Cardiac ultrasound

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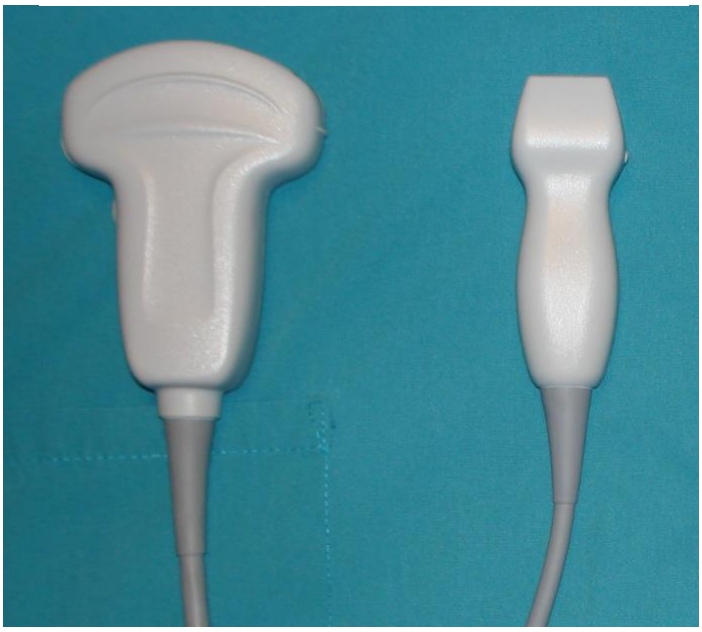
Point of care ultrasound can be very useful in many clinical settings, including those that may implicate the heart as the source of the issue. In this clinical setting, imaging the heart, lungs and inferior vena cava can produce information that can guide management.

Principles

Ultrasonography is based on the use of a piezoelectric crystal that converts electrical energy to ultrasound waves. The transducer or probe allows for both transmission and reception of an ultrasound signal. The frequency of ultrasound waves used for adult echocardiography ranges from 1-5 MHz. The frequency for pediatric echocardiography is 3-8 MHz. Both curvilinear and the phased array can be used but the smaller phased array transducer head allows for scanning between the ribs.

Curvilinear **Phase Array**



Images are generated based on the reflection of ultrasound from acoustic interfaces; for example, the boundary between the blood in the left ventricle and the myocardium. The following are the basic principles:

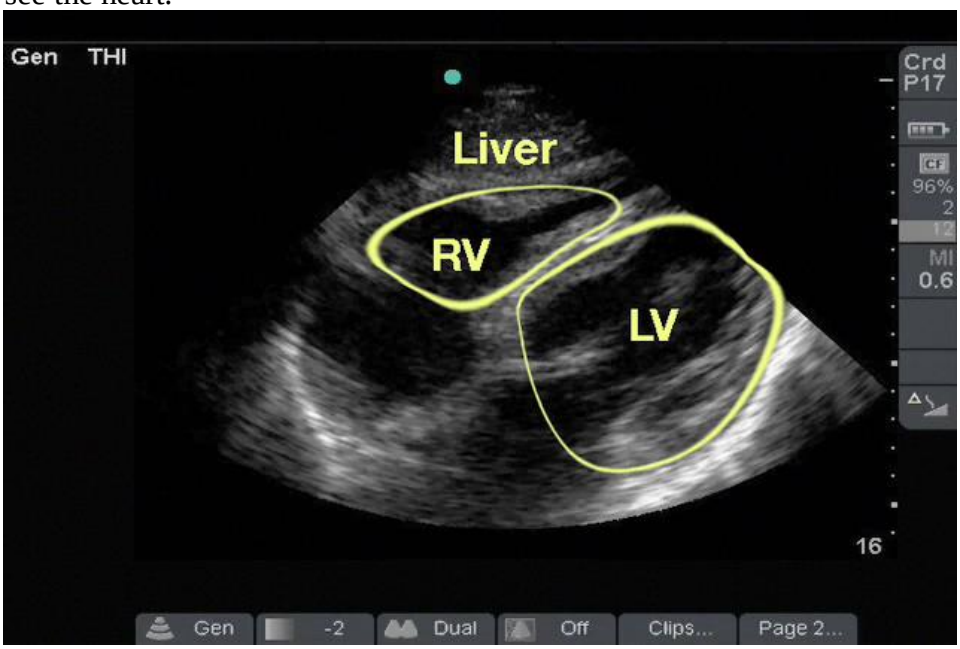
- The more perpendicular the ultrasound beam hits a structure, the greater the returning echo. Deviation from the perpendicular results in less return of the echo.
- Interfaces with different acoustic impedance, provides clarity in image. Acoustic impedance is the stiffness in molecular movement. Interfaces occurs when two tissues with different acoustic impedance interfaces.
- Image the structure from different angles by angling the transducer slightly to bring out the best interface.

