Ultrasound and the Anaesthetist Quo Vadis?

Over the last 10 years, ultrasound has been successfully incorporated into many aspects of anaesthetic practice. Some members of the 'older' generation of anaesthetists were initially reluctant to learn this new skill, and clung steadfastly to their belief that regional anaesthesia could be carried out adequately by relying on their clinical skills and experience.

There is however little doubt that not only does ultrasound improve the accuracy and success rate of a large variety of nerve blocks, but also reduces the dosage requirement as a direct consequence of placing local anaesthetic solutions more precisely. Inadvertent puncture of nerves, vessels and pleura has decreased substantially and the time taken to perform 'blocks' has been reduced. While very few anaesthetists would now argue that ultrasound is unnecessary, its full implementation is still limited by the unavailability of suitable machines in many theatre complexes.

Ultrasound machines have improved significantly, and their cost has come down. There are now a number of machines that are both portable and provide excellent image quality, but unlike our surgical counterparts, individual anaesthetists have relatively little influence in convincing hospitals of the necessity of providing an ultrasound machine in each theatre complex. It will require an official sanction from the Australian and New Zealand College of Anaesthetists as well as the Australian Society of Anaesthetists that hospitals be mandated to provide such equipment in order to maintain their accreditation before ultrasound machines will be available to us on demand.

Amongst anaesthetists who have adopted ultrasound into their practice, most have limited their use of ultrasound to acting as an aide in performing nerve blocks, placing central lines and arterial catheters. A large number of anaesthetists are not comfortable with regional anaesthesia or are not involved in 'major' surgery requiring full haemodynamic monitoring. Many have never used an ultrasound machine or had any form of ultrasound training.

A growing 'subspecialty' is the use of ultrasound to perform transthoracic echocardiography (**TTE**). A full TTE examination seeks to answer the following questions:

1) Are there any intrinsic or extrinsic anatomical abnormalities of the heart, lungs or mediastinum, which may have a bearing upon the anaesthetic management?
2) What is the 'haemodynamic state' of the patient?
3) Is there significant heart valve pathology?

There are a number of courses and workshops currently available to facilitate the acquisition of the knowledge and skills required to perform TTE. While most attendees of these courses are 'bitten' by the TTE bug, few end up incorporating this as a routine part of their practice. The limiting factors being the cost and availability of suitable machines, a suitable location for its performance, the time required to perform a full TTE and the relatively low gain of the investigation in terms of its immediate influence upon their patient's anaesthetic management.

In many 'Accident and Emergency' departments however, focused ultrasonography has now become an extension of the physical examination of the trauma patient.

Focused **A**ssessment with **S**onography for **T**rauma (**FAST**) is a limited ultrasound examination directed solely at identifying the presence of free intraperitoneal or pericardial fluid. The training required to become proficient in performing a FAST scan is not lengthy or extensive, and the gain in terms of having a reliable decision-making tool for the timely diagnosis of potentially life-threatening haemorrhage to help determine the need for transfer to the operating room, CT scanner or angiography suite is significant.

Anaesthetists are frequently involved in resuscitating patients who have suffered a cardiorespiratory arrest (code blue calls) from whatever cause.

There is much evidence in the literature and a growing awareness that ultrasound in this application is currently underutilised despite having huge potential benefits for patients. Bedside echocardiography as part of a focused approach to the critically ill or shocked patient is emerging as a key skill for the resuscitationist.

The Focused Assessment with Sonography for Trauma (**FAST**) has moved up to the heart and thorax, and **F**ocused **E**chocardiography **E**valuation in **L**ife support (**FEEL**) is proving to be an incredibly useful tool in the resuscitation room.

"Every time you see a sick patient, perform bedside ultrasound. Look at the heart, look at the belly. You will save lives." - Amal Mattu, quoted - "He simply looks sick…."

