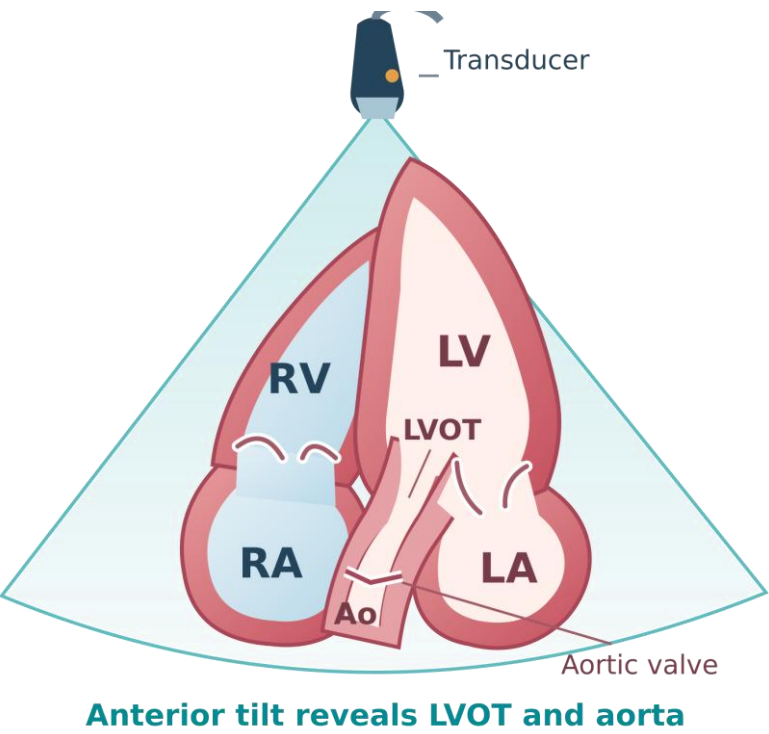
From the A4C view, tilt the ultrasound beam anteriorly to reveal the LVOT and aortic root.

01 Echo view

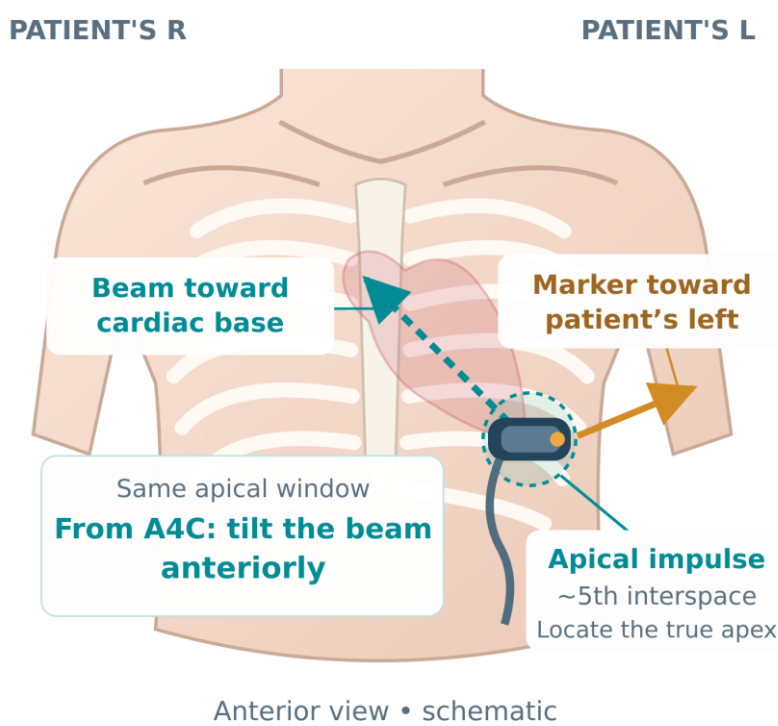


The “fifth chamber” is the aortic outflow

02 Heart in the imaging plane



03 Probe on the chest



PATIENT Left lateral decubitus

PLANE Four chambers + LVOT and aortic root

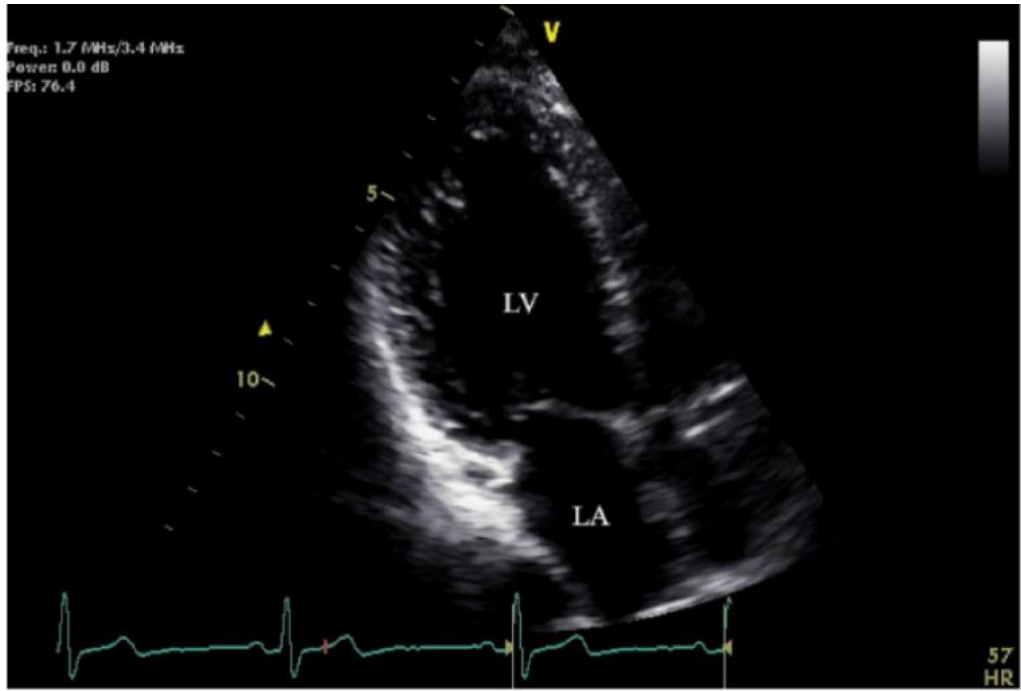
Phased-array transducer

LV / RV: left / right ventricle • LA / RA: left / right atrium • LVOT: left ventricular outflow tract • Ao: aorta

Apical two-chamber view (A2C)

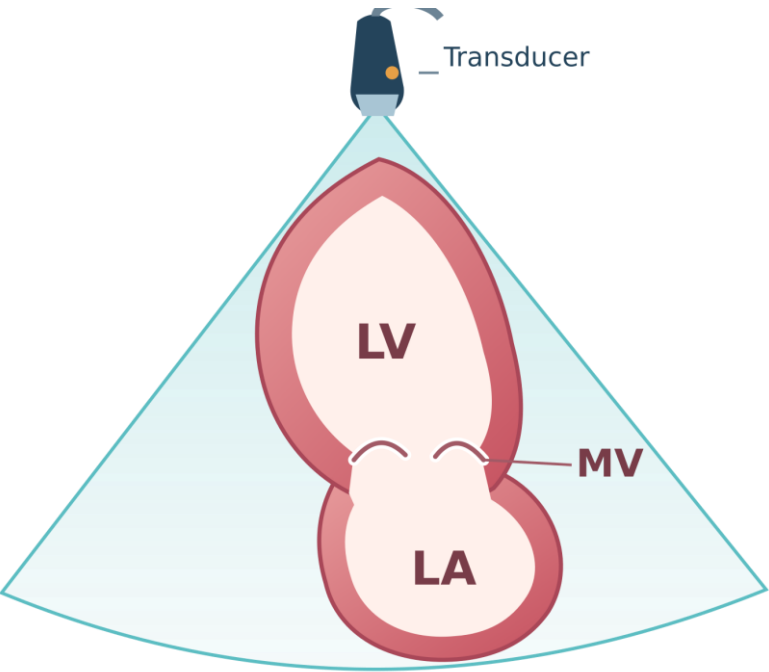
From the A4C view, rotate the transducer about 60° counterclockwise while maintaining apical contact.

01 Echo view



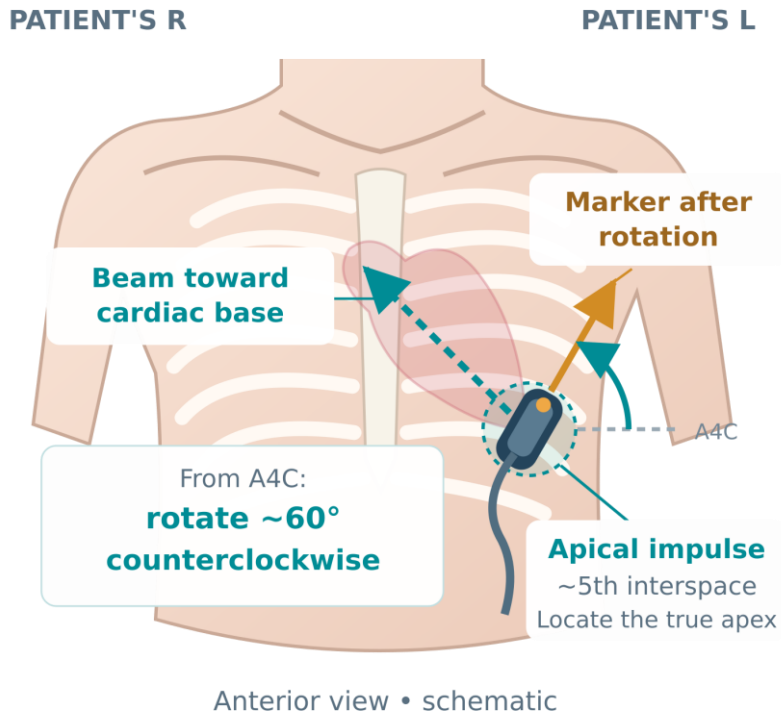
Left ventricle • mitral valve • left atrium

02 Heart in the imaging plane



Two-chamber slice • LV, MV and LA

03 Probe on the chest



PATIENT Left lateral decubitus

PLANE Long-axis slice through LV, MV and LA

Phased-array transducer

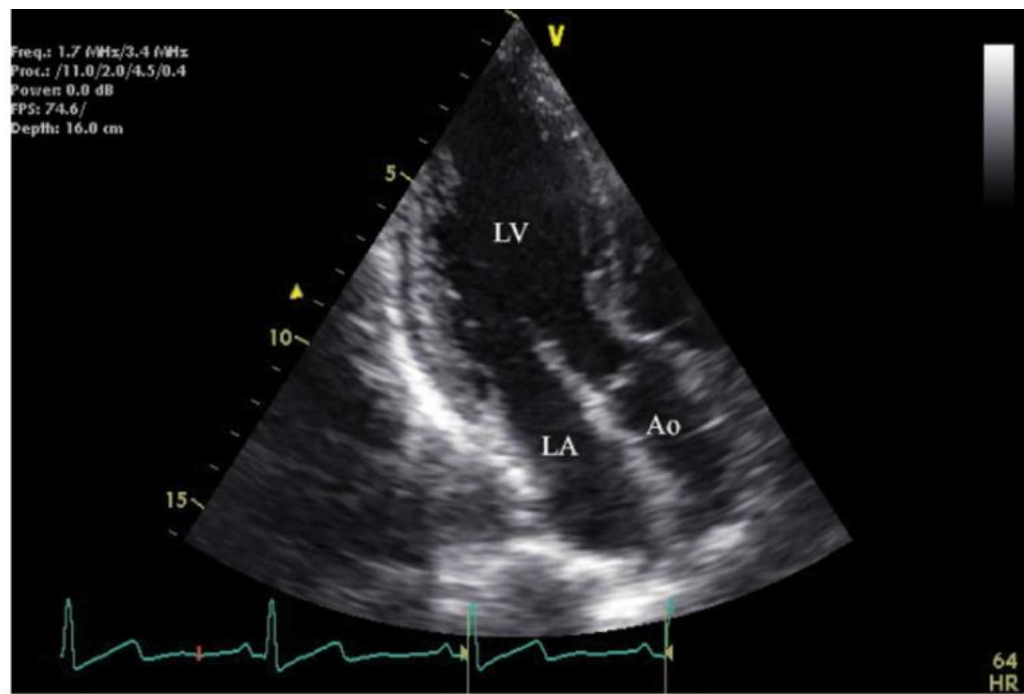
LV: left ventricle • LA: left atrium • MV: mitral valve • A2C: apical two-chamber • A4C: apical four-chamber

Source: ASE comprehensive TTE recommendations (Mitchell et al., 2018), §IV.C.5, Tables 2.19–2.20. Echo image supplied by user. Diagrams are schematic.

