Basic Echocardiography in the ICU: A Practical Guide for Anaesthetists and Intensivists Part 2

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KEY POINTS

- Focused transthoracic echocardiography serves as a dynamic, goal-directed extension of the clinical examination in critically ill patients, allowing for real-time assessment and dynamic monitoring of cardiac function, volume status, and key causes of circulatory failure (such as tamponade and right heart strain).
- It relies on a structured, systematic approach using 4 core views: parasternal long-axis, parasternal short-axis, apical 4-chamber, and subcostal, plus the inferior vena cava view.
- Effective scanning requires attention to optimising image quality through careful machine settings (depth, gain, and M-mode) and proper ergonomics.
- Training programs like Focused Ultrasound in Intensive Care facilitate the safe and standardized application of this tool, with findings always requiring interpretation within the full clinical context for timely and informed decision-making.

INTRODUCTION

- Haemodynamic instability is a common and life-threatening problem in the intensive care unit (ICU), and rapid identification of its underlying cause is essential for effective management.
- Transthoracic echocardiography (TTE) has become a valuable tool for anaesthetists and intensivists, offering real-time, non-invasive assessment of cardiac function, preload status, and potential obstructive pathologies at the bedside.
- Unlike formal comprehensive echocardiography, focused TTE in critical care is goal directed. It aims at answering specific clinical questions, such as: Is there a pericardial effusion? Is the left ventricle (LV) or right ventricle (RV) failing? Is the patient hypovolaemic? These focused questions can often be answered using a limited number of standard views, supporting timely clinical decisions in unstable patients.[1]
- The increasing availability of portable ultrasound (US) machines, along with structured training pathways, has enabled non-cardiologists to perform focused TTE safely and effectively. In the UK and Europe, Focused Ultrasound in Intensive Care (FUSIC) supports clinicians in acquiring the skills needed to perform and interpret these scans at the bedside.[1,2]

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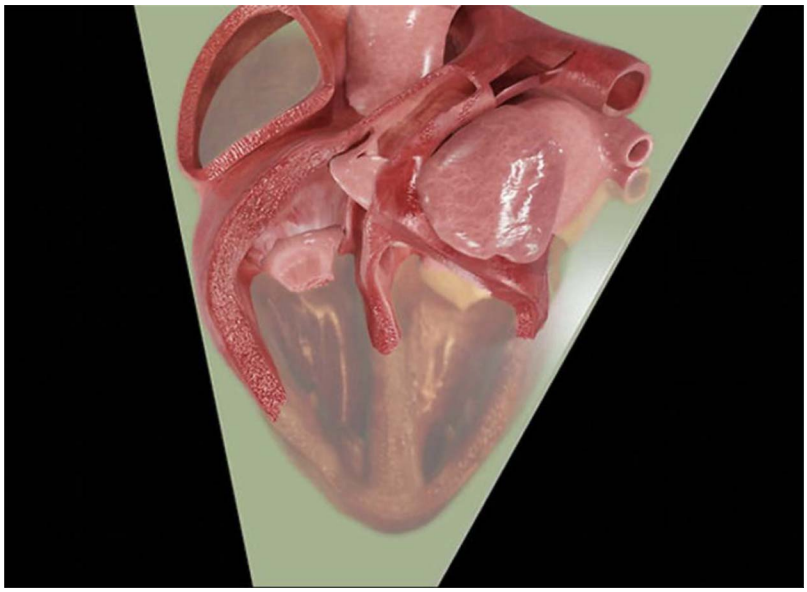

Figure 1. Three-dimensional (3D) animation of heart showing ultrasound (US) plane of apical 4-chamber (A4C)[5].

- This tutorial provides a practical guide to basic TTE for anaesthetists and intensivists. It focuses on image acquisition, interpretation, and troubleshooting of the 4 key views: parasternal long-axis (PLAX), parasternal short-axis (PSAX), apical 4-chamber (A4C), and subcostal.
- The aim is to support confident, consistent bedside use of TTE to aid in the assessment and management of critically ill adults.
- This tutorial, part 2 of 2, will focus on A4C and subcostal views and more advanced measurements.
- The addition of US of the lungs can complement the findings of TTE.

APICAL 4-CHAMBER VIEW

Purpose

The A4C view enables simultaneous visualisation of both atria, both ventricles, and the atrioventricular (AV) valves (Figure 1 & 2). It is the key transthoracic view for assessing biventricular size, interventricular septal motion, and AV valve structure. A4C allows direct comparison of RV and LV function, visual estimation of RV : LV ratio, and measurement of tricuspid annular plane systolic excursion (TAPSE) using M-mode (Figure 3).[3] As the most informative view for detecting right heart strain, it is central to focused echocardiography in critical care.[3,4]

How to Obtain the View

- Place the probe at the point of maximal impulse (PMI) which is the fifth or sixth intercostal space, midclavicular line with the marker toward the patient's left side (approximately 3:00 position).
- If the PMI is not clearly palpable, sweep across the left anterior chest to identify a window showing cardiac motion, then fine-tune with small adjustments to optimise the image.
- Start with a depth of 14–16 cm, centring both ventricles and ensuring the true apex is included. Apply tail-down angulation (anterior and medial tilt) to align with the heart's long axis.[4]
- On screen, the apex should be at the top, the atria at the bottom, and the interventricular septum should appear vertical.
- A true on-axis view also shows both AV valves moving during the cardiac cycle and the LV apex reaching the top of the image.

