Focused Acute Medicine UltraSound (FAMUS)

HANDBOOK

Thoracic, Abdominal and Vascular Modules

V1

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1) Introduction to FAMUS:

In many parts of the world ultrasound is learnt as part of the undergraduate medical curriculum, but within the United Kingdom it has traditionally been practised under the auspices of radiology departments. With the increasing availability of ultrasound machines that are portable and relatively cheap, there has been much interest in the use of Point of Care Ultrasound (POCUS). There is significant potential for POCUS to both facilitate clinical decision making and increase patient safety, particularly during invasive procedures. It is now considered mandatory for chest drains for pleural effusion to be undertaken with ultrasound guidance, and central line insertion has long been facilitated by the use of ultrasound. Specialties have started to develop their own training and governance standards; Emergency Medicine has incorporated the Focused Assessment with Sonography in Trauma (FAST) protocol within their curriculum, and Intensive Care Medicine has recently published Core Ultrasound Intensive Care (CUSIC). The Royal College of Radiologists have issued standards relating to individual system examinations, and there is good evidence for the utility of protocolised chest ultrasonography (the ‘BLUE protocol’) in the adult patient presenting with acute respiratory failure. There has not previously been an ultrasound curriculum designed to aid the management of the unwell adult medical patient outside of Critical Care.

Within Acute Medicine, a recent trainee survey conducted by this group, highlighted enthusiasm among trainees for some form of ultrasound training to be a core part of the Acute Internal Medicine (AIM) curriculum. In addition, clinicians on the Acute Medical Unit (AMU) support the use of ultrasound on the AMU and the development of specific guidelines for AMU clinicians.

We present here the Focused Acute Medicine Ultrasound (FAMUS) Handbook developed specifically for physicians on the AMU to aid in the management of the breadth of patients who present to Acute Medicine.

2) Thoracic Module:

The principle of thoracic ultrasound is based primarily on the interpretation of artefacts. This is due to the presence of air in the lung which causes a high acoustic mismatch with the surrounding tissues, and therefore a significant reflection of the ultrasound beam preventing direct imaging of the pulmonary parenchyma. In a normally aerated lung, the only detectable structures are the pleura, visualized as a hyperechoic horizontal line; this is also known as the *lung surface* or the *pleural line*. Point of care thoracic ultrasound utilises patterns of artefacts to describe the pathology that could possibly be associated with the presentation of the patient. Such patterns have been extensively studied and have been demonstrated to be a helpful tool in identifying the cause for the respiratory failure. The purpose of this educational material is to demonstrate the use of such artefactual images in identifying the common respiratory pathologies that present to the hospital. Such pattern recognition is the key concept in thoracic ultrasound interpretation.

I. The Basics

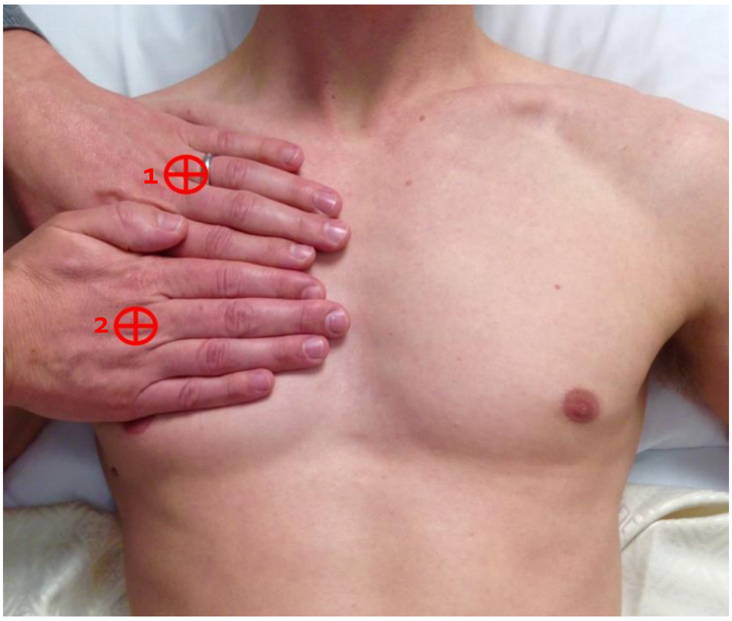
The Probe:

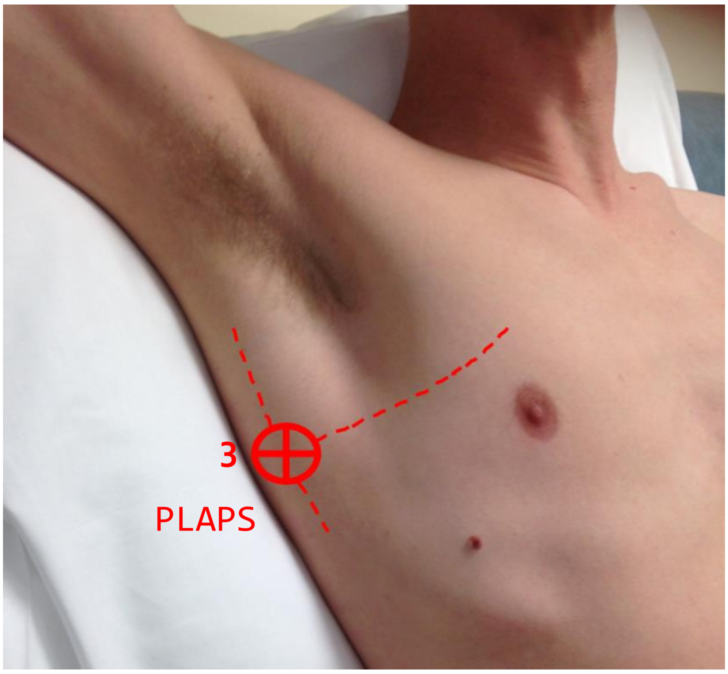
The general preference for thoracic ultrasound to visualise parenchymal pathologies would be to use the curvilinear probe as the low frequency would help better penetration. However, for pleural and superficial pathologies (such as pneumothorax), a high frequency probe (linear array) may be helpful.

The Scan Points and probe positioning:

For the purposes of FAMUS, the advice is a 6-point scan as per the 'Blue protocol'. The probe is positioned longitudinally with the marker pointing in the cephalad direction. The longitudinal approach allows visualization of the so-called "bat-sign" – produced by two echobright lines of rib periosteum and the pleural line in between (see Figure 2). Figure 1 demonstrates the positions of the upper and lower BLUE points on the anterior chest, and the most postero-lateral point available in the supine patient called the PLAPS (postero-lateral alveolar and/or pleural syndrome) point – together these 3 points on either side make up the 6-point thoracic ultrasound scan. Sometimes upper lateral chest ultrasound may be helpful especially in the interpretation of the alveolar interstitial syndrome.

Figure 1. A.: Scan points (adopted from Blue protocol. Lichenstein et al.)





II. Common Patterns in Lung Ultrasound

Lung sliding

When the probe is placed in the upper blue point (Figure 1), with the marker pointing toward the head end of the patient, the ribs yield artefactual anechoic shadow images. In between the two ribs, there is a hyperechogenic line > 0.5cm below the rib periosteum. This line is the interface between the soft tissues of the chest wall and the aerated lung - the pleural line. The pleural line flanked by the two bright anterior rib surfaces generates the “bat sign”, a permanent landmark visible in most circumstances (Figure 2).

Using M-mode can help to demonstrate the seashore sign, which is present when there is lung sliding and so helps to rule out a pneumothorax (among other pathologies). The subcutaneous tissues and pleura generate horizontal lines (the ‘waves’), while the moving lung parenchyma generates artefact which looks like a sandy beach (Figure 3). Lung-sliding indicates that the parietal and visceral pleura are closely opposed, and so helps to rule out a pneumothorax and pleural effusions. It is physiologically more discrete in the upper zones, and can be very discrete in pathological conditions.

Figure 2. The Pleural line and Bat sign

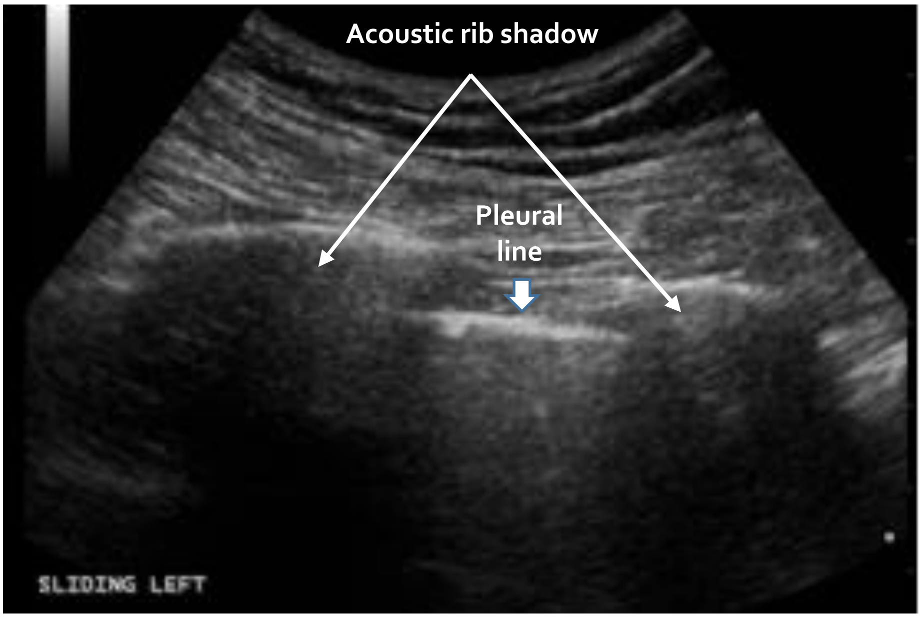
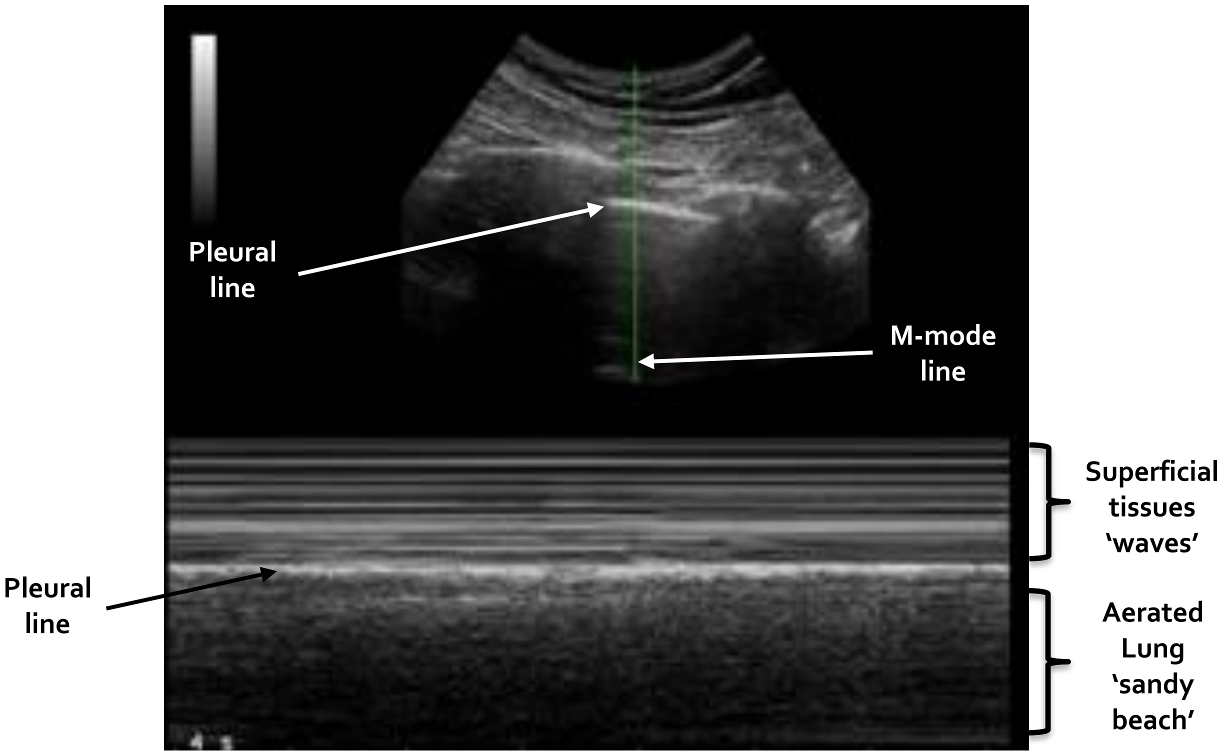


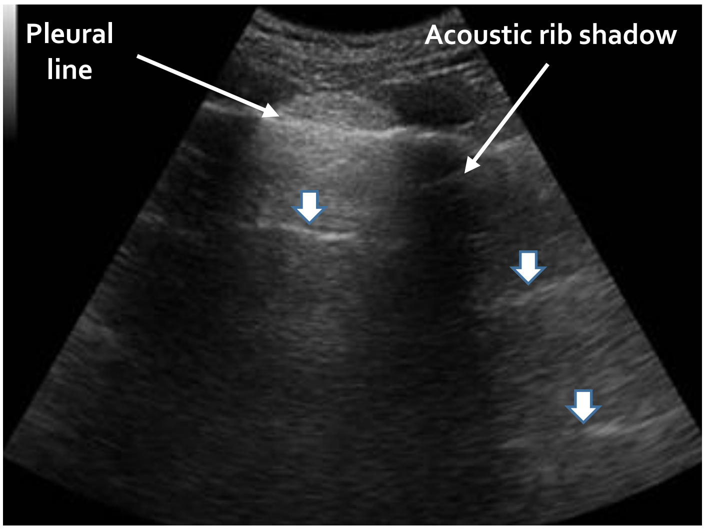
Figure 3. Seashore Sign



A lines

It is often possible to see regular horizontal lines which appear to be within the lung parenchyma, called A-lines (Figure 4). They indicate air below the pleural line (physiological or free air like a pneumothorax). A lines are horizontal and are regularly spaced hyperechogenic lines representing reverberations of the pleural line. They are motionless, artefacts of repetition and fade the deeper they go. In two-thirds of normal lungs, this is the only artefact pattern that can be seen.

