How to do it: ultrasound-guided pleural biopsy

D. Ghosh
T.Q. Howes

Dept of Respiratory Medicine, Colchester General Hospital, Colchester, UK

Correspondence
Dept of Respiratory Medicine
Colchester General Hospital
Colchester
C04 5JL
UK
E-mail: dipansu.ghosh@gmail.com

Background

Malignancy is the cause of 40,000 pleural effusions in the UK and 175,000 in the USA [1], with pleural fluid cytology able to diagnose, at best, up to 57% of malignant effusions [2]. Investigative options for cytology-negative exudative pleural effusions include: surgical video-assisted thoracoscopy (VATS); medical thoracoscopic pleural biopsy; "blind" Abrams' needle biopsy; or imaging-guided biopsy. The diagnostic yield of the more invasive medical thoracoscopy is 91–98% [3], while for blind biopsies it ranges 27–57% [4], depending on the underlying condition; the yield is higher for tuberculosis and lower for malignancies. In the UK, the availability of medical thoracoscopy is limited; hence blind biopsy has prevailed as the most common investigation. Imaging-guided biopsy can improve the diagnostic yield, with computed tomography (CT) guidance producing a yield of 87% [5] and ultrasound guidance yielding similar sensitivity when performed by radiologists [1].

What is the best investigation?

The literature would suggest that thoracoscopy, either medical or VATS, is the gold standard and should be practised routinely. Unfortunately, for various reasons, most notably availability, this is not always the case. First, many patients are managed at district general hospitals, with no cardiothoracic surgeons or medical thoracoscopy facilities and, therefore, they have to be transferred for VATS. Secondly, even in hospitals with the necessary facilities, thoracoscopy, whether medical or surgical, is an invasive procedure and the majority of patients are of advanced age and have multiple comorbidities with a higher risk of morbidity and mortality. Thirdly, these procedures are not without complications and medical thoracoscopy has a reported major complications rate ranging 2–15% [6]. There are a wide range of complications. Major complications include bleeding, empyema, pneumonia, persistent air leak, heart failure and myocardial infarction. Subcutaneous emphysema, hypotension and fever are some of the minor complications [6]. This wide range of reported complications reflects the importance of patient selection for this procedure. Many patients with pleural effusions are not fit for medical thoracoscopy or VATS procedures. More recent figures for complication rates are lower because of tighter selection criteria. This improves the safety of thoracoscopy but leaves more patients without a diagnosis. Many units find that scheduling thoracoscopies within busy bronchoscopy schedules also puts pressure on the running of the unit with inevitable delays and missed bed days.

Medical thoracoscopy is usually performed by chest physicians, under local anaesthesia with a rigid thoracoscope, and is essentially a diagnostic procedure. Talc poudrage can also be performed as part of the operation so that further pleurodesis may not be required. Cardiothoracic surgeons use VATS under general anaesthesia and have the added advantage of being able to take lung biopsies, when necessary, and perform decortications in multiloculated empyema. The anaesthetist must pass a double lumen tube and the patient must be fit enough for "one-lung anaesthesia".

Abrams' needle biopsy was developed by L.D. Abrams in 1958 [8]. It is a simple and less invasive technique, hence has fewer complications, and until very recently was widely practised. However, the diagnostic sensitivity has steadily fallen over the years. Studies from the 1970s and 1980s show a sensitivity of ~64%

[9, 10], whereas a very recent retrospective study [4] showed an overall sensitivity of 38% [4]. This fall in sensitivity could be attributed to two factors. Firstly, the disease spectrum has changed over the years as mesothelioma and other malignancies are now much more prevalent and the incidence of tuberculosis (TB), which contributed heavily to the high diagnostic yield, is falling [10]. Also, malignancies require a more targeted sampling than pleural TB, which is more generalised. Secondly, there has been a decline in the skill level. Abrams' needle biopsy is a user-dependent procedure and with falling numbers of TB cases, combined with a reduction in trainee doctors' hours in the UK, it has been difficult to maintain the level of skill needed for this procedure.

