British Thoracic Society Clinical Statement on pleural procedures

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► Additional supplemental material is published online only. To view, please visit the journal online (http://dx.doi.org/10.1136/thorax-2022-219371).

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► http://dx.doi.org/10.1136/thorax-2022-219630

To cite: Asciak R, Bedawi EO, Bhatnagar R, *et al*. *Thorax* Epub ahead of print: [*please include* Day Month Year]. doi:10.1136/thorax-2022-219371

INTRODUCTION

A total of 21 659 pleural aspirations or drain insertions were conducted in England in 2019/2020 with a combined cost of £13.4 million.[1] There are now a variety of different pleural procedures, which have different invasiveness, risks and benefits, and an abundance of data driving high-quality practice in interventional pleural practice. In the context of a number of national safety alerts related to pleural procedures in the last 10 years, it is therefore important that clinicians are as up to date as possible in interventional practice.

This statement is intended to sit in parallel with the BTS Guideline for Pleural Disease 2023,[2] and with a particular focus on pleural interventions in adults. The statement provides a narrative review of areas not covered in the main guideline.

The main statement focuses on important areas of safe clinical practice, patient selection, evidence for complication rates, the consent process and troubleshooting guidance in the following areas:

- Safety and preparation for pleural procedures.
- Pleural aspiration (diagnostic and therapeutic).
- Intercostal drain insertion.
- Indwelling pleural catheter (IPC) insertion, management and removal.
- Image-guided pleural biopsy.
- Medical thoracoscopy.

Online supplemental appendices cover brief "how to" guides on areas that will be of use to clinicians:

1. Local anaesthetic for pleural procedures (online supplemental appendix 1).
2. Sample consent form for pleural procedures (online supplemental appendix 2).
3. Pleural aspiration (online supplemental appendix 3).
4. Intercostal drain insertion (online supplemental appendix 4).
5. IPC insertion technique (online supplemental appendix 5).
6. Image-guided pleural biopsy (online supplemental appendix 6).
7. Medical thoracoscopy (online supplemental appendix 7).
8. How to set up a chest drain bottle and underwater seal drain (online supplemental appendix 8).
9. How to drain an IPC with vacuum bottle (online supplemental appendix 9).
10. Suction and digital chest drain devices (online supplemental appendix 10).
11. Ambulatory devices (online supplemental appendix 11).
12. Intrapleural treatment guides (online supplemental appendix 12).
13. Sample patient information leaflet—IPC (online supplemental appendix 13).

SCOPE

The purpose of this document is to provide concise and pragmatic guidance to help clinicians in secondary care settings to safely undertake pleural interventions in adults.

The statement addresses adults undergoing the following procedures:

1. Pleural aspiration—diagnostic and therapeutic.
2. Intercostal drain insertion—guidewire and blunt dissection (including suture and securing).
3. IPC—insertion and removal.
4. Image-guided pleural biopsy.
5. Medical thoracoscopy—rigid and semi-rigid.
6. Setting up a chest drain bottle/underwater seal/vacuum bottle for IPC.
7. Digital suction.
8. Ambulatory devices.
9. Intrapleural treatment—talc/autologous blood patch/combined intrapleural tissue plasminogen activator (t-PA) and recombinant human DNase/irrigation.

Areas for future research focus are highlighted at the end of each section.

METHODOLOGY

The clinical statement group (CSG) was chaired by NMR, with membership drawn from experts in respiratory medicine and respiratory nursing. The CSG identified key areas requiring clinical practice points and the overall content was developed to reflect the scope approved by the BTS Standards of Care Committee (SOCC). While BTS guidelines follow the Grading of Recommendations, Assessment, Development and Evaluation (GRADE) methodology for guideline development,[3 4] which includes a full systematic review of the literature, BTS clinical statements focus on a narrative review of the literature to give a 'snapshot in time' of current knowledge and best practice.[5] Following discussions of broad statement content, individual sections were drafted by group members. A final edited draft was reviewed by the BTS SOCC before posting for public consultation and peer review on the BTS website in

June 2022. The revised document was re-approved by the BTS SOCC in October 2022 before final publication.

SUMMARY OF CLINICAL PRACTICE POINTS

Safety and preparation for pleural procedures

- Before carrying out a pleural procedure, safety and preparation should be taken into consideration.

Pleural aspiration (diagnostic and therapeutic)

- Thoracentesis should be performed above a rib to minimise risk of damage to the neurovascular bundle.
- Thoracic ultrasound (TUS) must be used for aspiration of pleural effusion.
- Small bore needles are preferred to minimise the risk of complications from a thoracentesis.
- For therapeutic pleural aspiration >60 mL, a catheter should be used rather than a needle alone.
- Use of the Veress needle may reduce the risk of damaging underlying structures.
- Routine use of pleural fluid manometry does not help to reduce the risk associated with large volume pleural aspiration.
- Therapeutic pleural aspiration should be performed slowly using either manual syringe aspiration or gravity drainage. Vacuum bottles or wall suction should not be used.
- In general, a maximum of 1.5 L should be drained in one attempt.
- The procedure should be stopped if symptoms of chest tightness, pain, persistent cough or worsening breathlessness develop.