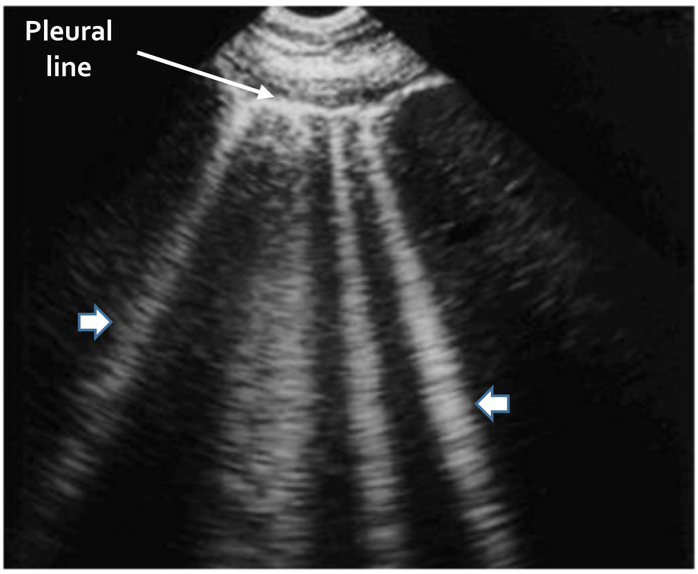
Figure 4. A Lines, indicated here by down white arrows



B Lines

When the air content in the lung decreases and lung density increases due to the presence of fluid, the acoustic mismatch between the lung and the surrounding tissues is lowered, and the ultrasound beam can be repeatedly partly reflected at deeper zones. This phenomenon creates vertical reverberation artefacts known as B-lines (Figure 5).

Figure 5. B Lines, with the two lateral most lines indicated by white arrows



B-lines are defined as discrete laser-like vertical hyperechoic reverberation artefacts that arise from the pleural line. They extend to the bottom of the screen without fading, and move synchronously with lung sliding. Multiple B-lines are considered the sonographic sign of interstitial syndrome, and they represent increasing fluid within the lung (oedema) or inflammation (usually due to infection).
Three or more B-lines between two ribs are called lung-rockets. They originate from water-thickened interlobular septa. Lung-rockets correlate with interstitial syndrome with 93% accuracy using alveolar-interstitial radiographic changes as a reference, and CT as the standard. Up to 3–4 B-lines are called septal rockets, correlated with Kerley B-lines. Twice as many B lines are called ground-glass rockets, and correlate with ground-glass areas. In the BLUE-protocol, only anterolateral lung-rockets are considered pathological as posterior interstitial changes *can* be due to gravity alone.

Consolidation
When the air content further decreases - such as in lung consolidation - the acoustic window of the lung becomes completely open and the lung may be directly visualized as a solid organ, looking like the liver or the spleen. Consolidation of the lung may be the result of an infectious process or an infarction due to pulmonary embolism. There are two separate appearances of lung consolidation. The first is the “Shred sign” (Figure 6): the border between consolidated and aerated lung is irregular leading to a ‘fractured’ or ‘shredded’ pleural line (as opposed to the usually straight pleural line). The other sign of consolidation is called the “tissue-like sign” (Figure 7); this is where the lung parenchyma has become hepatized and looks like a solid organ such as the liver. The dynamic air bronchogram and the lung pulse, which visualizes heart beats at the pleural line through a non-inflating lung, can distinguish pneumonia from atelectasis.

Figure 6. Shred sign

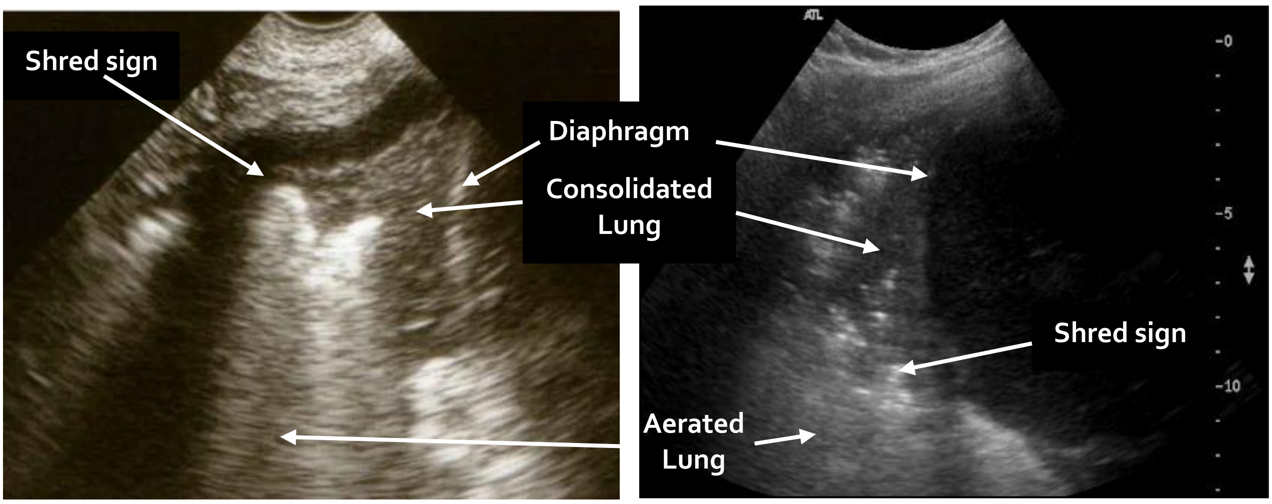
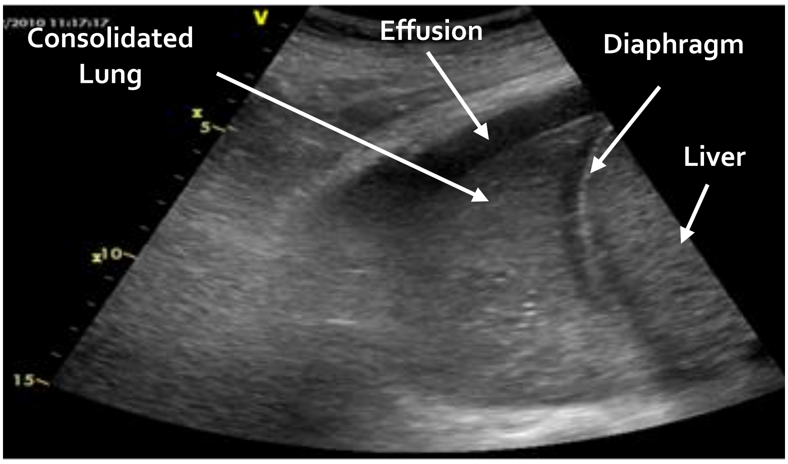


Figure 7. Tissue-like sign with small parapneumonic effusion

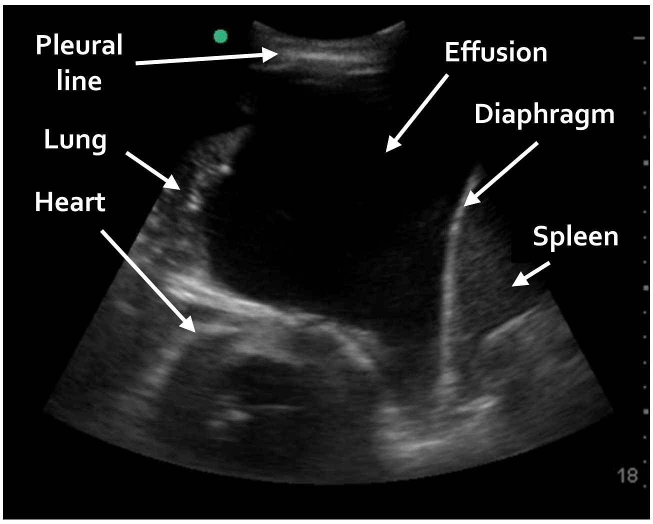


III. Pleural Effusion

Thoracic ultrasound offers a simple and effective way of assessing the size and nature of a pleural effusion and can also act as a guide for safely performing pleural procedures. Pleural ultrasound outperforms chest X rays in the accurate assessment of an effusion and is comparable to CT scanning, with ultrasound being more accessible and avoiding radiation exposure.

Pleural fluid is easily visualised by its characteristic appearance on ultrasound imaging. As effusions usually collect in dependent areas within the thoracic cavity it is usually best to scan the patient in an upright or semi-recumbent position. An effusion is usually seen as an echo-free area (a black area) below the pleural line (Figure 8). Effusions may also contain hyperechoic densities floating within them and give the appearance of a more complex effusion or exudate. The effusion area may change its shape with respiration as the diaphragm moves up and down.

Figure 8. Pleural effusion – Simple



As pleural fluid easily transmits the ultrasound signal, this facilitates the clear visualisation of mediastinal structures below. These structures are often difficult to visualise in the absence of pleural fluid as the aerated lung is not penetrated by the ultrasound waves. Visualising these mediastinal structures can help to confirm that you are in fact seeing fluid above, and that this is not merely an acoustic shadow caused by the rib or another problem such as poor scanning technique.

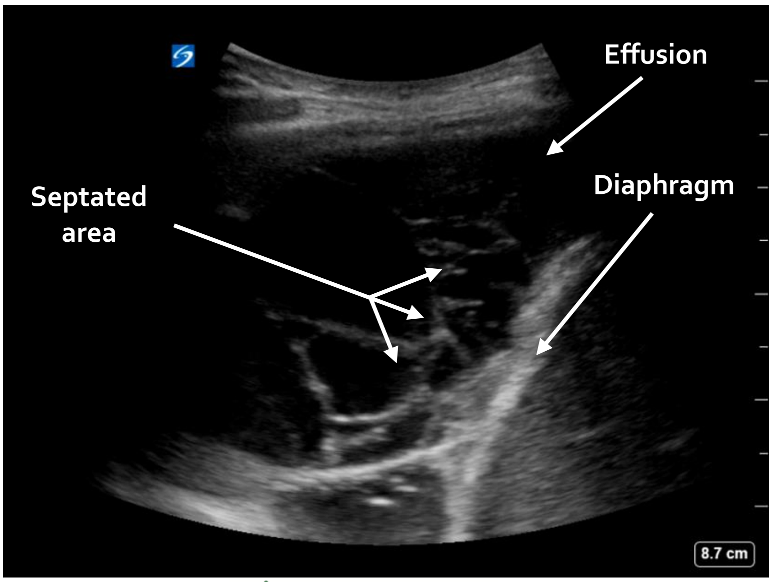
It is important to locate and identify clearly the mediastinal and thoracic structures surrounding the effusion so as not to miss the important differential diagnoses such as a subdiapragmatic collection or dilated left ventricle or ventricular aneurysm.

It must be remembered that due to underlying pathologies, the hemidiapragm may be elevated, paralysed or moving paradoxically. It is vital to visualise it clearly when performing your examination.

It is possible to estimate the size of an effusion by measuring the depth of the collection. This will help in assessing the safety of proceeding with a pleural procedure. Several methods have been described to make an accurate measurement of the size, but it is difficult to reproduce these results and in reality, these measurements are probably not that helpful. Generally, classifying an effusion into small, medium or large based on its approximate size when visualized posteriorly with the patient sitting upright, is the most pragmatic approach

The sonographic appearance of the effusion may help in determining the underlying nature of the fluid. There are four basic patterns which are a simple effusion (anechoic) (Figure 8), complex non-septated, complex septated (Figure 9) and echogenic (Figure 10). The latter is difficult to distinguish from pleural thickening.