- Orient the image so it correlates with the patient so that the left of the screen is on the left of the patient.

Standard Image Planes for Cardiac Imaging

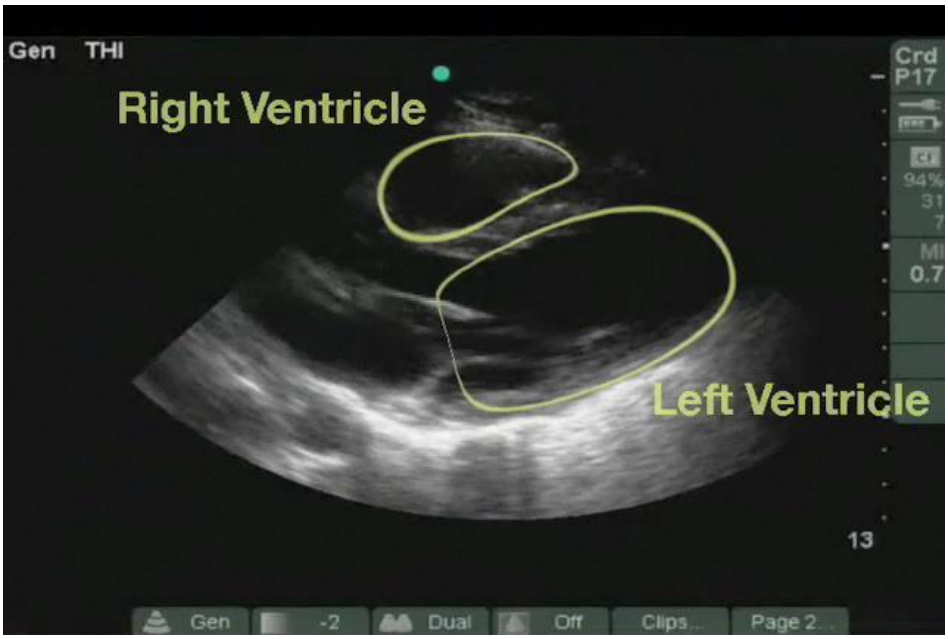
For the substernal view the transducer is place under the xiphoid and aim towards the center of the chest in a coronal plane. Pressure has to be applied to the transducer to push it into the abdomen. This may be difficult in an obese person or a patient with distended abdomen. It may provide the best in patients with emphysema when the over inflated lungs, covers the heart anteriorly and push the heart inferiorly.

The liver is seen in the near field through which the right ventricle can be seen next to it and the left ventricle further behind. The depth of the field usually needs to be increased to fully see the heart.