Intercostal drain insertion

- Small-bore drains (<14F) are suitable for most indications including draining empyema.
- Larger bore drains should be considered in unstable trauma patients and pneumothorax complicating mechanical ventilation.
- Consider a larger bore drain (>14F) if pleurodesis is intended.
- Before drain insertion, aspiration of air or fluid with the needle applying the anaesthetic is necessary, and failure to do so should prompt further assessment.
- Where possible, using guards over the plastic dilators for Seldinger drains is advised to reduce the risk of insertion of unnecessary excessive lengths of the sharp-tipped dilators.
- All chest drains should be fixed with a holding suture to prevent fall out.
- A chest drain inserted for managing pleural effusion should be clamped promptly in patients with repetitive coughing or chest pain to avoid re-expansion pulmonary oedema (RPO) which is a potentially fatal complication.
- A follow-up chest radiograph should be conducted within a few hours of insertion to ensure appropriate drain position inside the thorax.
- For pleural fluid, the volume to be drained over specific time periods should be specified in the procedure report and in handover (eg, 500 mL/hour).
- In cases of a non-functioning intercostal drain where another drain is required, the old track must be avoided when inserting the new drain.

IPC insertion, management and removal

- IPCs have a well-defined role in malignant pleural effusion (MPE) management.
- The role of IPCs in transudative non-MPE remains controversial and there is currently insufficient evidence to advocate routine use in transudative non-MPE, although they may have a role in selected patients with very frequent therapeutic aspiration requirements despite optimisation of treatment of the underlying pathology.
- An IPC should not be a contraindication to chemotherapy, although judicious IPC insertion timing, and meticulous aseptic catheter care is advisable.
- After both sutures are removed, patients can have a bath and swim, although care should be taken to keep the IPC site clean and dry, such as with a waterproof dressing and prompt changing of the dressing should it get wet.
- There is a lack of robust data on treatment of non-draining septated IPC-related effusions, however, a trial of intrapleural fibrinolytics may be considered in selected patients.
- Consider removal of IPCs when <50 mL are drained on three consecutive occasions and there is an absence of symptoms of fluid reaccumulation and no substantial residual pleural effusion on imaging.
- Drainage frequency should be guided by patient symptoms, unless aiming for pleurodesis in those with expansile lungs, in which case IPC drainage should be as frequent as possible (daily) as tolerated by the patient.

Ultrasound-guided pleural biopsy

- The preferred patient position is lateral decubitus and biopsies should be targeted along the mid-axillary line to minimise complications.[6]
- A real-time, freehand technique is advocated whereby a suitable site is identified using a low frequency probe (2–5 MHz) and the biopsy performed while the patient remains in the same position. Doppler ultrasound screening of the intercostal vessels using the same probe can be conducted to avoid vessels.[7]
- Inferior biopsy sites closer to the diaphragm have shown to be more likely to elicit positive biopsy samples due to the anatomical predilection of secondary metastases to this area.[8]
- A biopsy site with underlying pleural effusion to act as a buffer is preferable to reduce the risk of lung perforation and subsequent pneumothorax. If pleural fluid is not present it is preferable for the procedure to be performed under CT guidance.
- When preparing the cutting biopsy needle, it is helpful to demonstrate the ‘firing’ mechanism of the needle to the patient outside their chest so as not to cause alarm when they first hear the sound.
- The cutting needle should be angled in a way to ensure that the core of tissue obtained will contain the full thickness of the pleura and the needle tip ends in the pleural fluid creating an oblique biopsy tract.
- While an assistant releases the tissue cores into a cytolyte container (with saline for samples for microbiology) and rinses the needle in a small pre-prepared tray of saline between biopsies, it is useful for the operator to intermittently check for any evidence of bleeding by looking for echogenic material gathering in the pleural space, or use of Doppler.[9]
- Usually at least six cores are obtained (extrapolated from TB practice[10]). If the pleura is not very thickened, it may be judicious to perform more (as the number of passes increases, be aware that the introduction of air with each biopsy may negatively impact the quality of the real-time ultrasound image).

How to set up a chest drain bottle and underwater seal drain

(The clinical practice points below are taken from online supplemental appendix 8)

- Aseptic non-touch technique (ANTT) should be employed when changing a chest drain bottle/underwater seal drain or drain tubing.
- The drain bottle must be kept below the insertion site at all times.
- The drain must be kept upright at all times.
- The drain must have adequate water in the system to cover the end of the tube.
- For patients with pneumothorax and suspected/confirmed COVID-19, a viral filter should be considered to minimise the risk of droplet exposure via the chest drain circuit.
- Drains should be checked daily for wound infection, fluid drainage volumes and the presence of respiratory swinging and/or bubbling should be documented on a dedicated chest drain observation chart.
- Clamping a bubbling chest tube should be avoided unless under specialist pleural supervision and in specific circumstances only.
- Instructions related to chest drain clamping/rate of fluid drainage must be given and recorded.[11 12]
- Drainage of a large pleural effusion should be controlled to prevent the potential complication of RPO.