Figure 9. Pleural effusion – Complex septated



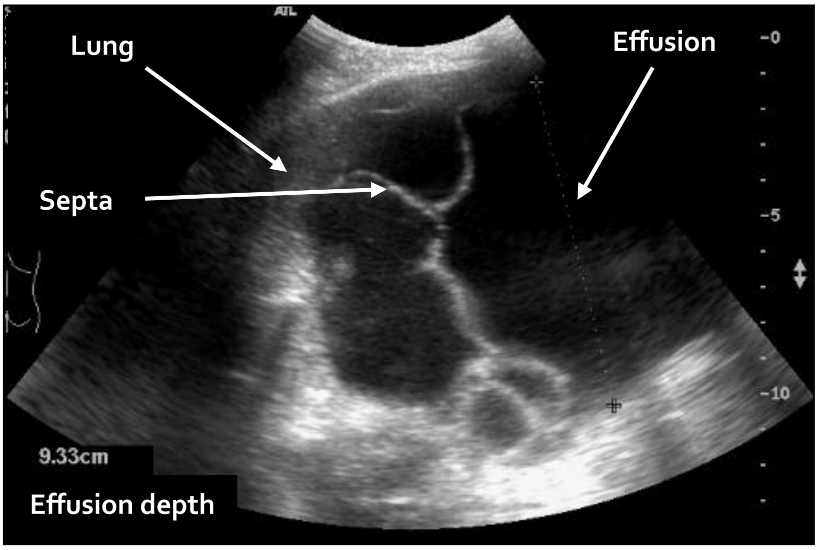
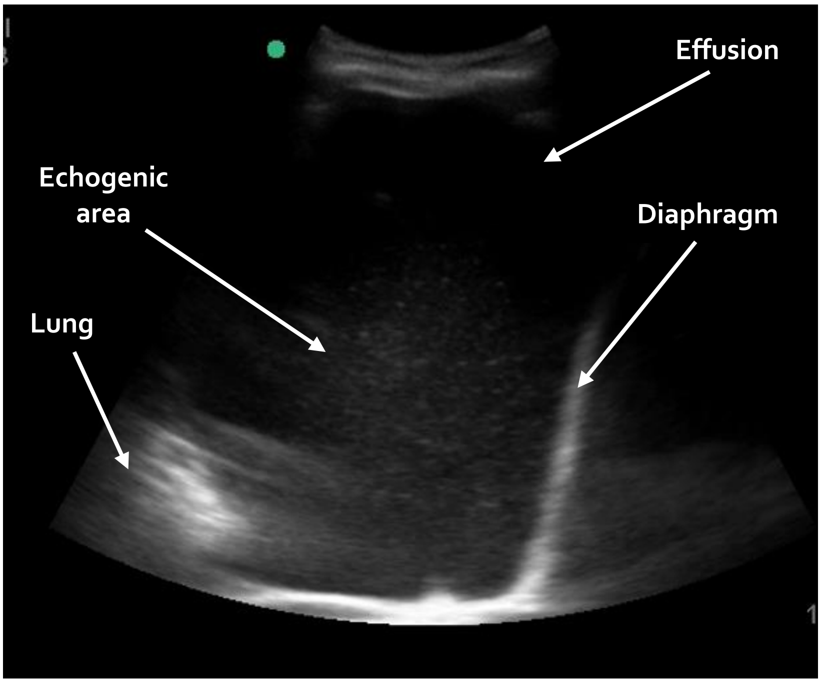
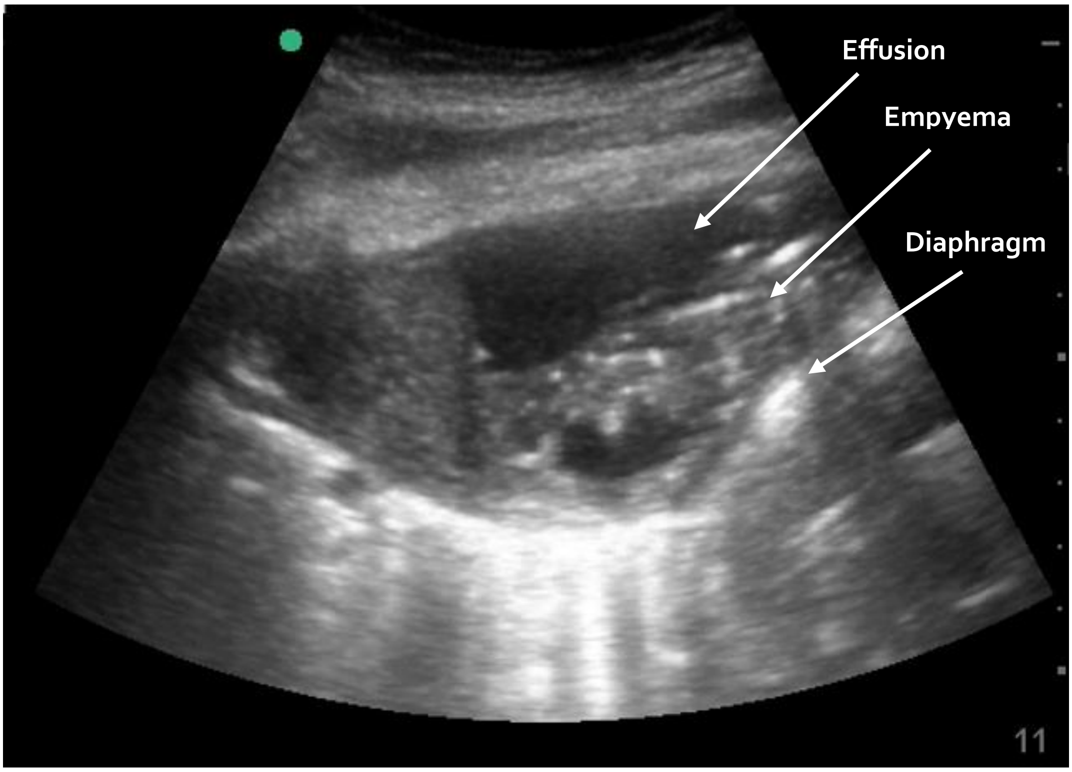


Figure 10. Pleural effusion – Echogenic



Within a pleural effusion it is also possible to visualise parietal pleural abnormalities ie. pleural tumours/thickening, as well as pathology on the visceral pleura and on the surface of the diaphragm. These can help to give clues to the underlying cause of the pleural collection. The presence of echogenic material within the pleural fluid can indicate an underlying exudative effusion. This material is often due to pus, protein, blood or fibrin within the collection. The absence of echogenic material within the fluid, however, does not exclude an exudative effusion and is therefore only helpful as a positive indicator. Empyemas can sometimes contain multiple small loculations which are caused by air bubbles within the pus-filled space (Figure 11).

Figure 11. Pleural effusion – Empyema



Septations are caused by fibrin within a pleural collection and can divide the collection into several pockets. This is distinctly different from a ‘loculation’ which is where pockets of fluid are separated within completely different areas of the pleural space. Septations often, but not always, indicate that an effusion has been present for some time or has had multiple interventions.

Thoracic ultrasound is firmly established as providing a safe way of assessing an effusion prior to performing a pleural procedure. It reduces the risk of damage to organs and vessels by guiding the operator into a safe area to insert the needle or drain. This can be done using a ‘real time’ approach where the needle is inserted under direct observation or by finding the ideal insertion point and then putting the probe down and performing the procedure immediately.

IV. Pneumothorax

Ultrasound can be a helpful technique in identifying a pneumothorax. It is not as reliable as a good quality chest X ray or as sensitive as a CT scan but can be used in the emergency setting prior to obtaining one of the aforementioned tests. It is the use of ultrasound artefacts that enables the accurate detection of a pneumothorax but it is essential to identify several key signs. These signs are: the absence of lung sliding, comet tails and B-lines and (usually) the presence of a distinct A line. One can also look for the absence of a lung pulse and the identification of a lung point – the latter being pathognomonic for pneumothorax.

In order to best see these signs we would recommend scanning the patient in the supine position. Either a linear probe or the standard curvilinear probe may be used depending on the preference of the operator. The probe should be placed in the third intercostal space in the mid clavicular line. You should set your depth and focus to best visualise the pleural line.

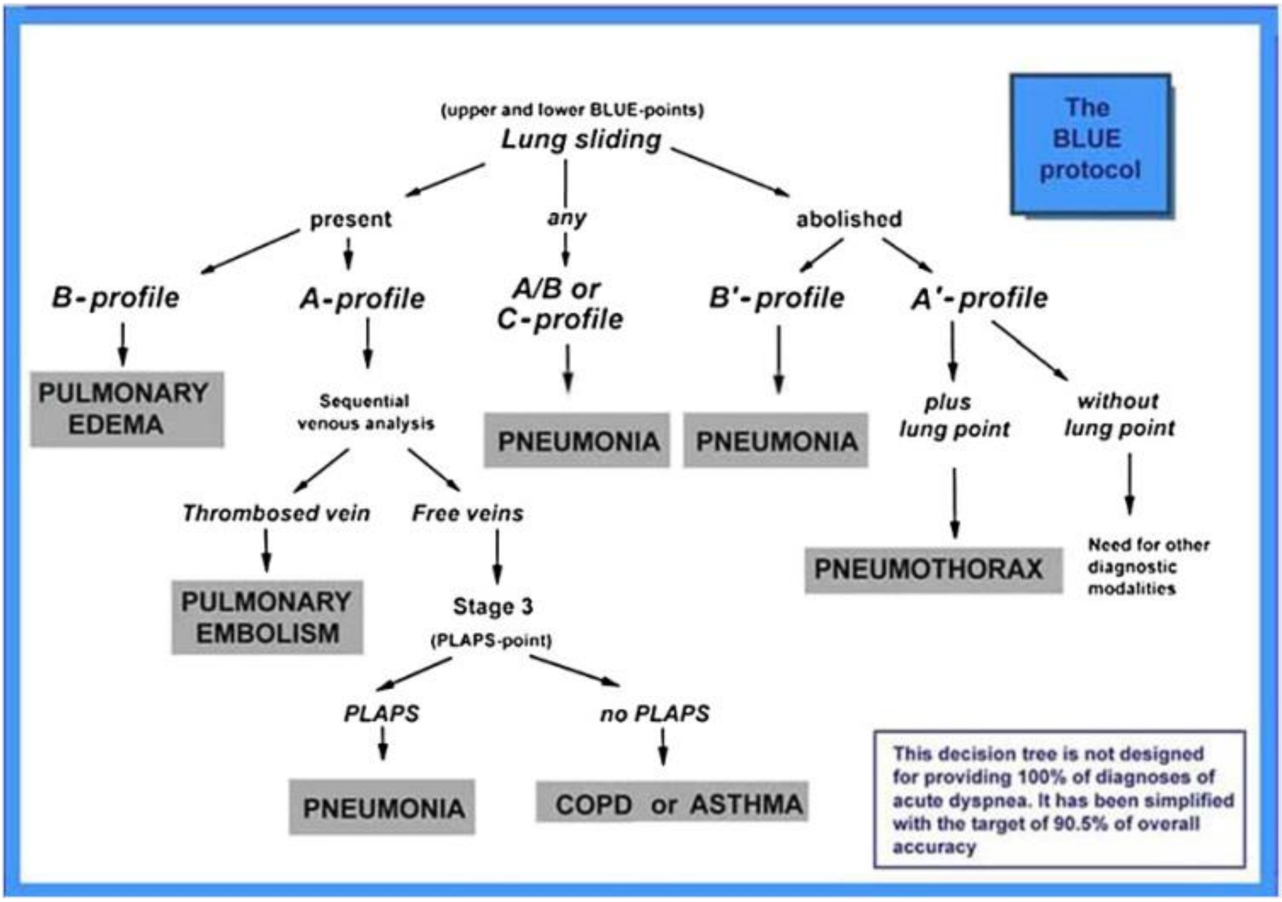
The absence of 'lung sliding' (see in above section) should first be sought. A lines are also described in the above section and should usually be identified. These should be present with an absence of comet tails or B lines – either of these would exclude a pneumothorax. If the above findings are confirmed, this has a very high sensitivity for diagnosing a pneumothorax.

Another sign that can be identified is the absence of the lung pulse. This is the vertical movement of the pleural line in time with the cardiac pulse, and is best appreciated with an absence of lung sliding (for example during breath holding). It is caused by the cardiac pulse being transmitted through a poorly ventilating lung. Its use therefore is most useful in differentiating a pneumothorax from an alternative cause of loss of lung sliding.

The final sign that can be elicited is that of the 'lung point'. It is essential that the absence of lung sliding and B lines/comet tails has already been confirmed. The probe can then be moved laterally until lung sliding has been confirmed - this is known as the lung point and anatomically is where the lung (technically the visceral pleura) makes contact again with the chest wall and so shows the border of the pneumothorax.

It is essential to remember that there are certain conditions that may mimic a pneumothorax including those that cause hypoventilation of the lung (causing loss of lung sliding), and bullous emphysema. The use of ultrasound should, therefore, always be used in the context of the patients' history and presentation along with the level of clinical suspicion.

V. The Blue Protocol



VI. Reporting Sheet: Thoracic Ultrasound

Focused Acute Medicine Ultrasound (FAMUS)

Reporting sheet – thoracic ultrasound

Trainee name: Date:

Patient identifier:

Image quality: Good Adequate Poor

		Lung sliding?	A+-B lines present?	Effusion?	Consolidation/ Collapse?
Right	Upper anterior	Yes □ No □	Yes □ No □	Yes □ No □	Yes □ No □
Right	Lower anterior	Yes □ No □	Yes □ No □	Yes □ No □	Yes □ No □
Right	Postero-lateral	Yes □ No □	Yes □ No □	Yes □ No □	Yes □ No □
Left	Upper anterior	Yes □ No □	Yes □ No □	Yes □ No □	Yes □ No □
Left	Lower anterior	Yes □ No □	Yes □ No □	Yes □ No □	Yes □ No □
Left	Postero-lateral	Yes □ No □	Yes □ No □	Yes □ No □	Yes □ No □
Has a suitable site for pleural procedure been identified?			Yes (performed)	Yes (not performed)	No

Comment/further details and conclusion of scan:

e.g. description of effusion type/size
presence of shred sign
dynamic air/fluid/bronchograms seen

Trainee reflection on scan (optional)

e.g how did the scan affect management

Mentor/supervisor comments:

Signed (trainee):

Signed to confirm above findings (mentor/supervisor):

Initial to confirm trainee suitable to commence mentored practice (only required once):
(minimum 10 supervised scans)

Is a Departmental scan required? Yes ☐ No ☐ Requested? Yes ☐ No ☐

Once completed trainee must maintain logbook of countersigned report sheets. Please remember not to remove patient confidential information from Trust property

famus
FOCUSED ACUTE MEDICINE ULTRASOUND

3) Abdominal Module:

Attempting to image the abdomen using ultrasound can be daunting due to the technical ability required, the complex abdominal anatomy and significant anatomical variation. An appreciation of the different echogenicity of abdominal organs and artefacts such as acoustic enhancement and shadowing seen when scanning through the abdomen are key in interpreting the images obtained and making a correct diagnosis.