Once one has acquired the necessary skills, ultrasound can be used to rapidly diagnose and differentiate:

1. *Cardiac standstill*
2. *Left ventricular dysfunction (Heart size and contractility)*
3. *Pericardial tamponade*
4. *Pulmonary embolism*
5. *Assess fluid status (IVC filling)*
6. *Aortic dissection*
7. *Pneumothorax*
8. *Pleural effusions*
9. *Presence of free fluid in the abdomen*
10. *Assess the right ventricle, dilatation, hypokinesis, pulmonary hypertension*

One does not need to be a cardiologist or a radiologist to use ultrasound effectively to make these diagnoses, though a certain level of training and skill is required. There are a number of protocols that have been put forward to achieve these goals, most of which can be performed by a skilled operator in less than three minutes. Frequently a rapid diagnosis can be made without resorting to MRI scans, CT scans or exploratory laparotomy which is beneficial not only to the patients but ultimately to the hospital and medical system in term of cost savings.

The essential requirements are:

1. A good quality ultrasound machine with a rapid start up time, portability and a high degree of user friendliness. As a consequence of the time constraints and pressure of working in an 'arrest' situation, the machine should ideally not be overly expensive or too complicated. We require good image quality with a minimum of fuss and few buttons or controls to fiddle with or adjust.

GE, Sonosite, SIUI and Mindray all have suitable models and the eZono has a built in textbook with videos and cue cards for both FAST and FEEL protocols.

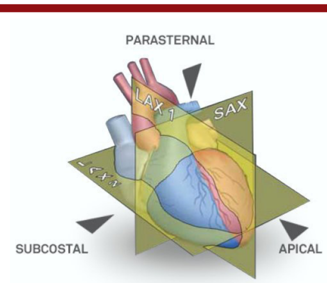
2. Adequate training. The required skills can be acquired in as little as a one-two day course. There are a number of training courses available.

Approaches to bedside echo in the critically ill patient

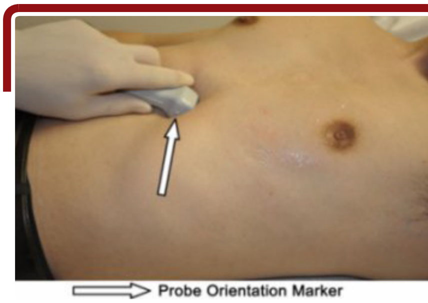
FEEL is a simple procedure that can be readily used in the ER, wards or operating theatre, as an extension of focused abdominal sonography for trauma (FAST). The rationale is a shift in paradigm in the use of ultrasound. Non-imaging specialists can safely and effectively apply ultrasound in the clinical context in a focused manner, to diagnose to exclude specific disease states rather than a time-consuming comprehensive exam.

There are three approaches or scanning planes:

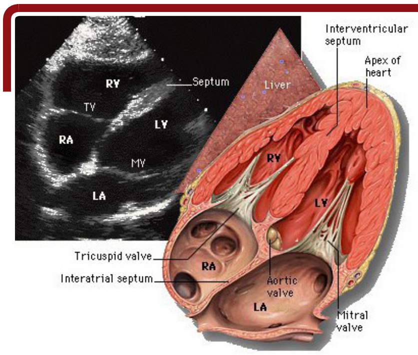
1. Subcostal approach = short axis plane
2. Parasternal approach = long axis plane
3. Apical approach = four chamber plane



A. The subcostal view (sub-xiphoid)

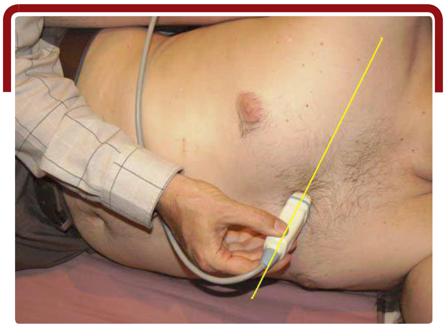


Have the patient lie flat in the supine position and bend their knees to relax their abdominal musculature. The probe should then be placed under the xiphoid process and angled at the cardiac apex to show the Sub-Xiphoid window. It is a useful image as it can show a great deal of cardiac imaging even in difficult patients.