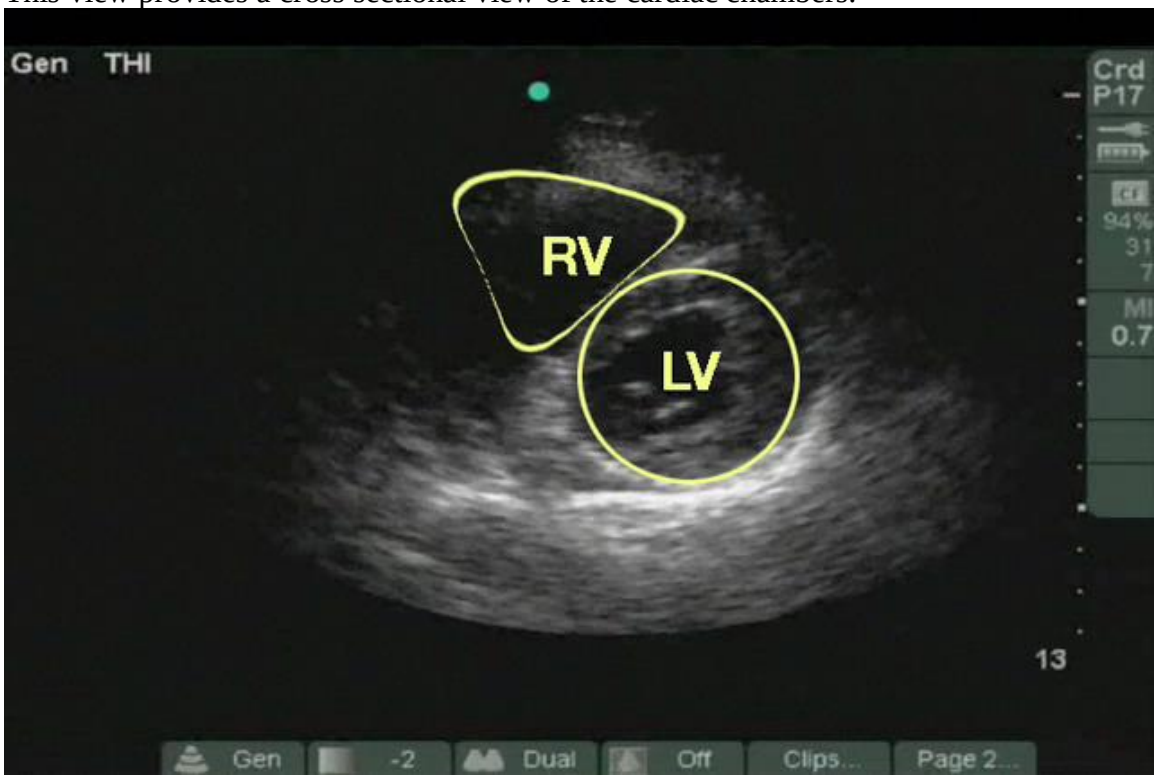
For the parasternal view, the transducer is placed in the left parasternal border usually between the 3rd and 4th ribs. The image plane is adjusted manually to provide long- and short-axis views. The long axis defined as the plane that intersects the cardiac apex and the middle of the aortic valve. Short-axis views are perpendicular to this long axis, with standard image planes at the cardiac base (aortic valve level), mitral valve, and mid ventricular levels.

In the long axis view, the right ventricle is seen in the near field and the left ventricle in the far field.



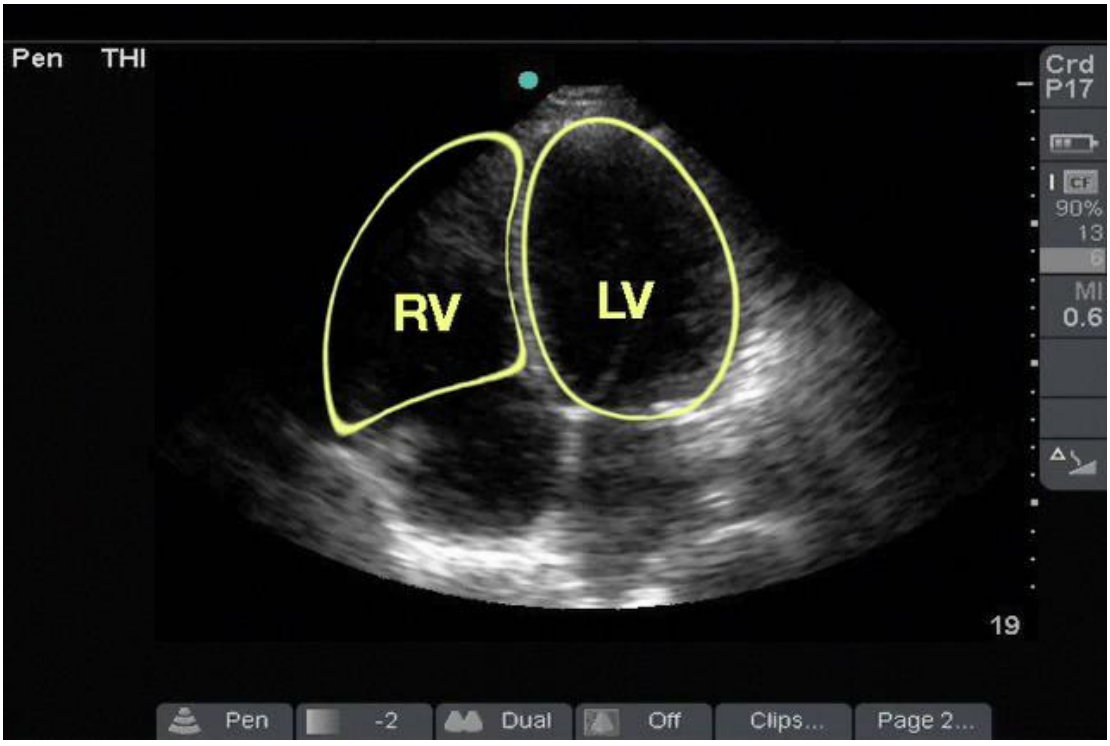
Turning the transducer 180º counterclockwise so that the directional indicator is pointed towards the right hip will give the short axis view.

