Focused Acute Medicine UltraSound (FAMUS)

HANDBOOK

Thoracic Ultrasound Module

V1.1

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Contributors to the FAMUS Handbook

Editor
Dr Eugene Tabiowo
Consultant in Acute Medicine, Royal Glamorgan Hospital
Eugene.tabiowo@wales.nhs.uk

1) Introduction to FAMUS

Dr Nicholas Smallwood (*Nick.smallwood@gmail.com*)
Consultant in Acute Medicine, East Surrey Hospital

2) Thoracic Module

Dr Ramprasad Matsa (*Ramprasad.matsa@uhnm.nhs.uk*)
Consultant in Acute & Intensive Care Medicine, Royal Stoke University Hospital

Dr Jenny Messenger (*Jenny.messenger@bsuh.nhs.uk*)
Consultant in Respiratory & Acute Medicine, Royal Sussex County Hospital

Graphics & Images

All Individuals Above Including

Dr Andy Walden (*Apwalden@hotmail.com*)
Consultant in Acute & Intensive Care Medicine, Royal Berkshire Hospital

Dr Martin Dachsel (*Rdachsel@nhs.net*)
Consultant in Acute Medicine, East Surrey Hospital

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

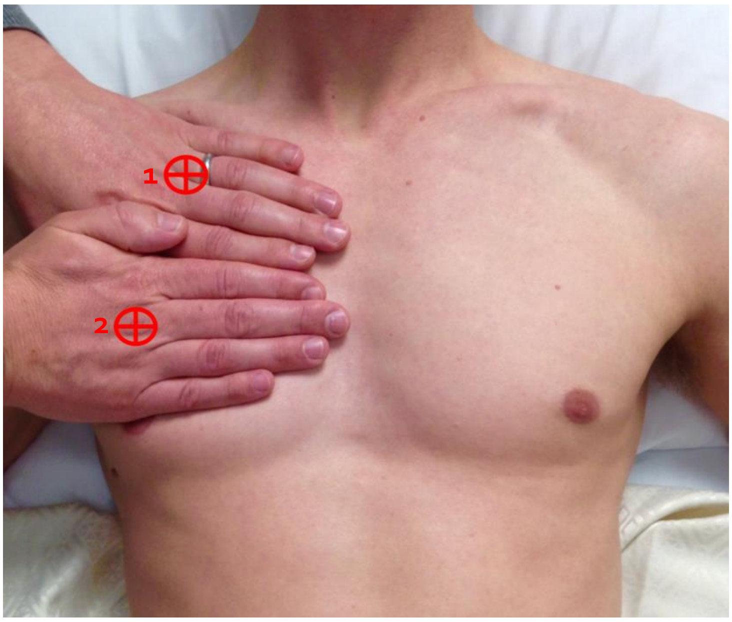
The Probe:

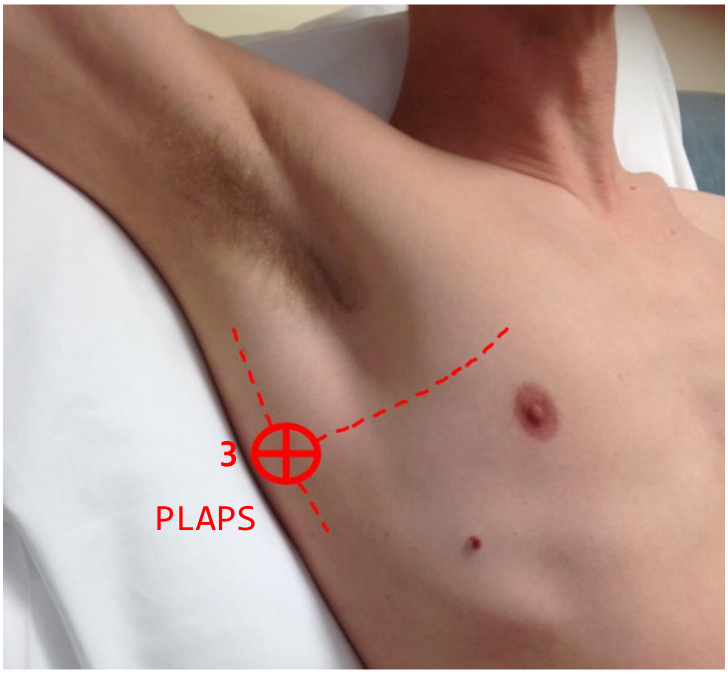
The general preference for thoracic ultrasound to visualise parenchymal pathologies would be to use the curvilinear probe as the low frequency would help better penetration. However, for pleural and superficial pathologies (such as pneumothorax), a high frequency probe (linear array) may be helpful.

