

Basic echocardiography

Introduction to basic cardiac ultrasound

In contrast to formal echocardiography in which multiple views and techniques provide a comprehensive structural and functional assessment of the heart, resulting in a quantitative report, basic echo in the resuscitation setting aims to answer focused clinical yes/no questions.

Principles of basic echo in critical care

- Opportunistic – all views may not be obtainable in the critically ill but at least one useful view almost always is
- Qualitative ‘gross visual’ assessment (no measurements)
- Limited to 2D ‘B’ mode scanning, sometimes with some M-mode thrown in
- Complements CLINICAL assessment
- Life threatening abnormalities are usually obvious
- Getting the views is harder than interpreting them

What are we looking for?

In the shocked, dyspnoeic, or arrested patient it looks for (or rules out):

- Pericardial effusion (with or without signs of tamponade)
- An enlarged RV (with or without hypokinesis and paradoxical septal motion)
- LV size, in conjunction with IVC (eg small LV suggests hypovolaemia)
- LV systolic function (rough estimate only)

Normal chamber sizes / wall thickness in the average adult are as follows:

- Internal diameter LV (in diastole) 3.5-5.7cm (4-6cm roughly)
- Internal diameter RV diameter (in diastole) 0.9-2.6cm (1-3cm roughly)
- RV diameter < 0.6 x LV diameter
- LV wall / IV septum in diastole <1.1cm (note that walls should thicken by about 50% in systole)
- RV free wall < 0.6cm in diastole
- Internal diameter of LA, RA & Ao root each < 4cm

Note that these figures are averages only. They depend on factors such as sex (male usually bigger than female) and height (large people have large hearts).

Probe and scanner settings:

The above information can be obtained using the curvilinear 'FAST' probe on usual FAST settings. However, the cardiac phased array probe and echo preset will provide better images of the beating heart and more easily obtained transthoracic views , since the smaller 'footprint' of the probe allows scanning between the ribs.

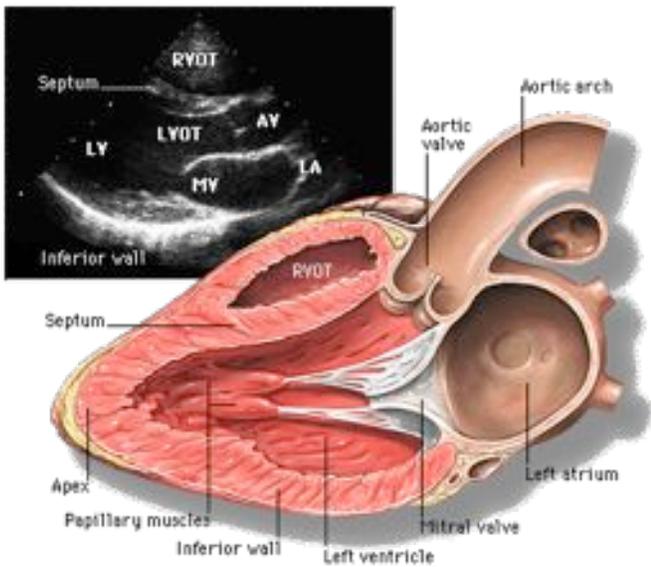
Remember: - the cardiac preset flips the image in a left-right direction, giving you a mirror image of what you would see with the abdominal probe on FAST settings. Best ways not to get confused are to develop a routine of placing the probe in a certain way, and also (in some views) to identify the liver, since any adjacent heart chamber will be right-sided.

Where to scan – the cardiac windows

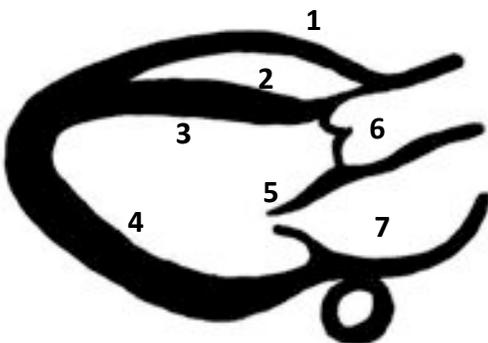
In addition to the subxiphoid (aka subcostal) approach of a FAST scan, parasternal and apical approaches are used. The patient is best examined supine for the subxiphoid approach, but for the other views you should position the patient if the clinical situation allows – have the patient roll to the left and if possible put their left hand up behind their head. This drops the heart away from behind the sternum and opens up the rib spaces.

Parasternal Long Axis View (PLAX)

The aim is to orientate the beam with the long axis of the left ventricle. The transducer is placed to left of the sternum in the 3rd, 4th, or 5th intercostal space with the marker orientated towards the right clavicle (approximately 11 o’clock).