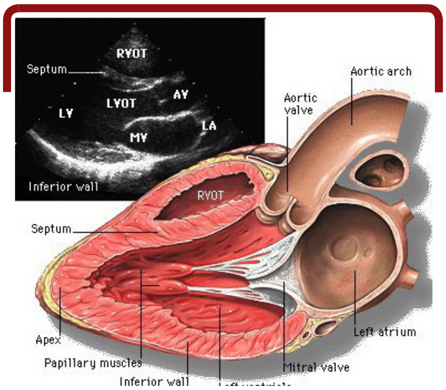


Sub-xiphoid space, probe marker to patient's left, probe face directed towards patient's left shoulder. Start by locating the liver and moving the probe midline and angled anterior to bring the left and right atria and ventricles into view. Assess for global LV function, wall motion abnormalities, and pericardial effusions. Assess the IVC and hepatic veins for collapse and inflow. Rotating the probe 90 degrees will obtain a short axis view.

B. The parasternal approach



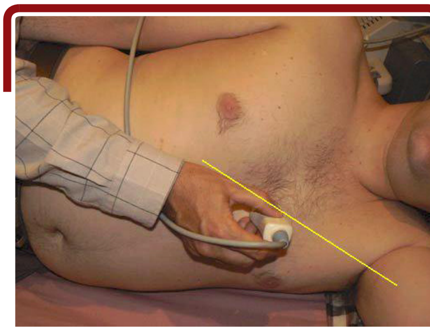
Patient and transducer position for the parasternal long axis view.



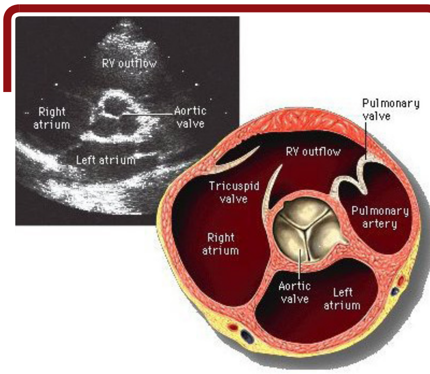
From the parasternal long axis the mitral and aortic valves may be imaged. Gross ventricular function may be determined as well as wall motion abnormalities. Pericardial effusions may be assessed. Measurements may be taken of the left ventricular cavity in both systole and diastole. Each of the valves may be examined for structural and motion abnormalities. A duplex study using colour flow Doppler superimposed on a two dimensional image – is not part of the FEEL protocol.

Parasternal short axis views are obtained optimally with the patient in the same position as for the parasternal long axis view. The transducer is rotated 90 degrees clockwise from the long axis position. The transducer reference index will now point towards the patients' left shoulder. Changing the angle of the ultrasound probe results in being able to view short axis images from the aortic root down to the apex.

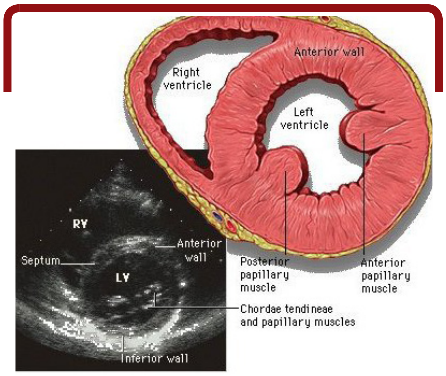
In this position, the classic donut view of the left ventricle is seen along with the right ventricle. In each position, important aspects and cardiac structures are seen.