There is currently a mesothelioma epidemic. It is important to have a diagnostic test that is reliable, safe and widely available and above all, it is vitally important that the diagnostic yield is improved. One of the simplest ways to do this is by ultrasound guidance. Previous studies have shown ultrasound guidance to have similar sensitivity to CT-guidance [1, 5, 7]. These studies were performed by radiologists but recently, the present authors conducted a study comparing the sensitivity of ultrasound-guided Abrams' pleural biopsy (UGAB) performed by chest physicians, with medical thoracoscopy and previous studies on "blind" biopsies (still unpublished data, Colchester General Hospital) [11]. Though it is not the intention of this article to be an original research paper, references are made to this study as this is the only data available in this area. The study involved ultrasound-guided biopsy on only those patients who were deemed unfit for medical thoracoscopy on clinical grounds and who would otherwise have received no further invasive investigation. This selection bias was due to the inability to randomise patients into guided and "blind" arms, for ethical reasons. A total of 31 patients were included in the study over a period of 1 year, 16 of whom were in the UGAB arm. The data showed a significant improvement with the use of ultrasound, with a diagnostic sensitivity of ~65%, almost twice that of blind biopsy. D. Ghosh learnt chest ultrasound immediately prior to the study and his skills improved as the study progressed. T.Q. Howes was trained in ultrasound as part of his research on the renal tract. Results should improve with further practice of the ultrasound technique.

In many hospitals pleural biopsies are carried out by radiologists using CT guidance. The diagnostic yield is good (87%) but radiation exposure is high [11].

How to do it?

The first and foremost requirement is formal training in the use of the ultrasound machine. There are various courses that provide the basic theoretical aspects of ultrasound in addition to the practical aspects of performing chest ultrasound. Such courses serve as an introduction to ultrasound and regular use and practice, preferably with a radiologist as mentor, are required in order to develop these skills. T.Q. Howes acted as mentor to D. Ghosh prior to and during the study.

The aim of ultrasound guidance is two-fold. First, an area of pleura that might be pathological, *i.e.* a pleural thickening or pleural undulations, should be identified; however, this may not always be possible. Secondly, using the Doppler mode, a safe area from which to take a biopsy must be identified. The biopsy can either be performed immediately, keeping the probe in contact with skin and guiding the biopsy needle; or later, by marking the area and subsequently taking a biopsy, keeping the patient in the same position. The former option is preferred by radiologists, who use Trucut needles that can be manipulated with one hand. However, the Abrams' needle requires the use of both hands; therefore, it is much more convenient to mark the biopsy point and then take the sample when using this device.

Which equipment?

Any decent ultrasound machine will suffice. Most ultrasound machines (*e.g.* Sonosite®) used for inserting central lines have probes for visualisation of deeper structures. Visualisation of superficial structures, like veins or the chest wall, requires a higher-frequency linear probe (5–7.5 MHz), whereas pleural and pulmonary pathology is better detected with a sector or phased-array probe with lower frequency (3.5 MHz). A convex array probe (3.5–5 MHz) combines the advantage of adequate close resolution and the ability to access deeper structures between the ribs [12]. The current authors used a phased array probe in their study.

Positioning the patient

Positioning the patient is extremely important for optimal views. Ideally, the patient should be in a sitting position with hands clasped behind the neck. However, this position may be impractical for elderly patients gasping for breath. In such patients, the use of a supporting table, on which the patient can lean, is beneficial (figure 1). The probe can then be applied to the back.

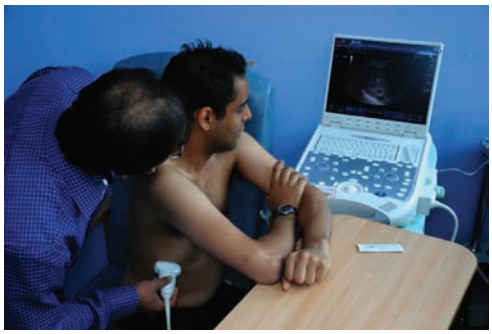

Figure 1
Positioning of the patient.

Scanning the chest

While applying the probe it is important to keep it parallel to the ribs to avoid any interference from the ribs. The probe is moved in an anterior direction from the posterior axillary line along the intercostal space (figure 2). It is good practice to identify a solid structure, such as the liver or spleen, in order to determine the orientation of the probe (figure 3). There is normally less than 1 mm of space between the parietal and visceral pleura. A thin echogenic lining represents parietal pleura (figure 4). The visceral pleura may be slightly blurred due to reflection artefacts from the lung surface. The parietal pleura does not move, whereas the visceral pleura moves with respiration [12].