The difficulty in scanning is often the body habitus and position of the patient. Furthermore having a technical ability along with an understanding of the ultrasound machine is critical to obtaining good quality images that can then be interpreted to influence clinical decision-making.

A key part of abdominal scanning is to appreciate the effects of preparation of the patient for elective scanning against that of scanning the patient at the bedside, point of care scanning. In essence bowel gas is difficult to predict and often challenges the most experienced sonographer to obtain good quality images. The fasted patient will often allow for an appreciation of the gall bladder and biliary system and a patient who is able to fill their bladder will enable better images of the bladder and urinary system when scanning.

Generally the probe for abdominal scanning is a low frequency (generally 3-5 Mhz) curvilinear probe. It is essential to ensure there is correct usage of the depth to ensure that the organs being scanned are viewed without too much ‘dead space” below the organs being scanned. It is also essential to utilise the gain effectively to allow focus on a particular organ along with manoeuvring the focus or multiple foci again to enhance the images and area being scanned to aid interpretation. It is therefore necessary to understand how to operate the machine being used this will maximise the quality of images produced, particularly when scanning the acutely unwell patient. Particular attention to Depth; Gain; Focus/Zoom is required.

I. Seven-Point Focused Abdominal Ultrasound

Access to high quality departmental ultrasound in UK hospitals is generally very good and there is rarely a need for detailed imaging at the bedside. Comprehensive scanning of abdominal organs and pathology should be left to the experts - usually sonographers or radiologists - who undertake regular scan lists on high performance equipment.

The FAMUS abdominal module has been designed to enable acute physicians to gather useful diagnostic information quickly and to improve the safety and efficiency of urgent bedside abdominal procedures for sick medical patients.

Two specific focus areas of abdominal ultrasound have been identified which are covered in a reproducible seven-point scan. By way of answering specific questions detailed on the data-sheet the operator should be competent to:

1) Assess the presence and/or degree of peritoneal free fluid [ascites]

2) Assess the kidneys and bladder to rule in/rule out urinary tract obstruction

II. Abdominal Organs

To be able to capture the precise views required the operator will need to have a basic understanding of the appearance of other abdominal structures and organs which may act as landmarks or acoustic windows when imaging the free peritoneal spaces and the urinary tract.

The mnemonic '**PLiSK**' is useful to remember the descending order of echogenicity in healthy abdominal organs: from the brightest **P**ancreas →**Li**ver →**S**pleen→ the least echogenic **K**idney.

Liver

The normal liver is easily visible as a large, smooth edged, homogeneous textured organ with the left lobe seen primarily in the epigastrium, and caudate and right lobes in the right upper quadrant and flank. It is bordered superiorly by the brightly reflective diaphragm. Liver should be more echogenic than the renal cortex at a similar depth though excessive echo-brightness might suggest fatty infiltration. Portal and hepatic vessels are visible in normal liver architecture, but visible intra-hepatic ducts suggest dilatation and obstruction.

Gallbladder

When patients are fasted the gallbladder will appear as a thin-walled, black (anechoic) pear shaped structure lying centrally beneath the liver. Sludge, brightly reflective gallstones or polyps may be visible within the gallbladder. Acoustic enhancement by bile may make distal structures appear bright.

Spleen

The spleen is homogeneous textured and crescent shaped with a smooth convex surface adjacent to the diaphragm and an irregular edged hilum abutting the stomach and left kidney. Generally it is best seen in the 9^{th} – 11^{th} intercostal spaces in the left mid-axillary line. Bear in mind that interposing aerated lung may obscure the window hence scanning on expiration may improve views.

Uterus

When scanning the bladder in female patients the uterus should be visible in the midline posterior to the bladder. The body of the uterus (myometrium) should appear homogeneous in texture with a thin bright line of endometrium visible down the centre. It may be anteverted towards the bladder or retroverted towards the rectum into the pouch of Douglas, of which it forms the anterior border.

III. Assessment of Peritoneal Free Fluid

While other focused ultrasound protocols e.g. FAST require urgent identification of peritoneal fluid to signify intra-abdominal haemorrhage, the unwell medical patient is more likely to develop free fluid in the abdomen due to ascites, usually from liver disease, but also malignancy or cardiac failure. The appearances of blood and ascites may have subtle differences but the techniques and probe positions required to visualise them are the same. Confirming the presence of ascites clinically can be challenging in the acute setting. Sonographic confirmation at the bedside can improve diagnostic accuracy and guide safe diagnostic and therapeutic abdominal paracentesis, which may be urgent e.g. in the sick liver patient.

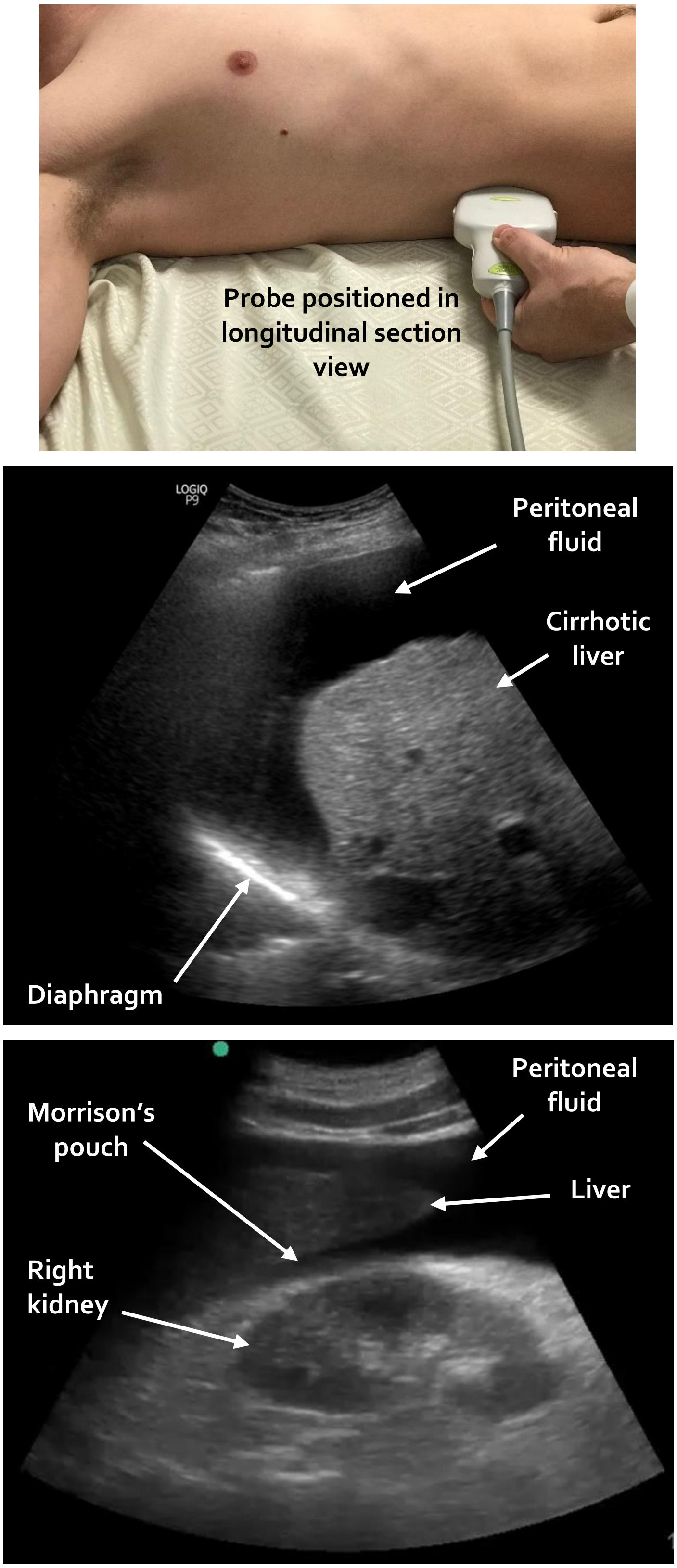
Patient Position

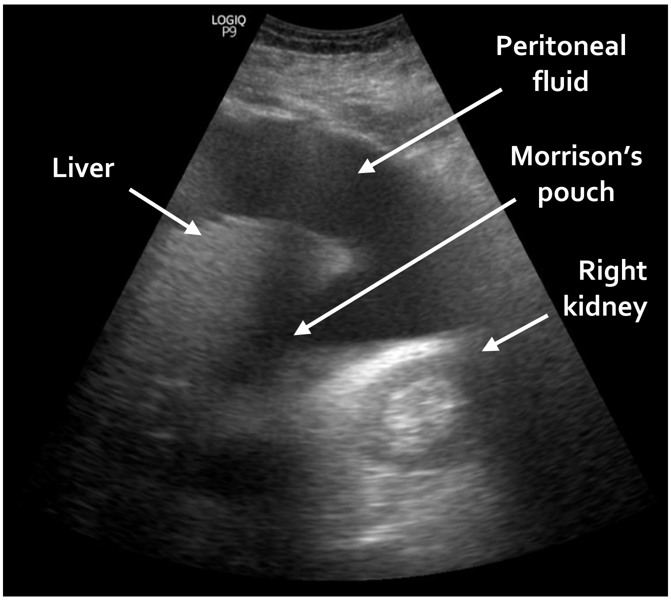
Supine

Probe Position

A. Right upper quadrant

Figure 12.



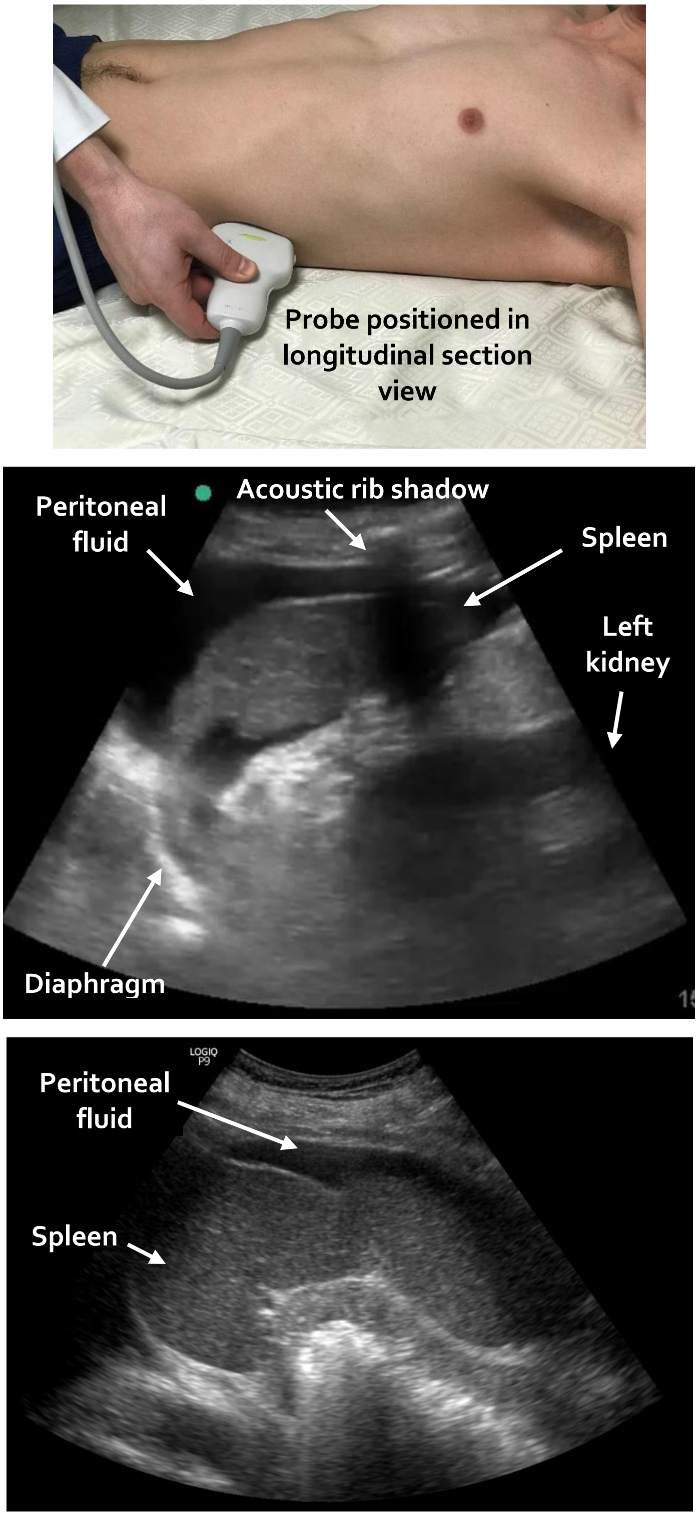


Diaphragm, Liver, R Kidney, Morrisons's Pouch

Small volumes of fluid may only be seen in Morrison's pouch between the liver and right kidney. As volume increases fluid will surround the liver and adjacent bowel and fill the sub-diaphragmatic space.