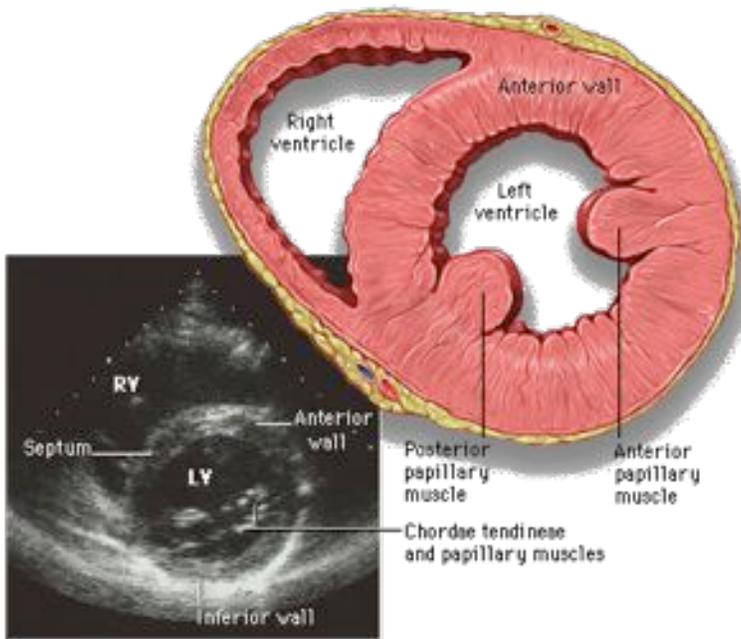
A structured approach is required to examine each sector of the image while asking specific questions:



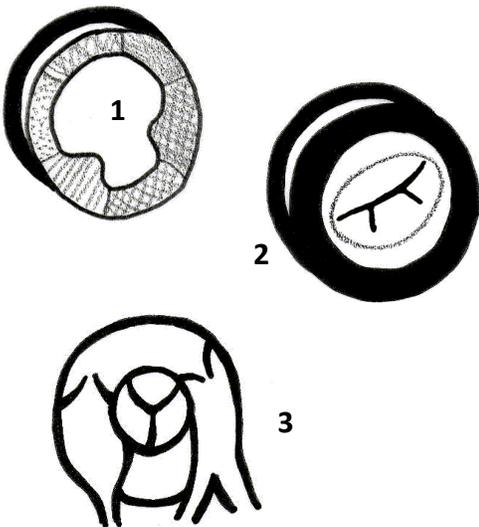
1. Examine the pericardial space. Is there fluid, or a fat pad? Is fluid pericardial or pleural? If there is pericardial fluid, can you demonstrate tamponade physiology?
2. Is the RV a normal size and contracting normally?
3. Is the septum a normal size and moving normally?
4. Is the LV a normal size and contracting normally?
5. Does the anterior MV leaflet approximate the septum (sign of good LV function)
6. Is the aortic root normal size; is there a dissection flap?
7. Is the LA a normal size?

Parasternal Short Axis View (PSAX)

The transducer remains in the intercostal space used to obtain the parasternal long axis view and is rotated clockwise 90 degrees so that it is perpendicular to the long axis of the LV (probe marker to left shoulder). It is then tilted to sweep through from base to apex of the heart, obtaining a number of different views.



The principal applications of this view in basic echo are to assess the relative shapes and sizes of the two ventricles in suspected PE, and to visually assess LV function, both globally and regionally, by looking for abnormal wall motion. It's also useful for confirming suspected pericardial effusion.



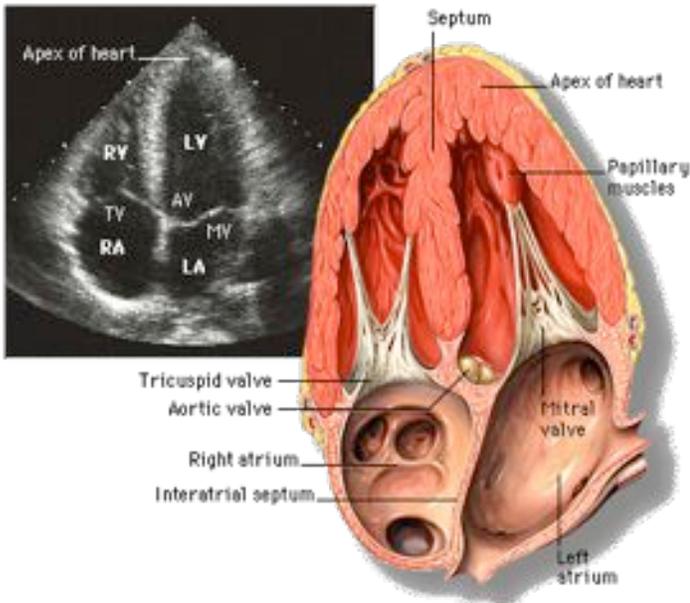
Examine the shapes and sizes of the ventricles. The LV should be bigger than the RV. The LV should be round and the RV crescent shaped, like a reverse letter 'D'. This relationship is reversed in acute cor pulmonale due to pulmonary embolism.