Patient and transducer position for the parasternal short axis view



Aortic valve left parasternal short axis view



Short axis view at papillary muscle level

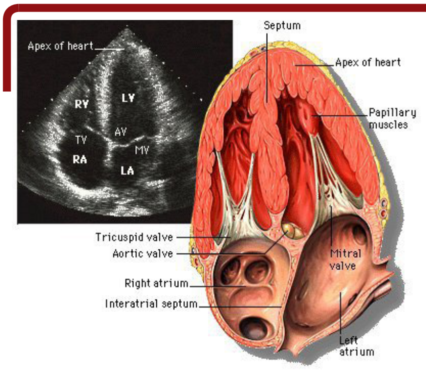
C. Apical windows

To obtain the apical view, the probe should be placed along the left chest wall at the cardiac apex in the APICAL WINDOW. Often in patients with significant lung disease or obesity, these images can be challenging. Shifting positions and imaging at end expiration can often assist in obtaining optimal images.

The apical four chamber

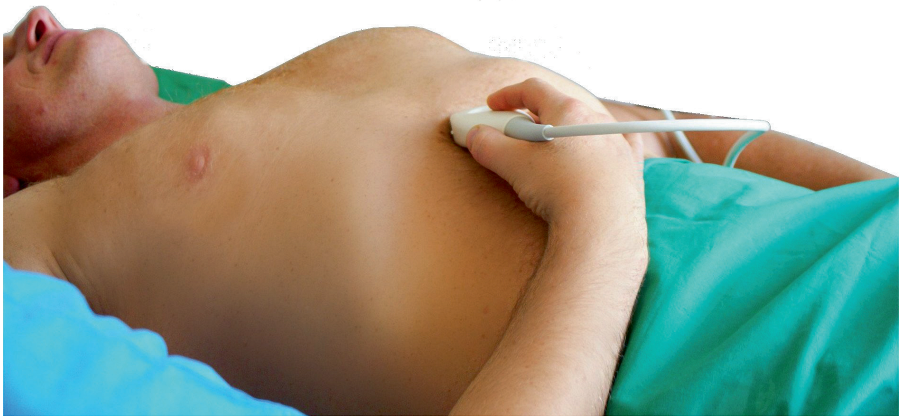
Patient and transducer positioning for an apical view

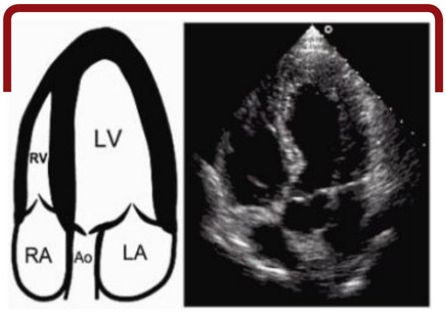
Imaging of the heart in the apical region is performed with the patient rotated between 60 and 90 degrees to the left with the transducer applied inferiorly and lateral to the point of cardiac impulse. The reference index of the transducer is pointed towards the left side of the patient.



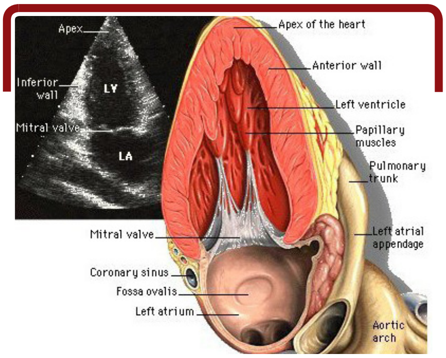
Apical four chamber view

Shift the transducer to obtain all four chambers with the left and right ventricles in view. Image the mitral and tricuspid annulus and assess for RV and LV function and the presence of any wall motion abnormalities. Pericardial effusions should be assessed. Zoomed





Apical five chamber view



Apical two chamber view

imaging of the septum should be obtained to assess the presence of raised intra-atrial pressure.

After obtaining the apical four chamber, the probe may be tilted anteriorly to open up the LVOT. This will facilitate the apical five chamber view:

The aortic valve should be imaged and magnified to assess for sclerosis or stenosis. Significant aortic stenosis is assessed with measurements taken in this view.