This view provides a cross sectional view of the cardiac chambers.



The apical or four-chamber view is obtained by placing the transducer the point of maximum apical impulse with the ultrasound beam pointing towards the tip of the left scapula. Having the patient lie on the left side can enhance the apical pulse and the image.

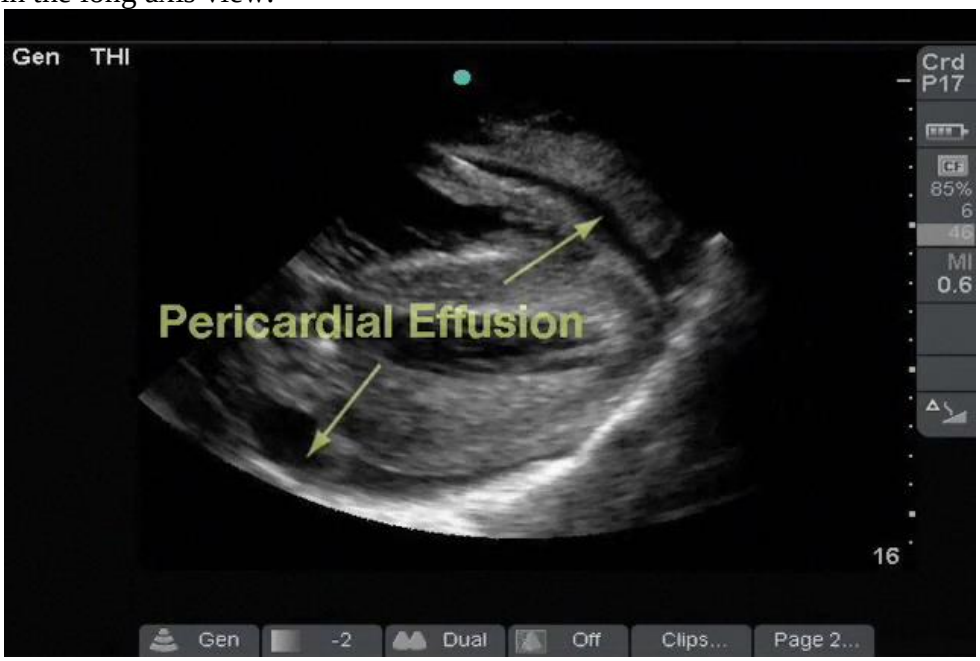
All four chambers of the heart can be visualized with the ventricles in the near field.