Key Findings and Visual Cues

Left Ventricular Function

- Reduce depth to focus on the LV and ensure the true apex is visualised.
- Normal: Symmetric thickening of the inferoseptal and anterolateral walls with coordinated apical motion.

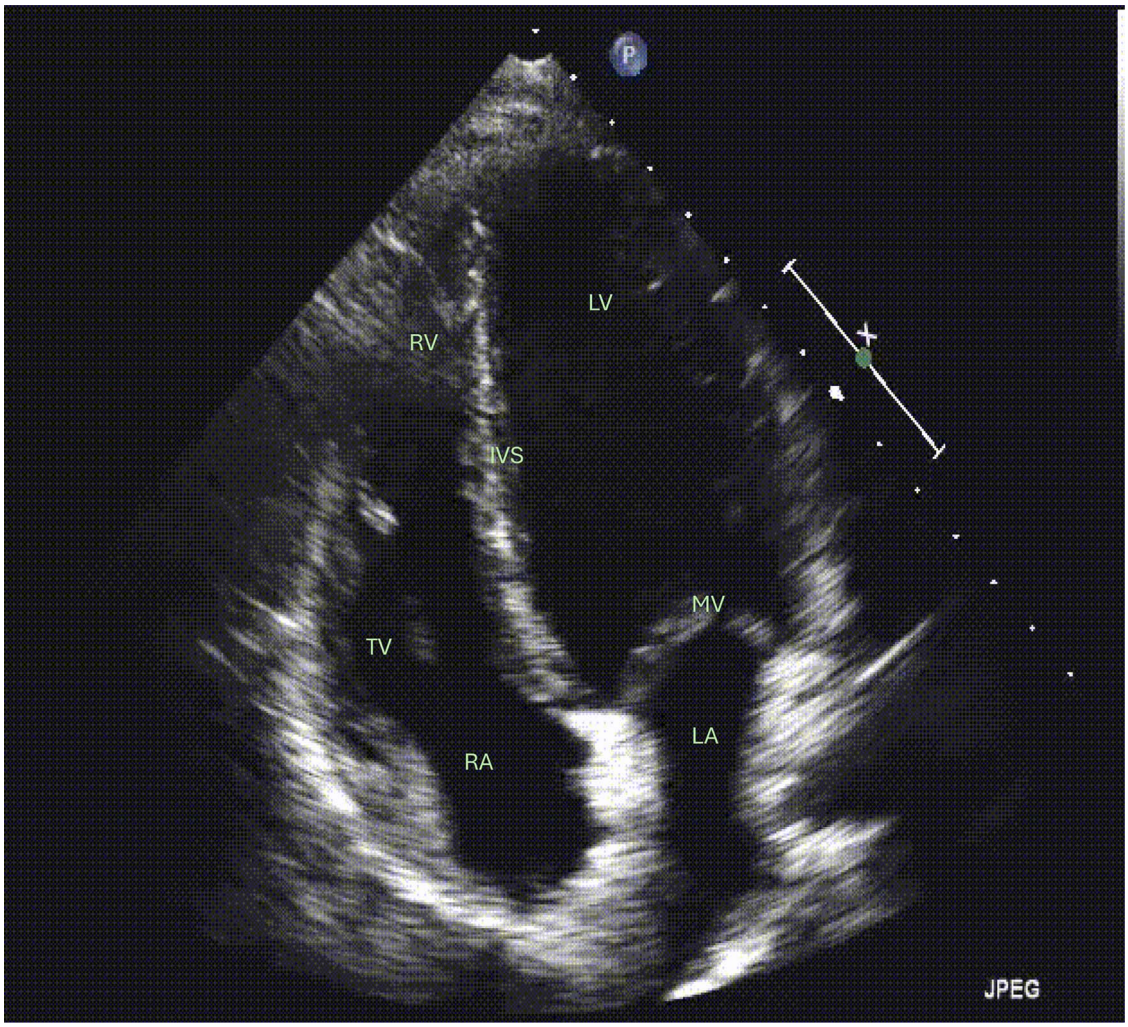

Figure 2. Labelled view of apical 4-chamber view[5].

- Impaired: Hypokinesis (reduced wall thickening), akinesis (no wall motion), or dyskinesis (paradoxical outward motion (Figure 4).
- Regional wall motion abnormalities may affect the septal, lateral, apical, or inferior segments—confirm in other views if uncertain.

Right Ventricle

- In the A4C view, the RV lies adjacent to the LV (left side of the image, patient's right), appears triangular, and should measure no more than two-thirds the LV size at end diastole.[3]
- Assess RV free wall motion and global systolic function visually.
- Specific measurements (e.g., TAPSE) can also be used and are covered in the next section.
- Fractional area change (FAC) estimates global RV systolic function by comparing RV area in diastole and systole (Figure 5):
  - A normal FAC is ≥35%; values below this suggest impaired RV function.[3]
  - In focused studies, this can be approximated visually: Look for a clear reduction in cavity area by at least one-third during systole.

