CT-guided percutaneous lung biopsy

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Introduction
Percutaneous transthoracic lung biopsy (PTLB) is a safe and reliable method of achieving a definitive diagnosis for most thoracic lesions. The procedure can often be performed on an out-patient basis using either fluoroscopic, CT or CT fluoroscopic guidance.

The majority of pleural based, mediastinal and lung parenchymal lesions can be sampled safely. The primary goal is to provide a tissue diagnosis for the patient while minimising discomfort and potential complications.

Indications and patient selection
The result of any invasive biopsy should significantly alter patient therapy. This holds true for PTLB where the risk of potentially serious complications must be weighed against the benefit of a tissue diagnosis for treatment planning and prognosis estimation.

PTLB should be a last resort in obtaining a tissue diagnosis. Abnormal axillary and supraclavicular lymph nodes can be sampled safely under ultrasound guidance. Many mediastinal nodes and some proximal pulmonary parenchymal masses can be sampled at bronchoscopy, using endobronchial ultrasound for more accurate lesion localisation.

The decision to perform PTLB should be made at a pulmonary multidisciplinary meeting with respiratory medicine, thoracic surgery, pathology and medical oncology input. In addition, this provides an excellent forum for continuous audit of all invasive thoracic biopsy procedures.

Consent
Informed consent should be obtained by the radiologist performing the procedure. A detailed explanation of the procedure enables fully informed consent and increases patient compliance during the procedure. Explaining to the patient the important role they themselves play during the biopsy (eg maintaining position and breath holding on instruction) will increase compliance, increase the likelihood of a positive diagnosis and should result in a reduced complication rate.

Set-up and positioning
Patient comfort is vital during the procedure to maintain the desired position. The supine or prone position is best. The lateral position tends to change subtly over time, especially during long procedures. An “arms over head” position is desirable to reduce artefact over the thorax and also serves to minimise patient movement.

Analgesia and sedation
More so than most interventional radiology procedures, PTLB requires the patient to be able to follow simple breath holding commands. Intravenous sedation makes this difficult and in our practice the vast majority of cases can be safely performed under local anaesthesia only. Nevertheless, all cases should be evaluated on an individual basis.

Imaging modality
Fluoroscopic guidance was the modality of choice for many years. This technique allows rapid real-time needle positioning within the tumour.

CT has now become the modality of choice. CT fluoroscopy combines the accuracy of CT with the real-time capabilities of fluoroscopy. CT fluoroscopy is limited by availability and operator radiation dose.

In many cases, ultrasound can be safely used to guide biopsy of pleural based masses.

Technique for CT-guided lung biopsy
Following review of the relevant prior imaging, the patient is positioned in the appropriate position as outlined above.

A linear radio-opaque marker is fixed to the patient’s skin in the region of likely skin puncture. The marker is orientated along the scan plane (in the craniocaudal axis).

There are commercially available radio-opaque grids. However, a 10cm length of disposable wire is equally effective.

A non-contrast CT of the thorax is acquired. This confirms the presence of the target lesion, identifies any change in size or morphology and will detect new lesions.

It should be confirmed at this time that the previously identified target lesion remains indeed the safest target lesion for biopsy.

Needle path
Following the decision to proceed, a planned needle trajectory is calculated on review of the CT. Careful measurements are taken at this time outlining distance from skin to pleura and from pleura to the target lesion.

Local anaesthetic should be administered with care. In slim patients the pleural surface can be reached easily with a 21G (green) needle and a pneumothorax at this stage will often require the procedure to be deferred.

If one can avoid transgressing aerated lung, a pneumothorax cannot occur. This can most readily be achieved in the sampling of lung nodules abutting the pleural surface. Similarly, passage through only collapsed or consolidated lung will greatly decrease the chance of pneumothorax formation.

Finally, lung lesions which abut the mediastinum can be sampled using an extrapleural approach (Figure 1). If needed the extrapleural pathway can be widened by injection of normal saline into the paraspinal soft tissues.

FIGURE 1
18G core biopsy of an anterior mediastinal mass using an extra-pleural approach.

If the pleura must be crossed to access the lesion, steps can be taken to minimise the risk of pneumothorax.

Puncturing the pleura at right angles is preferable as the needle is less likely to tear or slip over the pleura.

If possible, avoid crossing the horizontal or oblique fissure as this will result in needle passage through three layers of visceral pleura rather than one.

The ideal phase of respiration for PTLB is during a held small inspiration, ie within the range of normal shallow breathing. It is important to coach the patient in taking the same volume of inspiration at each scan during the procedure.

Ribs
There is often significant volume averaging from adjacent ribs in a section through the thorax. This can make the ribs appear more crowded than they actually are. 5mm sections through the biopsy path reduce this effect and show the true needle path.
If the needle path remains blocked, the lesion can be “moved” by imaging at a different phase of respiration. A transosseous approach is very rarely required. Due to the projected position of the neurovascular bundle, the needle should pass over (cranially to) the adjacent rib. This is less important when accessing via the anterior approach as the intercostal vessels narrow significantly as they pass anteriorly.