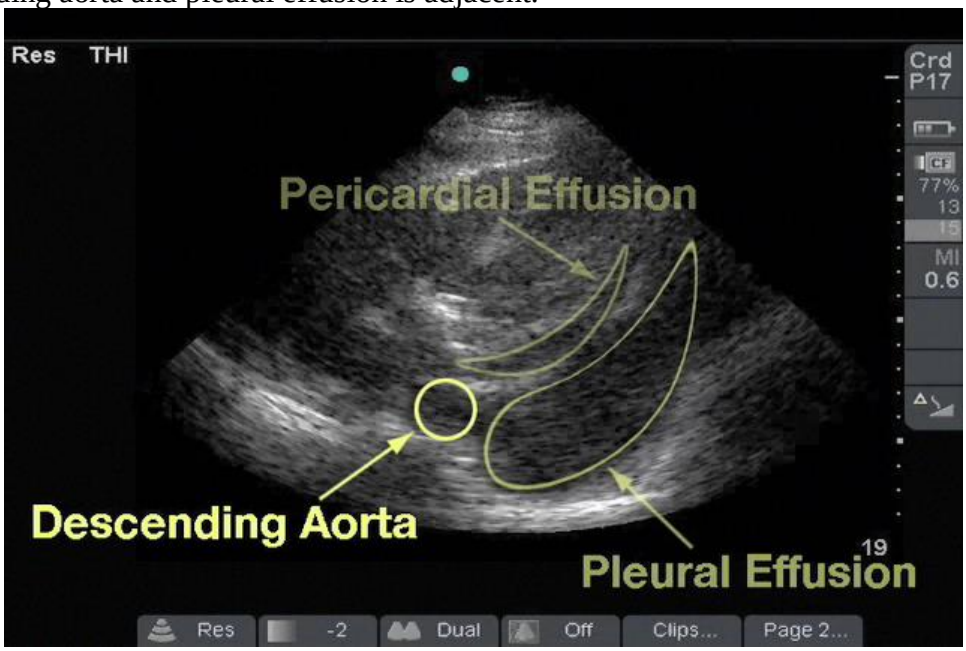
From the apical window, the transducer can be rotated to provide three views oriented 60º from each other, producing a four-chamber, a two-chamber, and a long-axis view (showing the anterior and posterior walls of the heart).

Pericardial Effusion

Pericardial effusion with hypoechoic shadow in front and behind the heart is shown below in the long axis view.



A small hypoechoeic shadow seen only in front is usually due to pericardial fat. Pleural effusion may be mistaken for pericardial effusion. Pericardial effusion is anterior to the descending aorta and pleural effusion is adjacent.



Pulseless Electrical Activity

In patients with pulseless electrical activity, echocardiography can be useful to determine cardiac standstill. It is also useful to determine whether the heart is still contracting in the absence of the carotid pulse. Being able to feel the central pulse can be tricky during the hype of resuscitation when extra pressure on the artery can obliterate the pulse.