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. 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

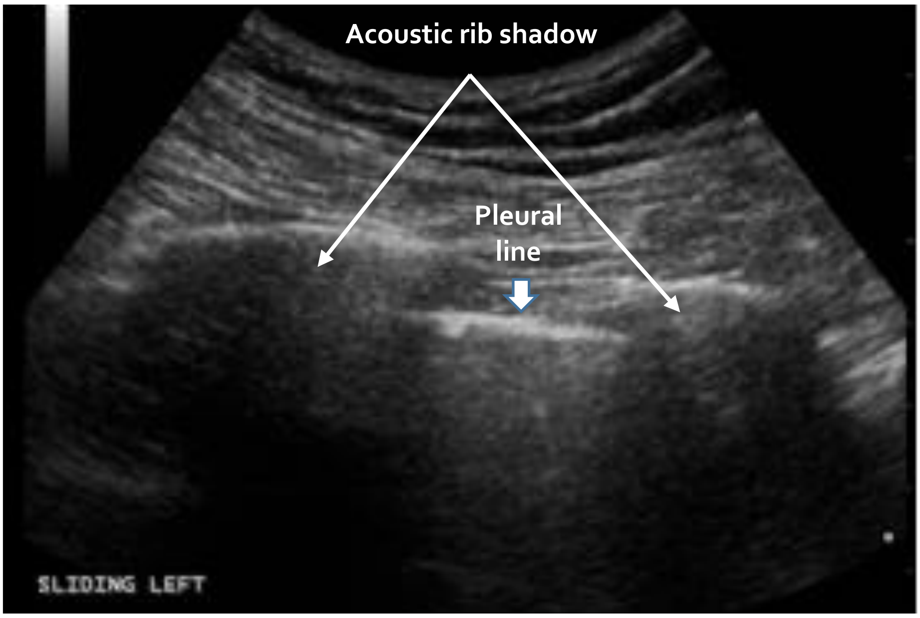
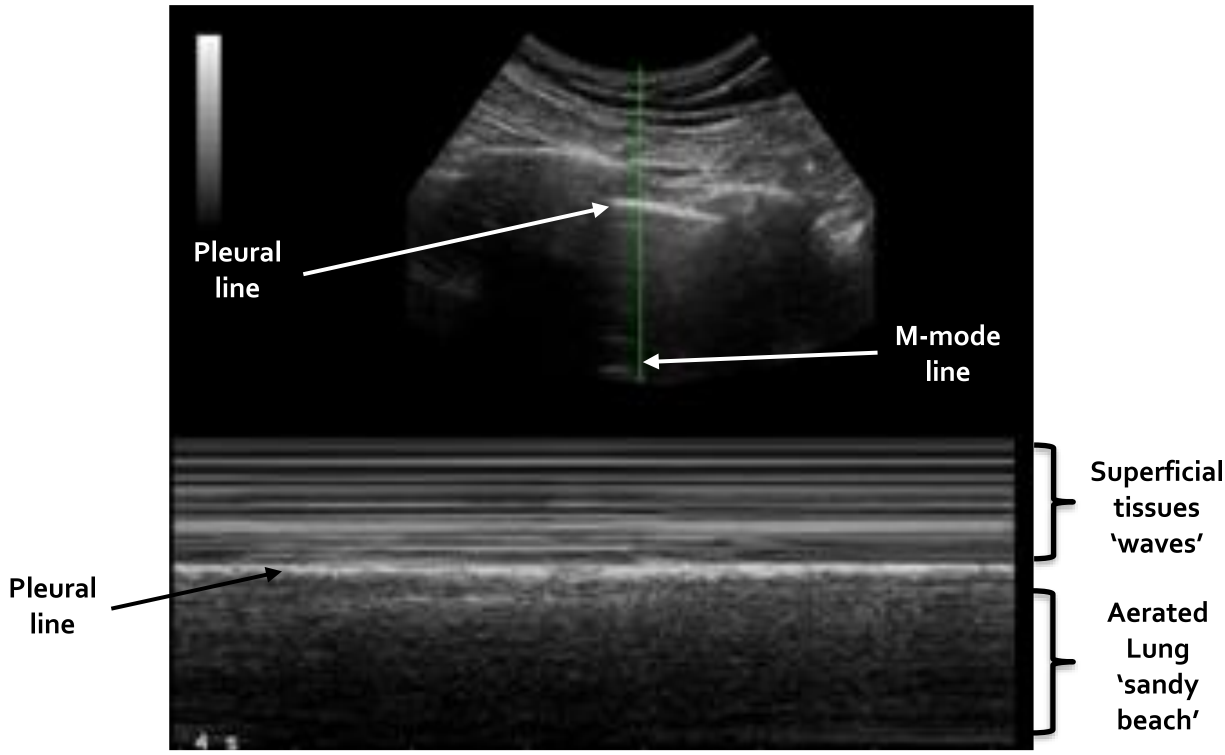