B. Left upper quadrant

Figure 13.



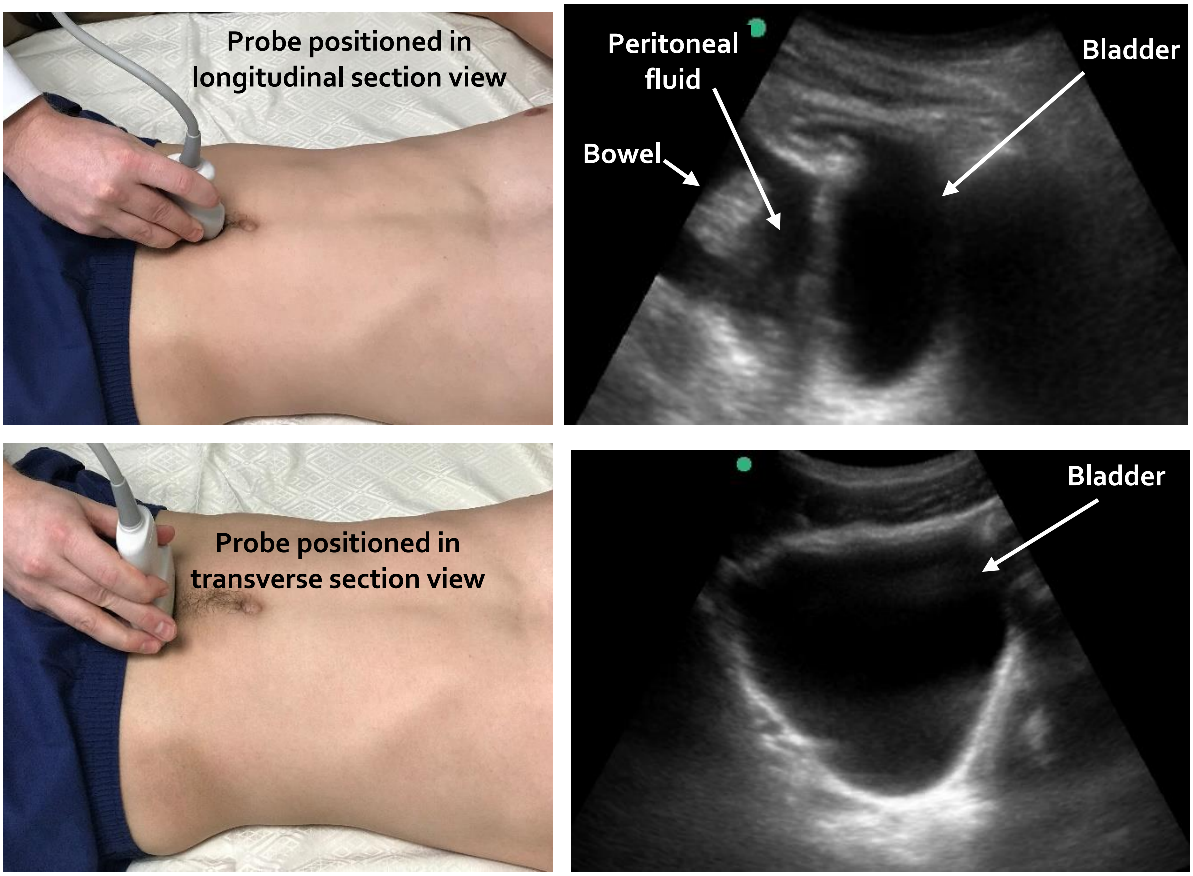
Diaphragm, Spleen, L Kidney, Spleno-renal recess

Depending on its origin and patient position fluid may first appear around the superior aspect of the spleen beneath the diaphragm or in the spleno- renal recess.

Significant hepatomegaly or splenomegaly may preclude those quadrants as sites for therapeutic drainage.

C. Suprapubic – longitudinal and transverse views

Figure 14.



Bladder

Look posterior to the bladder (and pouch of Douglas in females) for evidence of free fluid in both planes. A full bladder and its acoustic enhancement will help to pick up smaller volumes.

While these are the most sensitive points for picking up small volumes of fluid, many patients will have much larger volume ascites with fluid detectable throughout the peritoneal cavity and visibly surrounding small and large bowel.

If ascites is detected and fluid removal necessary, it is useful to slide the probe in an oblique position across the left and right lower quadrants and flanks to find the deepest (and therefore potentially safest) pocket of fluid to attempt needle paracentesis or drainage. It may assist the operator for the patient to lean 20-30° towards the side being imaged.

Bear in mind that the depth of fluid at any point will be dependent on probe position, the patient's position and gravitational dependency of the fluid. If further scanning requires the patient to move, the position and fluid depth should be reconfirmed with ultrasound immediately prior to commencing the procedure.

IV. Focused Assessment of Urinary Tract

The primary objective of a focused ultrasound examination of the urinary tract is to rapidly rule in or rule out urinary tract obstruction. In completing the seven-point abdominal scan, the operator should also be able to describe the likely level and severity of obstruction thus guiding further management.

The commonest forms of urinary tract obstruction seen in acutely ill patients are bladder outflow obstruction and unilateral ureteric obstruction. Urinary stasis in both situations predisposes to bacterial infection which can quickly lead to sepsis if left unmanaged. Likewise, increased retrograde pressure can cause acute kidney injury which will not recover without relieving the obstruction, be it temporarily or definitively.

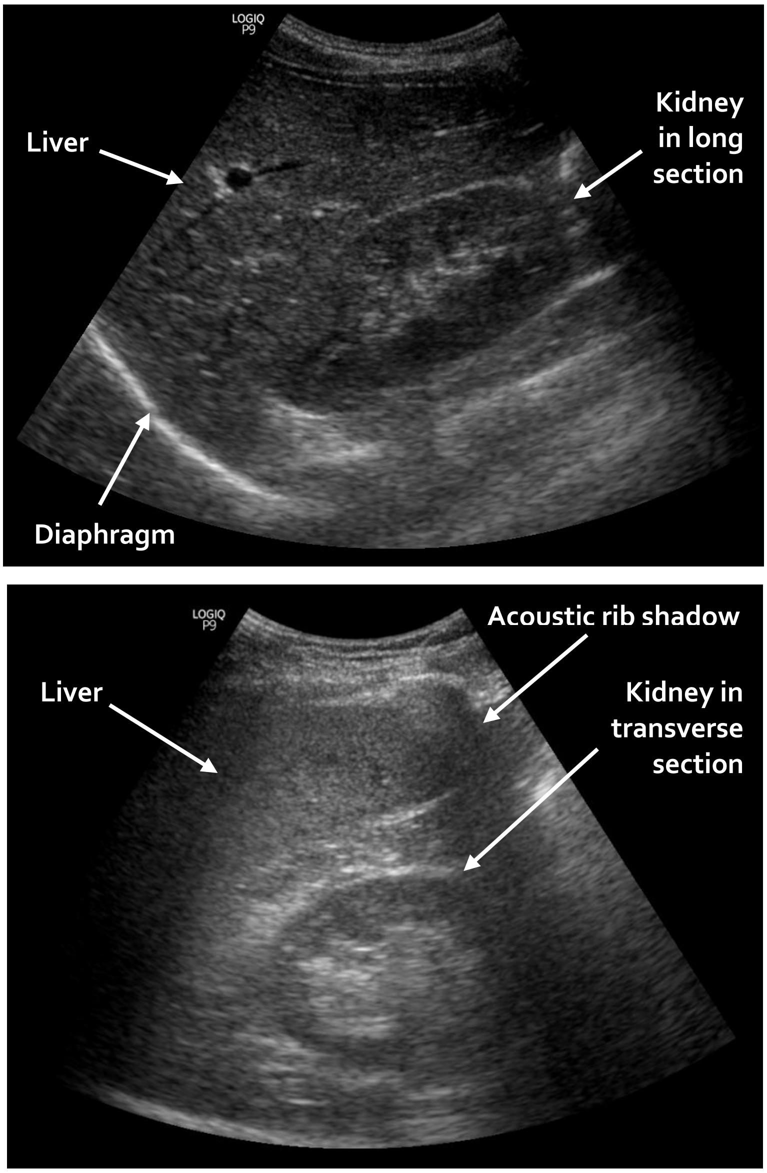
Competency in urinary tract ultrasound will require an understanding of both normal and abnormal appearances of kidney and bladder. This will enable the operator performing the scan to identify and classify the main types of obstruction and therefore classify hydronephrosis and gross bladder distension.

As with other areas of focused ultrasound, operators will inevitably pick up abnormal appearances in the urinary tract which lie outside the defined curriculum. Common abnormalities of the kidney might include cysts, polycystic kidneys, stones, abscess or even tumour. While the description and interpretation of these pathologies may be beyond the scope of our course, it is recommended to always describe and document any abnormal findings, save images where possible and refer the patient on for definitive imaging as appropriate.

A. Kidneys

Patient position: Supine / Lateral

Figure 15.



Scan Technique

In scanning any organ, the kidney must be visualised in its entirety in two planes – longitudinal (LS) and transverse (TS) sections. It is customary to locate the kidney in LS first and this can usually be found in the flank just posterior to the mid-axillary line with the tip of the probe pointing slightly back in a posteriorly oblique angle. Remember the kidneys are retroperitoneal and as such are further back than people often realise.

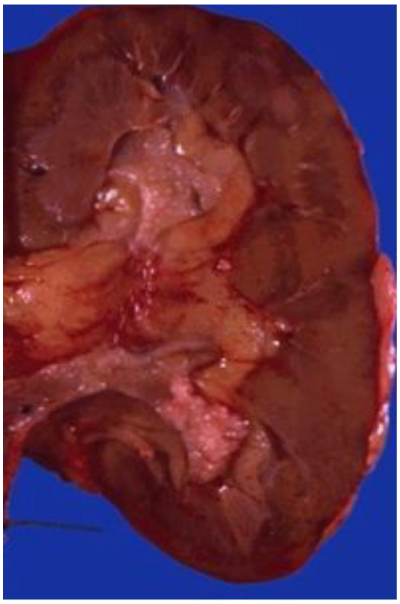
With the threat of obscuring bowel gas ever-present in abdominal ultrasound, different techniques may be required to see the whole kidney. Remember to use acoustic windows

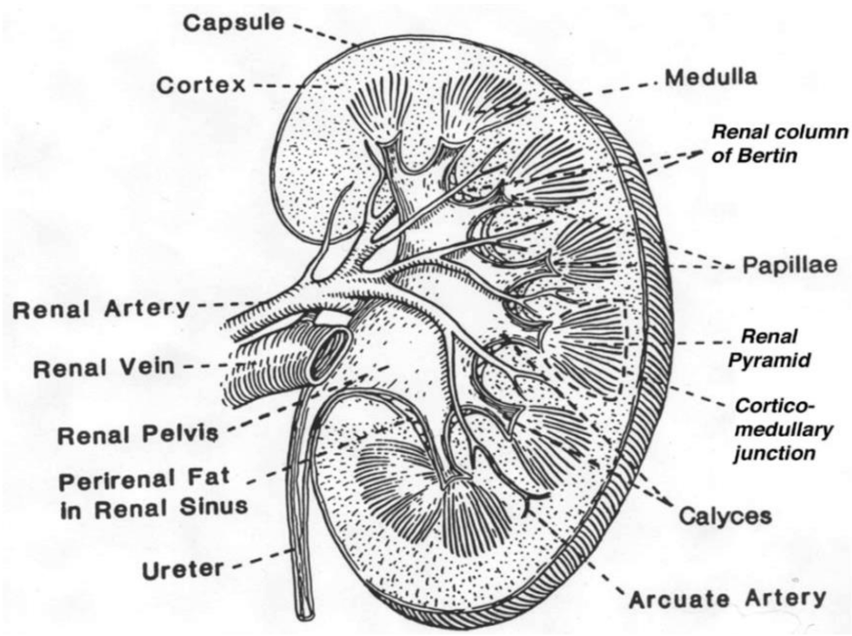
- the right lobe of the liver and the spleen can offer good views through to the kidneys while avoiding interposition of large bowel. It may help to move the patient between a supine and lateral decubitus position while sliding the probe antero- medially or posteriorly. Also deep inspiration and breath holding can be helpful to push the kidneys down into view and improve the image.

Once the kidney can be seen well in LS, manoeuvre the probe to achieve maximum pole-pole length and save an image. Then sweep through the organ in that plane to ensure the whole kidney has been seen.
Rotate the probe 90° anti-clockwise to see the kidney in TS. Save an image at the hilum where renal vessels and ureter may be seen. Sweep through kidney from top to bottom.

Normal kidney appearance

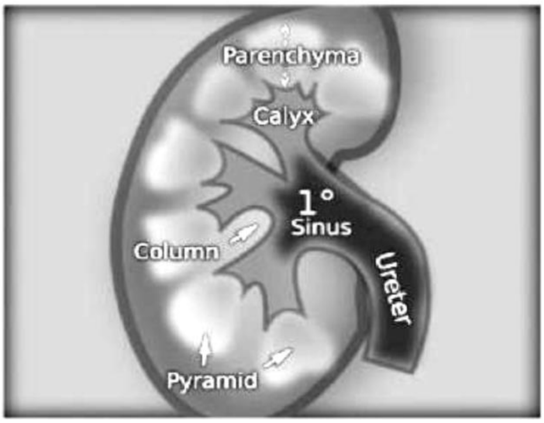
The kidney is enclosed by a fibrous capsule and Gerota's fascia which are visible as a thin hyperechoic line between the liver and kidney. Within the capsule lies the renal parenchyma made up of cortex and medulla. The cortex should be less echogenic than the liver of the same depth (nb PLiSK) and contains regularly spaced hypoechoic medullary pyramids. The central sinus complex of vessels and collecting system surrounded by fat is hyperechoic compared with surrounding parenchyma.