Apical three-chamber view (A3C)

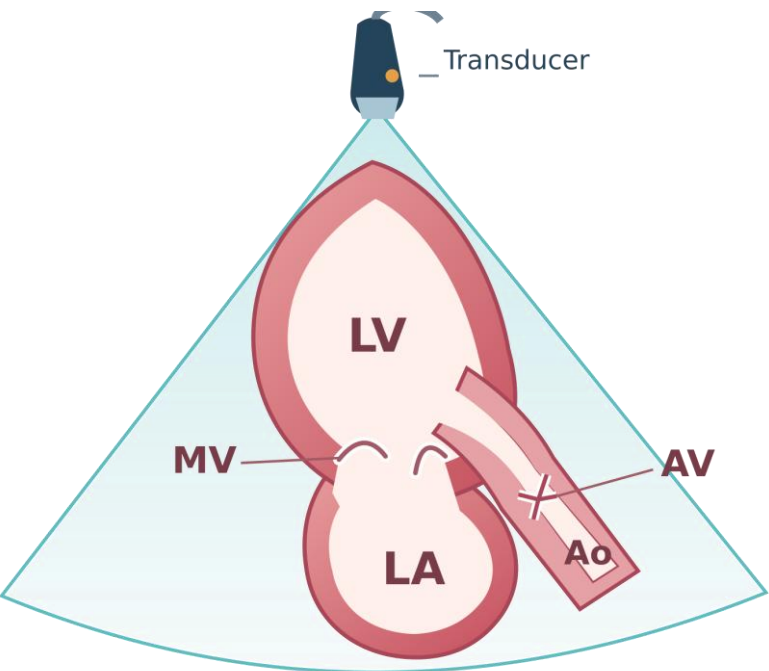
Apical long-axis view: rotate a further ~60° counterclockwise from A2C, keeping apical contact.

01 Echo view



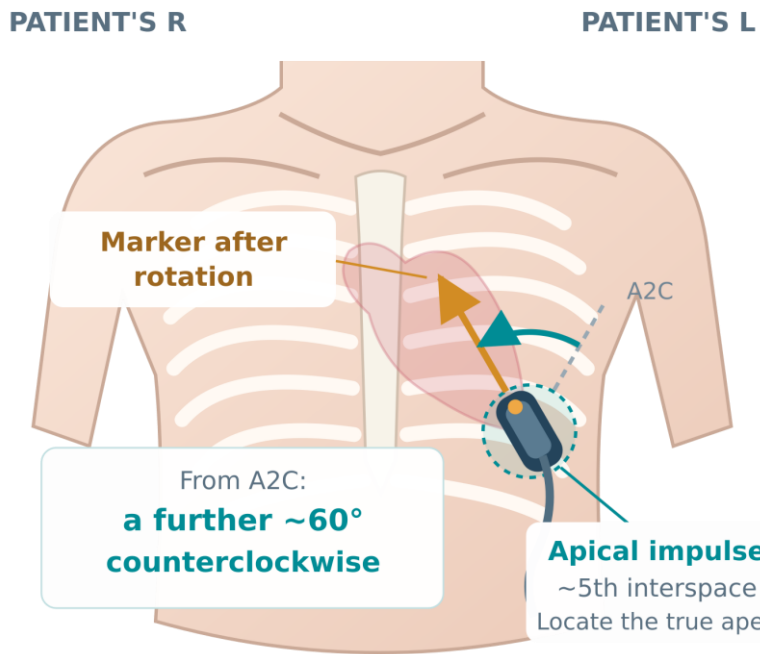
LV and LA with the aortic outflow

02 Heart in the imaging plane



Apical long-axis slice • LV, LA and Ao

03 Probe on the chest



Anterior view • schematic

PATIENT Left lateral decubitus

PLANE LV, mitral valve, LA and aortic root

Phased-array transducer

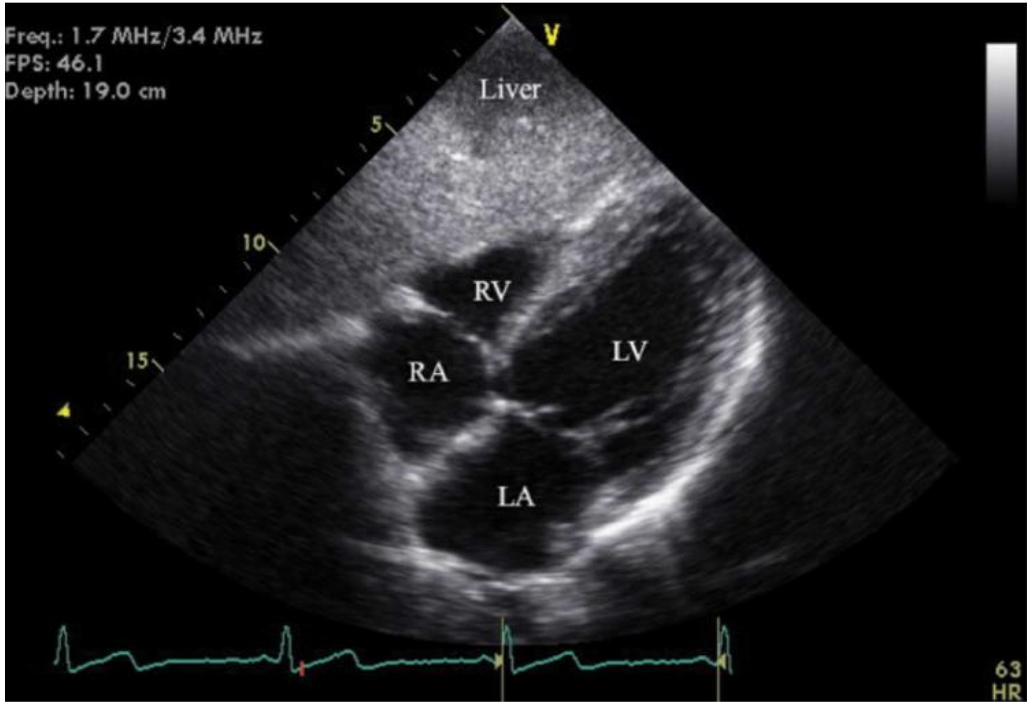
LV: left ventricle • LA: left atrium • MV: mitral valve • AV: aortic valve • Ao: aorta • A3C: apical three-chamber

Source: ASE comprehensive TTE recommendations (Mitchell et al., 2018), §IV.C.6, Tables 2.21–2.22. Echo image supplied by user. Diagrams are schematic.

Subcostal four-chamber view

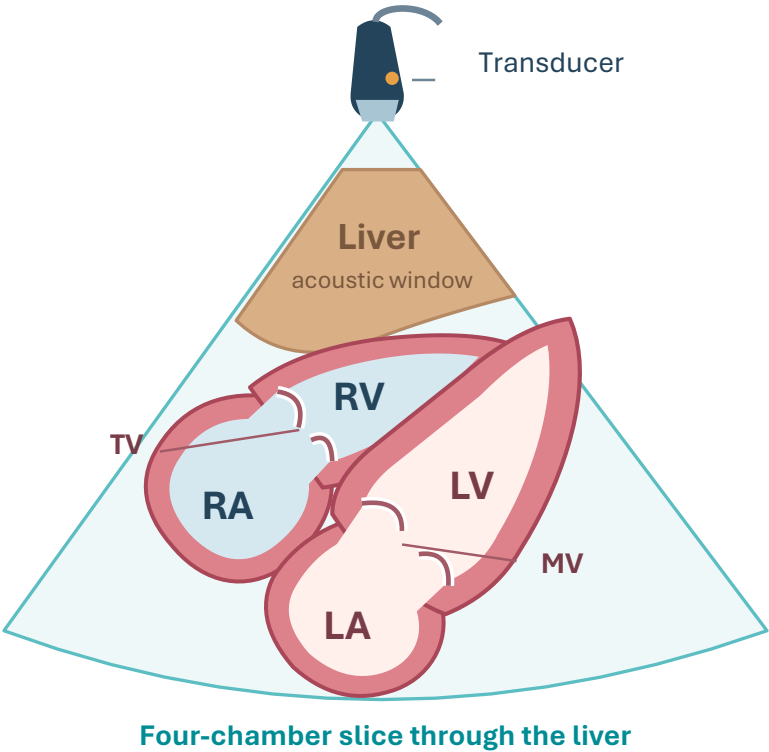
The echo image, the ultrasound slice through the heart, and the probe position that produces it.