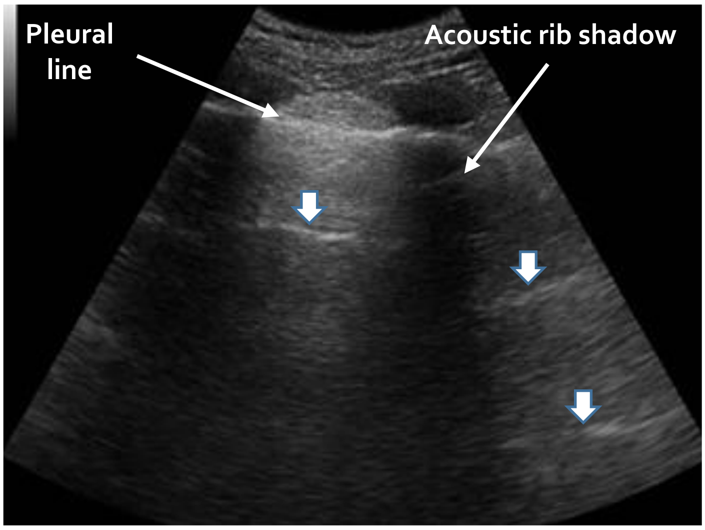
Figure 3. Seashore Sign



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.

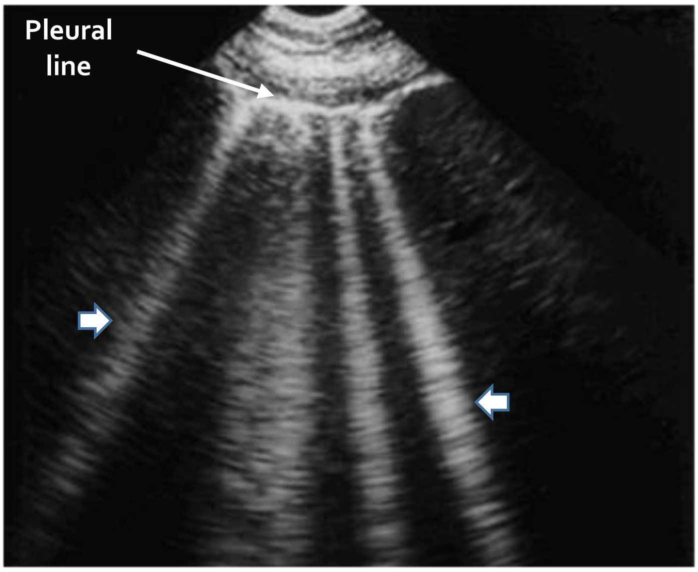
Figure 4. A Lines, indicated here by down white arrows