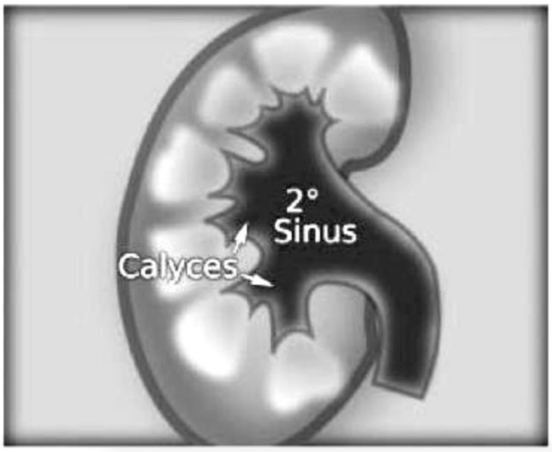
Mild (Grade 1)

Renal pelvis dilatation; no/mild calyceal dilatation; no parenchymal atrophy



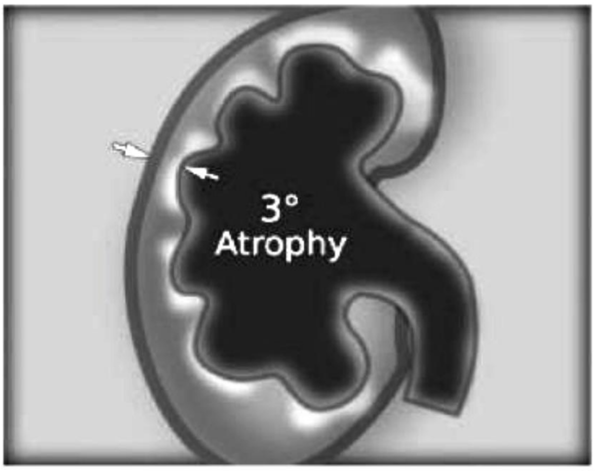
Moderate (Grade 2)

Moderate pelvis and calyceal dilatation; early parenchymal atrophy may be present



Severe (Grade 3)

Gross pelvic and calyceal dilatation; loss of normal architecture; cortical atrophy



B. Bladder

An adequately distended bladder will appear as a trapezoid anechoic structure in transverse section just superior to the symphysis pubis. It should be thin walled and free of stones or debris. It is easy to mistake reflected echoes at the back of the bladder for sediment so remember to adjust your gain/TGC.

As with other organs we recommend scanning through the entirety of the bladder in both LS and TS and recording images in the midline. If it is not adequately distended the normal bladder wall will appear thickened.

If bladder outflow obstruction is present, a diagnosis of acute urinary retention is most often made clinically and confirmed either via urethral catheterisation or bladder ultrasound. While the normal bladder volume can be somewhere between 400 and 600ml, single ultrasound measurements of bladder volume - an algorithmic approximation – may not be accurate and without asking the subject to empty their bladder will not prove or disprove urinary retention.

Clearly the extremes of bladder volume will be informative and a grossly distended bladder which cannot be voided supports the diagnosis of outflow obstruction . Post-void volume measurements may be useful in patients with persistent urine infection, but can be misleading in the acutely unwell or septic patient.

Note, most ultrasound machines will be able to calculate a volume based on maximal depths in two planes with three calliper measurements to enable the calculation of absolute volume.

V. Reporting Sheet: Abdominal/Renal Ultrasound

Focused Acute Medicine Ultrasound (FAMUS)

Reporting sheet – abdominal/renal ultrasound

Trainee name: Date:

Patient identifier:

Image quality: Good Adequate Poor

Abdominal and renal ultrasound focused scan	
Right kidney identified?	Yes □ No □
Morison's pouch identified?	Yes □ No □ Fluid present □
Left kidney identified?	Yes □ No □
Splenorenal recess identified?	Yes □ No □ Fluid present □
Liver including hemidiaphragm identified?	Yes □ No □
Spleen including hemidiaphragm identified?	Yes □ No □
Bladder identified? Distended?	Yes □ No □ Yes □ No □
Free fluid identified around bladder inc Pouch of Douglas?	Yes □ No □
Any evidence of hydronephrosis? Degree of hydronephrosis if present	Yes □ No □ Mild □ Moderate □ Severe □
Site identified for ascitic tap/drain if required?	Yes □ No □
Comments/further details and conclusion of the scan:	
Trainee reflection on scan (optional) e.g how did the scan affect management	
Mentor/Supervisor comments:	

Signed (trainee):

Signed to confirm above findings (mentor/supervisor):

Initial to confirm trainee suitable to commence mentored practice (only required once):
(minimum 10 supervised scans)

Is a Departmental scan required? Yes □ No □ Requested? Yes □ No □

Once completed trainee must maintain logbook of countersigned report sheets. Please remember not to remove patient confidential information from Trust property

4) Vascular Module:

I. Deep Vein Thrombosis

Venous thromboembolisim (VTE) accounts for a sizable workload within the National Health Service. It is an important cause of death in hospital patients and its non-fatal events carry a considerable cost to the health service.
VTE most commonly originates from the deep veins of the legs, hence called deep vein thrombosis (DVT).

The 2012 NICE guidance on VTE recommends proximal leg vein ultrasound scanning as the diagnostic endpoint in DVT investigations. This requires a formal, complete proximal vein assessment with ultrasound. In-other-words, a rule-out scan.
As part of the assessment of the sick or suspected VTE patient, early indication of a significant clot burden is important for the tailoring of management and overall care of the patient. There is now mounting evidence that is supportive of rule-in scans that help answer this critical question. In FAMUS, we have adopted a systematic rule-in scanning protocol that aids management (identifies significant clot load) at that critical time point in the patients care. This however is not a rule-out departmental scan.

Equipment

For the assessment of DVT, a Brightness (B) mode ultrasound machine is needed. There are a variety of shapes and sizes of ultrasound machines which are perfectly acceptable, as long as regular safety checks and services are carried out to maintain adequate function.
The probes needed for good vascular assessment need to be high in frequency. High frequency probes however have lower penetration, so in general, probes of over 3MHz would suffice. The vascular probe with a linear transducer have high frequency and are useful for high resolution assessment of small legs were low depths are anticipated. For legs requiring higher depths, the curvilinear transducer which has lower frequency is more appropriate.

Anatomy

The anatomy of interest is the area from the common femoral vein (CFV) down to the distal popliteal vein (tri-fication).
During the FAMUS scanning process, the common femoral vein, femoral vein, profunda vein and the popliteal vein are visualised.

Scanning process

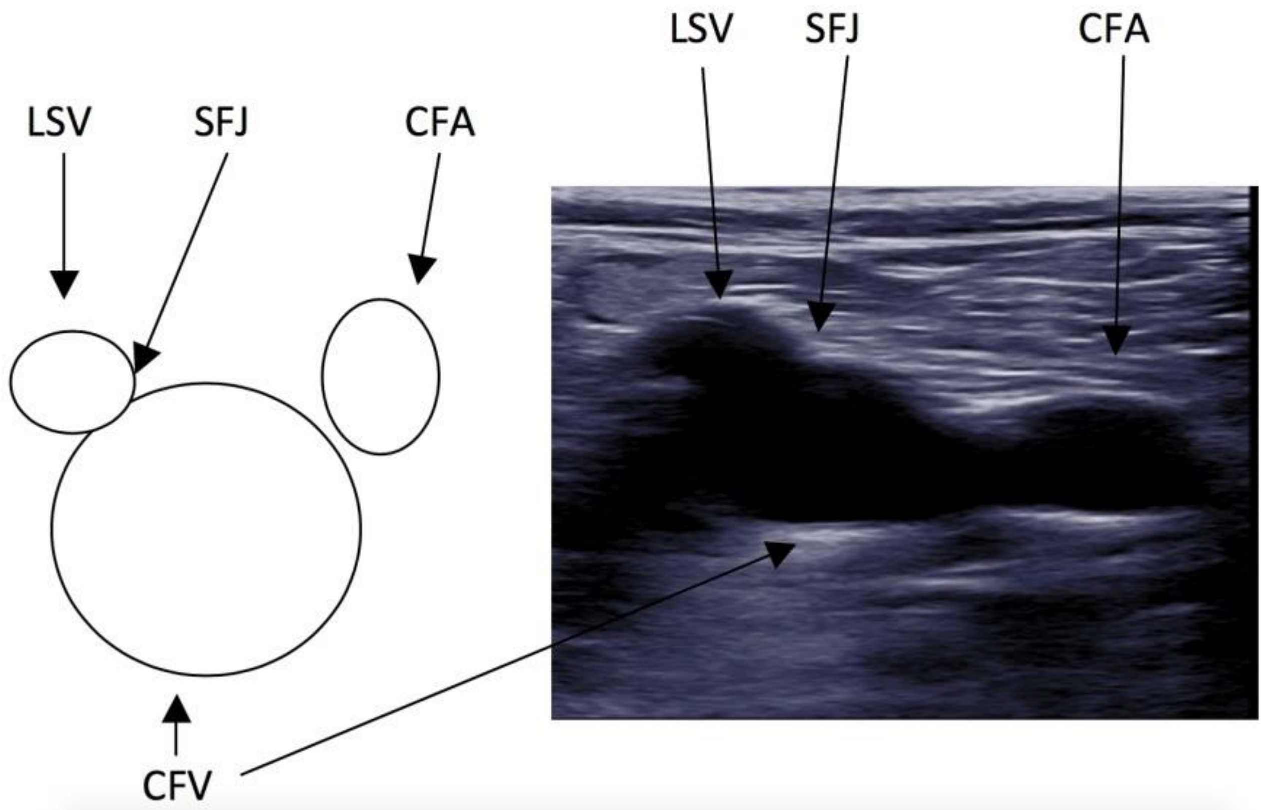
As with other medical processes, this should begin with an introduction by the person scanning, where possible. The machine should be set up with the patient's details and explanation of the process to the patient, where possible, is also a recommended starting point.

Verbal consent and patient cooperation is necessary before exposure of the exam area (groin to below knee). Patient positioning is a critical step to ensure comfort for the patient and the person scanning as well as helping to optimise image acquisition. Positioning is best supine with head tilt, hip externally rotated and with the knee slightly flexed.

Once the above is set, prepare the probe with gel and find the 'Mickey Mouse Sign'.

The Mickey Mouse sign represents the level (in transverse plane) at which the common femoral vein and the sapheno-femoral junction are visible. The face of Mickey Mouse represents the common femoral vein (CFV), while the ears represent the common femoral artery (CFA) and the long saphenous vein (LSV). The orientation of the 'ear' vessels depends on which leg is being scanned. The sapheno-femoral junction is therefore the attachment point of the corresponding ear, to the face of Mickey Mouse (Figure 16).

Figure 16. Schematic of the Mickey Mouse sign – Left Leg



After identifying the Mickey Mouse sign, apply a little downward pressure on the probe to ensure that the common femoral vein (CFV) compresses. Complete wall-to-wall compression signifies a patent vessel. Partial compression signifies non-occlusive thrombus and no compression signifies an occlusive thrombus (Figure 17 – ultrasonic differentiation of veins and arteries).

Figure 17. Ultrasonic differentiation of veins and arteries.

	Vein	Artery
Wall	Thin	Thicker (Brighter)
Pulse	Non-pulsatile	Pulsatile
Compression with minimal pressure	Compressible	Much less compressible
Spectral Doppler	Low velocity	Higher velocity

This represents the first point in the 3-point minimum dataset for a FAMUS DVT scan (Figure 18). After gentle compression, the probe should then be moved medially down the thigh, while keeping focus of the femoral vein in the middle of the screen. Compressing down the length of the femoral vein will increase the sensitivity of the scanning process. Once at the mid-thigh region, compression of the femoral vein should be attempted. This represents the second point in the minimum dataset.

After completion of above, continue to scan distally. Compress as you go along, until the femoral vein becomes difficult to visualise medially, as it continues on its course behind the knee. Lift the probe and place it in the popliteal fossa to visualise the popliteal vein. After attaining an acceptable image, compress. Assess for wall to wall vein compression, which signifies patency. This is the third point on the minimum dataset.

For good clinical governance, we recommend saving representative images of the scanning process which should match at least, the minimum dataset and should be representative of the final report generated.

We recommend the use of the rule-in FAMUS DVT scan reporting sheet (Figure 19).

Figure 18.