In the apical four chamber, the transducer should then be rotated 75-90 degrees counter-clockwise to image the apical two chamber view.

LV function may be assessed as well as any wall motion abnormalities.

FEEL can give vital information regarding the presence, size, and functional relevance of a pericardial effusion as a cause of haemodynamic instability and can expedite pericardiocentesis with fewer complications and a higher success rate.

FEEL helps in the distinction of cardiogenic shock from shock of other Causes, which is extremely important.

FEEL in the right clinical context, this evaluation can direct the clinician at the bedside in deciding upon the most appropriate treatment interventions, optimize diagnostic efficiency, and assess the response to performed interventions.

An alternative approach which incorporates elements of both **FAST** and **FEEL** is the **RUSH** Protocol (**R**apid **U**ltrasound for **S**hock / **H**ypotension). This is a 5-step approach formulated by Weingart, Duque and Nelson's which can be completed in just two minutes and uses the '**HI-MAP**' mnemonic.

1. **H**EART — Parasternal long and then 4 chamber cardiac views, with the general purpose or cardiac probe.

2. **I**VC view with the same probe

3. If not already using it, switch to general purpose abdominal probe and scan **M**ORISON's and splenorenal views with thorax images and then examine the bladder window**.**

4. Increase your depth and find the **A**ORTA above and below the renal artery with four views.

5. Scan both sides of the chest for **P**NEUMOTHORAX. It may be beneficial to switch to a small - parts, high frequency transducer, but the general purpose probe will often supply sufficient views of the pleural interface.

When used correctly as part of an integrated approach, focused sonographic examination of the chest and abdomen is a cost effective and useful diagnostic tool.

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A SUMMARY OF THE KEY ABNORMALITIES TO LOOK FOR ON BEDSIDE ECHO

Cardiac standstill (mechanical asystole)	During cardiopulmonary resuscitation and 'arrest' situations
Left ventricle dimension and function **How big is the LV?** **What is the LV systolic function?**	Normal LV end diastolic diameter is 3 to 5.5 cm <30% change from systole suggests a hypodynamic heart >90% change from systole suggests a hyperdynamic heart (e.g. hypovolemia) Normal fractional shortening is 25 to 44% and normal ejection fraction is 50 to 65%
Pericardial tamponade	Collapse of the right ventricle during early diastole (specific) Collapse of the right atrium during diastole (sensitive) Pericardial fluid
Pulmonary embolism	RV wall hypokinesis moderate or severe McConnell's sign - (akinesia of the mid free wall but normal motion at the apex (77% sensitivity and 94% specificity for PE) RV dilatation end-diastolic diameter >30 mm in parastemal view , RV larger than LV in subcostal or apical view Increased tricuspid velocity >26 m/sec Paradoxical RV septal systolic motion Pulmonary artery hypertension:- Pulmonary artery systolic pressure >30 mmHg Dilated IVC with lack of respiratory collapse
IVC filling	IVC diameter of <1.5 cm with complete inspiratory collapse suggests low CVP (<5) and is likely to be fluid responsive IVC diameter of >2.5 cm with no inspiratory collapse represents a high CVP (> 20) and cardiac output is unlikely to improve with fluid loading. It is reasonable to give fluid if there is more than 50% IVC collapse with respiration, or even if collapse is clearly visible without a specific measurement. Have another look once the fluid is in.
Aortic dissection	Dilated aortic root Aortic flap Pericardial effusion and evidence of tamponade
Pneumothorax	Loss of the lung sliding sign (in the normal lung it looks like there are ants marching along the pleural interface during respiration) Loss of comet tails Appearance of reverberation artefact Try to identify a contact point (the interface between the pneumothroax and normal lung) Look for subcutaneous emphysema Look for subcutaneous emphysema
Pulmonary effusions	Look for a triangle of black at the costophrenic angle. If there are clots or loculations there may be some echogenic matter visible.