How to drain an IPC with vacuum bottle

(The clinical practice points below are taken from online supplemental appendix 9)

- All manufacturers' drainage packs contain comprehensive procedure guidelines which should be adhered to.
- The rate of fluid drainage should be slowed or stopped if pain is experienced during drainage.
- Antibiotic therapy should be commenced if IPC-related infection is suspected.
- Prompt referral to the respiratory team is required if pleural infection/empyema is suspected.
- Secondary care advice should be sought in the event drainage stops in the presence of worsening breathlessness.
- If the catheter drains less than 50 mL on three consecutive occasions the respiratory team should be contacted for consideration of catheter removal.

Suction and digital chest drain devices

(The clinical practice points below are taken from online supplemental appendix 10)

- Suction should be avoided soon after drain insertion to minimise the risk of RPO.
- Suction pressures should be prescribed or documented by the medical team before it is commenced and institutions should be consistent about the units of suction they use (KPa/mm Hg/cm$H_2$0).
- Routine use of thoracic suction should be avoided given a lack of data demonstrating clinical benefit.
- If suction is used, low pressure, high volume thoracic suction should be used to minimise complications.
- Digital suction devices are an alternative technology that can be used to deliver thoracic suction and measure air leak. This may have a role in patients with pneumothorax.
- Patients receiving suction should have a viral filter or a digital device should be used to minimise the risk of aerosol generation.

Ambulatory devices

(The clinical practice points below are taken from online supplemental appendix 11)

- Build expertise by using the devices for early ambulation on the ward before establishing an ambulatory pneumothorax service.
- A pleural nurse is an essential component of an ambulatory pneumothorax service.

GLOSSARY

ANTT, Aseptic non-touch technique
BMI, Body mass index.
CPAP, continuous positive airway pressure.
CrCl, creatinine clearance.
CSG, clinical statement group.
CT.
CXR, chest X-ray.
DOAC, direct oral anticoagulant medication.
FBC, full blood count.
GMC, General Medical Council.
HCT, haematocrit.
HFFM, high fraction-inspired oxygen facial mask.
HFNO, high-flow nasal oxygen.
ICU, intensive care unit.
INR, international normalised ratio.
IPC, indwelling pleural catheter.
LAM, lipoaribomannan assay.
LAT, local anaesthetic thoracoscopy.
LDH, lactate dehydrogenase.
LFT, liver function test.
LMWH, low-molecular-weight heparin.
LocSSIPs, local safety standards for invasive procedures.
MC and S microscopy, culture and sensitivity.
MPE, malignant pleural effusion.
NEL, non-expandable lung.
NPSA, National Patient Safety Agency.
PTX, pneumothorax.
RCT, randomised controlled trial.
RPO, re-expansion pulmonary oedema.
SOCC, BTS Standards of Care Committee.
TB, tuberculosis.
t-PA, tissue plasminogen activator.
TUS, thoracic ultrasound.
U&E, urea and electrolytes.
US, ultrasound.
UGBx, ultrasound-guided pleural biopsy.

SAFETY AND PREPARATION FOR PLEURAL PROCEDURES

Pleural procedures are commonly undertaken but are associated with significant risks, and thus, consideration of safety and appropriate preparation are key to good practice.

The following were the views of the committee:

Operator training and competence

- The operator for any pleural procedure should have been adequately trained.
- Operators learning to undertake a pleural procedure must be adequately supervised and should record anonymised details of the procedure in their training portfolio.
- Procedures must be appropriately documented in the medical notes (please refer to 'BTS Guidance to support the implementation of Local Safety Standards for Invasive Procedures

(LocSSIPs)-Bronchoscopy and Pleural Procedures'[13]). In line with the BTS guidance,[13] this should include at least:
  - The intervention conducted.
  - All medication given.
  - The recovery plan and observations required postprocedure.
  - Any immediate complications.
- It is advised that all operators monitor procedure outcomes and complications (see relevant sections for major and common complications).

Consent and preprocedure patient written information

- Informed patient consent must be taken and clearly documented before any pleural procedure, in line with General Medical Council (GMC) recommendations.[14] The discussion should include recognised risks and any risk of serious harm, however unlikely it is to occur. For those without capacity, those close to them, or advocating for them, should be involved.
- The decision to proceed should be reviewed immediately before the procedure, especially in cases of delay between consent being taken and the procedure, or if the operator did not take initial consent. It should be made clear to the patient, or their advocate, that they can withdraw their consent at any time.
- In accordance with GMC guidance, an accurate record of the exchange of information leading to a decision must be kept in the medical notes.[14] Consent forms are a standard way to record decisions which can make regular review easier.
- It is advised that written information for the patient is provided, particularly for more invasive procedures. For elective procedures, where possible, written information should be given to the patient to read in their own time.