Tricuspid Annular Plane Systolic Excursion

- TAPSE measures longitudinal RV function by assessing how far the lateral tricuspid annulus moves toward the apex during systole.
- Although TAPSE is a useful surrogate for RV function in steady-state conditions due to predominantly longitudinal contraction of the RV, it may be falsely reassuring in critically ill patients where loading conditions are altered.[6]

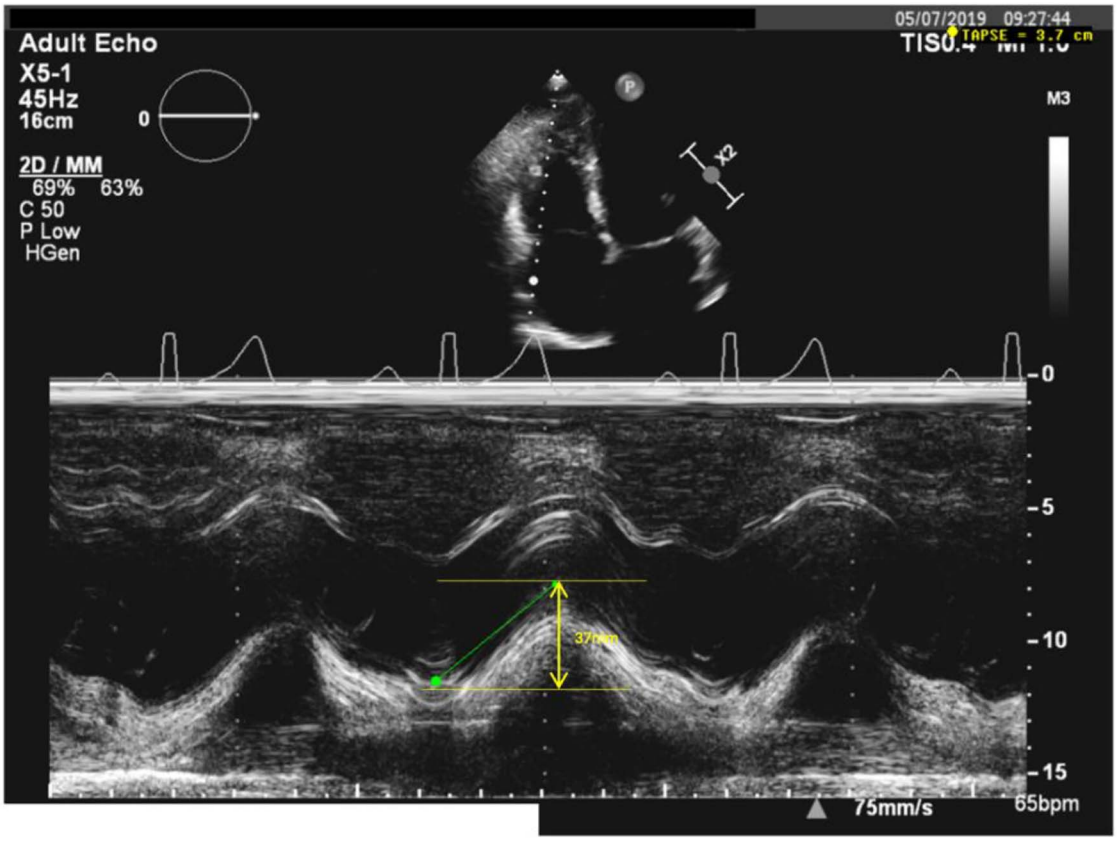

Figure 3. Measurement of tricuspid annular plane systolic excursion (TAPSE).

- If there is concern, a comprehensive assessment including both longitudinal and radial RV function is recommended.
- How to measure TAPSE (Figure 3):
  - From a high-quality A4C view, freeze the image and activate M-mode.
  - Place the M-mode cursor through the lateral tricuspid annulus, where the valve meets the RV free wall.
  - Ensure the cursor is aligned vertically, capturing the annular motion.
  - On the M-mode trace, measure the distance from the trough (end diastole) to the peak (end systole). A TAPSE $\leq$ 16 mm indicates reduced RV systolic function.[3]

Valves and Septum

- Assess the mitral and tricuspid valves for gross leaflet structure, mobility, and coaptation.
- Septal flattening toward the LV suggests RV overload[3]: diastolic flattening indicates volume overload, while systolic ($\pm$ diastolic) flattening suggests pressure overload. Ensure images are on-axis to avoid misinterpretation.
- Use colour Doppler to screen for significant mitral or tricuspid regurgitation identified by central jets occupying a large proportion of the atrium.