01 Echo view

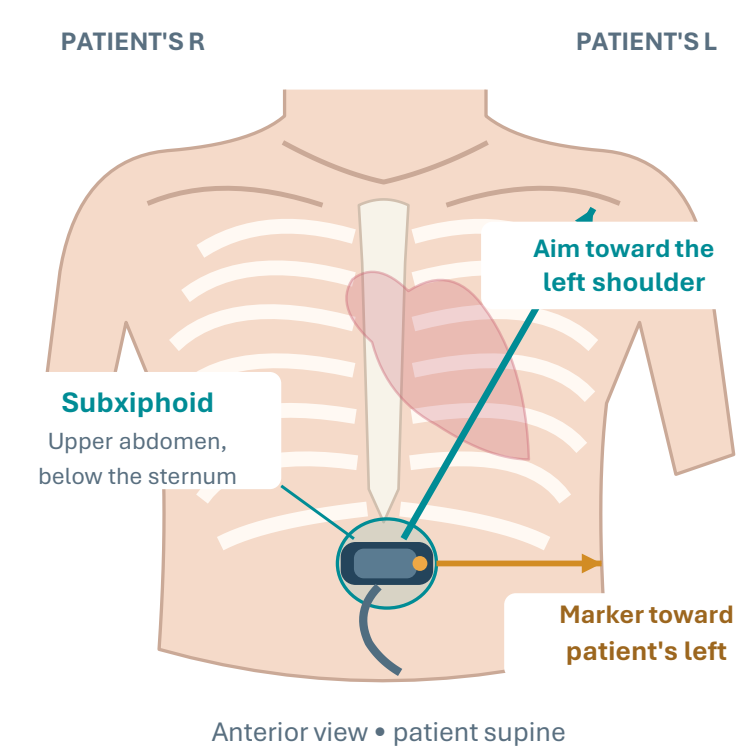


Liver in the near field • four cardiac chambers

02 Heart in the imaging plane



03 Subxiphoid probe position



PATIENT Supine • relaxed abdomen

PLANE Four chambers via the liver

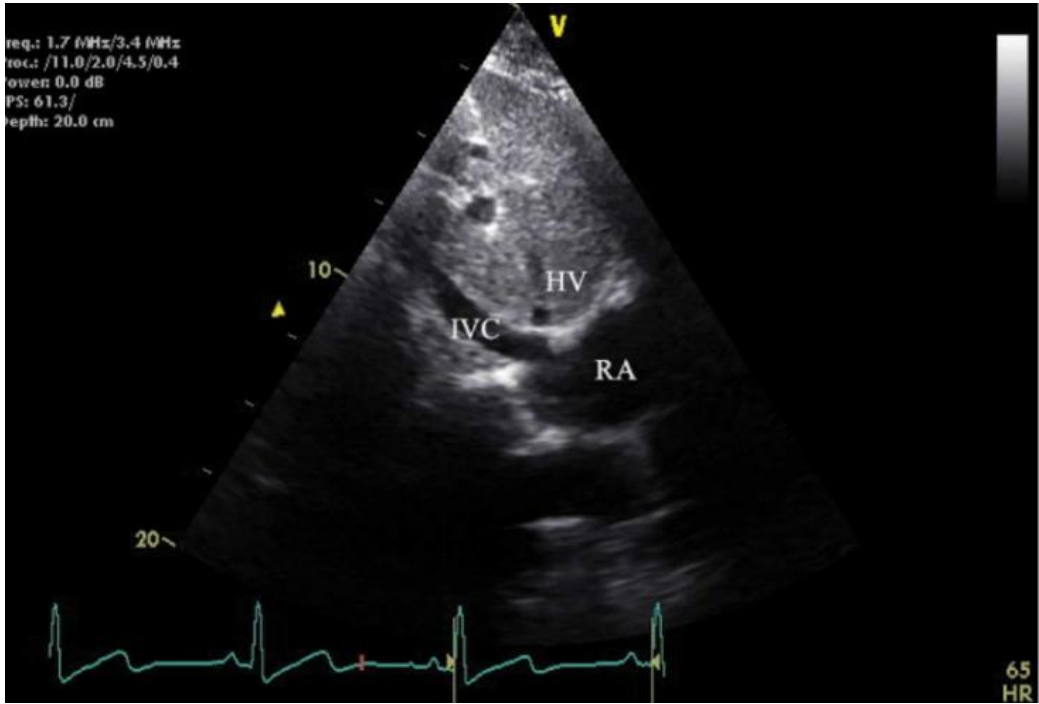
Phased-array transducer

RV: right ventricle • LV: left ventricle • RA: right atrium • LA: left atrium • TV: tricuspid valve • MV: mitral valve

Subcostal IVC long-axis view

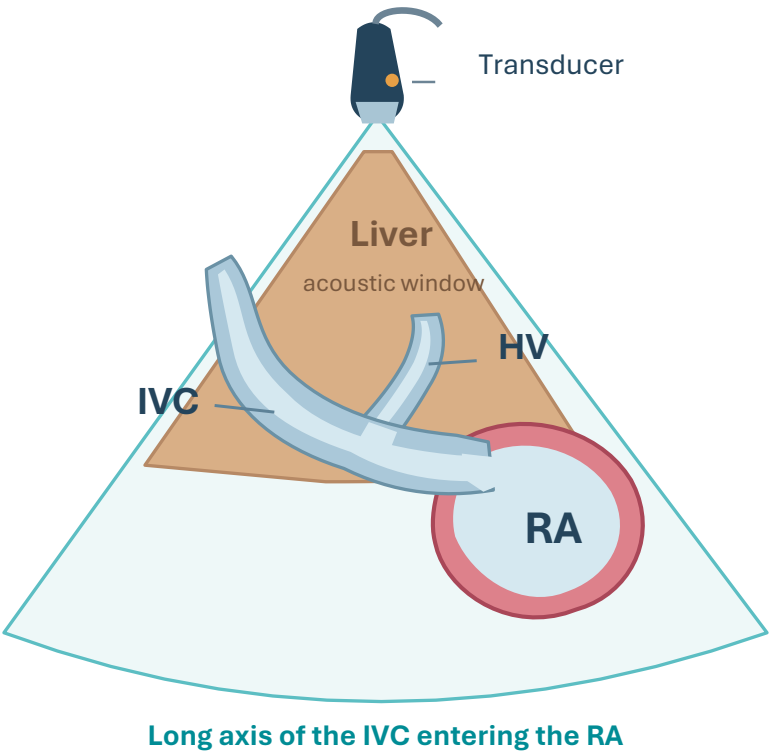
The echo image, the longitudinal IVC plane, and the probe position that produces it.

01 Echo view

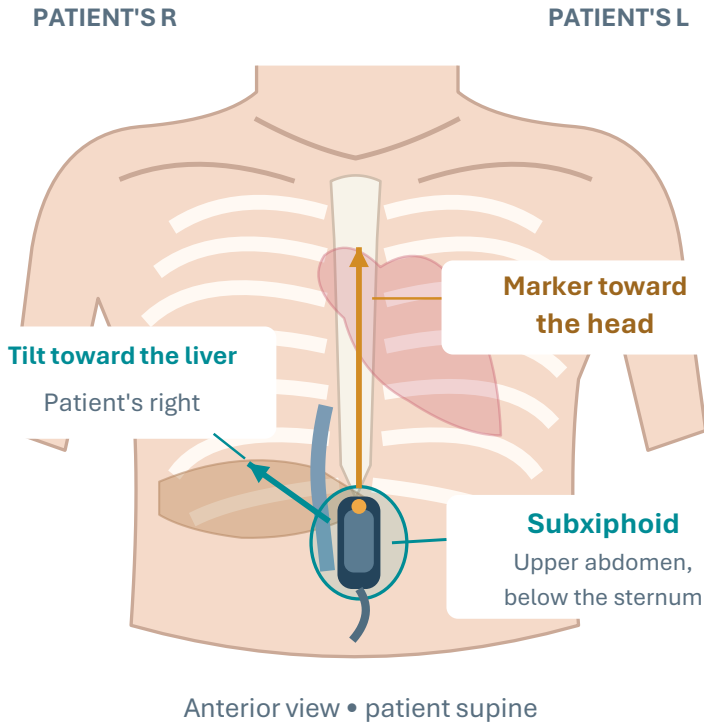


IVC-RA junction and hepatic vein

02 IVC in the imaging plane



03 Subxiphoid probe position



PATIENT Supine • relaxed abdomen

PLANE IVC entering the right atrium

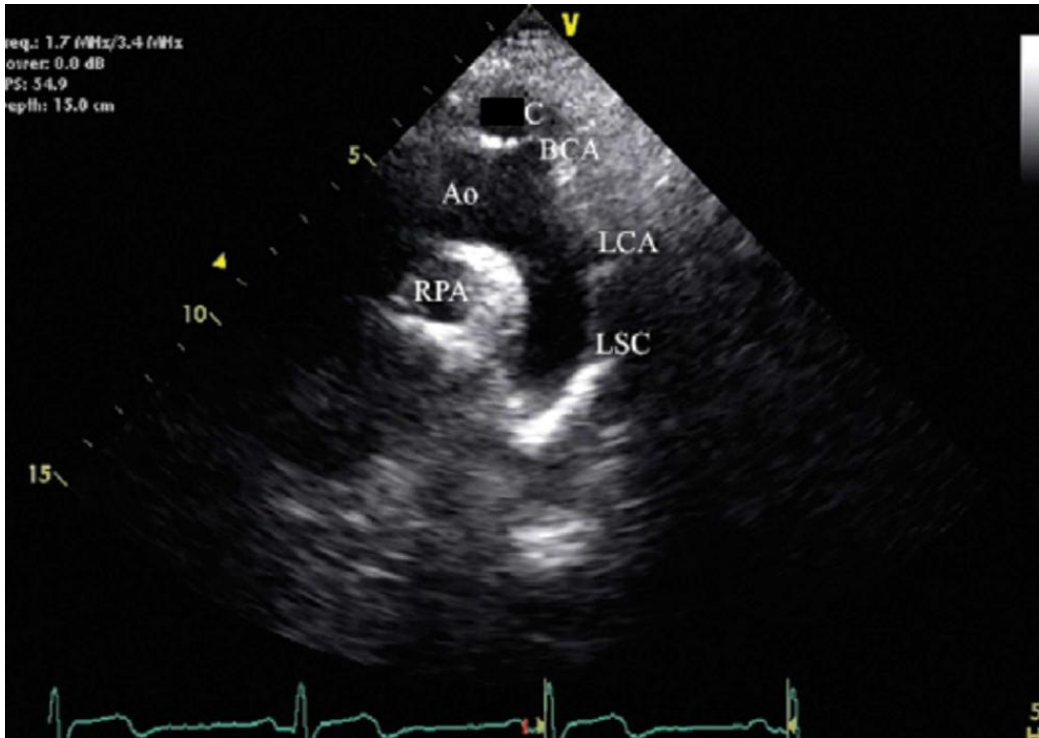
Phased-array transducer

IVC: inferior vena cava • HV: hepatic vein • RA: right atrium

Suprasternal aortic arch view

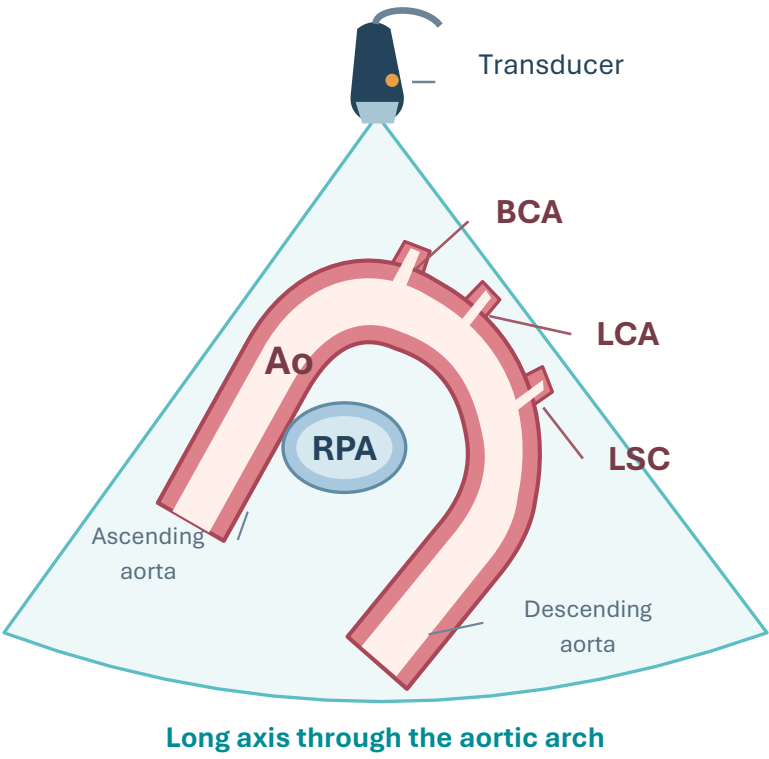
The echo image, the ultrasound plane through the aortic arch, and the probe position that produces it.