The probe can be tilted to examine the SAX view at different levels:

1. Level of papillary muscles
2. Mitral valve
3. Level of aortic valve

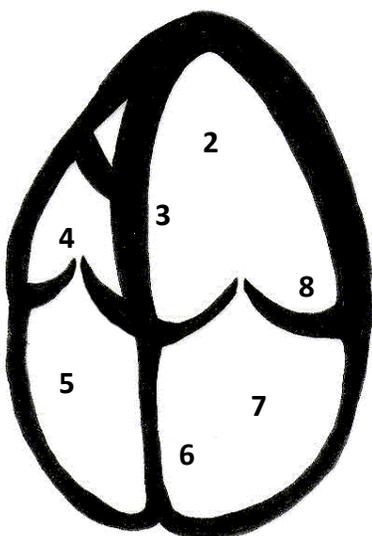
Apical Four Chamber View (A4C)

The transducer is placed at the point of maximum impulse if the patient has a palpable apical beat; otherwise it is placed in the fifth intercostal space near the anterior axillary line. The beam is directed up towards the patient's head, and the transducer is rotated so the marker is at around 3 o'clock.



In basic echo this view is helpful for the identification of pericardial effusions and demonstrating tamponade physiology (right sided diastolic chamber collapse), as well as RV dilation in massive and submassive pulmonary embolism.

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1. Examine the pericardial space. Is there fluid? If there is pericardial fluid, can you demonstrate tamponade physiology?
2. Is the LV a normal size and contracting normally?
3. Is the septum a normal size and moving normally?
4. Is the RV a normal size and contracting normally?
5. Is the RA a normal size?
6. Is the interatrial septum in a normal position?
7. Is the LA a normal size?
8. Is the MV annulus moving up and down, suggesting good long axis function of the LV?

Apical Two Chamber View (A2C)

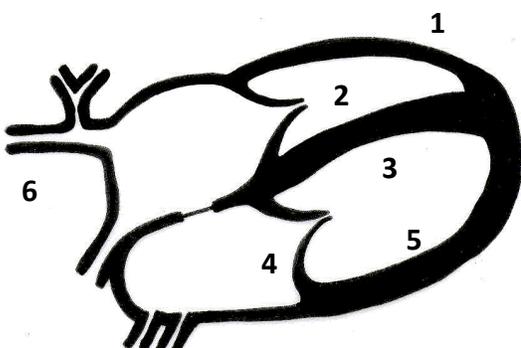
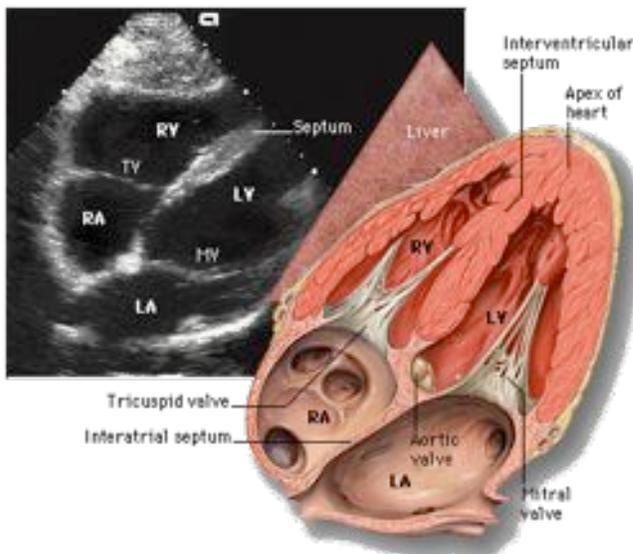
This is achieved after the apical four chamber view by rotating the transducer approximately 45 to 90 degrees anticlockwise: probe marker to 12 o'clock. This visualizes the true anterior and true inferior walls of the left ventricle which is important for the assessment of regional wall motion abnormalities.

Subcostal Long Axis View

This window may provide the only achievable view in technically difficult patients such as those with chronic obstructive pulmonary disease or who are receiving mechanical ventilation. The patient is supine and if possible the knees are slightly bent to reduce abdominal wall tension. The transducer is placed below and slightly to the right of the xiphisternum.



The side marker is in the 3 o'clock position and the transducer is tilted anteriorly. It may be necessary to push slightly downwards into the abdomen in order to achieve this scan plane.