Timing of pleural procedures

- It is strongly endorsed that pleural procedures are undertaken in normal working hours wherever possible. Procedures should only be undertaken out of hours in an emergency.

Medication check including antiplatelets and anticoagulation

There are no large prospective studies to accurately define bleeding risk associated with pleural procedures in patients who are taking antiplatelet agents, anticoagulant therapy, or those with coagulopathy.

Several small studies have found no increased bleeding risk of thoracentesis or small-bore chest drain insertion in patients on clopidogrel, or with an uncorrected bleeding risk.[8 15–19]

Elective pleural procedures

The risks and benefits of interrupting medication and/or the need for bridging therapy before the procedure should be discussed with the patient. For those with a high thrombotic risk (eg, cardiac stents), the discussion may need to include other relevant specialty teams.[20]

In line with anticoagulation and antiplatelet therapy guidelines, published in the British Journal of Haematology,[21] when a decision has been made to interrupt medication for an elective procedure:

- It is advised that warfarin is stopped 5 days before the procedure with an international normalised ratio (INR) check preprocedure to confirm INR is ≤1.5.
- Direct oral anticoagulant medication (DOAC) should be stopped 24–48 hours before the procedure. The guidance is based on the drug half-life, the bleeding risk of the procedure, a clinical evaluation of individual risk factors for thrombosis and bleeding, and in the case of dabigatran, the creatinine clearance (CrCl). DOAC should be resumed 1 day after a low risk procedure and 2–3 days after a high risk procedure. Daily prophylactic heparin should be considered for patients at high risk of venous thrombosis prior to DOAC recommencement (figure 1). Clopidogrel and prasugrel should be stopped 5 days pre-elective procedure and ticagrelor 7 days preprocedure. Aspirin therapy and prophylactic dose heparin can be continued.
- No specific guidance is given regarding phosphodiesterase inhibitors, such as dipyridamole, but most local guidelines recommend they should be stopped at least 24 hours before a procedure with a high risk of bleeding.

Emergency pleural procedures

If an emergency procedure is required, it may not be possible to fully treat factors associated with increased bleeding risk, particularly in patients who are taking antiplatelet or anticoagulation agents. The operator should consider the risks and benefits of the proposed procedure and the timing of the procedure. Any bleeding risk should be corrected where practical and in complex situations, input from haematology specialist teams may be required.

Environment, procedure room and aseptic precautions

- All required equipment should be available and prepared before commencing any procedure. Procedures should be undertaken in a clean, dedicated procedure room. Procedures undertaken 'at the bedside' should be avoided.

DOAC	Procedural bleeding risk	Perioperative DOAC management									
		Day -5	Day -4	Day -3	Day -2	Day -1	Day 0	Day +1	Day +2	Day +3	Day +4
Direct Xa inhibitors and Dabigatran (CrCl ≥ 50 mL/min)	Low	✓	✓	✓	✓	OMIT	Day of procedure DO NOT administer any DOAC	✓	✓	✓	✓
	High	✓	✓	✓	OMIT	OMIT		OMIT	Resume day +2 or day +3		✓
Dabigatran (CrCl < 50 mL/min)	Low	✓	✓	✓	OMIT	OMIT		✓	✓	✓	✓
	High	✓	OMIT	OMIT	OMIT	OMIT		OMIT	Resume day +2 or day +3		✓

✓ - DOAC may be taken or administered

Figure 1 Usual time to discontinue DOAC before surgery or invasive procedures for which anticoagulation needs to be stopped. (Reproduced with permission of the British Society for Haematology and John Wiley & Sons 2022 British Society for haematology and John Wiley & Son).[149] DOAC, direct oral anticoagulant medication.

- Equipment/stock lists for specific procedures may help with efficiency and ensure supply of equipment.
- In line with BTS Guidance to implement LocSSIPs for bronchoscopy and pleural procedures,[13] the following should be considered:
  - Sufficient floor space.
  - Scrubbing facilities/sink which should be in the room.
  - The presence of an ultrasound machine.
  - Sterile trollies and space for initial sample processing.
  - Oxygen supply and suction.
  - Patient monitoring equipment.
  - Access to the crash trolley with availability of an advanced life support trained individual.
  - Consideration of safe equipment storage both during and after procedures.

Preprocedure physiological parameters

- Physiological measurements should be measured before, and after pleural procedures (and during for longer procedures as required) to ensure complications are recognised and safety is maintained. In the case of abnormal baseline physiological parameters, operators should be aware that these may influence risk and this information should inform discussions as to the risks/benefits.