01 Echo view

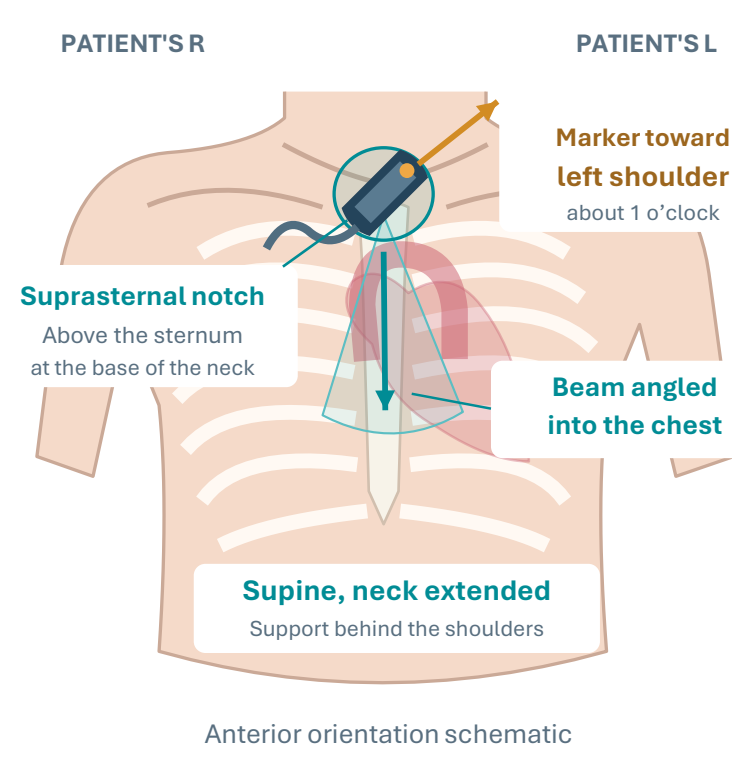


Aortic arch, branch vessels and RPA

02 Aortic arch imaging plane



03 Suprasternal probe position



PATIENT **Supine • neck extended**

PLANE **Aortic arch and its major branches**

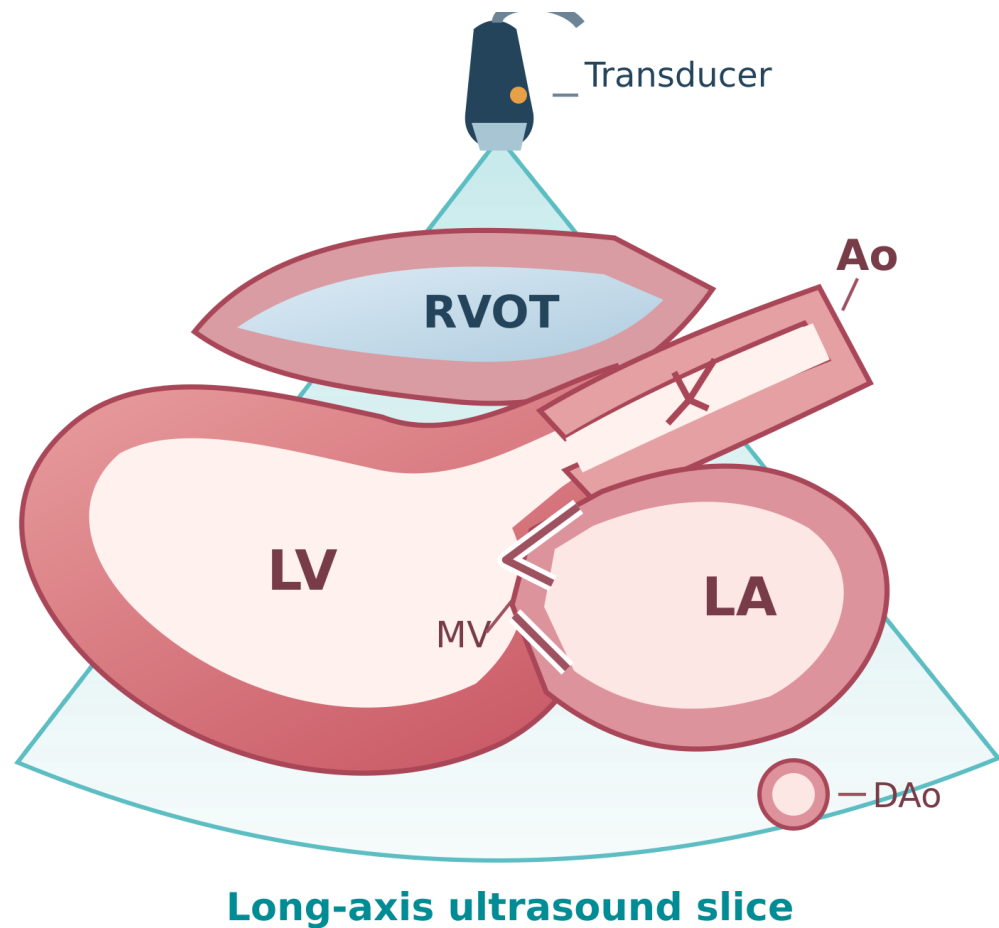
Phased-array transducer

Ao: aorta • BCA: brachiocephalic artery • LCA: left common carotid artery • LSC: left subclavian artery • RPA: right pulmonary artery

Source: ASE comprehensive TTE recommendations (Mitchell et al., 2018), §IV.E and Table 2.27. User-supplied echo. Schematic diagrams.

Left ventricle: size and pumping function

The first questions are whether the LV is enlarged and whether it contracts well.



- LV enlargement suggests remodelling.
- Reduced ejection fraction indicates impaired pumping.
- Regional abnormalities may suggest ischaemic disease.

A preserved ejection fraction does not exclude heart failure.

Linear LV dimensions and mass

Sex-specific reference ranges and severity categories

Males

Measure	Normal	Mild	Moderate	Severe
LVIDd (mm)	37–56	57–61	61–65	>65
LVIDs (mm)	22–41	41–45	46–50	>50
IVSd (mm)	6–12	–	–	–
LVPWd (mm)	6–12	–	–	–
LVMi (g/m ²)	40–110	111–127	128–145	>145
LV mass (g)	72–219	–	–	–

Females

Measure	Normal	Mild	Moderate	Severe
LVIDd (mm)	35–51	52–55	56–59	>59
LVIDs (mm)	20–37	38–42	43–46	>46
IVSd (mm)	5–11	–	–	–
LVPWd (mm)	6–12	–	–	–
LVMi (g/m ²)	33–99	98–115	116–131	>131
LV mass (g)	51–173	–	–	–

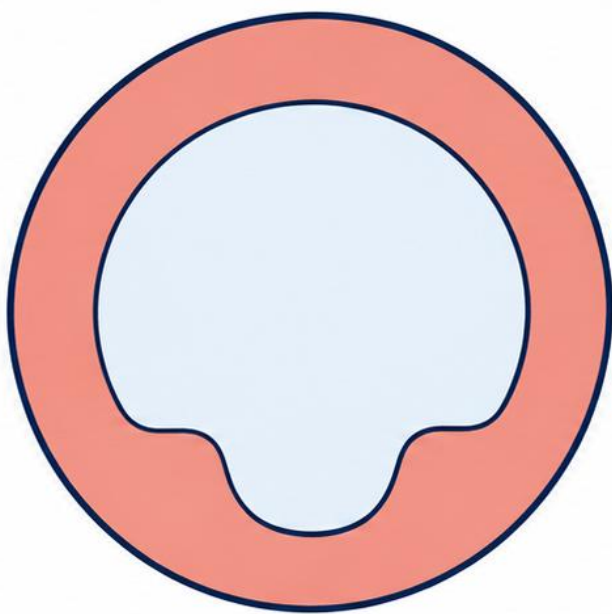
LVIDd / LVIDs: LV internal diameter in diastole / systole. IVSd: diastolic septal thickness.

LVPWd: diastolic posterior wall thickness. LVMi: LV mass indexed to body surface area.

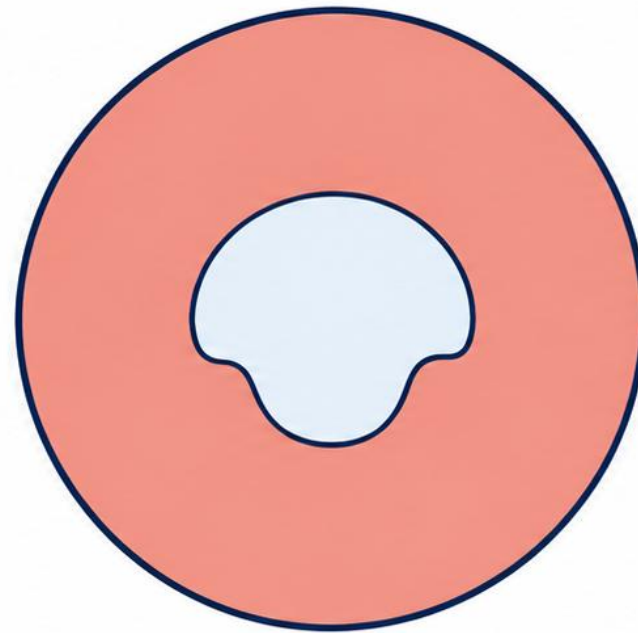
Ranges reproduced as supplied. Overlapping category boundaries in the source have been retained.

LV geometry: visual patterns

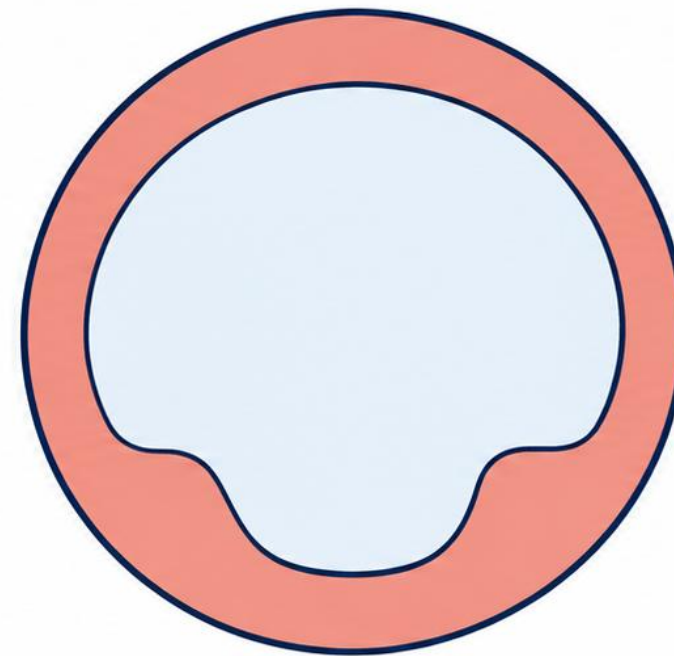
Compare cavity size and the distribution of myocardial thickening.