Troubleshooting

- Foreshortened or rounded LV: Apply tail-down angulation, slide the probe laterally, or kick the tail out posteriorly/laterally to bring the true apex into view.
- RV appears enlarged: May result from lateral foreshortening; confirm RV size in the PSAX view before concluding pathology.
- TAPSE difficult to measure: Ensure M-mode cursor is aligned through the lateral tricuspid annulus, parallel to the direction of motion.
- Valves poorly visualised: Optimise gain and focus, centre the heart, and stabilise the probe to reduce drift or rotation

Pathologies

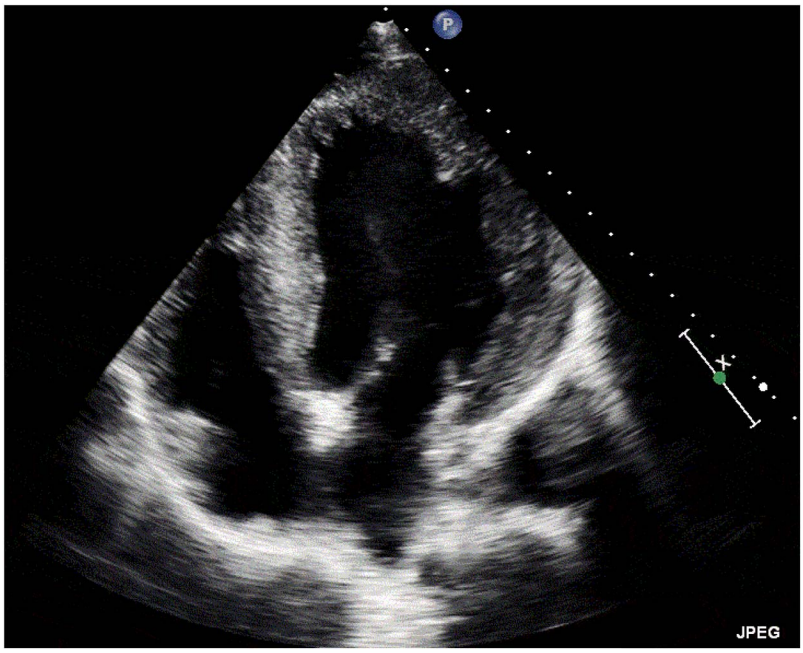

Figure 4. Apical 4-chamber (A4C) with depressed left ventricular (LV) function[5].

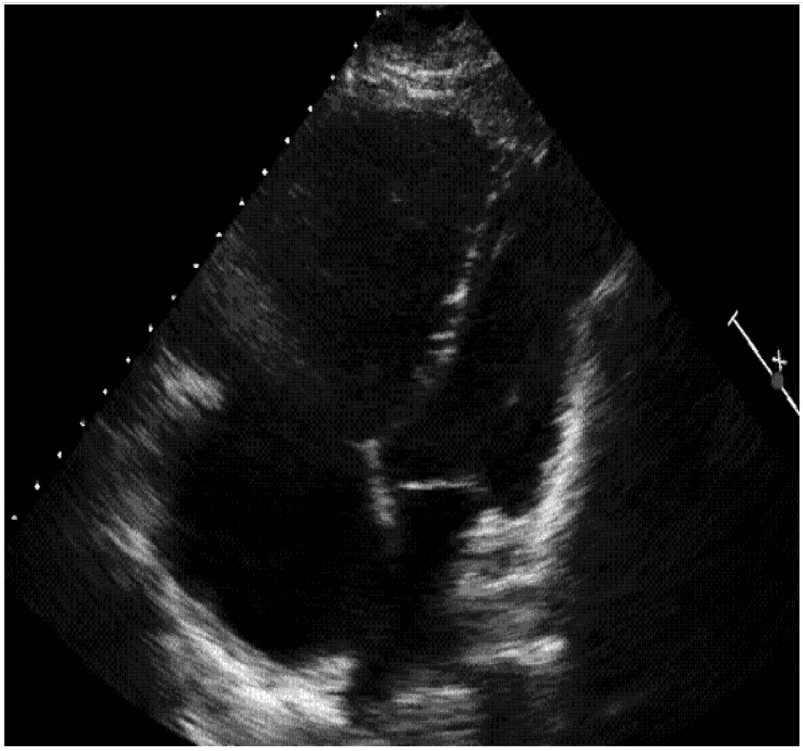

Figure 5. Dilated right ventricle (RV) and right atrium (RA)[5].

SUBCOSTAL (SUBXIPHOID) VIEW

Purpose

The subcostal view (Figure 6) is especially useful in critically ill, ventilated, or trauma patients when transthoracic windows are limited. It enables assessment of pericardial effusion, biventricular function, and inferior vena cava (IVC) dynamics and is often the most accessible view in supine or patients who are periarrest.[1]

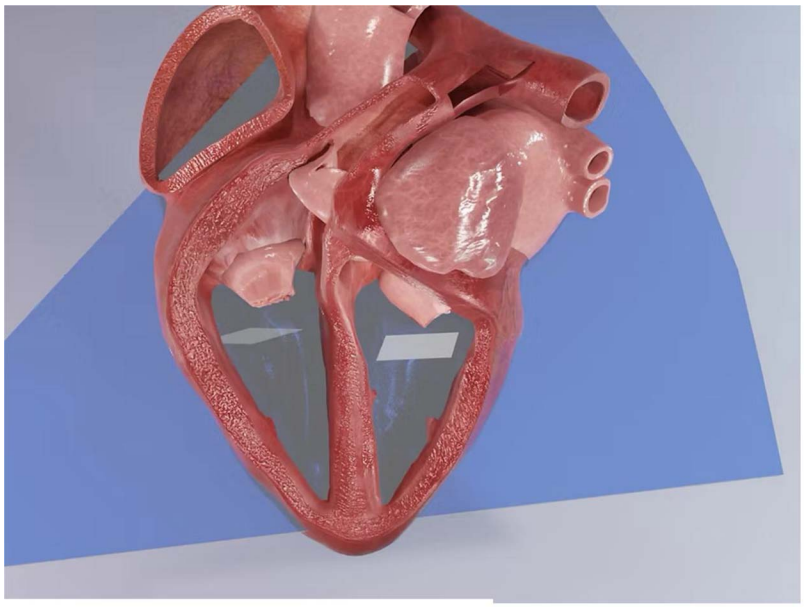

Figure 6. Three-dimensional (3D) animation of heart showing subcostal ultrasound (US) plane[5].