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

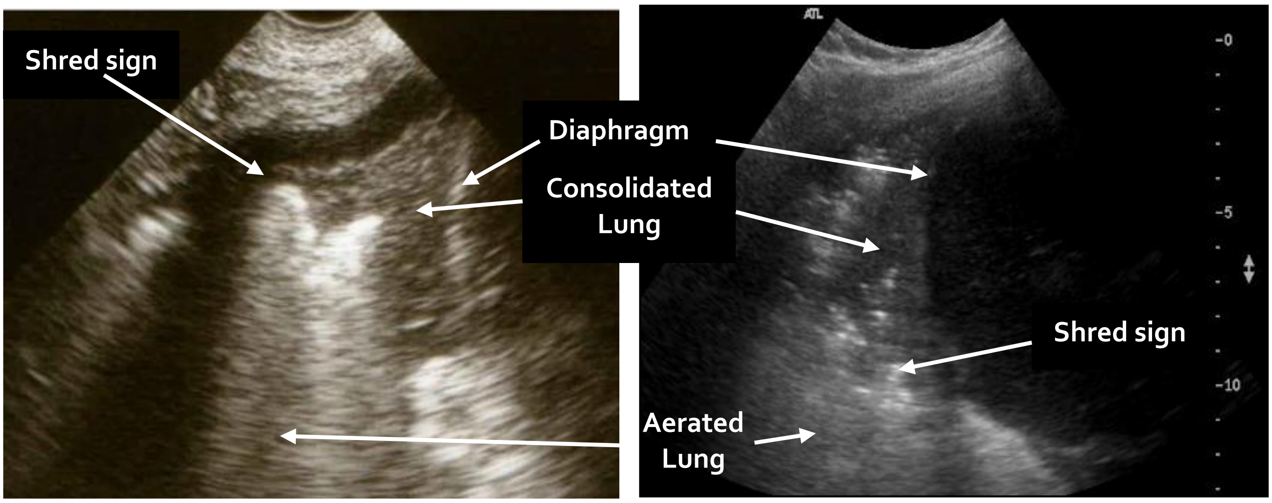
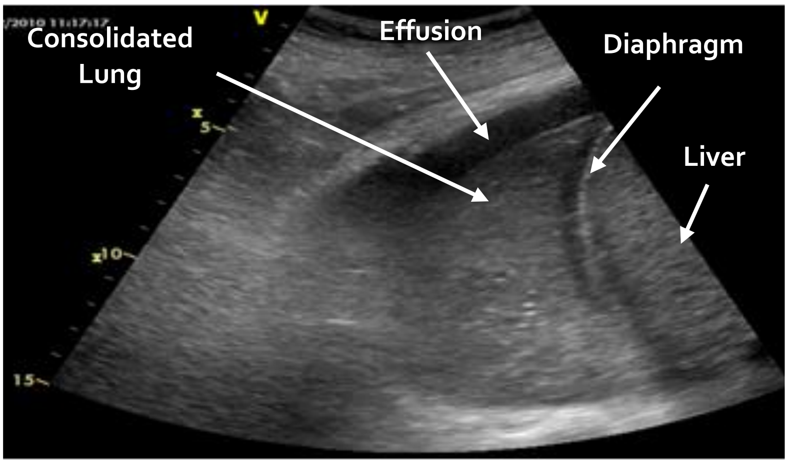


Figure 7. Tissue-like sign with small parapneumonic effusion

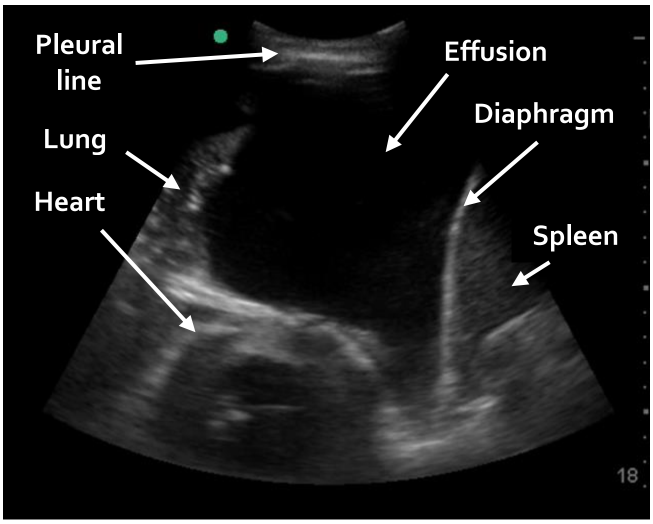


III. Pleural Effusion

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.