Minimum Dataset

Standard 3-Point Lower Limb Deep Vein Thrombosis 'RULE-IN' FAMUS Scan

From the Society of Acute Medicine Ultrasound Working Group

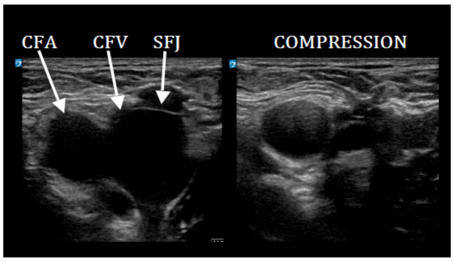
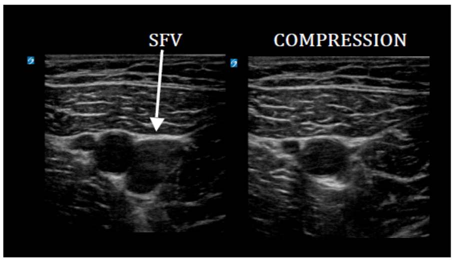
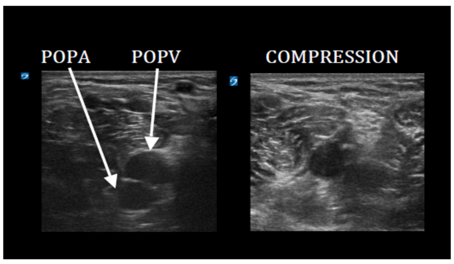
Patient Position	Probe Position	Modality	Ultrasound Image	Explanatory Notes
	Transverse	2D		Patient: Supine with slight external rotation of leg Probe: Transverse & positioned in groin crease Anatomy: Locate CFA, CFV & SFJ Study: Compress the vein for complete wall to wall apposition Note: Compression at valve level may be difficult
	Transverse	2D		Patient: Supine with slight external rotation of leg Probe: Transverse & positioned at mid thigh level Anatomy: Locate SFV Study: Compress the vein for complete wall to wall apposition Note: Anatomical variants like two SFV's are possible
	Transverse	2D		Patient: Supine with slight external rotation of leg Probe: Transverse & positioned at knee crease Anatomy: Locate POPA & POPV Study: Compress the vein for complete wall to wall apposition Note: Sitting patient on bed side dilates the vein, improving visualisation

Figure 19.

Focused Acute Medicine Ultrasound (FAMUS)

Reporting sheet – 'rule in' DVT

Trainee name: Date:

Patient identifier:

Image quality: Good Adequate Poor

LEFT LEG			RIGHT LEG		
Examined?	Yes □	No □	**Examined?**	Yes □	No □
'Mickey Mouse' sign (CFA, CFV, SFJ) visualised?	Yes □	No □	**'Mickey Mouse' sign (CFA, CFV, SFJ) visualised?**	Yes □	No □
Common Femoral Vein (CFV) Compressible?	Yes □	No □	**Common Femoral Vein (CFV)** Compressible?	Yes □	No □
Superficial Femoral Vein (SFV) Compressible?	Yes □	No □	**Superficial Femoral Vein (SFV)** Compressible?	Yes □	No □
Popliteal vein trifurcation visualised?	Yes □	No □	**Popliteal vein trifurcation visualised?**	Yes □	No □
Popliteal Vein (PV) Compressible?	Yes □	No □	**Popliteal Vein (PV)** Compressible?	Yes □	No □
Deep vein thrombosis confirmed? Yes ☐ No ☐					
Comments/further details and conclusion of the scan: e.g. site of DVT if confirmed need for formal imaging					
Trainee reflection on scan (optional) e.g how did the scan affect management					
Mentor/Supervisor comments:					

Signed (trainee):

Signed to confirm above findings (mentor/supervisor):

Initial to confirm trainee suitable to commence mentored practice (only required once):
(minimum 5 supervised scans)

Is a Departmental scan required? Yes □ No □ Requested? Yes □ No □

Once completed trainee must maintain logbook of countersigned report sheets. Please remember not to remove patient confidential information from Trust property

FOCUSED ACUTE MEDICINE ULTRASOUND

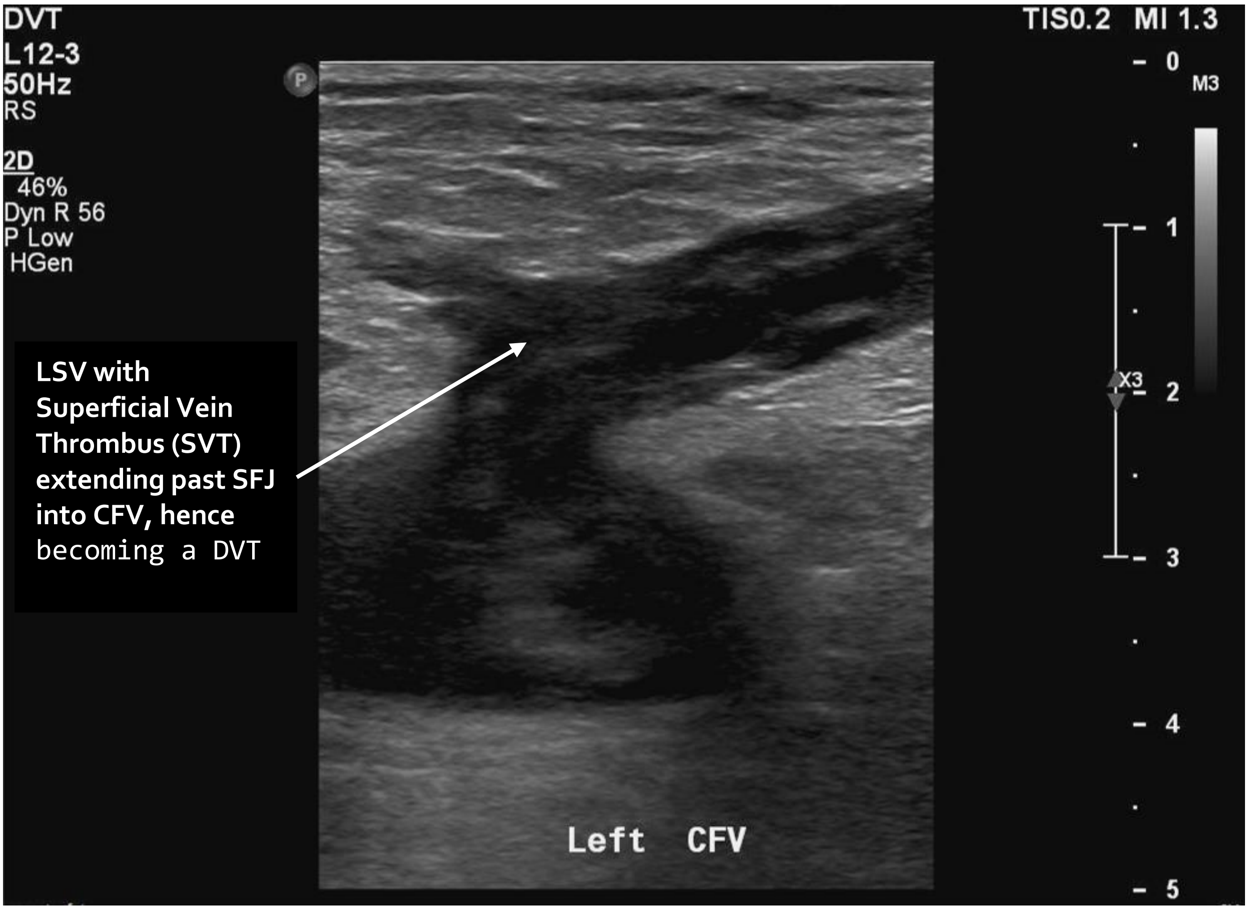
What’s ‘normal’ or not

A ‘normal’ scan in this context does not mean the exclusion of a DVT, as this is a rule-in process alone.

Clear identification of the common femoral vein, down to the distal femoral vein and popliteal vein, with normal wall-to-wall compression is ‘normal’ in this context.

A positive scan in this context identifies the presence of thrombotic material within the examined vessel. This identification occurs visually, or in the absence of wall-to-wall compression. The vessel could be identified as completely occluded (with obvious thrombus seen within ± no compression) or partially occluded (with obvious thrombus seen within part of the lumen ± partial compression). See FAMUS website for movie of normal FAMUS DVT Rule-in Scanning Process and examples of clinical findings

Figure 20.



II. Vascular Access

Point of care ultrasound for vascular access is increasing in its availability and use. In the right hands, ultrasound guided vascular access can improve successful cannulation rates, reduce iatrogenic injury and the number of attempts at cannulation. Broadly, the use of ultrasound improves safety and success in vascular access procedures.

For access problems, ultrasound can be used to aid in central or peripheral venous procedures, as well as arterial access where needed. The main limiting factor for ultrasound use, where a machine is available, is an appropriately qualified individual. As a result, in the right hands, there are no absolute contraindications to using ultrasound as an adjunct in the vascular access processes.

Vascular access sites

Choice of site is largely based on the reason generating that access need. One should also consider the calibre of the vessel to be accessed, the depth and course of the vessel, as well as superficial (like overlying cellulitis) and surrounding structures.

Central sites of use are predominantly internal jugular vein, femoral vein and possibly subclavian vein. Peripheral sites may include cubital, cephalic or basilica veins in the upper limb.

Pre-procedure set up

The clinician performing the procedure should be fully aware of the clear indication for the access need, the site and potential site complications, and the systemic risks that could complicate the procedure (like coagulopathy). Familiarity with the equipment (ultrasound machine, lines or needles), full explanation to the patient (where possible), obtaining consent, and having a clear understanding of the on-going care are also important.

Once there is clarity on the indication, site and consent, then preparation regarding the ultrasound equipment and site should begin. Patient positioning is of great importance and will influence the chances of a successful procedure. Ideally also, the ultrasound machine should be positioned opposite the clinician therefore making it possible to visualise the site of access and the screen of the machine simultaneously. Preparation of the machine, probe, sterile sheath, gel, local anaesthetic and venous access equipment should then occur. Strict sterile barrier precautions are necessary for central access and much less so, for peripheral venous access.

The skin over the site should be prepared in a sterile manner and barrier precautions should be set up. The ultrasound probe also should have a sterile sheath (the probe is dropped into the sheath, which is then extended up the cord of the probe to maintain sterility) and sterile gel (which is applied to the base of the sheath before the probe is dropped in). For good function of the probe, the sterile gel must be applied on both sides of the sheath (inside and outside) adjacent to the probe face.

Once the equipment is organised and barrier precautions set up, the local infiltration of the site with anaesthetic is a logical next step. This helps patients become more comfortable during the process and is likely to reduce the possibility of unexpected movements due to pain. First visualisation of the structures using ultrasound would normally occur before local anaesthetic application.

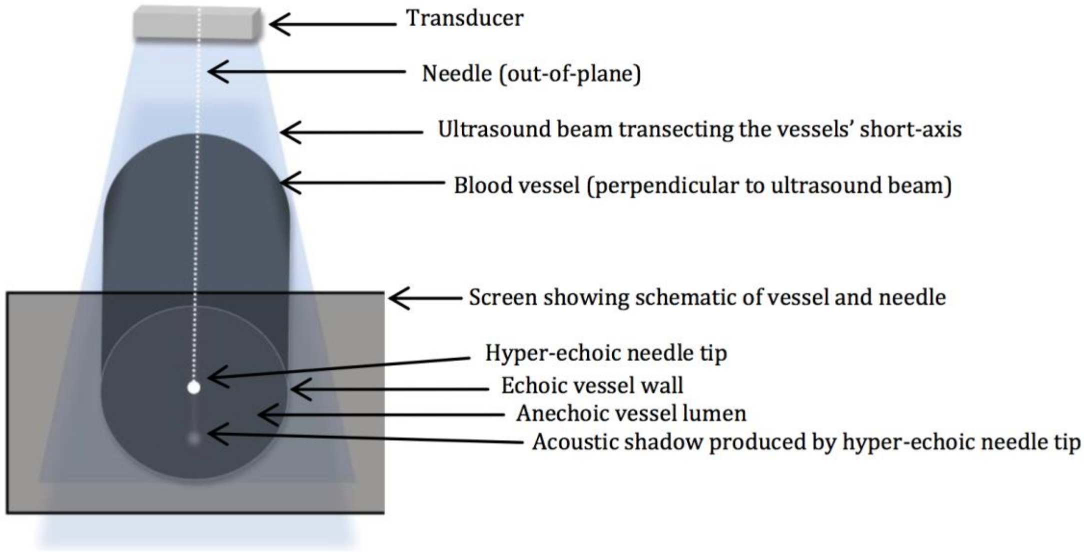
The Process

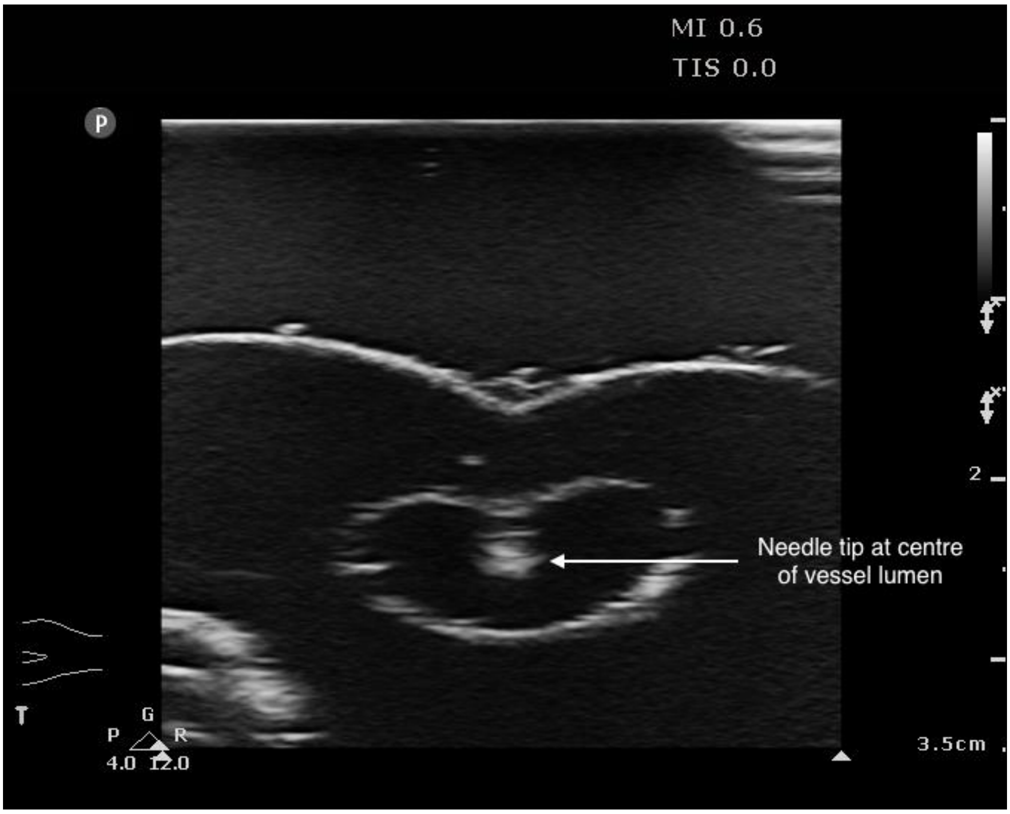
In FAMUS, we promote the use of real time visualisation of the needle tip during the vascular access process. This dynamic approach is in favour of a more static approach, where the ultrasound is used to identify the structures of importance, site marking then occurs before performing the invasive procedure. Although the static approach is not completely landmark based, the lack of visualisation of the needle tip suggests that this approach is not superior to the dynamic approach.