How to Obtain the View

- Place the probe just below the xiphisternum, in the midline, with the marker pointing to the patient's left (3:00).
- Hold the probe like a torch and angle it superiorly and slightly posteriorly, aiming toward the left shoulder.
- Use the liver as an acoustic window (a fluid-filled structure that provides a clear US path by avoiding overlying bowel gas, which can scatter or block the beam).
- Begin with a depth of 15–20 cm, then reduce once the heart is centred.

Key Findings and Visual Cues

Subcostal 4-Chamber View

- Displays the heart in a long-axis plane from an inferior angle, with the right atrium (RA) and RV nearest the probe (top of the screen) and the left atrium (LA) and LV more posterior (Figure 7).
- All 4 chambers are typically visualised, allowing estimation of global biventricular function when transthoracic views are limited.
- A pericardial effusion appears as an anechoic stripe, often most clearly seen posterior to the heart in this view.
- This is also the most sensitive window for tamponade, as it facilitates detection of RA systolic and RV diastolic collapse.[1]
- Confirm image orientation: The RA and RV are closest to the probe and should appear at the top of the screen, with the LA and LV deeper (posterior).
- Visualise movement of both the AV valves during the cardiac cycle to help confirm an on-axis view.

Inferior Vena Cava View

- Slide the probe slightly right and rotate the marker to 12:00 to align with the long axis of the IVC (Figure 8).
- The IVC appears as a thin-walled, non-pulsatile vessel entering the RA, with the hepatic vein joining just before this junction (caution: transmitted cardiac or respiratory pulsations can be misleading).
- Differentiate from the abdominal aorta, which lies deeper, has thicker pulsatile walls, and shows no respiratory variation or collapse.
- Use two-dimensional or M-mode to assess the IVC approximately 1–2 cm proximal to the RA, ideally just beyond the hepatic vein confluence (Figure 9).
- In spontaneously breathing patients, assess for collapse:
  - A small IVC (<2.1 cm) with >50% inspiratory collapse suggests low RA pressure and may indicate volume responsiveness.
  - A dilated IVC (>2.5 cm) with minimal or absent inspiratory collapse suggests raised RA pressure, as seen in tamponade or RV failure (Figure 10).
  - The collapsibility index is calculated as:
    - (maximum diameter − minimum diameter) ÷ maximum diameter.
  - A collapsibility index >0.5 (>50%) supports the presence of low RA pressure and possible fluid responsiveness but should always be interpreted alongside clinical context and other echocardiographic findings.
  - It is not reliable in isolation.