Safety checklists

A safety checklist should be completed before, and after, all pleural procedures to reduce harm and risk of complications. A local document should be produced for pleural interventions and detailed guidance is available in 'the BTS Guidance to support the implementation of LocSSIPs-Bronchoscopy and Pleural Procedures'.[13]

Important preprocedure checks include:

- Checking site and side of procedure (particularly important in pleural procedures).
- Verification of patient details.
- Review of consent.
- Review of radiology.
- Allergy review.
- Review of bleeding and other patient-specific risks.
- Marking of procedure site if appropriate.
- Review of monitoring equipment.

Important postprocedure checks include:

- Confirmation of the procedure site and side.
- Specimen count and correct label check.
- Recovery management plan.
- Documentation of any equipment issues.
- Completion of the procedure report.
- Medication check and signature.
- Disposal of equipment confirmation.

Preprocedural investigations

A set of routine blood tests (full blood count, urea and electrolytes, liver function test) prior to the procedure are normally conducted to identify potential causes of breathlessness or pleural pathology. There is no agreement on timing of preprocedure blood tests.

Coagulation profile check is not required if there is no past history of coagulopathy and the patient is not on anticoagulants.[22]

In patients with cirrhosis, the EASL (European Association for the study of the liver) guidelines state that traditional haemostasis tests cannot generally predict procedural bleeding risk although they may guide management in the case of postprocedure bleeding. Specific recommendations can be found at EASL Clinical Practice Guidelines on prevention and management of bleeding and thrombosis in patients with cirrhosis.[23]

Preprocedural imaging in the operative position and marking of position

A recent radiological image (chest X-ray (CXR), CT or ultrasound) should be available to confirm the indication for the procedure and side of the pathology.[24] The only exception of note is tension pneumothorax. This is diagnosed using clinical signs and should be treated urgently without imaging if required.

Ultrasound guidance is mandatory prior to pleural fluid procedures (except in emergency situations) and in the position the procedure is done. This allows marking of the appropriate site for the procedure (with the procedure conducted immediately after and without moving the patient) and reduces risk of inadvertently operating on the wrong side. Overall, use of ultrasound guidance in pleural aspiration increases yield and reduces risk of complications; in particular the risk of pneumothoraces and inadvertent organ puncture.[25] Ultrasound guidance will reveal underlying abnormalities not apparent on plain chest radiograph such as cardiac enlargement/displacement, a raised hemidiaphragm or adherent lung.

In patients with pneumothorax, ultrasound is generally not required (as the CXR provides sufficient information and ultrasound does not permit assessment of lung position) but can be useful in locating a site for chest drain insertion in cases of loculated pneumothorax/tethered lung.[26] The use of ultrasound requires training and expertise as described in the British Thoracic Society Training Standards for TUS.[25]

CT guidance may be required in some situations, including loculated pneumothorax with tethered lung, the presence of bullae, or posteriorly loculated pleural fluid collections, where sonographic views are not optimal.

Local anaesthesia

Lidocaine 1% (10 mg/mL) is the most common preparation used for local anaesthesia at a dose of up to 3 mg/kg (max. 250 mg=25 mL). However, there is no consensus on the maximum dose and many use doses of up to 4.5 mg/kg (max. 300 mg or 30 mL) without significant increase in side effects.[27] Combination of lidocaine with 1:200 000 adrenaline allows larger dose of up to 7 mg/kg (max 500 mg or 50 mL of 1% lidocaine) to be infiltrated.[28] Larger volumes (rather than doses) aid spread of the effective anaesthetic area and therefore a dilute preparation (1% rather than 2%) is preferable. Smaller volumes are sufficient for simple procedures such as diagnostic pleural aspiration and larger volumes for more invasive procedures such as medical thoracoscopy.

Please see online supplemental appendix 1 (Local anaesthetic for pleural procedures) for a guide on how to target local anaesthesia for pleural procedures.

General aftercare applicable to all pleural procedures

Patients should be carefully observed after the procedure, with the duration dependent on the specific procedure. For simple procedures (such as pleural aspiration) a set of observations soon after the procedure is sufficient provided that observations remain stable. However, for major procedures, such as thoracoscopy, there is no consensus as to the frequency of observations, but more frequent observations are advisable during and immediately after the procedure (table 1).[12]

Table 1 Advised postprocedure monitoring for pleural procedures

Procedure	Postprocedure observations	Monitoring
Pleural aspiration	Immediately after completion of procedure	None unless admitted
Chest drain or IPC* insertion	Immediately after completion of procedure and at 15 min	Every 30 min for 1 hour followed by four hourly observations (if admitted)
Thoracoscopy	Continuous until completion of procedure and at 15 min	Every 30 min for 1 hour followed by four hourly observations

*IPC insertions should be observed for a minimum of 30 min before discharge.
IPC, indwelling pleural catheter.