References

1. Raoul Breitkreutz, , Susanna Price, Holger V. Steiger, Florian H. Seeger, Hendrik Ilper, Hanns Ackermann, Marcus Rudolph, Shahana Uddin, Markus A. Weigand, Edgar Müller, Felix Walcher from the Emergency Ultrasound Working Group of the Johann Wolfgang Goethe-University Hospital, Frankfurt am Main. Focused echocardiographic evaluation in life support and peri-resuscitation of emergency patients: A prospective trial. Resuscitation Volume 81, Issue 11, November 2010, Pages 1527-1533
2. Schmidt JA. The role of ultrasound in patients with possible penetrating cardiac wounds: a prospective multicenter study. J Trauma 1999;46:543–51.
3. Jones AE, Tayal VS, Sullivan DM, Kline JA. Randomized, controlled trial of immediate versus delayed goal-directed ultrasound to identify the cause of nontraumatic hypotension in emergency department patients. Crit Care Med 2004;32:1703–8.
4. Orme RM, Oram MP, McKinstry CE. Impact of echocardiography on patient management in the intensive care unit: an audit of district general hospital practice. Br J Anaesth. 2009 Mar;102(3):340-4. Epub 2009 Jan 18.
5. Raoul Breitkreutz1, Felix Walcher2, Hendrik Ilper1, Florian H. Seeger , Susanna Price. Focused Echocardiography in Life Support: The Subcostal Window What the Surgeon Should Know for Critical Care Applications. European Journal of Trauma and Emergency Surgery Volume 35, Number 4, 347-356
6. Echocardiography for Intensivists and Emergency Medicine Clinicians http://cme.hms.harvard.edu/cmeups/custom/03124369/index.htm
7. Saved by focused echo evaluation in resuscitation http://casereports.bmj.com/content/2011/bcr.11.2010.3490.abstract http://www.bioportfolio.com/resources/pmarticle/65883/Focused-Echo-cardiographic-Evaluation-In-Life-Support-And-Peri-resuscitation-Of-Emergency-Patients.html
8. Trauma Ultrasonography - The FAST and Beyond http://www.trauma.org/archive/radiology/FASTintro.html
9. FAST Scan: Ultrasound's Role in Trauma. http://www.britannica.com/bps/additionalcontent/18/32007871/FAST-Scan-Ultrasounds-Role-in-Trauma
10. AMERICAN SOCIETY OF ECHOCARDIOGRAPHY CONSENSUS STATEMENT. Focused Cardiac Ultrasound in the Emergency Setting: A Consensus Statement of the American Society of Echocardiography and American College of Emergency Physicians. Arthur J. Labovitz, MD, FASE, Chair, * Vicki E. Noble, MD, FACEP,** Michelle Bierig, MPH, RDCS, FASE,* Steven A. Goldstein, MD,* Robert Jones, DO, FACEP,** Smadar Kort, MD, FASE,* Thomas R. Porter, MD, FASE,* Kirk T. Spencer, MD, FASE,* Vivek S. Tayal, MD, FACEP,** and Kevin Wei, MD,* St. Louis, Missouri; Boston, Massachusetts; Washington, District of Columbia; Cleveland, Ohio; Stony Brook, New York; Omaha, Nebraska; Chicago, Illinois; Charlotte, North Carolina; Portland, Oregon: http://www.asecho.org/files/EchoinES.pdf
11. Sisley, Amy C. MD; Rozycki, Grace S. MD, FACS; Ballard, Robert B. MD; Namias, Nicholas MD; Salomone, Jeffrey P. MD; Feliciano, David V. MD, FACS. Rapid Detection of Traumatic Effusion Using Surgeon-Performed Ultrasonography Journal of Trauma-Injury Infection & Critical Care: February 1998 - Volume 44 - Issue 2 - pp 291-297