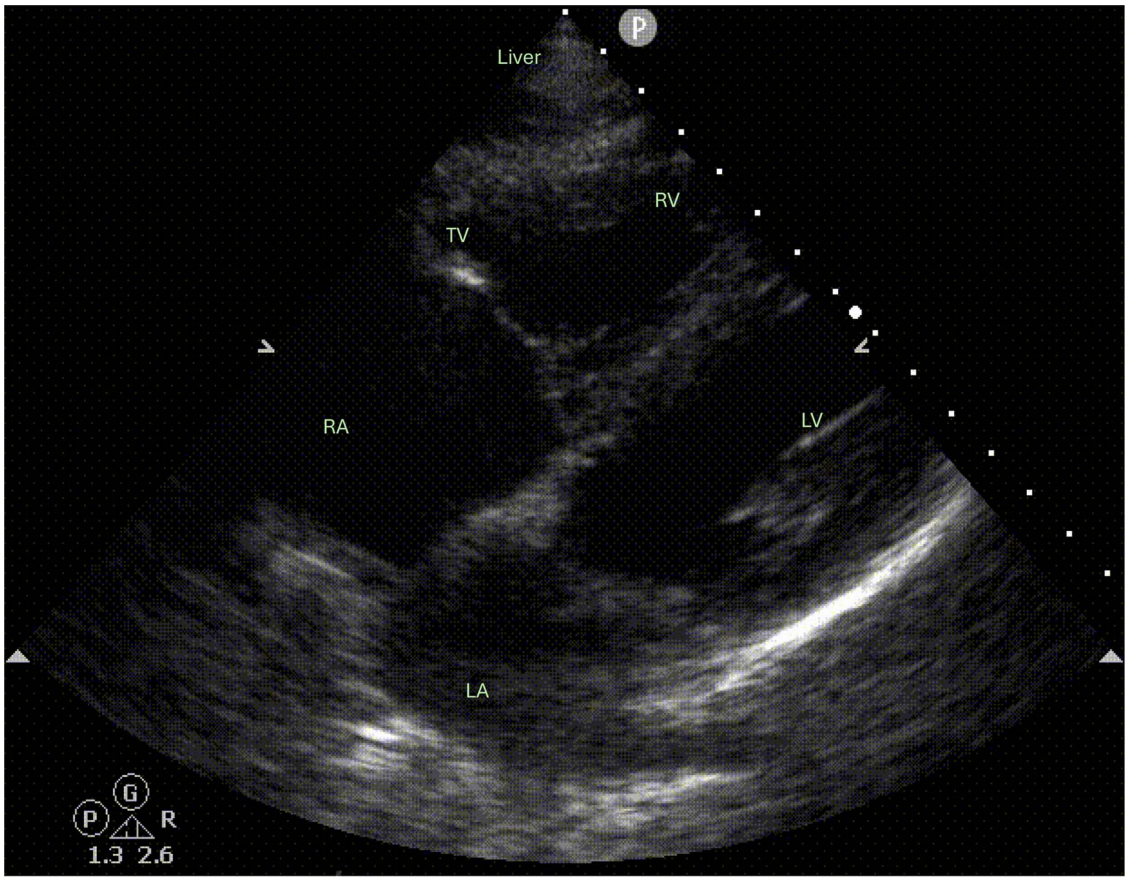

Figure 7. Labelled subcostal[5].

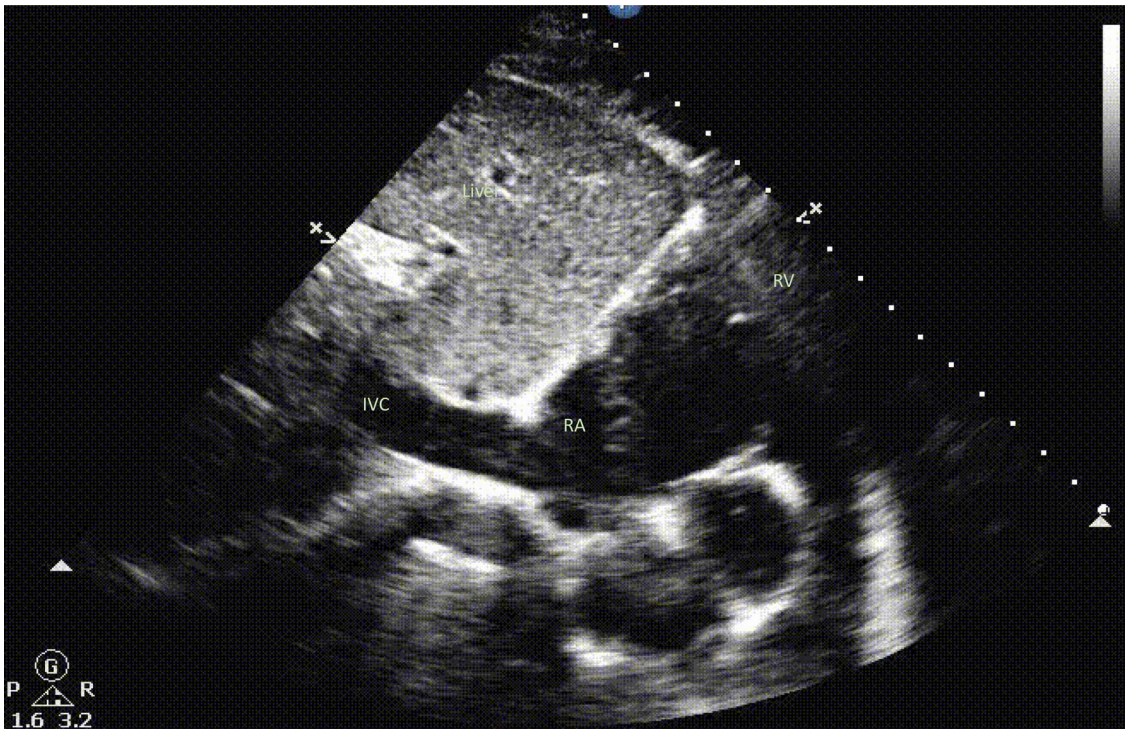

Figure 8. Labelled subcostal inferior vena cava (IVC) view[5].