Clinical practice point

- Before carrying out a pleural procedure, safety and preparation should be taken into consideration

Research questions

- Do drugs such as clopidogrel need to be withheld in patients undergoing pleural procedures including thoracoscopy?
- Can pleural procedures be undertaken safely within a 20–24 hour window in patients taking low-molecular-weight heparin with normal renal function?

PLEURAL ASPIRATION (DIAGNOSTIC AND THERAPEUTIC)

Indications and relative contraindications

Pleural aspiration (thoracocentesis/thoracentesis) may be performed for diagnostic purposes when a sample of around 50 mL of fluid is removed, or for therapeutic purposes where between 500 mL and 1500 mL is removed to relieve symptoms. Indications[29] and contraindications are summarised in box 1 and box 2. Box 2 identifies relative contraindications to pleural aspiration whereby risks of adverse outcome may be increased, and caution may be required.

Complications

Pleural aspiration is a low-risk intervention; however, the most serious complications such as pneumothorax, haemothorax and RPO can lead to increased morbidity, mortality and healthcare cost.[26 30] Other complications which should be included in the consent process include pain, infection, vasovagal syncope, other organ puncture and procedure failure, including failure to make a diagnosis or improve breathlessness. The frequency of these complications is discussed below.

Pneumothorax

Pneumothorax is the most common complication associated with pleural aspiration, although the incidence varies widely between series. The identification of a pneumothorax on a post aspiration CXR can result from a number of mechanisms:

- Iatrogenic pneumothorax due to an alveolar/bronchopleural fistula caused by either inadvertent puncture of the visceral pleura or shearing of the visceral pleura during lung re-expansion.
- Non-expandable lung (NEL or pneumothorax ex vacuo) where a thickened visceral pleural rind reduces elasticity of the visceral pleura, preventing lung re-expansion when effusion is aspirated.
- Entrainment of air into the pleural cavity through the aspiration device during the procedure.

Therefore, the true incidence of clinically significant postprocedural pneumothorax is difficult to establish, as many small pneumothoraces identified on CXR are a result of entrainment of air or NEL which are of no clinical consequence.

Several studies have demonstrated ultrasound guidance reduces pneumothorax incidence.[31–36] Risk of iatrogenic pneumothorax may be increased when larger volumes of fluid are removed[37–40] in underweight patients[37] and may be related to operator experience and smaller depth of fluid marking.[40] A summary of the risk data is presented in Appendix 1 which can be used as a guide to inform consent discussions.

Bleeding

Bleeding complications following pleural aspiration are uncommon although iatrogenic intrapleural haemorrhage is potentially life-threatening (see Appendix 1).

Appropriate site selection is important to reduce risk of haemorrhage. The aspiration site should always be directly above a rib

Box 1 Indications for pleural aspiration[29]

Pneumothorax
⇒ Spontaneous primary pneumothorax (any size).
⇒ Small secondary spontaneous pneumothorax.

Pleural effusions
⇒ Small volume aspiration for diagnosis.
⇒ Larger volume aspiration to relieve symptoms of dyspnoea.
⇒ Evaluate whether non-expandable lung is present to help guide future management (particularly in MPE).
⇒ In the context of sepsis (suspected empyema), a diagnostic aspiration may help guide management (eg, need for chest drain).

MPE, malignant pleural effusion.

Box 2 Relative contraindications to pleural aspiration

⇒ Uncooperative patient.
⇒ Coagulopathy or concurrent anticoagulation treatment (see safety and preparation section).
⇒ Local infection/cutaneous disease at proposed puncture site.

Pneumothorax
⇒ No safe site for aspiration of pneumothorax (eg, lung tethering, suspicion of bullous disease mimicking pneumothorax, small volume pneumothorax).
⇒ Mechanical ventilation which may increase the likelihood of tension pneumothorax or bronchopleural fistula (chest drain preferred).

Pleural effusions
⇒ No availability of thoracic ultrasound to identify procedure site.
⇒ No safe site for aspiration of fluid identified on thoracic ultrasound (very small or posterior fluid collections (given risk to neurovascular bundle)).

to avoid the neurovascular bundle. A posterior approach should be avoided as the neurovascular bundle may not be covered by the lower flange of the rib in this position.[41 42] The preferred site of insertion of the needle should be the triangle of safety, directly above a rib to avoid accidental puncture of the intercostal vessels.[43]

There are some early data to show it may be feasible to use doppler ultrasound to identify intercostal vessels to minimise the risk of puncture, although there is, as yet, no comparative evidence to suggest this reduces bleeding complications.[7 41]

Re-expansion pulmonary oedema

RPO is a rare but potentially life-threatening complication, characterised by development of hypoxaemia and new diffuse alveolar infiltrates as a result of rapid lung re-expansion, usually occurring within the first hour after thoracentesis.[44 45]

The true incidence of RPO is not well established, particularly as some patients may display radiographic changes on CXR without substantial symptoms and for most, symptoms resolve spontaneously.[46] The largest case series report symptomatic RPO in <1% of patients undergoing thoracentesis.[37 46] The National Patient Safety Agency (2020) recorded 16 UK incidents of RPO over 3 years (including two deaths and one cardiac arrest).[12] As a result, an alert was issued to highlight the risk and ensure close monitoring of patients after chest drain insertion and controlled drainage of large effusions.