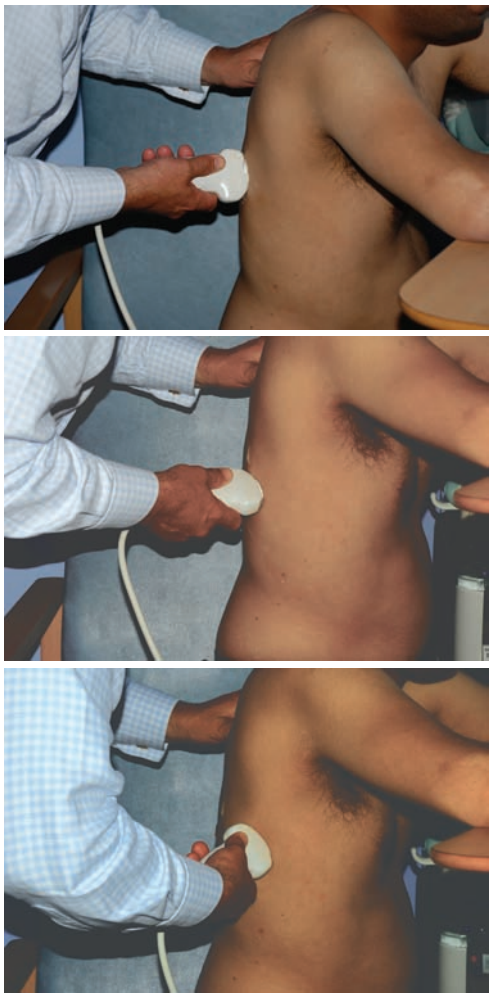

Figure 2
The probe is moved in an anterior direction along the intercostal space.

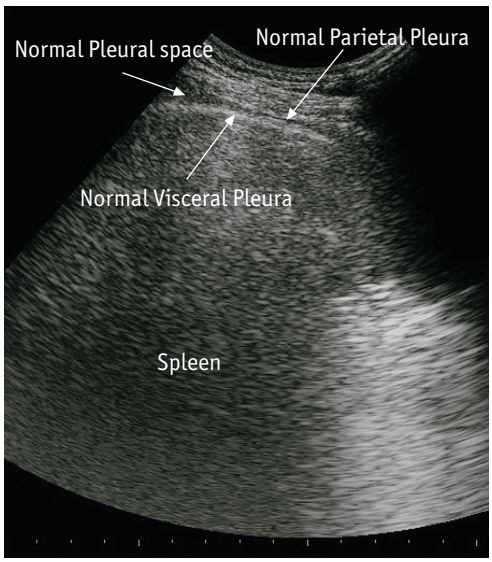

Figure 3
Normal pleural space and pleura.

Pleural effusion is identified as an echo-free or dark area (figure 5). The collapsed lung may be seen as an echogenic area within this dark zone. With experience it is possible to differentiate between transudate and exudate. Transudates have an echo-free pattern. Inflammatory pleural diseases produce exudates that contain fibrous strings and mobile or immobile septae with encapsulated liquid.

Pleural thickening is identified as a thickened layer of echogenic tissue and may be due to pleurisy, empyema or secondary to mesothelioma.

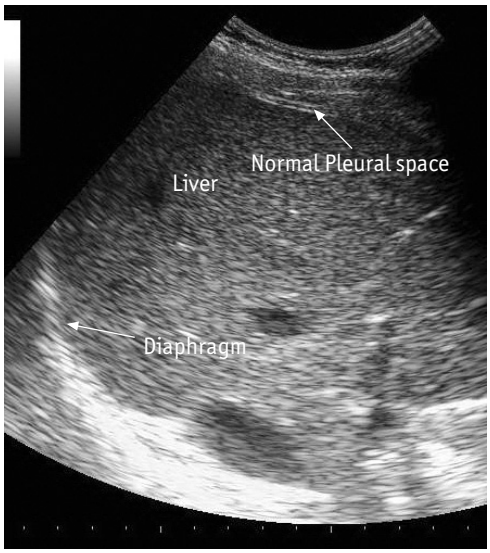

Figure 4
Normal pleural space showing the tiny echo-free area.