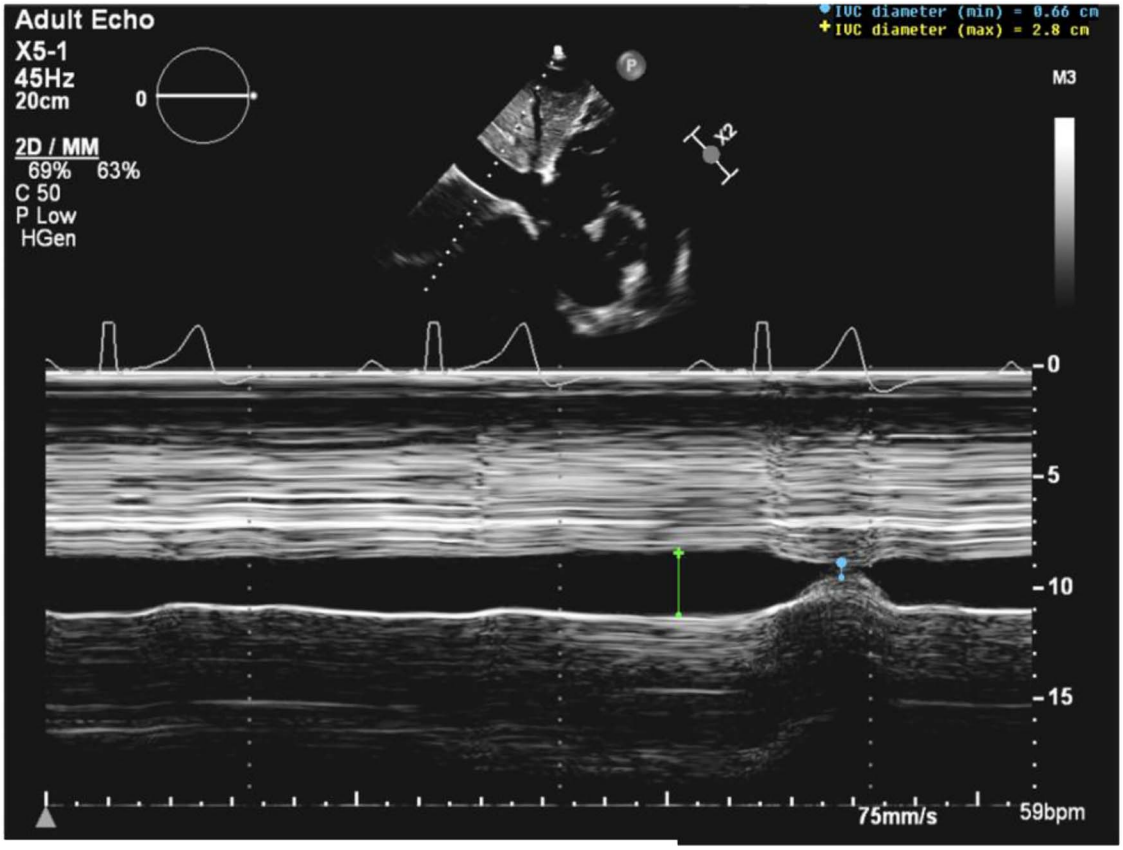

Figure 9. Subcostal short axis—measurement of inferior vena cava (IVC) in M-mode.

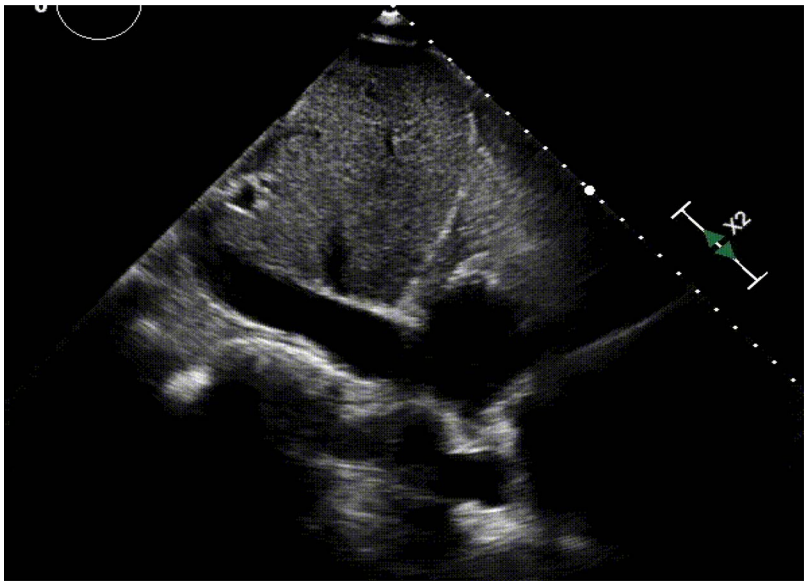

Figure 10. Distended inferior vena cava (IVC)[5].

- In mechanically ventilated patients, assess for distension: The IVC may distend during inspiration due to positive intra-thoracic pressure.
- The distensibility index is calculated as:
  - (maximum diameter − minimum diameter) ÷ minimum diameter.

Clinical Question	Best Views	Key Echo Findings	Interpretation Tip
Is the LV significantly impaired?	PLAX, PSAX, A4C	Globally reduced wall thickening and motion; small, underfilled LV if hypovolaemic	Check the apex for foreshortening; confirm in multiple views
Is the RV significantly impaired or dilated?	A4C, PSAX	RV > LV size; reduced TAPSE (<16 mm); septal flattening (D-shaped LV)	Confirm RV : LV ratio and RV function in both A4C and PSAX
Is the patient volume depleted?	PLAX, PSAX, IVC	Small, hyperdynamic LV; IVC < 2.1 cm and collapses >50%	Combine IVC and LV appearances; repeat after fluid challenge if uncertain
Is the patient volume overloaded?	A4C, IVC	Dilated LV or RV; IVC > 2.5 cm with minimal collapse, distensibility and collapsibility indices	Look for signs of elevated filling pressures, often with poor systolic function
Is there a pericardial effusion?	Subcostal, PLAX	Anechoic stripe; RA or RV collapse	Subcostal is most sensitive; confirm collapse in 2 views
Is there evidence of tamponade physiology?	Subcostal, PLAX	Large effusion; RA systolic and RV diastolic collapse; dilated IVC	RV diastolic collapse is key; use M-mode or cine loop to confirm timing
Are there gross valvular abnormalities?	PLAX, A4C	Thickened or flail leaflets; poor coaptation; large regurgitant jets on colour Doppler	Use colour Doppler in A4C; focused echo cannot grade severity
Are there regional wall motion abnormalities?	PSAX, A4C	One or more LV segments hypokinetic, akinetic, or dyskinetic	Map to coronary territories (Figure 11); confirm in multiple views