RPO has been reported following drain insertion for pneumothorax. Limiting the rate of lung re-expansion in this setting is more challenging given the rare but serious risk of tension by clamping a bubbling drain.

Management of RPO is summarised in box 3.

Minor complications

There is a scarcity of published data regarding incidence of minor complications associated with thoracentesis, particularly related to iatrogenic infection. Symptoms of chest discomfort, cough or low oxygen saturations should prompt early termination of the procedure, but these usually settle shortly afterwards. The consent process should include the risk of failure to make a diagnosis from the diagnostic samples (see online supplemental appendix 2 (Sample consent form for pleural procedures)). Pleural fluid cytology has a diagnostic sensitivity of around 60% for all malignancies,[29 47] however, with the development of personalised oncological treatments, 47% of cytology positive effusions may contain insufficient material to permit molecular testing and guide oncological treatment.[48] The initial pleural aspiration therefore may not achieve either definitive diagnosis or treatment given the recent advances in oncological treatments. The 2015 BTS national pleural procedures and patient safety audit[49] recorded some minor complications in 1162 patients undergoing either diagnostic or therapeutic aspiration (included in Appendix 1).

A brief guide on how to perform a pleural aspiration and the equipment required is shown in online supplemental appendix 3 (Pleural aspiration).

Box 3 Management of re-expansion pulmonary oedema

1. Rapid A–E assessment, including full set of observations.
2. If chest drain in situ for pleural effusion, clamp the drain or stop therapeutic aspiration.
3. Commence oxygen according to target prescribed oxygen saturations.
4. Request urgent CXR to confirm drain position and assess for complications.
5. Consider:
   - ICU referral if appropriate
   - CPAP/HFNO/HFFM (if the patient has a pneumothorax as the indication of drain insertion, a functional, open chest drain must be in situ if CPAP is considered, given risk of worsening pneumothorax and risk of tension by the positive pressure).
   - Opiates and diuretics are suggested by some practitioners (not evidence based).

CPAP, continuous positive airway pressure; CXR, chest X-ray; HFFM, high fraction-inspired oxygen facial mask; HFNO, high-flow nasal oxygen; ICU, intensive care unit.

Size and type of needle

Small bore needles should be used to minimise the risks associated with diagnostic pleural aspiration (often a 21G/40 mm (green) needle is used). Although a number of observational studies have suggested, using univariate analysis, that smaller needles reduce the risk of postprocedure pneumothorax, this association was not maintained when considering other factors in multivariable analysis (thoracentesis method, effusion amount and tap type).[50 51] Other observational case series did not find an association between needle diameter and pneumothorax risk.[52]

If inadvertent puncture of an intercostal vessel or visceral injury occurs during the procedure, smaller needles are theoretically likely to result in less damage than larger needles, although there are no comparative studies.

The depth of the pleural cavity from the skin surface varies between patients and can exceed that of a 21G/40 mm (green) needle often used for diagnostic aspiration.[53] The distance from the skin to the parietal pleura can be measured using ultrasound to select optimal needle length, and measurement of effusion depth can ensure the needle is not advanced too far, risking damage to distal structures.

Commercially available therapeutic pleural aspiration kits generally have a larger needle diameter than would routinely be used for a diagnostic aspiration (6F (2 mm outer diameter) or 8F (2.7 mm outer diameter) vs 0.9 mm outer diameter for a 21G needle).

Speed and method of drainage

Given the rare but potentially serious complication of RPO, the use of pleural fluid manometry to monitor pleural pressure and elastance change has been evaluated, but has not been shown to predict development of RPO.[38] A recent randomised controlled trial (RCT) of 191 patients comparing manometry-guided to symptom-guided large volume therapeutic thoracentesis found no difference in patient symptoms, suggesting that use of manometry does not prevent pain or procedure-related complications.[54]

The speed of pleural fluid drainage may be of importance in preventing complications. Theoretically, slower, more controlled drainage may allow the lung to re-expand more gradually and symptoms/signs that might suggest the onset of RPO (such as worsening breathlessness, hypoxia or chest tightness) to be identified earlier, allowing the procedure to be stopped before more serious symptoms develop. The aspiration kit should include a three-way tap (or equivalent) to allow drainage to be terminated quickly if needed (NPSA 2020).[12]

