Pneumothorax: an evidence-free space?

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AIMS

- Understand the clinical background to and pre-existing controversies in the management of patients with pneumothorax
- Understand the technical requirements for, limitations and challenges associated with ultrasonography in the patient with suspected pneumothorax
- Understand the key ultrasonographic features that allow the diagnosis of pneumothorax to be either confirmed or excluded
- Understand the evidence base underpinning the use of thoracic ultrasound in patients with suspected pneumothorax

SUMMARY

Clinical background

The management of pneumothorax remains a source of clinical debate and controversy, with a limited evidence base in many areas leading to variation in practice frequently based on anecdote and individual experience. It is important to recognise that the role of thoracic ultrasound in the diagnosis of pneumothorax is equally uncertain – there are fields of practice where the use of ultrasound seems established, and other significant areas where there is little or no evidence at all.

Guidelines generally agree that pneumothorax can be sub-classified into primary spontaneous (PSP); secondary spontaneous (SSP); iatrogenic; and traumatic. The purpose of this is predominantly to guide clinical management given the variation in outcomes in these different groups – PSP is regarded as having low mortality and morbidity (from a clinician’s perspective), as opposed to SSP which has been reported as being associated with mortality in the region of 15%. Furthermore, although SSP is “secondary” to underlying lung disease, there is growing recognition that the lung parenchyma of patients with PSP is also frequently abnormal. The concepts of pleural porosity and emphysema-like change mean there is likely to be an overlapping clinical spectrum seen in this condition between what have been considered to be two distinct groups.

The clinical management of patients with pneumothorax is decided on the basis of likely aetiology, radiological features and clinical symptoms – the latter of which is most important. Guidelines are exactly that and incorporate flexibility to allow clinicians to make individual judgements, recognising limitations in our current evidence base and understanding.

Ultrasound – technical considerations and technique

The use of ultrasound to diagnose pneumothorax has practical advantages over standard chest X-ray – this is particularly the case in specific clinical environments such as the emergency department and critical care where plain radiography is frequently sub-optimal and difficult to interpret accurately.
Ultrasound is portable, available at the bedside and provides the operating clinician with immediate feedback to inform their clinical decision making process.

Ultrasound for pneumothorax (and indeed any clinical condition) should be systematic, thorough and reproducible. It is worth remembering that ultrasound for pneumothorax is arguably the most difficult diagnostic usage to master, and requires a different skill set and level of practice in comparison to other indications (e.g. pleural effusion, interstitial syndrome). The operator must focus initially on non-dependent areas of the chest where free air is most likely to accumulate, utilising an anatomical zoned approach to examination (e.g. upper, mid and lower anterior chest; AAL; MAL etc.) Both longitudinal and transverse views should be employed in each location, along with B- and M-mode assessment to maximise diagnostic yield and accuracy. The hand and probe must be kept steady to avoid causing artificial changes that might confound assessment; and any noise filters or “smoothing” software algorithms employed by the ultrasound machine should be switched off.

Above all else, it is important to remember that ultrasound is not definitive and is merely an adjunct to support clinical assessment. Any findings should be taken in the context of the overall clinical picture, and any obvious discrepancies between the two should prompt further thought and investigation.

**Ultrasound – key findings**

The ultrasonographic diagnosis of pneumothorax is entirely dependent on the absence of normal lung artefacts. Specifically, this includes the loss of features seen with normal lung such as B-lines, Z-lines, lung pulse and sliding signs. A-lines may become multiple and hyper-accentuated, but this is not diagnostic in itself. M-mode imaging will demonstrate the typical “stratosphere” sign (as opposed to “seashore”) caused by static free air and loss of lung movement. The identification of any features that would be considered normal essentially exclude pneumothorax – the presence of lung sliding and B-lines (even just one) in a non-dependent area of the chest has a near-100% sensitivity and specificity for the exclusion of pneumothorax. The interpretation of ultrasound images in this setting requires experience and confidence, and clinicians should beware the potential confounding impact of underlying pathology (e.g. COPD) that can mimic pneumothorax.

**Ultrasound – evidence base in clinical practice**

It is easiest to consider the utility of ultrasound in diagnosing pneumothorax in two different clinical settings. Post-procedural ultrasound assessment with the aim of excluding iatrogenic pneumothorax following e.g. lung biopsy is probably the best established and “safest” clinical use – the operator has the advantage here of being able to compare pre- and post-procedural ultrasound images, and the development of changes consistent with pneumothorax (e.g. loss of lung sliding) is consequently made that much easier. There are a number of published studies relating to this use of ultrasound – whilst numbers are small, the accuracy of ultrasound is excellent and generally outperforms chest X-ray.

The front-door or “point of care” use of ultrasound to diagnose pneumothorax in the acute setting has also been studied – it is worth noting that the majority of work in this field has focused on either critical care patients with e.g. suspected barotrauma or acute respiratory decline; or polytrauma patients in the emergency department. In both these settings chest X-ray is notoriously poor from a diagnostic perspective, and therefore ultrasound (in expert hands) has an automatic advantage. The published studies bear this out, with the sensitivity and accuracy of ultrasound far exceeding supine portable chest X-ray.

There is little to no prospective study data evaluating the use of thoracic ultrasound to diagnose primary or secondary spontaneous pneumothorax at presentation, and this is an area that warrants future assessment – most likely as part of a study looking at the utility of ultrasound in evaluating the acutely breathless patient. There is study data looking at how ultrasound might be used to monitor
patients post-intervention to confirm pneumothorax resolution, and again this shows promise although further research is needed to replicate these findings.

**Ultrasound – limitations**

The most obvious limitation of ultrasound is the operator. Systematic reviews have highlighted operator experience as being critical to the sensitivity and specificity of ultrasound being used to diagnose pneumothorax. Ultrasound findings can be confounded by underlying lung pathology such as COPD or pleural adhesions that can mimic the imaging findings seen with pneumothorax; and there is evidence that even in expert hands (thoracic radiologists) this results in a significant fall in sensitivity and specificity. Ultrasound is also first and foremost a binary test—it allows the operator to say whether or not a pneumothorax is present, but does not allow easy quantification of size in comparison to chest X-ray or CT—an important factor in considering how to manage the patient.

**SUGGESTED READING**

   *This recent and comprehensive review article written by a collection of experts in pleural disease provides an overview of the evidence base and controversies relating to the diagnosis and management of pneumothorax*

   *A meta-analysis looking at the clinical studies that have been done on the use of ultrasound in diagnosing pneumothorax, providing a useful overview of the evidence base (including its limitations) underpinning current practice.*

   *A large early study looking at the point of care use of thoracic ultrasound in the emergency department for the diagnosis of pneumothorax in comparison to chest X-ray, demonstrating its potential utility in this specific clinical scenario.*

   *There is very little data looking at the use of ultrasound in “conventional” cases of spontaneous pneumothorax. This study of patients in the post-acute setting shows how ultrasound can be used to enhance inpatient care away from the front door.*

   *This consensus document is a few years old now and the field has moved on somewhat since its publication—however, it remains a good starting point for the advanced ultrasound enthusiast still and provides a useful overview (as well as a reference point for individual studies) of all aspects of point-of-care ultrasound including its use in pneumothorax.*