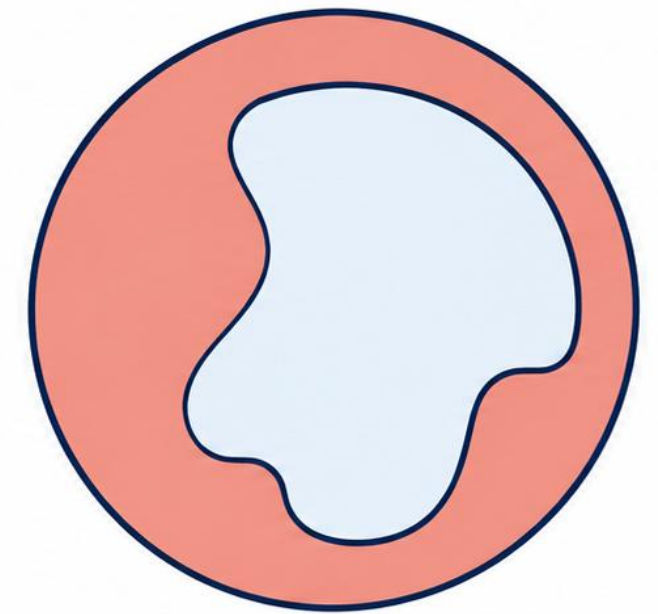
Normal



Concentric



Eccentric



Asymmetric

LV geometry: recognize the pattern

Describe the distribution of wall thickening as well as the cavity size

Pattern	Source description	Typical association
Concentric	Thicker walls with relatively smaller cavity	Pressure load: hypertension or aortic stenosis
Eccentric	Larger cavity with increased myocardial mass	Volume load: aortic or mitral regurgitation
Asymmetric	Localised thickening, such as septum or apex	Describe the location and extent

Relative Wall Thickness

$$RWT = 2 \times \text{posterior wall thickness} / \text{LV end-diastolic diameter}$$

Sources: supplied Table 2.3 and newly supplied Fig. 4.9. LV geometry is classified using LV mass index and RWT.

Regional LV wall motion

Assess each segment in multiple views

Evaluate systolic thickening and the timing of contraction.

Assess each arterial territory across the available views.

Describe abnormalities by segment, using the 17-segment framework.

Document limited apical visibility rather than assuming normal motion.

A4C: inferoseptal and anterolateral walls. A2C: inferior and anterior walls. A3C: inferolateral and anteroseptal walls.

LV ejection fraction

Biplane Simpson’s grading reproduced from the source

Normal	Borderline	Impaired	Severely impaired
≥55%	50–54%	36–49%	≤35%

$LVEF = (LVEDV - LVESV) / LVEDV \times 100\%$

Interpret borderline values with previous EF, image quality and loading conditions.

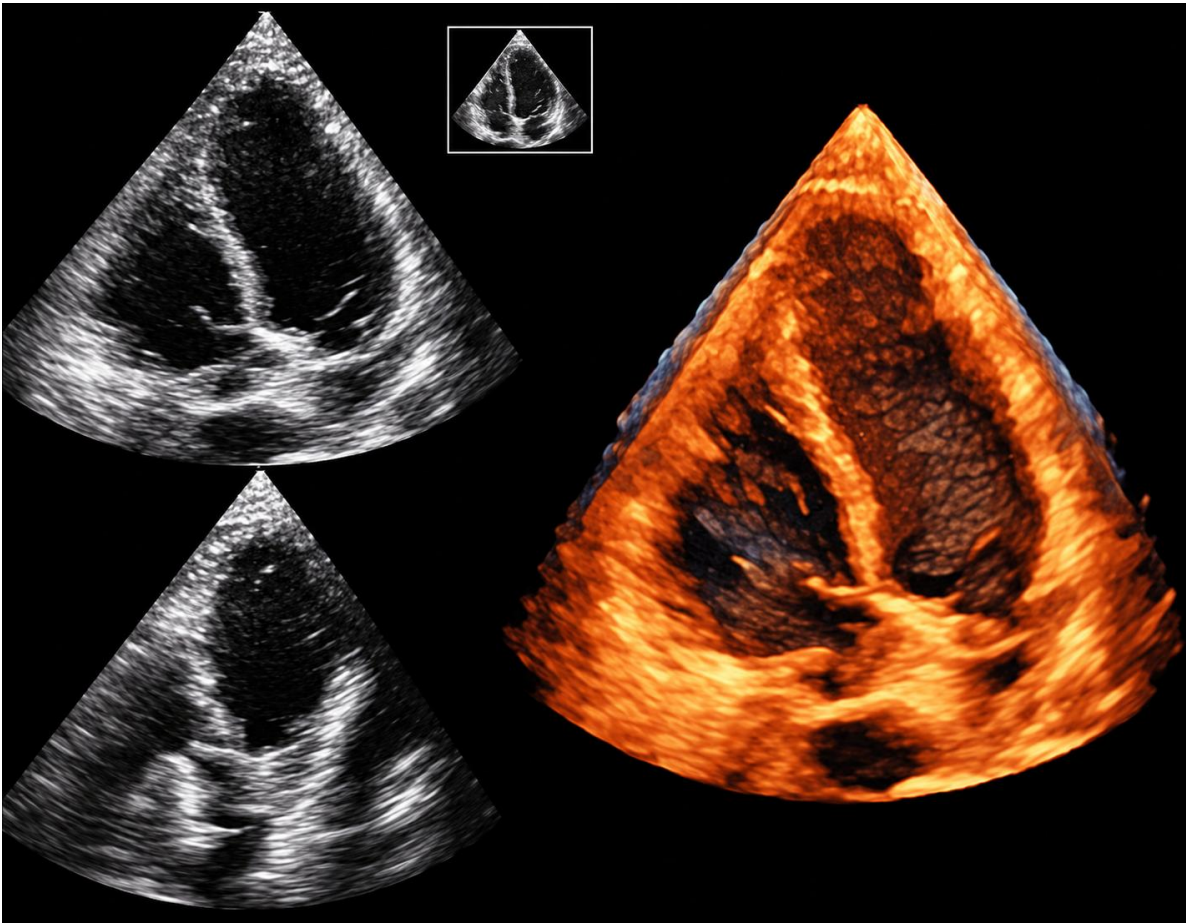
A normal EF can coexist with regional wall motion abnormalities, low LVOT VTI or abnormal longitudinal function.

For 3D EF, use the relevant system’s reference intervals.

Source: supplied chapter “Left Ventricular Dimensions and Function”, Table 2.7. Reference ranges follow the source edition.

Right ventricle: the key chamber in pulmonary disease

Size and function describe the cardiac response to pulmonary vascular load.

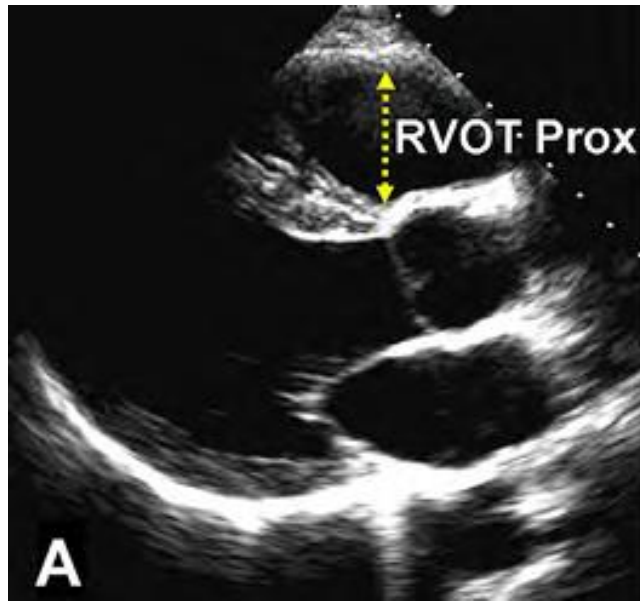


- Is the RV enlarged?
- Is its wall thickened?
- Is contraction preserved or reduced?
- How does it compare with the LV?

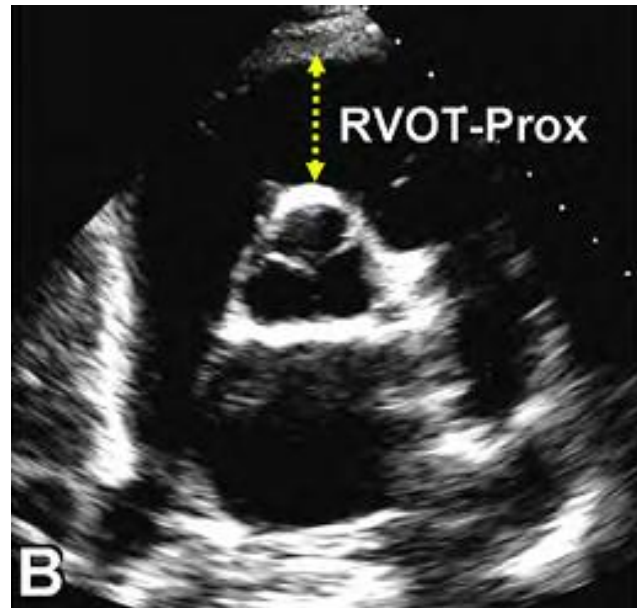
An enlarged RV is a finding. The underlying cause still needs assessment.

RV size: use complementary views

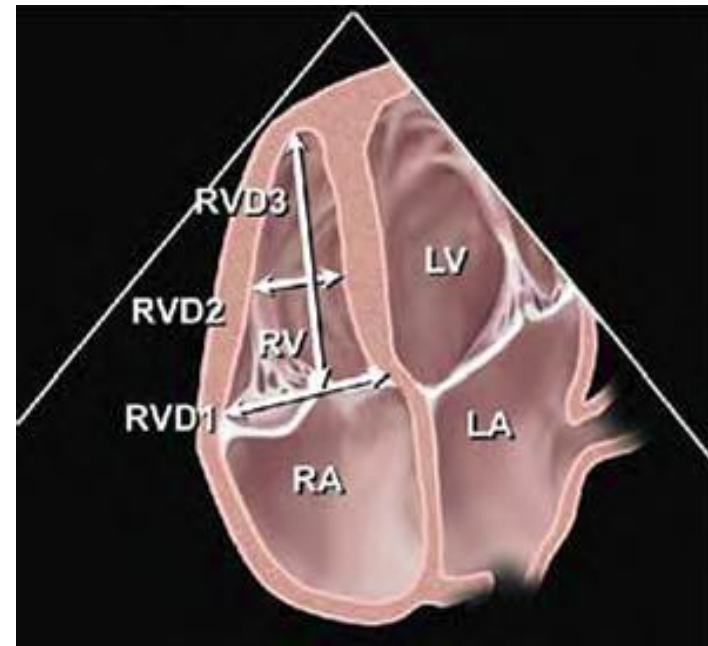
Parasternal views assess the outflow tract. The RV-focused apical view assesses the chamber.