Another procedural consideration would be in the decision to use an out-of-plane (short-axis) or in-plane (long-axis) visualisation technique.

Using the short-axis view, the vessel lies (and the needle appears) perpendicular to the image plane. This gives the view of an oval shaped vessel (echoic/bright wall (better seen in arteries) with an anechoic/dark lumen) passing into the screen, with the needle appearing as a hyper-echoic/ very bright point (in cross-section; out-of-plane) within that image (Figure 21).

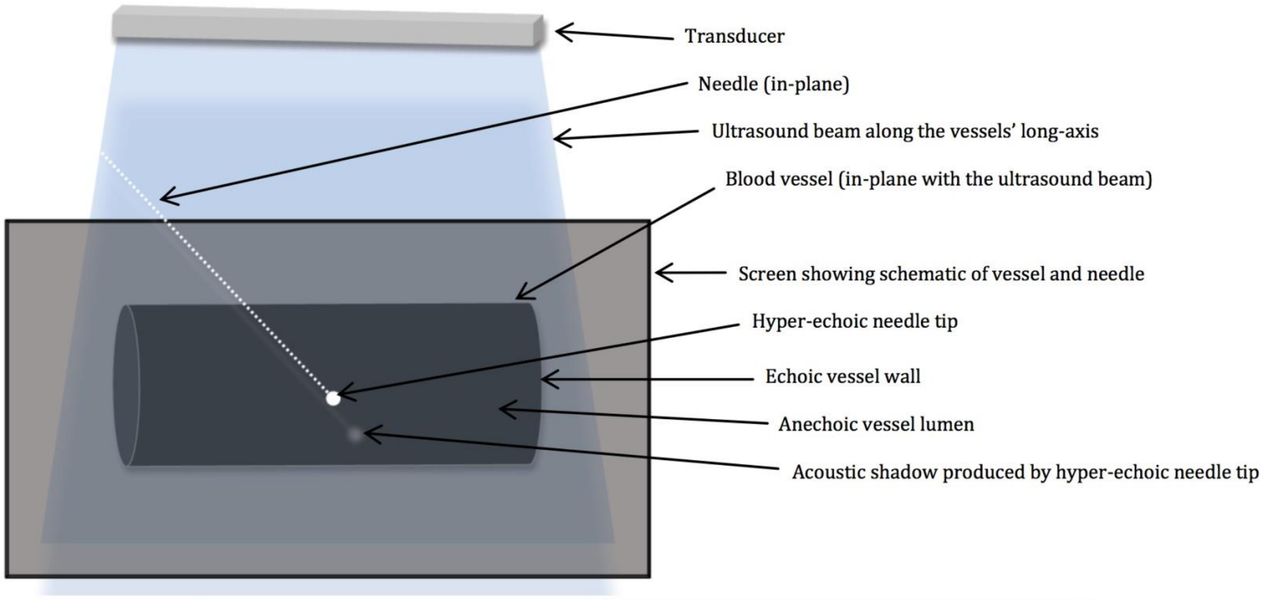
Figure 21.

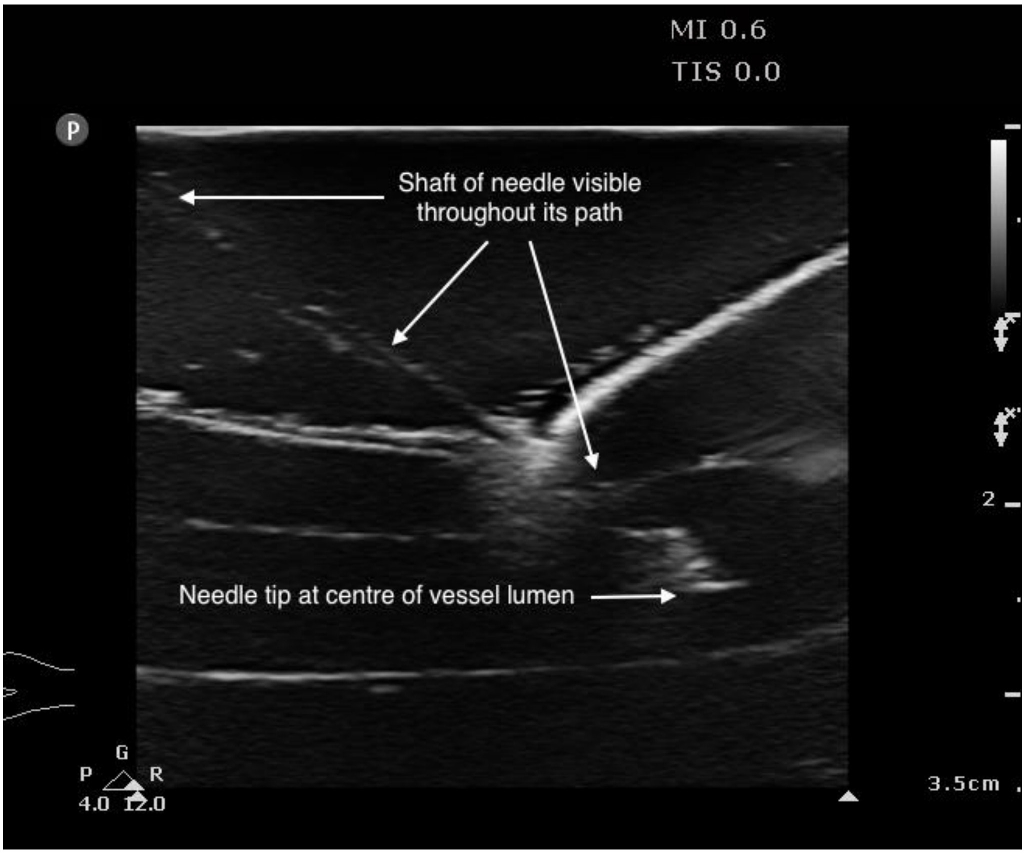




In the long-axis view, the ultrasound beam runs parallel to the vessel path and gives the opportunity for full visualisation of the needle tip and shaft (as it advances) which is in-plane (Figure 22). Bearing in mind that the ultrasound beam is only a few millimetres thick, care should be taken to ensure that the needle and vessel remain in-plane with that beam. So careful positioning, ensuring adequate space to allow for the probe footprint and the needle, and steady hands are required. The obvious benefit of this technique is the visualisation of the needle shaft and tip all the way as it advances to the target point.

Figure 22.





After the above considerations have been resolved, an awareness of the ultrasound depth from skin to the target (vessel centre) is important. This distance is useful in the short-axis approach, as inserting the needle at a 45-degree angle, at that equivalent distance from the probe will ensure that the needle tip will roughly be at the target point (vessel centre). (Figure 23)

It is worth pointing out however, that with either the short-axis or long-axis approach, needle tip visualisation and the maintenance of sterile technique (especially in central line placement) is paramount.

When using the short-axis method, insert the needle as described above and in Figure 23, at a 45-degree angle with the insertion site being at approximately the same distance from the probe, as the depth to the target (skin to vessel centre). Slow introduction of the needle is advised at intervals. One approach is to tilt the probe towards the skin until the needle tip is seen at the entry point more superficially, then by tilting the probe deeper and then advancing the needle point deeper (small depths at a time) until visualised on the screen and then repeat the process in increments until the target is reached. As long as the initial setup (vessel in the middle of the probe with the needle inserted in alignment of this) is maintained in the short-axis, a flashback of blood into the needle or cannulae will be seen as well as the needle tip visualisation within the lumen indicating successful cannulation, when the critical depth is reached.

Problems that one may encounter include advancing the needle off-plane in short axis (resolved by stopping and rocking the probe to find the needle tip. If not found, then withdraw the needle to a point just deep to the skin, and start again); and advancing the needle beyond the posterior wall of the vessel (resolved by withdrawing the needle until the needle tip is seen again within the lumen, target sign). The operator should be mindful of this.

Another approach is of course to keep the probe steady, visualising the vessel, inserting the needle at an equivalent distance from the probe and at 45 degrees and with small, gentle incremental depths, the target will be met by the needle.

In the long axis, once there is good visualisation of the vessel and the probe is held steady, insert the needle adjacent to the probe and in plane with the beam. The tip of the needle should first be seen and then with gradual advancements, then shaft is seen. Both the needle tip and shaft can then be followed as it slowly advances towards the vessel, indents the vessel wall and then penetrates into the lumen producing a blood flashback in the needle or cannulae. The obvious problem here is to ensure that the vessel and needle remain in plane of the narrow ultrasound beam.

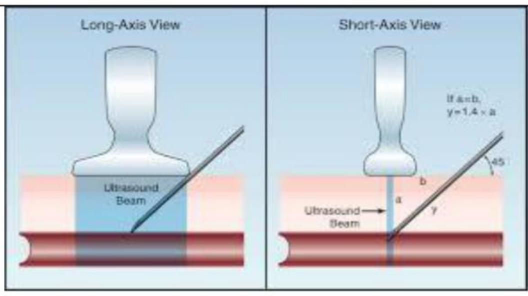
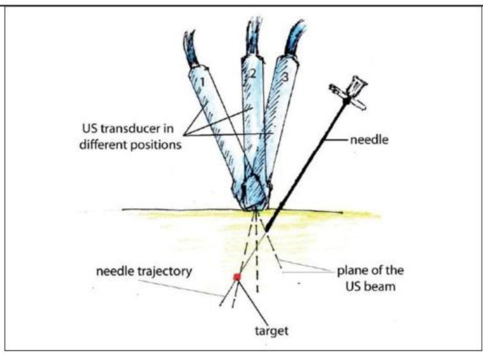
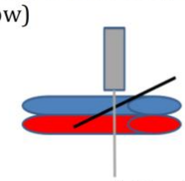
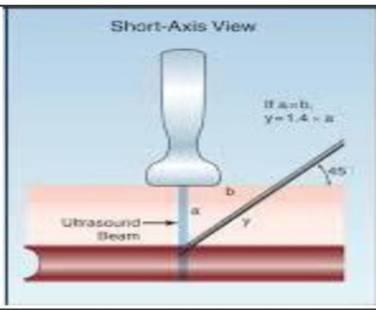
Once flashback is achieved (using any above method), advance a little further to be clear of the vessel wall. Then use the ultrasound to confirm the position (within the central lumen of the vessel of choice). After this, then simple cannulation, placement of the guide-wire then dilator then line can proceed.

Figure 23.

Minimum Dataset

Vascular Access - FAMUS Scan

From the Society of Acute Medicine Ultrasound Working Group

Steps	Image	Explanatory Notes
Set up and prepare all your equipment		• Tegaderm Dressing for Linear USS probe • Use **longer cannula** (at least 4 cm long) • Chloroprep
Position USS device in line with limb		• Consider device on opposite side of patient • You should be able to see Ultrasound screen and cannula at the same time
Look for appropriate blood vessel		• Veins are more oval and easily compressible • In elderly patients or low output states arteries might be compressible as well → compress slowly, arteries will be more pulsatile • Follow the vein with your ultrasound to understand course of vein for later insertion
Decide on in plane / out of plane technique		• In plane technique is better if vein and artery on top of each other, however vein need to be straight enough • Out of plane technique better when vein and artery next to each other
Use either: • Follow the needle approach		• Move transducer first, then follow with needle until needle tip appears on Ultrasound screen (always keep ultrasound ahead of needle to avoid needle tip injuring deeper structures (i.e. artery in picture below)  • Repeat these steps until blood vessel is reached
• 45 degree angle		• Depth of vessel (a) and insertion distance from ultrasound transducer (b) should be equal. • If an angle of 45 degrees is used, than needle should hit target
The final steps are similar to cannula or central line insertion		

famus FOCUSED ACUTE MEDICINE ULTRASOUND