Table 1. Clinical Questions and Their Features on Echocardiogram. A4C, apical 4-chamber; IVC, inferior vena cava; LV, left ventricle; PLAX, parasternal long-axis; PSAX, parasternal short-axis; RA, right atrium; RV, right ventricle; TAPSE, tricuspid annular plane systolic excursion.

- A distensibility index >18% has been associated with fluid responsiveness, but this measurement is technically challenging and affected by positive end expiratory pressure (PEEP) tidal volume, and RV function[6].
- Distensibility indices are part of advanced echocardiography. In basic practice, they should be reserved for select cases where frank hypovolaemia has been excluded, and results should be interpreted with caution.
- IVC measurements and respiratory variation offer a useful approximation of RA pressure but are highly context dependent.
- Accuracy decreases with raised intra-abdominal pressure, arrhythmias, spontaneous respiratory effort, or extremes of mechanical ventilation.[6]

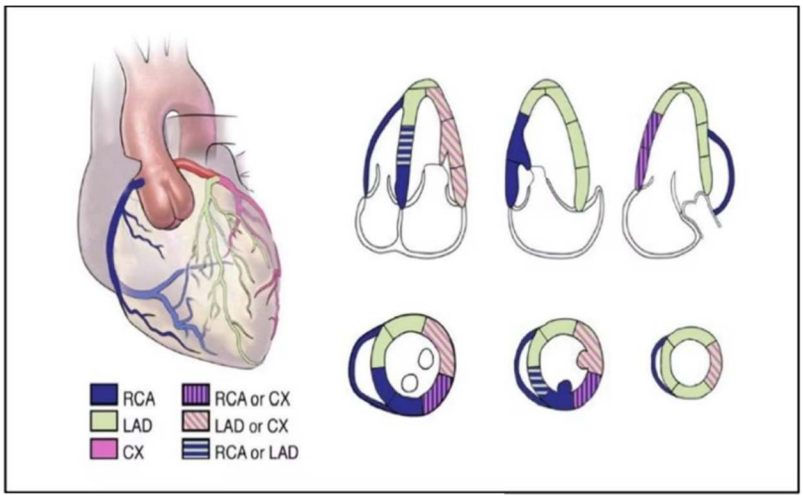

Figure 11. Coronary territories[7].

Troubleshooting (Subcostal-Specific)

- Poor image quality: Flex the patient's knees and apply gentle downward pressure to relax the abdominal wall. Reposition the probe slightly inferiorly or laterally and use gel generously to improve contact.
- Bowel gas interference: Rock or tilt the probe slightly. Gentle, sustained pressure may help displace overlying bowel gas.
- To differentiate the IVC from the aorta, trace the vessel proximally into the RA and look for the entry of the hepatic vein near the junction. The aorta lies deeper and slightly to the left on screen (patient's right), is more pulsatile, does not vary with respiration, and typically lacks visible venous branches.
- Image appears inverted: Check probe orientation and machine settings. In subcostal views, the right ventricle should appear anterior—closest to the probe and therefore at the top of the screen—with the apex directed toward the patient's left.

ACCREDITATION AND FURTHER TRAINING

- Focused echocardiography should be developed through supervised practice, scan documentation, and regular feedback from an experienced supervisor.
- A structured training process helps ensure safe and consistent image acquisition and interpretation.
- Accreditation pathways vary by region. Programmes such as FUSIC provide structured frameworks for focused cardiac US in critical care settings.
- Clinicians may choose to remain within focused scanning for bedside decision-making or pursue more comprehensive training, depending on their clinical role, local governance, and service needs.

SUMMARY

- Focused echocardiography in the ICU is not about producing a formal report but answering focused clinical questions to guide immediate management.
- Each view provides a piece of the puzzle; confident interpretation relies on integrating multiple windows into a coherent bedside narrative. As outlined in the Table 1.
- For example:
  - A small, vigorously contracting LV (PLAX, PSAX) with a collapsible IVC suggests hypovolaemia.
  - A dilated RV, septal flattening (PSAX), and reduced TAPSE (A4C) point toward acute right heart strain.
  - A large pericardial effusion with RV diastolic collapse supports tamponade physiology.
- Always confirm abnormal findings in at least 2 views and repeat scans to assess response to treatment.
- If findings are equivocal or more complex pathology is suspected, escalate early to formal transthoracic or transoesophageal echocardiography.
- When used appropriately, focused echo becomes a powerful bedside extension of clinical reasoning, not just for diagnosis, but for monitoring, triaging, and risk-stratifying the critically ill.

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