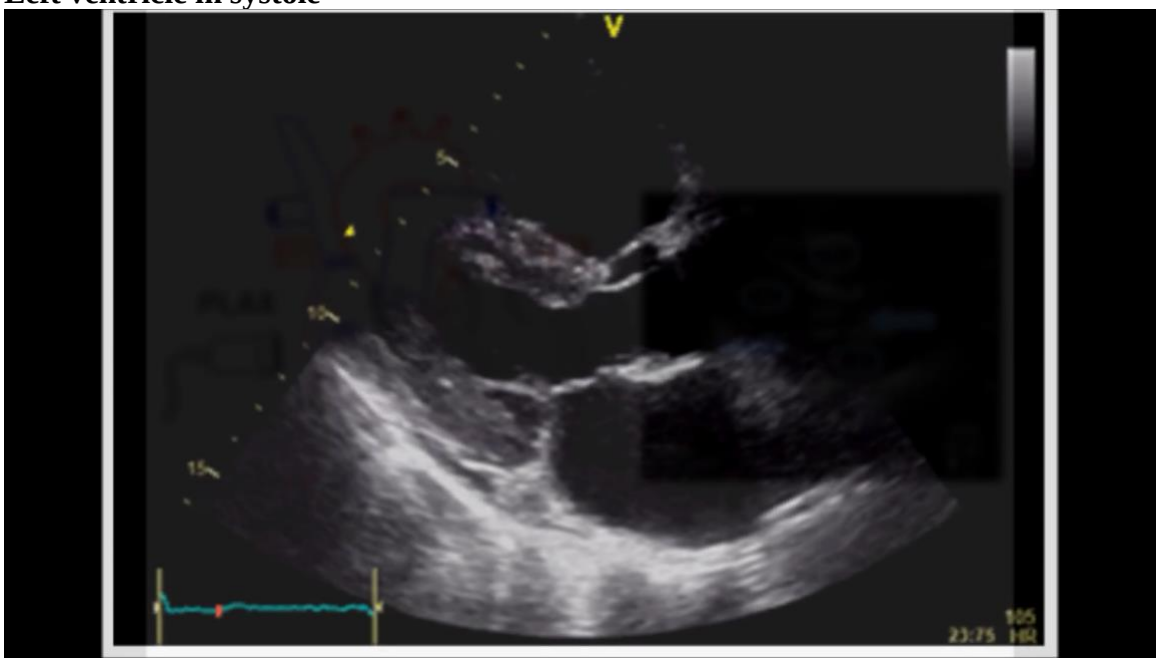
Dyspnea and Shock

In patients presenting with shortness of breath or shock, a quick limited echocardiography can help estimate cardiac function. In the clinical setting, visualization of cardiac size and contractility is just as effective as measurements of cardiac function. Direct visualization takes less time and can offer much more information than using the stethoscope or measurements of cardiac function. It also allows for a rapid check for improvements with intervention.

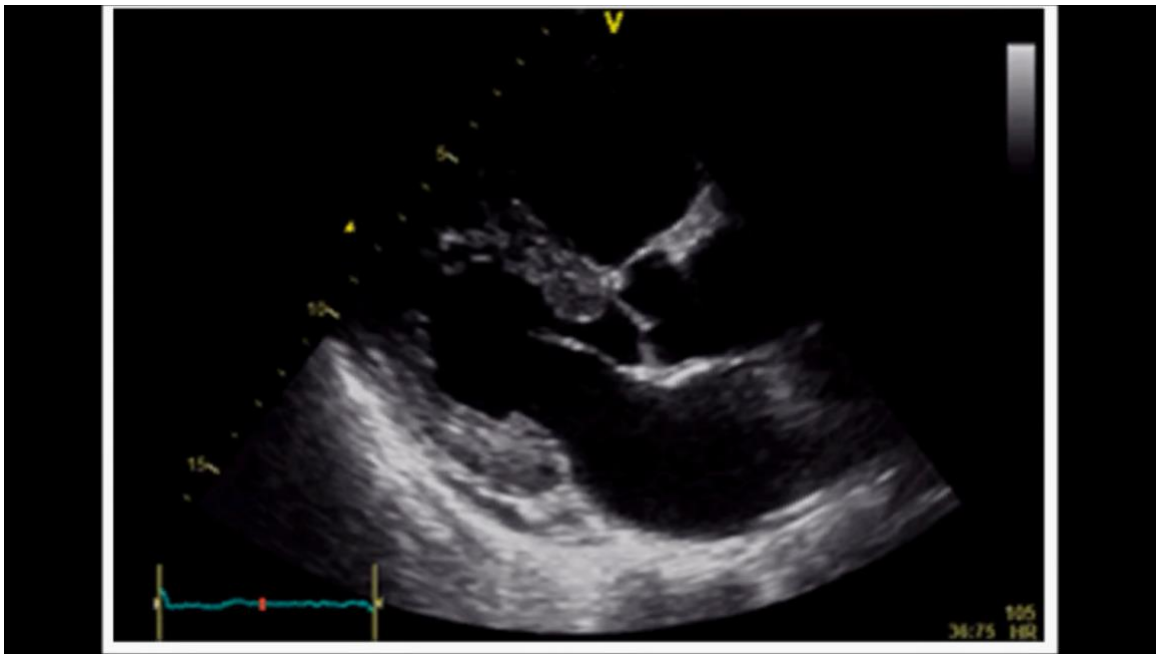
If there is poor contractility, an inotrope can be added, or dose increased. The parasternal long view usually provides the most information on cardiac contractility. In urgent situations, I may only use this view.

With normal left ventricular function, the anterior leaflet of the mitral valve touches or almost touches the ventricular septum in diastole. With normal systole, there is a shortening of the left ventricle and thickening of the myocardium of more than 25%.