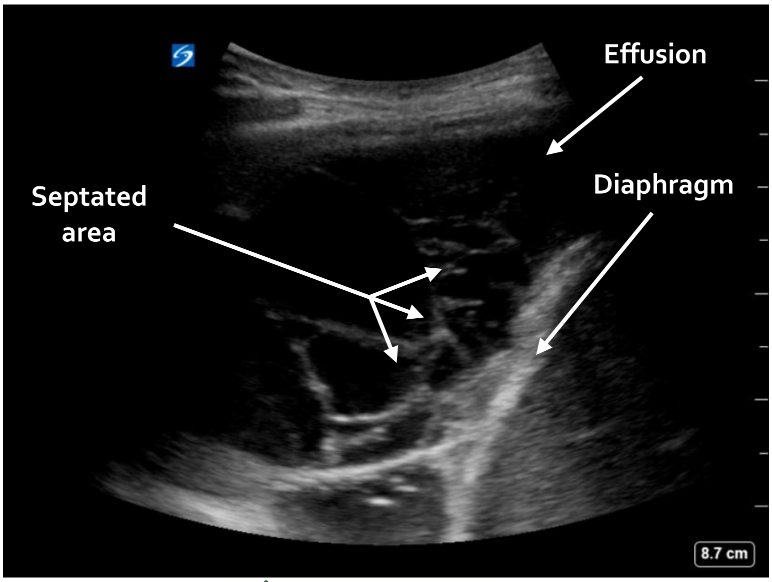
It is important to locate and identify clearly the mediastinal and thoracic structures surrounding the effusion so as not to miss the important differential diagnoses such as a subdiapragmatic