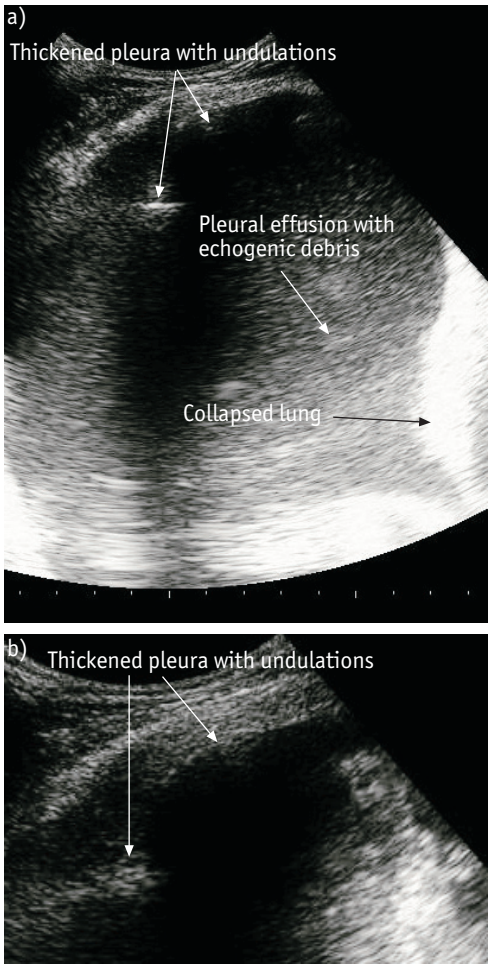

Figure 5
a) Thickened parietal pleura with undulation, pleural effusion with echogenic debris and underlying collapsed lungs. b) Close-up of the thickened pleura.

With the ultrasound scanner it is not possible to differentiate between the two. Metastatic nodules may be detected on the parietal and diaphragmatic pleura. These nodules are echogenic, may be round or polypoid and contrast well against the surrounding tissue or fluid [12].

Once an abnormal area is identified it is marked for biopsy. It is not always possible to identify such an area, in which case the ultrasound is used to ensure the pleural cavity is being entered correctly, with adequate fluid, and to prevent catastrophes like sampling the liver, spleen or even the lungs!

Taking samples

Biopsies are taken under local anaesthetic using a standard Abrams' needle, keeping the patient in the same position. The present authors took at least four samples. Samples were never taken from the 12 o'clock position to avoid damaging the intercostal neurovascular bundle. There is a definite correlation between number of samples and diagnostic yield. In most cases, a Seldinger chest drain was inserted after the procedure.

Lessons from the study

In the current authors' experience, UGAB is a safe procedure with fewer complications compared with medical thoracoscopy. Only one out of 16 patients developed significant pneumothorax requiring a large-bore chest drain. One patient suffered a vasovagal syncope and the procedure was stopped after taking only two samples. In the thoracoscopy arm, four out of 15 patients required a prolonged hospital stay because of surgical emphysema, infections or persistent collapsed lung.

A number of patients were breathless due to effusion or other factors, like heart failure. In such cases the pressure to complete the procedure rapidly may have adversely affected performance. Unfortunately, there is never a good time to carry out these procedures. Patients with overwhelming effusions were drained partially before biopsy was performed. Taking biopsy samples can be difficult in patients where chronic inflammation (empyema) is the final outcome, as the needle tends to slip off the thickened pleura, making it difficult to take adequate samples. Unfortunately, the thickened pleura may represent an underlying mesothelioma and occasionally, the fibrotic sample obtained during a difficult biopsy may not be representative of the underlying condition; thus leading to a sampling error. However, this problem was encountered in both arms of the study; UGAB and thoracoscopy. In situations where it was not possible to identify any obvious pleural abnormality, the ultrasound did at least provide the confidence that the biopsy probe was in the right space.

This modality was found to be extremely helpful in patients with mesothelioma, where sensitivity went up to 80% (overall 64.3%) [11]. However, the diagnostic yield was no better than "blind" biopsies in patients with metastatic pleural effusion, probably representing a failure to identify small pleural deposits that are difficult to find with the ultrasound.

It is important to appreciate that an Abrams' biopsy is not an easy procedure and, like all other practical procedures, it improves with experience. Similarly, ultrasound needs a lot of practice. The current authors strongly believe that access to an ultrasound machine, and formal training in chest ultrasound as part of the specialist registrar training programme, should be standard. Until such time, individual efforts are required to master this very useful modality in order to benefit our ageing patient population.

Indications for UGAB

Exudative pleural effusion with inconclusive cytology when:

- Clinically fit for thoracoscopy/VATS but facility not available on-site.
- Clinically unfit for thoracoscopy due to comorbidities *e.g.* heart failure, pre-morbid poor performance status, poor respiratory reserve, inability to lie flat, unwilling for invasive tests.
- Trained staff to perform Abrams' biopsy with ultrasound guidance is available.

Contraindications:

- Patient unable to sit for 20 minutes
- Coagulopathy

Possible complications: of pleural biopsy

- Pneumothorax
- Introduction of infection to the pleural cavity, can lead to empyema
- Bleeding, usually minor and self-limiting, but if intercostal artery is damaged could be disastrous (avoidable with UGAB)
- Puncturing the lungs (avoidable with UGAB)
- Puncturing the liver or spleen (avoidable with UGAB)
- Vasovagal syncope

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