Left ventricle in systole

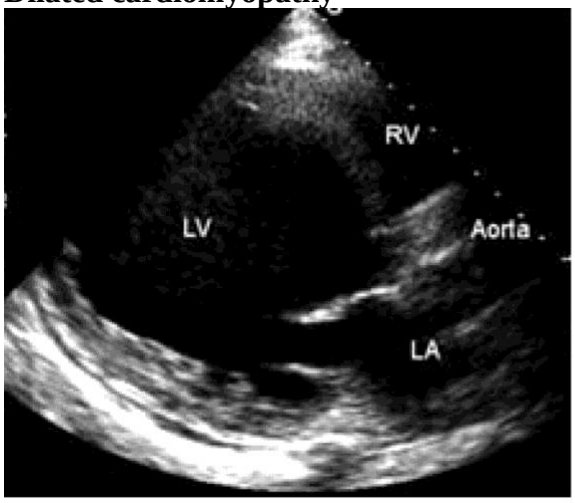


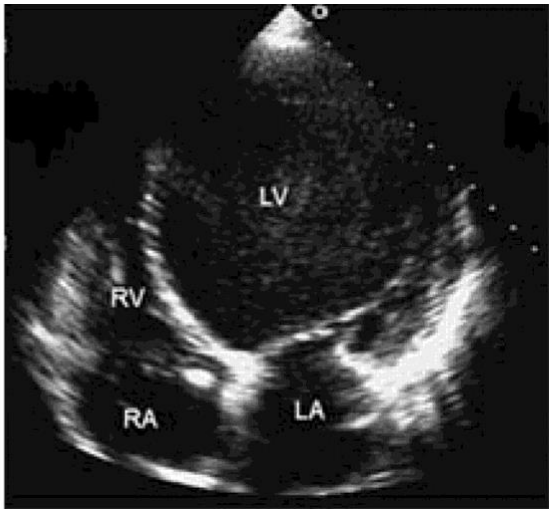
Left ventricle in diastole



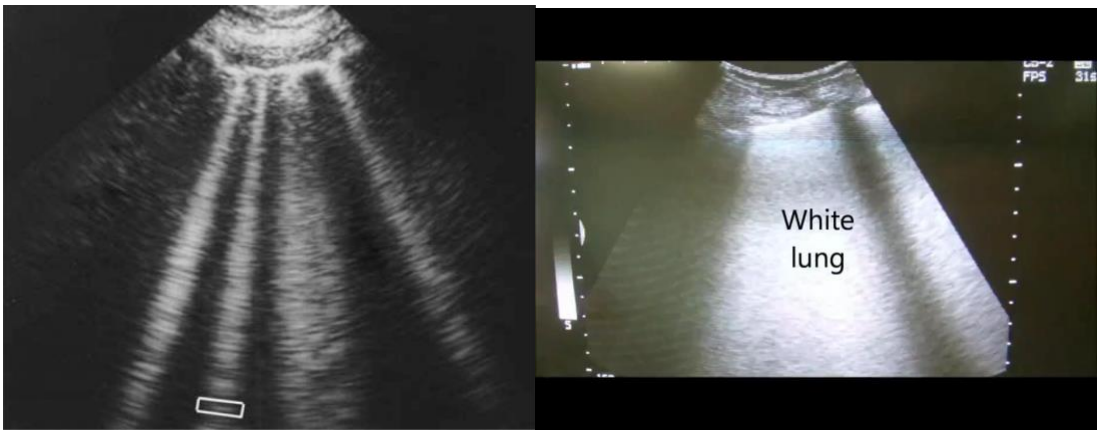
If the heart is dilated, beta-blocker can be started at a low dose and slow incremental doses.