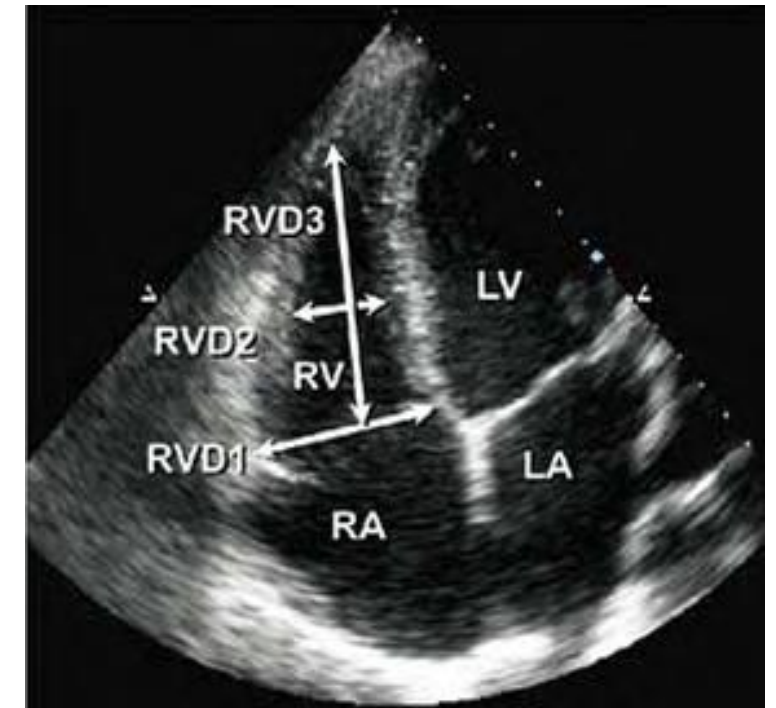
A: PLAX
Proximal RVOT



B: PSAX
Proximal RVOT



RV-focused A4C
Measurement diagram



RV-focused A4C
Echo measurements

RVD1: basal diameter RVD2: mid-cavity diameter RVD3: longitudinal dimension

RV dimensions: reference limits

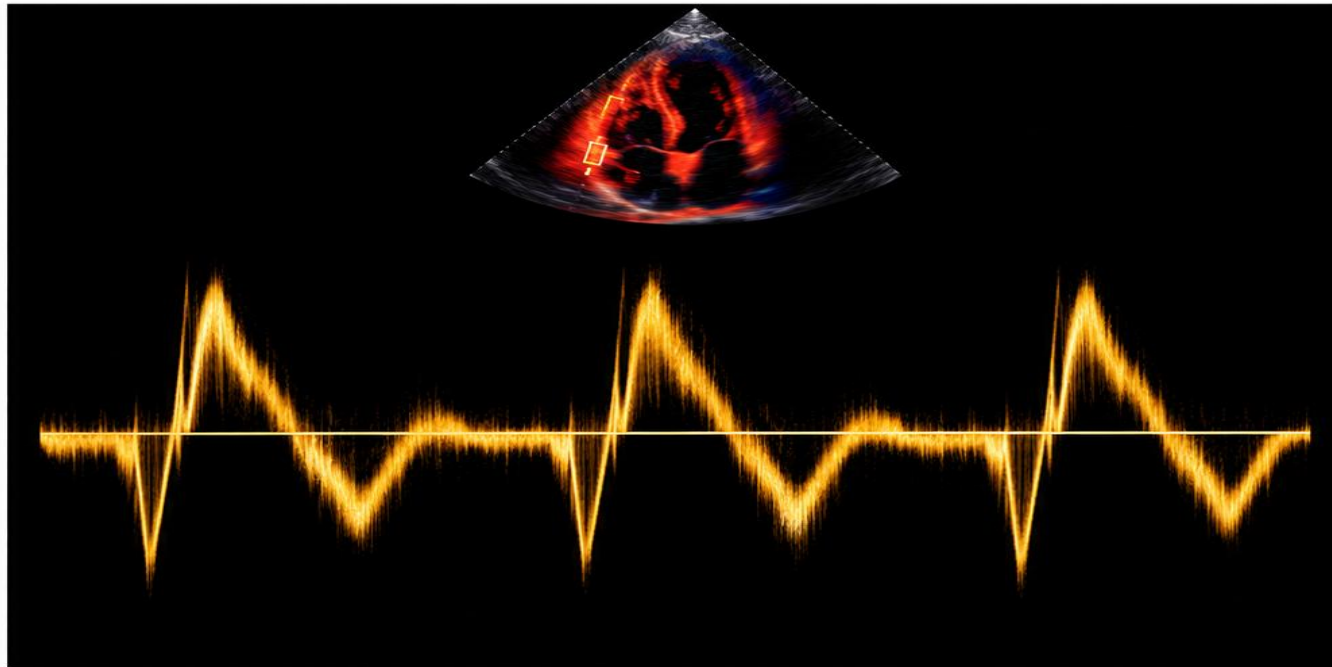
Abnormal thresholds from the newly supplied chapter (Table 3.14).

Measurement	Abnormal
Basal / mid-cavity / longitudinal	>42 / >36 / >84 mm
Proximal RVOT, PLAX	>31 mm
Proximal RVOT, PSAX	>36 mm
Distal RVOT, PSAX	>28 mm
Free-wall thickness	>5 mm

Earlier slides used ASE 2015 upper limits (41 / 35 / 83 mm). Use a stated reference consistently.

Tissue Doppler S' and TAPSE

Measure longitudinal RV systolic motion at the lateral tricuspid annulus.

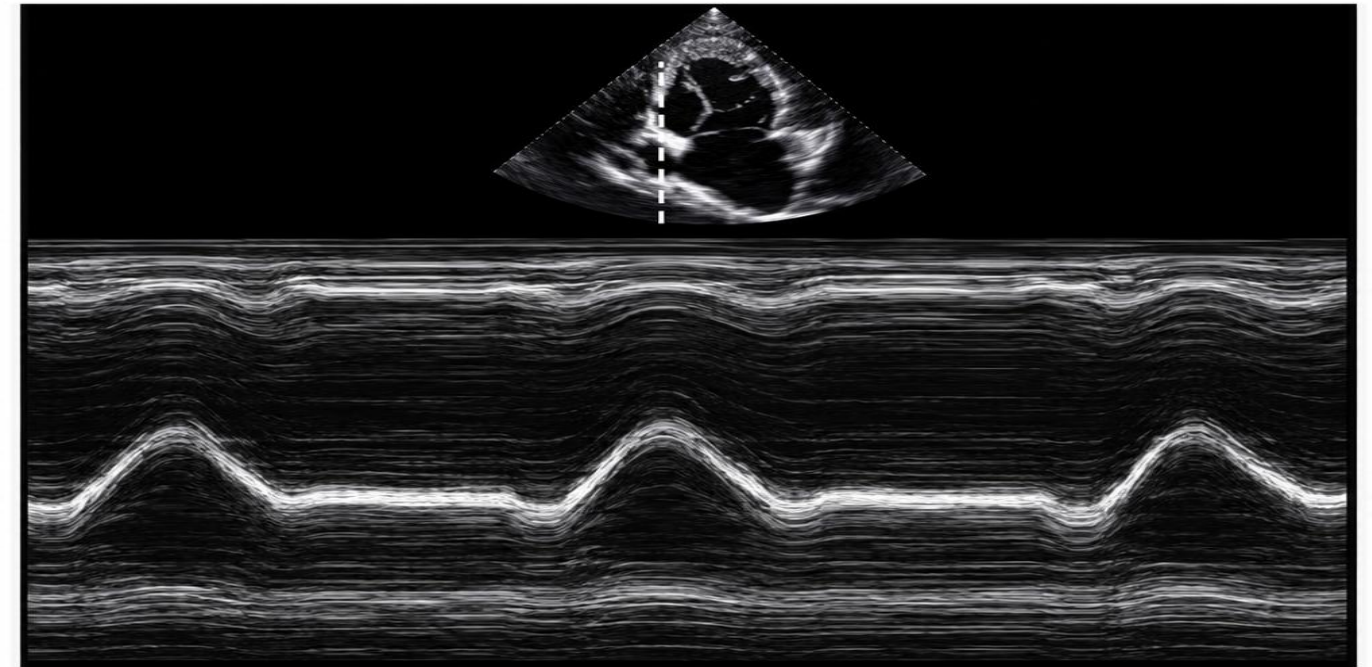


S': tissue Doppler

Place the sample at the lateral annulus.

Align with RV free-wall motion.

Source abnormal threshold: <9.5 cm/s.



TAPSE: M-mode

Align the cursor with lateral annular motion.

Measure peak-to-nadir excursion.

Source abnormal threshold: <17 mm.

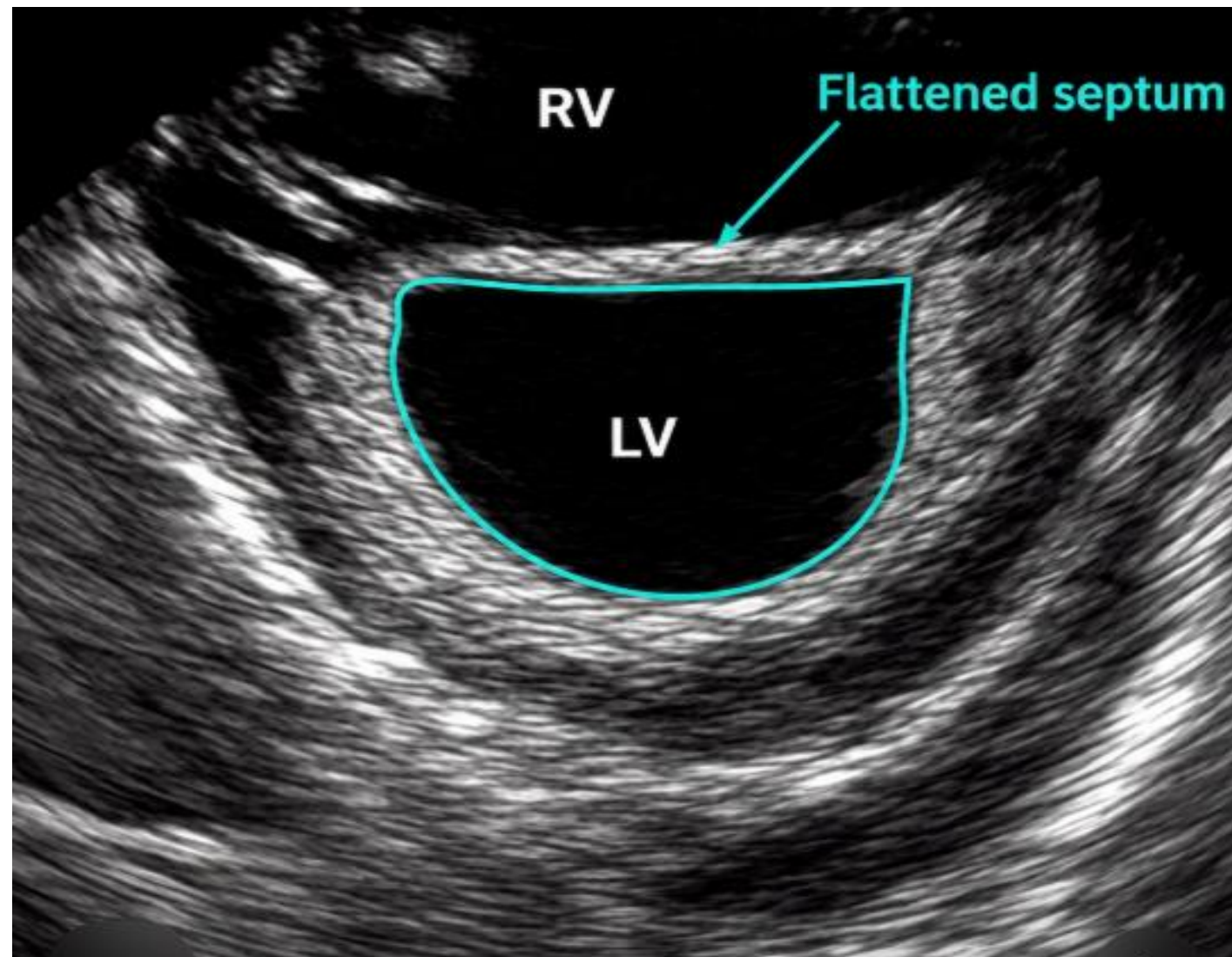
RV overload: pressure and volume produce different patterns

The septum provides a useful clue to ventricular interaction.