1. Examine the pericardial space. Is there fluid? If there is pericardial fluid, can you demonstrate tamponade physiology?
2. Is the RV a normal size and contracting normally?
3. Is the septum a normal size and moving normally?
4. Is the MV annulus moving up and down, suggesting good long axis function of the LV?
5. Is the LV a normal size and contracting normally?
6. Measure the IVC and assess its collapsibility

What BASIC echo can tell you in a critically ill patient

Hypovolaemia

In addition to the small, collapsing IVC described elsewhere, you may see:

- LV is small
- LV is hyperdynamic with systolic obliteration of the chamber – the so-called ‘kissing ventricle’.

Tamponade

Pericardial effusions must be differentiated from pericardial fat pads (effusion is usually darker and present in more than one view, often all around the heart) and pleural effusions (look at the lung base!). The diagnosis of cardiac tamponade requires not just an effusion but also:

- A shocked patient (tamponade is a clinical diagnosis)
- The demonstration of tamponade physiology, either clinically or sonographically - such as IVC dilation and diastolic RA or RV collapse.

LV Function

A gross qualitative assessment of LV function can be made by visual inspection of:

- LV wall thickening in systole (if it doesn't thicken, it's abnormal)
- Relative shrinking of the LV chamber in systole (that's the ejection fraction*);
- Systolic excursion (up-down movement) of the mitral annulus on the four chamber view;
- And proximity of the anterior mitral valve leaflet to the interventricular septum in diastole (best seen on PLAX view).

***Assess the ejection fraction qualitatively by commenting on ‘gross visual assessment of LV systolic function’: severely impaired, mild-moderately impaired, or grossly normal**

Aortic Dissection

Transthoracic echo cannot rule out aortic dissection, but it might rule it in. Basic ultrasound in patients with shock or chest pain may reveal features of aortic dissection, such as

- Pericardial effusion
- Dilated aortic root
- Visible dissection flap,
- Or extension of the dissection into the abdominal aorta.

Therefore combining basic echo with abdominal aorta assessment can increase the sensitivity of the exam.

Pulmonary Embolism

PE cannot be ruled out by echocardiography. However, submassive and massive PE result in acute cor pulmonale: a high pressure RV that pushes the septum towards the LV. Basic echo assessment in suspected PE may demonstrate:

- RV size and motion: is the RV as large as the LV?
- Septal motion: RV pushes septum towards LV ('D' sign)
- IVC distended (see *IVC* section of this manual)

Other causes of acute cor pulmonale should be considered in the differential diagnosis. Note that chronic cor pulmonale usually demonstrates a *thickened* RV wall.

Severe Sepsis / Septic Shock

This can be confusing, so keep your wits about you. For example:

- A hyperdynamic heart in sepsis may be indistinguishable from that seen in hypovolaemia: small, hyperdynamic LV.
- However, one third of septic shock patients will have a hypokinetic left ventricle.
- To make matters worse, concurrent ARDS can cause acute cor pulmonale in which the echo appearances resemble those of pulmonary embolism.

Serial evaluations of the heart and IVC using echo can contribute to goal-directed resuscitation in severe sepsis and septic shock (see also *Shock algorithm*).

Cardiac Arrest

- Cardiac standstill on echo is associated with a poor outcome.
- VF can be demonstrated by echo.
- Pulseless electrical activity may be due to 'true-EMD' or 'pseudo-EMD.' 'Pseudo-EMD' has a better prognosis if the underlying cause can be treated.
- Echo can provide direct or indirect evidence of cardiac tamponade and massive pulmonary embolism in cardiac arrest.
- Echo can be used to determine whether emergency cardiac pacing is generating mechanical capture.

Acute coronary syndrome

In chest pain, echo may: increase the sensitivity of assessment of acute coronary syndrome by identifying wall motion abnormalities; identify alternative causes of chest pain; and diagnose mechanical complications of myocardial infarction. It is absolutely NOT a rule-out tool!

Top Tips for improving your basic echo skills

1. Don't get put off by overcomplicated courses. The fancy Doppler stuff can be left to cardiologists for now.
2. Find an excuse to stick probes on patients. *Obtaining* the image is harder than *interpreting* the image. You get good at both by practice.
3. Save your scans and have an 'expert' review them: this is how you know when you're getting judgments right such as 'moderately impaired LV systolic function by gross visual assessment'.
4. Echo ALL hypotensive patients. You will discover surprise pathology that will blow your socks off and make you shudder about all those patients you've managed previously without knowing what the heart looked like. Believe it or not, tamponade is often a surprise!
5. Practice all four views but don't spend too long trying to get any particular one. Many critically ill patients may only have one or two good windows but it's rare to find one with none.
6. Use the sequence PLAX, PSAX, A4C, SC, with the probe marker rotating clockwise from roughly 11 to 2 to 3 o'clock and staying at 3 for the subcostal view until you need to rotate it anticlockwise to 12 for the IVC assessment. This routine avoids confusion about probe/marker orientation.

A FINAL THOUGHT

Stick to rough description of ventricular appearance and function. Over-interpretation of poor quality images is a classic trap for young players!