Dilated cardiomyopathy

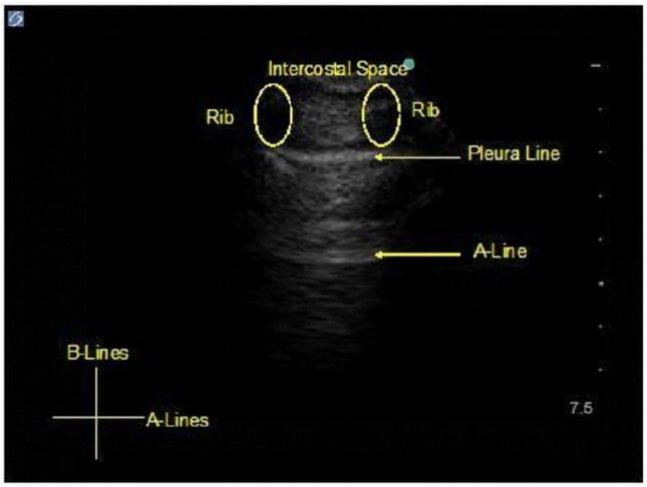




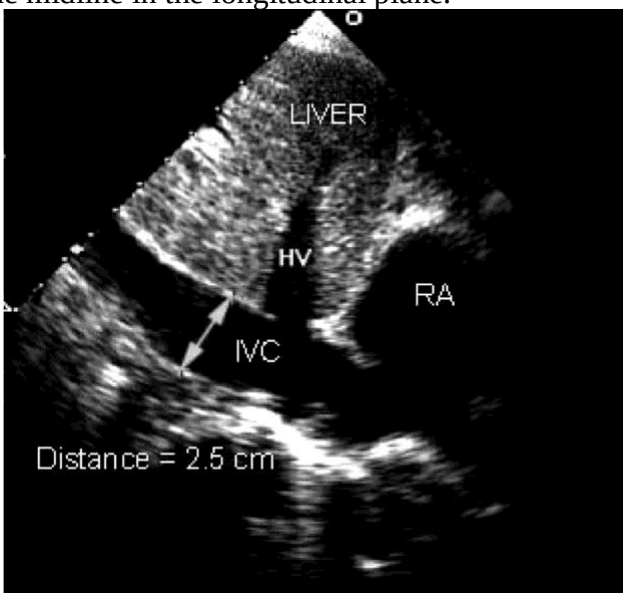
Lung ultrasound can help to determine if the amount of interstitial fluid in the lungs. In urgent situation a rapid look at the lung bases without scanning the whole lung can provide the information needed to determine if a fluid bolus is prudent. The number of b-lines that extend to the bottom of screen can help determine the amount of interstitial fluid. Four or more b-lines are considered abnormal.



The presence of horizontal A-lines at the lung bases means the lungs are dry and fluid bolus is a safe option.

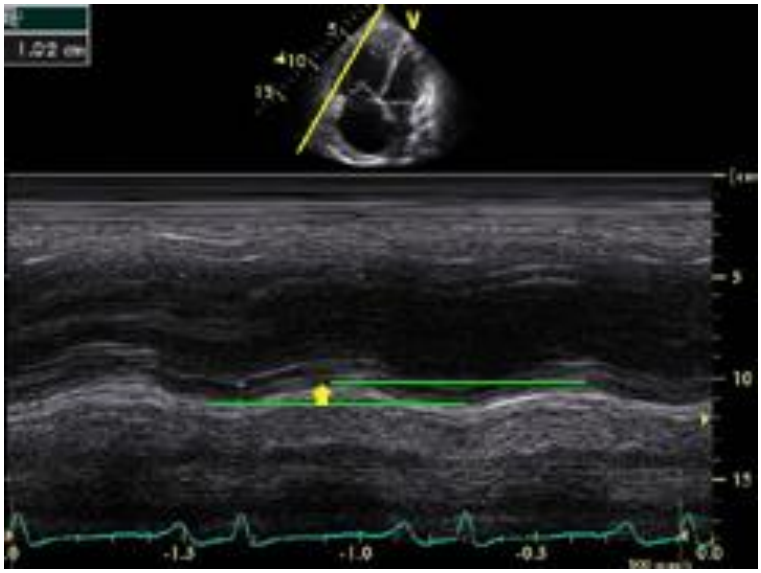


Images of the inferior vena cava (IVC) is best done in the subcostal view about one inch to the right side of the midline in the longitudinal plane.



A dilated IVC (> 20 mm) without the normal inspiratory decrease in calibre (> 50% on gentle sniffing) usually indicates elevated JVP and right atrial pressure (RAP). The absence or presence of the normal inspiratory collapse is more predictive of RAP. A dilated and absence of inspiratory collapse of IVC will prompt the search for right ventricular infarct, pneumothorax, pulmonary embolism etc., and manage accordingly. IVC that collapses with inspiration will lead us to a fluid bolus.

Tricuspid Annular Plane Systolic Excursion (TAPSE) can be used for measuring right ventricular dysfunction.



With right ventricular systolic dysfunction, tricuspid annulus excursion is less than 16mm. In the context of chest pain with shock, this would prompt the diagnosis of massive pulmonary embolism that may require thrombolysis.

Conclusion

In rural setting point of care cardiac ultrasound can help the clinician to make critical decisions in management. Using echocardiography regularly to augment the stethoscopes, EKG, chest x-rays and other investigations will help rural physicians to be more proficient in the use of ultrasound and help with the management of critically ill patients. Formal echocardiography if available can be done when patients are more stable.