	Pressure load	Volume load
Examples	Pulmonary hypertension Pulmonary stenosis	Tricuspid / pulmonary regurgitation Atrial septal defect
Typical RV response	Wall thickening, then dilation	Predominant dilation
Septal flattening	Often systolic	Often diastolic

Patterns overlap. Combine morphology with valve and haemodynamic findings.

Septal flattening



Pacing and defibrillator leads

Lead position and valve interaction form part of the RV examination.

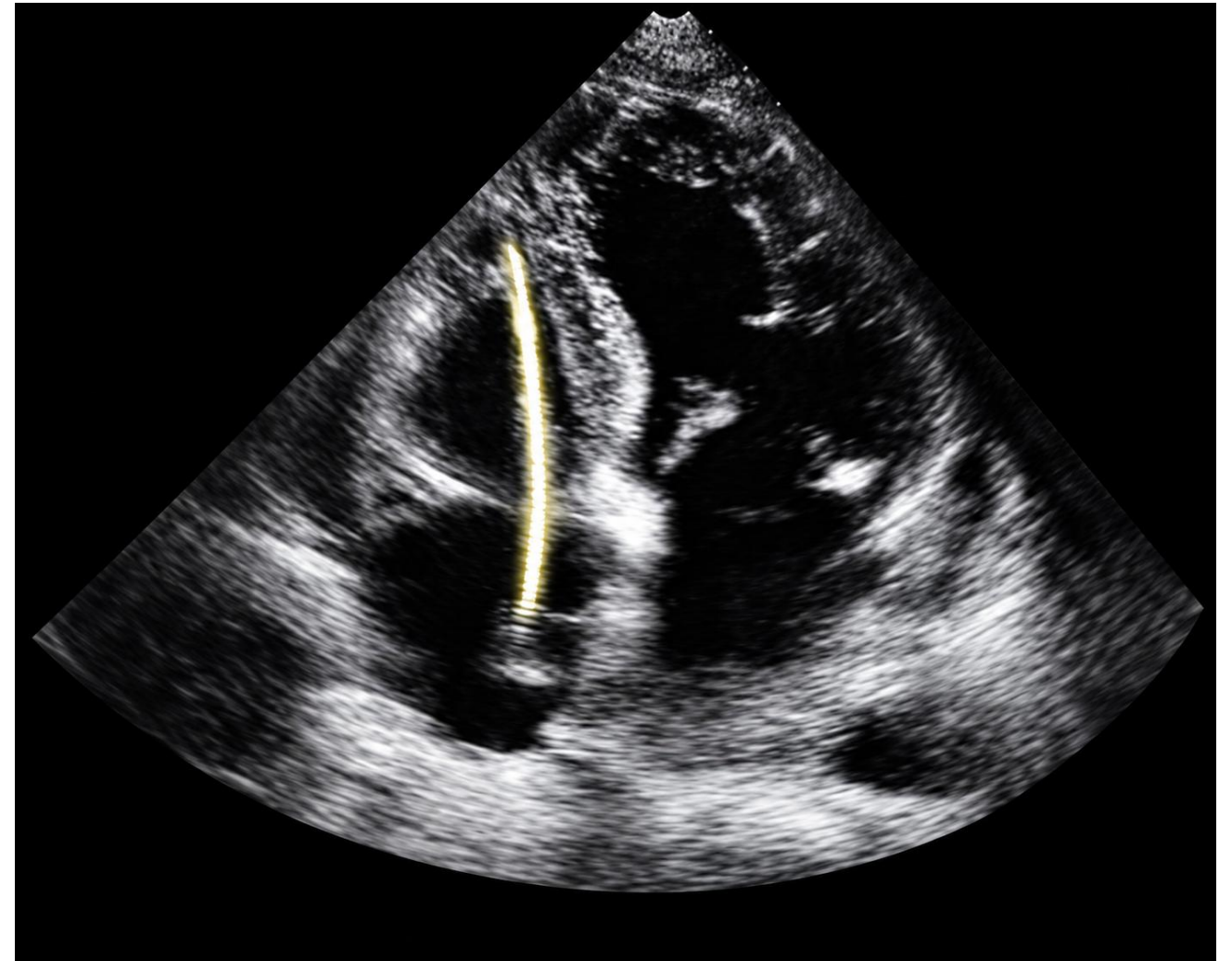
- Identify the reflective lead crossing the tricuspid valve into the RV. Use off-axis views when needed.
- Distinguish RV leads, right atrial leads and defibrillator coils. A CRT lead may appear in the coronary sinus.
- Assess leaflet interaction and associated tricuspid regurgitation.
- Describe visible lead abnormalities. In suspected infection, assess for vegetations within the clinical imaging pathway.

Lead in the right heart

Original echocardiographic image



Reconstruction highlighting the lead



Lead Bright linear structure crossing the tricuspid valve

Schematic reconstruction of the supplied image for educational use

Pericardium: echocardiographic assessment

Several imaging planes help detect focal disease and localized collections.

- Assess the pericardium in parasternal long-axis and short-axis, apical four-chamber and subcostal views.
- The normal pericardium often appears as a thin, bright line around the heart.
- A small echo-free space can reflect normal fluid. Describe an abnormal collection across several views.
- Report fluid distribution and appearance, then assess its effect on cardiac filling.

Pericardial and pleural fluid

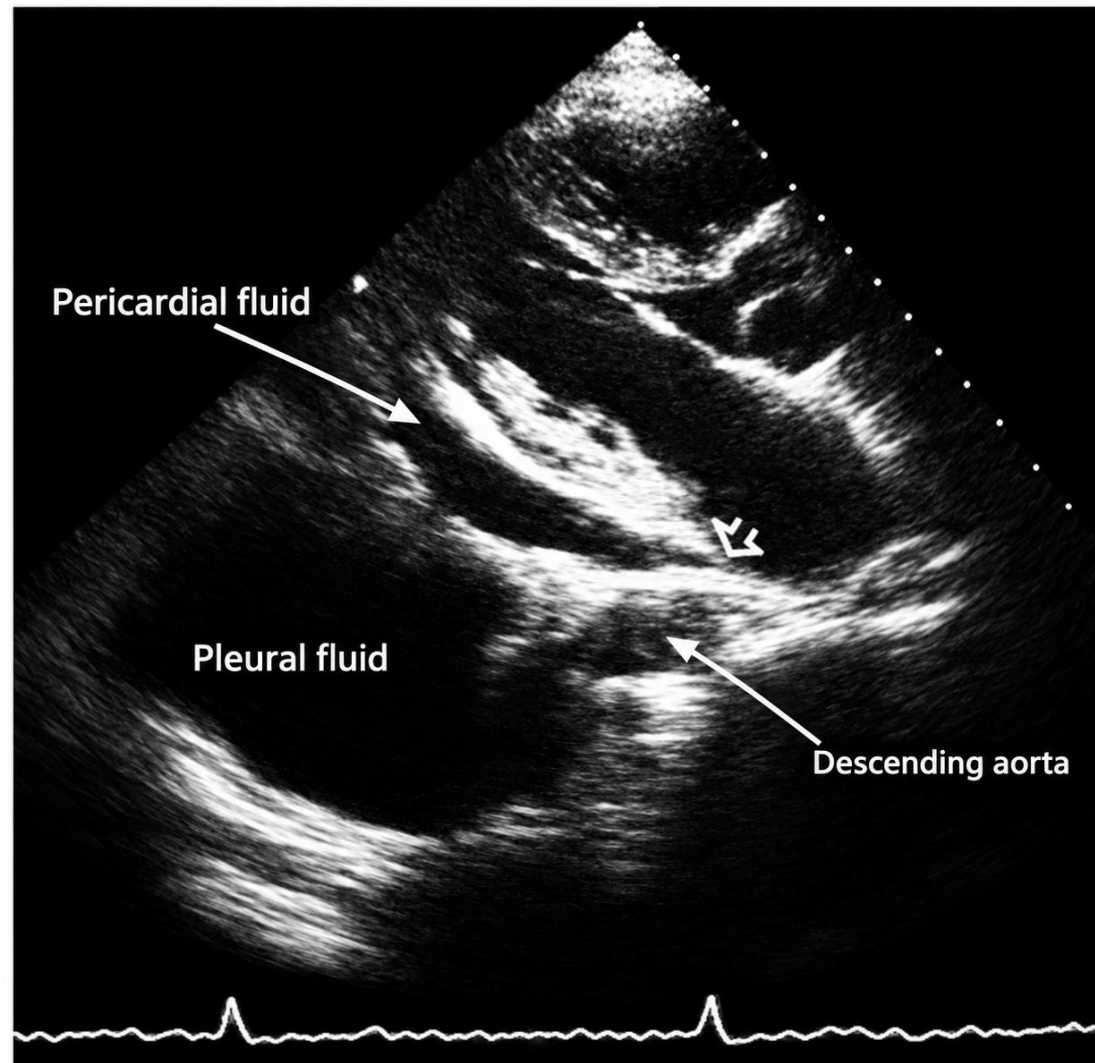
The descending thoracic aorta is the key landmark in parasternal long axis.

Feature	Pericardial fluid	Pleural fluid
Relation to descending aorta	Anterior to the aorta	Posterior to the aorta
Anatomic location	Within the pericardial sac around the heart	Outside the pericardial sac
When both coexist	Follow the pericardial boundary across views	Look for fluid extending beyond that boundary

Use additional views when the location is uncertain. Fat and other tissue can mimic an anterior fluid space.

Pericardial or pleural fluid?

The descending thoracic aorta is the key landmark in parasternal long axis.



Illustrative reconstruction

Pericardial fluid

Lies anterior to the descending aorta, within the pericardial sac.

Pleural fluid

Lies posterior to the descending aorta, outside the pericardial sac.

Confirm the location in additional views when the distinction is uncertain.

Pericardial effusion: source size categories

The uploaded chapter separates minimal fluid from mild effusion.

Fluid depth	Source category
<0.5 cm	Minimal
0.5–1 cm	Mild
1–2 cm	Moderate
>2 cm	Large

Depth gives a size estimate. It does not directly quantify fluid volume or haemodynamic impact.