collection or dilated left ventricle or ventricular aneurysm.

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



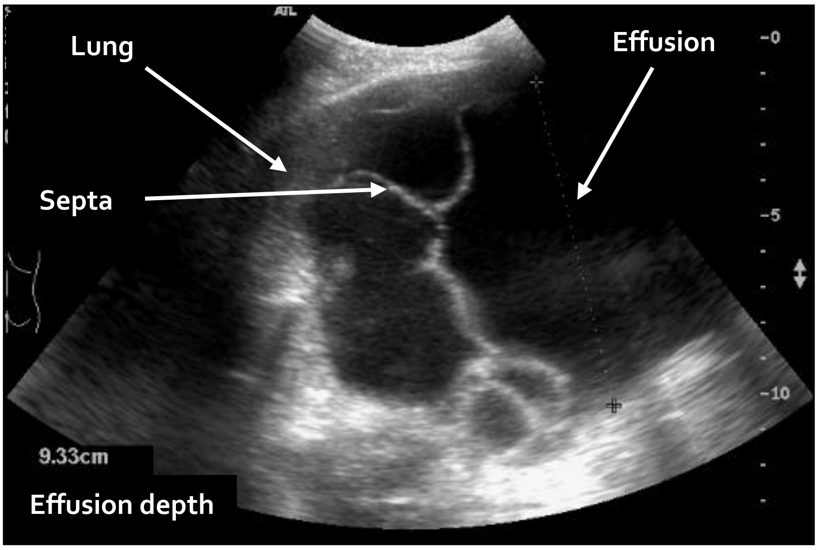
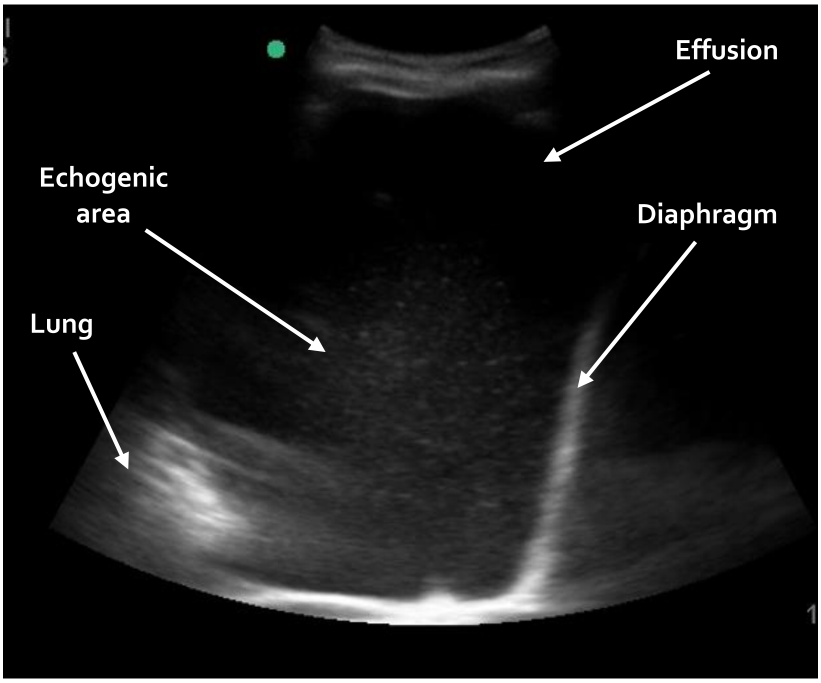
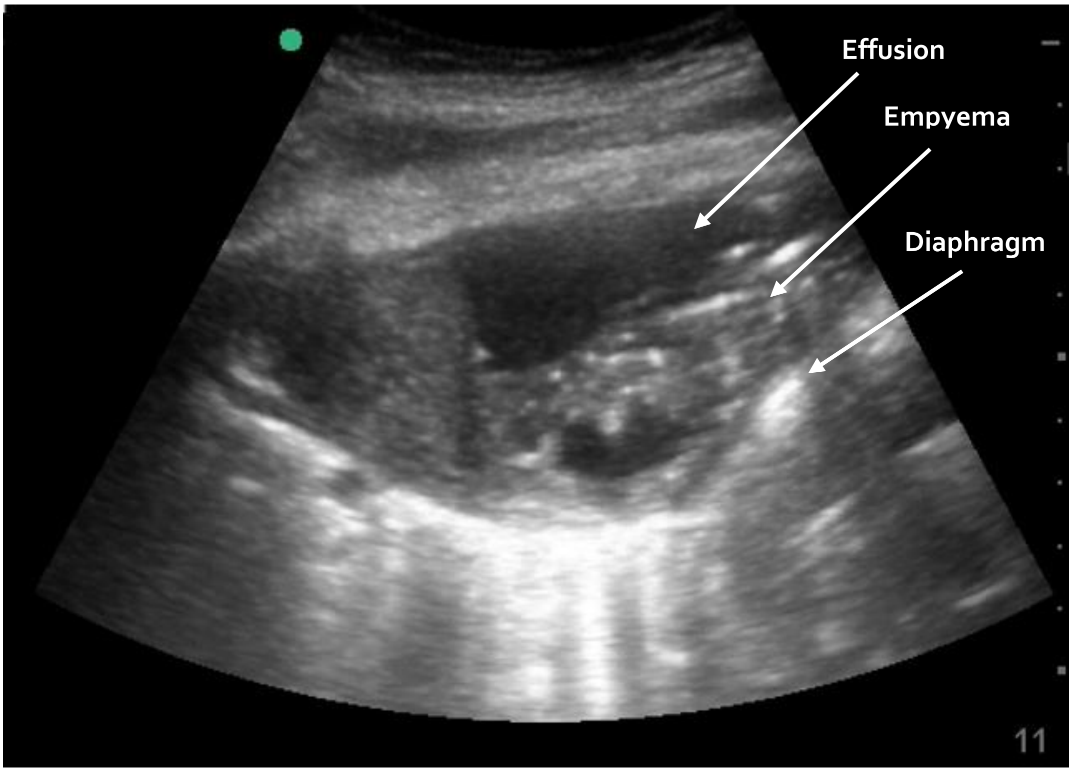