**Core biopsy**
Samples can be obtained using direct passage of a cutting needle or using a coaxial biopsy system. At our institution we use an 18G cutting biopsy needle for single pass biopsies of large thoracic lesions. The main advantage of the direct placement of the cutting needle is that it allows an image to be taken of the cutting needle within the lesion (figure 2).

The coaxial system involves the positioning of a 17G guide needle at the lesion with subsequent passage of a second (18G) biopsy needle through the guide needle to take the sample (figure 3). The main advantage of the coaxial technique is that it allows the operator to take multiple samples from a single image-guided needle position. In addition, a combination of core and FNA sample can be taken. The main disadvantage of the coaxial system is an increased risk of air embolism during needle exchanges (see below).

**Fine needle aspiration cytology**
With a good cytopathology service, an FNA sample is often all that is required to make a diagnosis. A 22G spinal needle is used at our institution. The availability of real-time cytological analysis greatly helps the operator in confirming when an adequate amount of tissue has been obtained.

**Complications**

**Pneumothorax**
Many authors consider a small pneumothorax to be part of the procedure. The majority of patients undergoing PTLB will have a (usually small) pneumothorax detectable on immediate post-procedure CT. When plain radiographs are used to detect a post-biopsy pneumothorax, the incidence rate falls to around 20%. (Bungay HK et al).

The majority of post-procedure pneumothoraces visible on chest radiographs are asymptomatic. However, approximately 5% of all patients undergoing PTLB will require eventual intercostal drain placement.

Factors that increase the risk of pneumothorax include long procedure time, traversing a fissure and a long intrapulmonary biopsy path (Khan MF et al). Patients with poor respiratory reserve are more likely to become symptomatic from a post-biopsy pneumothorax and subsequently require intercostal tube placement. (figure 4).

**Haemoptysis**
A small amount of haemoptysis can be considered normal following PTLB. It occurs in approximately 10% of core biopsies.

It is important to forewarn the patient at time of consent as sudden haemoptysis, no matter how small, can be quite alarming.

Large volume haemoptysis is rare, occurring in less than 1 in 5000pts. Large volume haemoptysis is, however, the most common cause of lung biopsy related mortality (Protopapas Z et al).

**Air embolism**
This is a unique complication of PLB. Air can enter a pulmonary vein branch either directly via the entry needle of a coaxial system or through a fistulous connection (created during the biopsy) between an airway and adjacent pulmonary vein. The air bubble may then pass into the left heart and subsequently embolise to the coronary or cerebral circulation. This can result in myocardial infarction or stroke.

The risk of air embolism is increased in the biopsy of more central lung lesions due to the increased diameter of the bronchovascular bundle (Hiraki T et al).

**Needle track seeding**
Seeding of the biopsy track with malignant cells is a risk in any biopsy procedure. Although such an occurrence is rare in PTLB, some authors propose that PTLB should not be performed in the setting of an operable tumour with imaging findings consistent with malignancy.

**Post procedure**
Some authors advocate placing the patient biopsy side down immediately following removal of the biopsy needle. This has the effect of tamponading the biopsy site (Zidulka et al).

At our institution, a post-procedure low dose non-contiguous CT thorax is taken five minutes following the procedure. This will demonstrate one of three things.

1. **No pneumothorax**
   The patient can be transferred gently to a stretcher and transferred back to the ward for close post procedural monitoring. An inspiratory PA chest radiograph is performed at four hours to assess for a delayed pneumothorax.

2. **Pneumothorax without cardio respiratory compromise**
If the patient remains haemodynamically stable, he or she can be transferred gently to a bed and transferred back to the ward for close post-procedural monitoring. The patient should be placed on 2L of supplemental oxygen for two hours.

An expiratory PA chest radiograph should be performed at four hours or sooner if any worsening of symptoms.

3. Symptomatic pneumothorax

Any deterioration in vital signs, or if the patient complains of shortness of breath or chest tightness, should prompt concern and usually warrants placement of a chest tube.

It is important to fully explain to the patient the importance of rest following the procedure. Inadvertent straining results in raised intrathoracic pressure and can lead to an air leak from the biopsy track and result in a delayed pneumothorax. Studies have shown that relatively innocuous activities such as coughing, sitting up in bed unaided and forced deep inspiration will significantly raise intrathoracic pressure and should be avoided in the six hours following PTLB (Moore et al).

Conclusion

The aim of PTLB is to achieve a diagnosis for the patient while minimising the risk of complications. Careful planning and patient selection, thorough patient education and a high volume of cases performed by experienced staff all lead to improved outcome.

With real-time cytopathological assessment, a diagnosis can often be made on FNA alone.

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References


FIGURE 4a
Portable AP chest radiograph two hours following PTLB of a right upper lobe mass demonstrates a 50% pneumothorax.

FIGURE 4b
PA chest radiograph following radiologically-placed intercostal tube demonstrates resolution of the pneumothorax with full expansion of the right lung. Note the biopsy related perilesional pulmonary haemorrhage.