Echocardiography in pulmonary hypertension

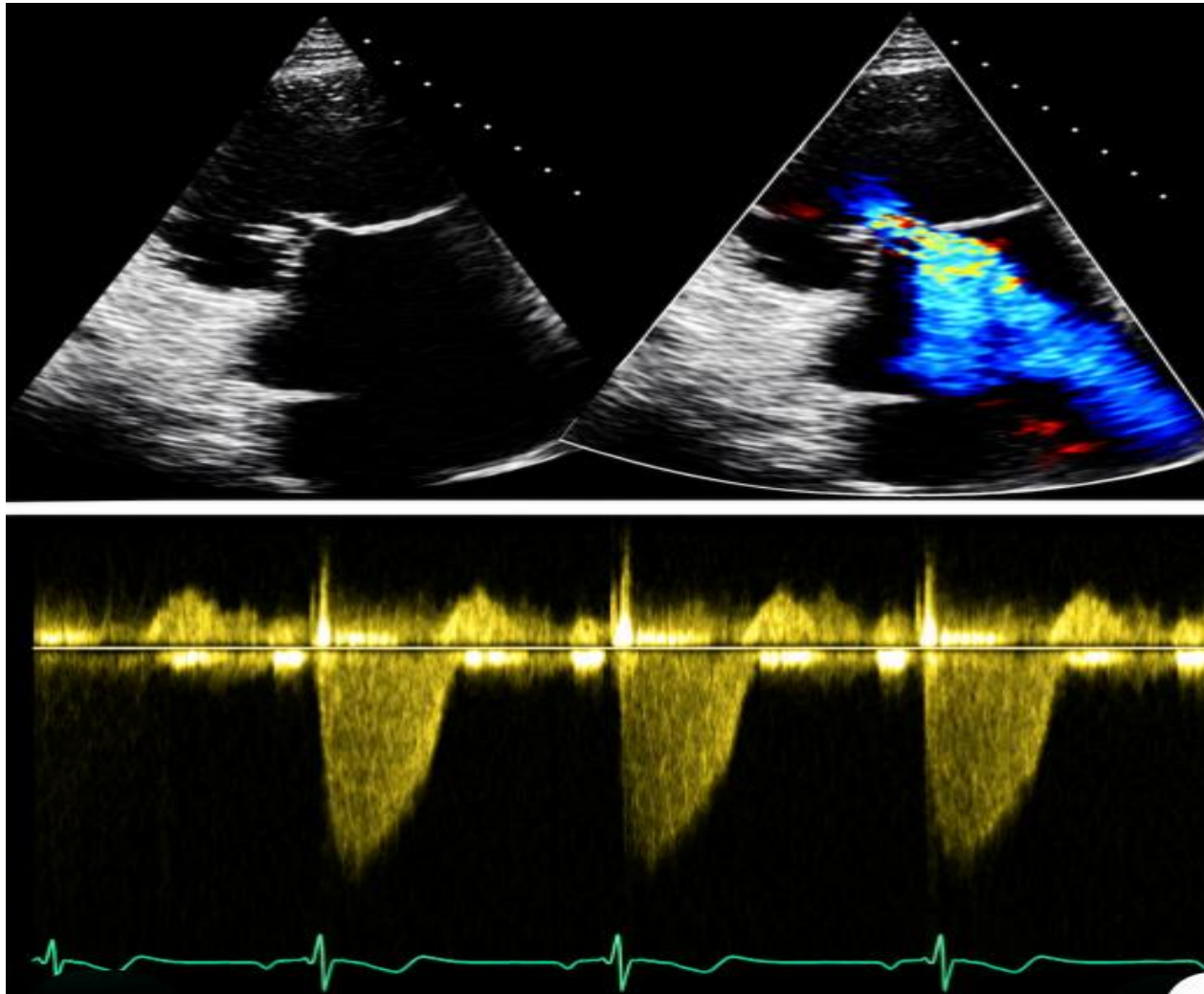
A practical measurement approach for pulmonologists

- Peak tricuspid regurgitation velocity (TRV) is the starting measurement.
- Additional signs come from the ventricles, pulmonary artery, and RA / IVC.
- RV function describes the cardiac consequences of PH.
- Right-heart catheterisation confirms and classifies PH when clinically indicated.

Current haemodynamic definition: resting mPAP >20 mmHg by catheterisation.

TR velocity and pressure estimation

Continuous-wave Doppler across the tricuspid regurgitation jet



Pressure calculation

$$\text{RV-RA gradient} = 4 \times \text{TRV}^2$$

$$\text{RVSP} = 4 \times \text{TRV}^2 + \text{estimated RAP}$$

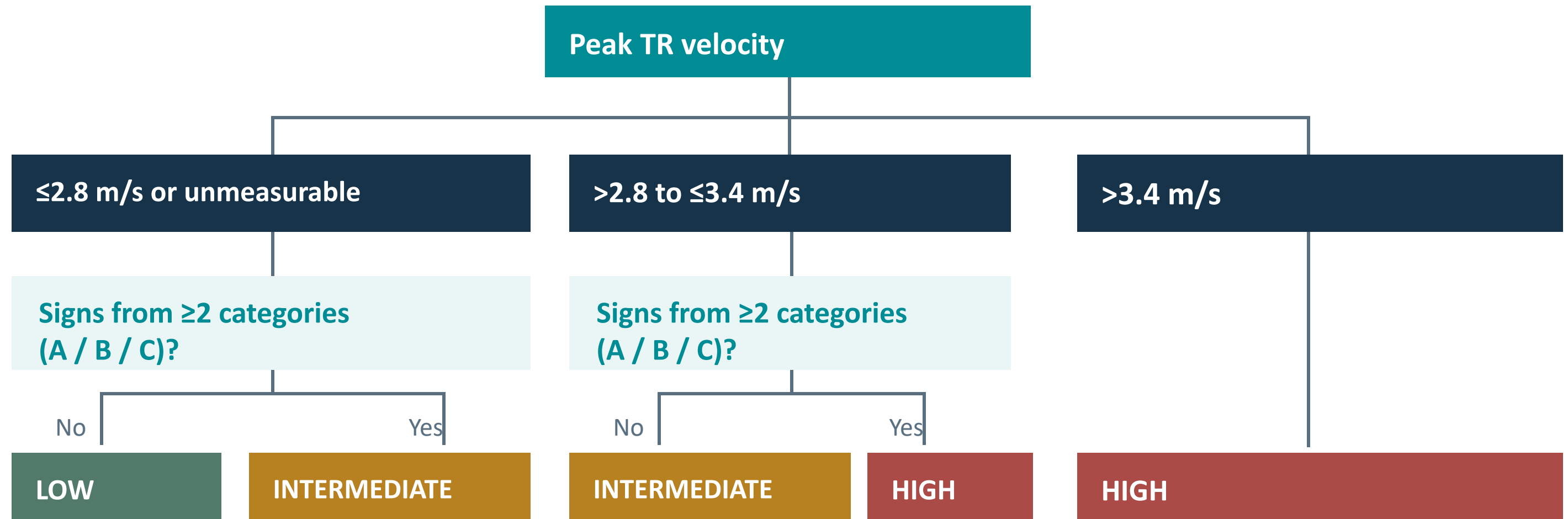
$$\text{PASP} \approx \text{RVSP}^*$$

*No RV outflow or pulmonary valve obstruction.
TRV in m/s, pressures in mmHg.

Poor signals, severe TR and uncertain RAP can distort the pressure estimate.

Echocardiographic probability of PH

Editable flowchart adapted from BSE 2018, Figure 1



Supporting signs must come from at least TWO DIFFERENT categories.

Category A: ventricular measurements

RV enlargement and septal flattening support an increased PH probability.

Measurement	Supporting threshold	How to measure
RV / LV basal diameter ratio	>1.0	Standard apical 4-chamber End-diastole
LV eccentricity index (D2 / D1)	>1.1 in systole and/or diastole	Mid-LV parasternal short axis D1 perpendicular to septum D2 parallel to septum

Septal flattening in systole supports RV pressure overload.
Avoid an oblique short-axis image, which can create false eccentricity.

Two abnormal ventricular findings still count as ONE category.

Category B: pulmonary artery measurements

Doppler flow and pulmonary artery size provide complementary signs.

Measurement	Supporting threshold	Acquisition
RVOT acceleration time	<105 ms and/or mid-systolic notch	PW Doppler below pulmonary valve Flow onset to peak
Early-diastolic PR velocity	>2.2 m/s	CW Doppler aligned with PR jet Measure early-diastolic peak
Pulmonary artery diameter	>25 mm	Parasternal short axis, end-diastole Midway between valve and bifurcation

RVOT acceleration time depends on heart rate and signal quality.

Category C: right atrium and IVC

RA size and venous congestion complete the supporting assessment.

Measurement	Supporting threshold	Timing / position
RA area	>18 cm ²	Apical 4-chamber End ventricular systole Immediately before TV opening
IVC diameter and collapse	>21 mm AND collapse <50% with sniff OR <20% with quiet inspiration	Subcostal view 1–2 cm from RA junction Diameter at end-expiration

The IVC criterion combines size with respiratory behaviour.

RA enlargement and abnormal IVC findings count as ONE category.

Category C: right atrium and IVC

RA size and venous congestion complete the supporting assessment.

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ΕΥΧΑΡΙΣΤΩ ΠΟΛΥ

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Left atrium: volume is the preferred size measure

A single diameter or area does not fully represent LA size

Measure LA volume in optimised apical four-chamber and two-chamber views.

Use biplane Simpson's method and exclude pulmonary veins and the LA appendage.

Measure at end-systole, when LA size is maximal.

The source retains PLAX anteroposterior diameter for selected electrophysiology and HCM assessments.

LA volume index upper normal limit: 34 mL/m² in both sexes.

LA volume: clinical indications

Systemic hypertension and suspected LV diastolic dysfunction.

Atrial fibrillation.

Mitral valve disease.

Assessment of an athletic heart versus early cardiomyopathy.

The source advises BSA indexing when BMI $<30 \text{ kg/m}^2$. Interpret indexed values cautiously in obesity.

Left atrial size: source reference limits

Use volume as the principal size measure

Measurement	Men	Women
AP diameter (mm)	43.3	40.6
AP diameter index (mm/m ²)	22.7	24.0
Area (cm ²)	20.3	22.0
Area index (cm ² /m ²)	11.9	12.7
Volume index (mL/m ²)	34	34

Suboptimal image quality can underestimate volume. The source notes that single-plane values may be 1–2 mL/m² lower than biplane values.

Source: newly supplied documents, Table 6.1. Reference limits and descriptions follow the supplied edition.

Right atrium: acquisition and indications

Use an apical four-chamber view optimised for the right heart

Measure RA area as part of the standard study.

RA measurement is particularly relevant in AF, RV/LV dysfunction, pulmonary hypertension, ASD and tricuspid valve disease.

Single-plane Simpson's volume can supplement area.

Atrial dilatation can provide a clue to the underlying diagnosis.

Right atrial size: source reference limits

Upper limits of normal quoted by the supplied chapter

Measurement	Men	Women
Area (cm ²)	21.9	19.0
Area index (cm ² /m ²)	11.1	11.0
Volume (mL)	70.6	55.3
Volume index (mL/m ²)	35.5	31.4

The source notes that contemporary reference data for RA volume are limited.

Atrial enlargement: consider the pattern

Chamber predominance helps organise the differential

Pattern	Causes listed in the source
Biatrial	Chronic AF, restrictive cardiomyopathy, rheumatic mitral/tricuspid disease
Mild biatrial	Athletic heart or pericardial constriction
Predominantly LA	Mitral stenosis/regurgitation or LV diastolic dysfunction
Predominantly RA	Tricuspid stenosis/regurgitation, pulmonary hypertension, ASD or RV cardiomyopathy

Source: newly supplied documents, Table 6.3. Reference limits and descriptions follow the supplied edition.

Atrial septum: thickening and mobility

Assess septal morphology in more than one view

Lipomatous hypertrophy typically spares the fossa ovalis and produces a dumbbell-shaped appearance.

An attached mass raises a different differential, such as myxoma.

The source defines an aneurysmal septum by a mobile segment with a base >10 mm and excursion ≥ 10 mm.

Septal bowing can reflect increased RA or LA pressure.

A mobile septum with excursion <10 mm is described separately in the source.

Atrial report: a practical checklist

Include measurements, septal findings and shunt evidence

LA and RA size, measurement method and indexing.

Likely cause of atrial dilatation.

Atrial septal morphology and mobility.

Evidence of a shunt and the quality of the colour/bubble study.

Avoid diagnosing dilatation from one diameter or ASD from SVC flow.