Figure 10. Pleural effusion – Echogenic



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

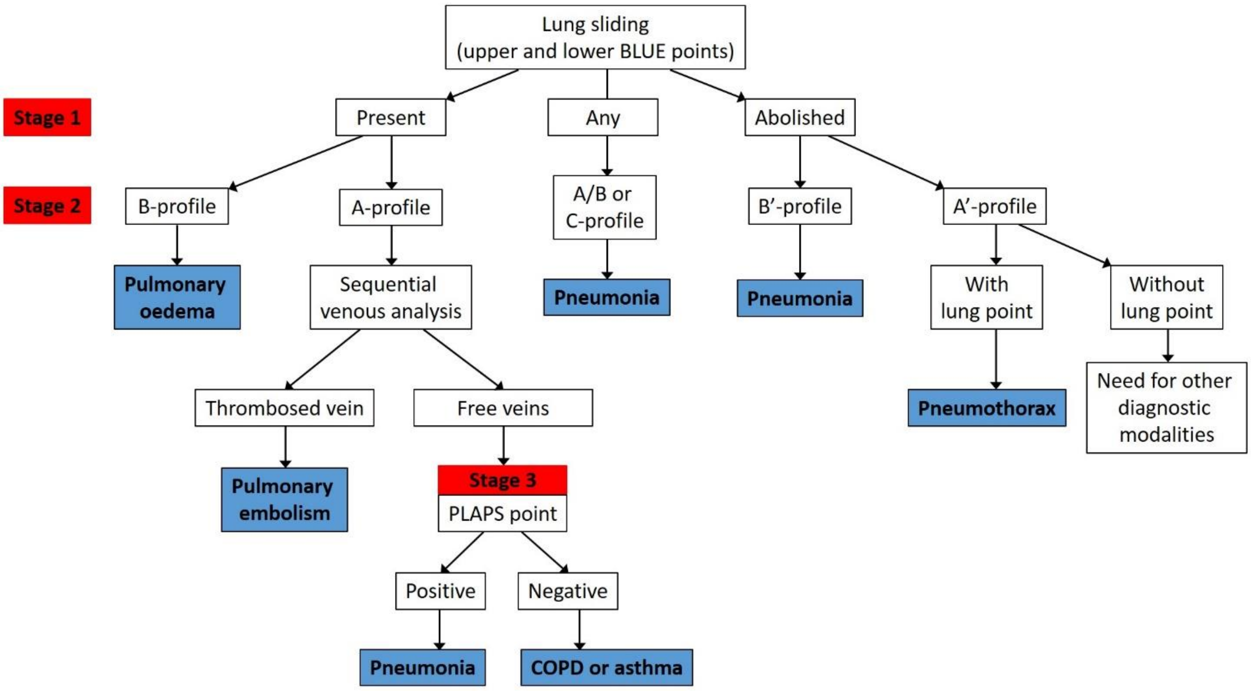
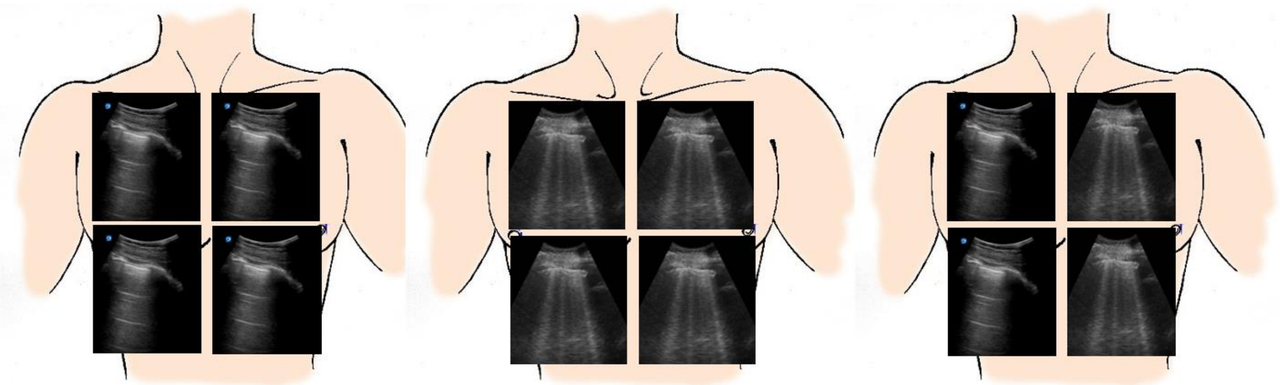


Figure 12. Simplified BLUE Protocol: Once pneumothorax excluded



A Profile (A lines +sliding)	B Profile (sliding)	AB Profile
+ COPD	+ pulmonary oedema	+ pneumonia
+ PE	-COPD	- Pulmonary oedema
+ Posterior pneumonia	-PE	-COPD
- Pulmonary oedema nearly ruled out	- pneumothorax	

VI. Reporting Sheet: Thoracic Ultrasound

Focused Acute Medicine Ultrasound (FAMUS)

Reporting sheet – thoracic ultrasound

Candidate name: Date:

Patient identifier:

Image quality: Good Adequate Poor

		Lung sliding?	A lines present?	B lines present?	Effusion?	Consolidation/ Collapse?
Right	Upper anterior	Yes □ No □	Yes □ No □	Yes □ No □	Yes □ No □	Yes □ No □
Right	Lower anterior	Yes □ No □	Yes □ No □	Yes □ No □	Yes □ No □	Yes □ No □
Right	Postero-lateral	Yes □ No □	Yes □ No □	Yes □ No □	Yes □ No □	Yes □ No □
Left	Upper anterior	Yes □ No □	Yes □ No □	Yes □ No □	Yes □ No □	Yes □ No □
Left	Lower anterior	Yes □ No □	Yes □ No □	Yes □ No □	Yes □ No □	Yes □ No □
Left	Postero-lateral	Yes □ No □	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

Candidate reflection on scan (optional)

e.g how did the scan affect management

Mentor/supervisor comments:

Signed (candidate):

Signed to confirm above findings (mentor/supervisor):

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

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

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

v1.9 Nov 2018