A recent RCT of 100 patients undergoing therapeutic pleural aspiration compared syringe manual evacuation (n=49) with continuous suction (vacuum bottle or wall system (n=51)) and found that vacuum use was associate with more complications, including pneumothorax (0 in the manual group vs 3 in the vacuum group), haemothorax (0 vs 1, respectively) and RPO (0 vs 1, respectively). Patients in the vacuum group were more likely to have the procedure terminated early (1 vs 8) and suffered more pain, although the procedures were faster. Therefore, manual aspiration appears safer and better tolerated than vacuum drainage.[55]

The GRAVITAS Trial randomised 142 patients undergoing therapeutic pleural aspiration to either active aspiration using a syringe or drainage by gravity. This demonstrated no difference in chest discomfort 5 min after the procedure or discomfort/breathlessness within 48 hours. Gravity drainage took substantially longer, although the amount of time gained was modest (7.4 min (10.2–4.6), mean difference (CIs), p<0.001).[56]

The use of aspiration via syringe or gravity for therapeutic aspiration is therefore advised. Vacuum drainage bottles or wall suction should be avoided in therapeutic thoracentesis.

Volume of drainage for a single procedure

For a diagnostic pleural aspiration, the use of a 60 mL syringe should provide ample fluid for diagnostic sampling. An overview of fluid to be sent routinely and in specific scenarios is summarised in table 2.

The maximum volume that should be safely drained during a single procedure has been subject to debate, given concerns regarding RPO and postprocedure pneumothorax. There are reports of large volumes being aspirated at one time without complication,[46] however, guidance is conservative due to the potentially high mortality of RPO if it does occur. As discussed in the previous section on complications, large volume aspiration may also increase the risk of postprocedure pneumothorax.[37 40]

Table 2 Pleural fluid diagnostics tests and sample collection guidance

Test	Notes		
Fluid appearance			
Advised tests for all sampled pleural effusions			
Biochemistry—LDH and protein	2–5 mL in plain container or serum blood collection tube depending on local policy. Blood should be sent simultaneously to biochemistry for total protein and LDH so that Light's criteria can be applied. Light's criteria: The fluid is an exudate if one or more of the following criteria are met: ► Pleural fluid protein is more than half the serum protein ► Pleural fluid LDH is more than 0.6 times the serum LDH ► Pleural fluid LDH is more than 2/3 the upper limit of normal of the serum LDH		
Microscopy and culture (MC and S)	5 mL in plain container. If pleural infection is particularly suspected a further 5 mL in both anaerobic and aerobic blood culture bottles should be sent.		
Cytological examination and differential cell count	At least 25 mL in a plain universal container. Refrigerate if delay in processing anticipated (eg, out of hours).		
Glucose	Useful in establishing degree of pleural inflammation and the diagnosis of pleural infection where pH measurement is not reliable, and useful in diagnosis of rheumatoid effusion. 1–2 mL in fluoride oxalate tube sent to biochemistry.		
Other tests sent only in selected cases as described in the text			
pH	In non-purulent effusions when pleural infection is suspected. 0.5–1 mL drawn up into a heparinised blood gas syringe immediately after aspiration. The syringe should be capped to avoid exposure to air. Processed using a ward arterial blood gas machine and consider use of a fine bore needle to prevent machine damage.		
Acid-fast bacilli and TB culture	When there is clinical suspicion of TB pleuritis, or in areas of high TB prevalence. Request with MC and S. 5 mL sample in plain container.		
Triglycerides and cholesterol	To distinguish chylothorax from pseudochylothorax in milky effusions.		
		Pseudochylothorax	Chylothorax
	Common causes	► TB ► Rheumatoid arthritis	► Trauma (including thoracic surgery) ► Neoplasia ► Other lymphatic disorders (eg, LAM); TB; cirrhosis; chyloascites ► Idiopathic (10%)
	Triglycerides		>1.24 mmol/L (110 mg/dL)
	Cholesterol	>5.18 mmol/L (200 mg/dL)	Usually low
	Cholesterol crystals	Often present	Absent
	Chylomicrons	Absent	Usually present
Amylase	Pleural fluid amylase/serum amylase >1 may suggest pancreatitis-related effusion. Can usually be requested with routine biochemistry.		
Haematocrit	>50% of serum HCT supports diagnosis of haemothorax. 1–2 mL sample in EDTA container sent to haematology.		
Flow cytometry and cytogenetics	Useful for the diagnosis of haematological malignancy, particularly in undiagnosed lymphocytic effusions (discuss with local haematology lab for guidance on sample container and volume required).		
Pleural fluid ADA	Useful in diagnosis of TB pleuritis in areas of high TB prevalence as a rule out test.		

ADA, adenosine deaminase; HCT, haematocrit; LAM, lipoaribomannan assay; LDH, lactate dehydrogenase; MC and S, microscopy, culture and sensitivity; TB, tuberculosis.

Symptoms of chest tightness, pain or breathlessness during an aspiration may be a marker of impending RPO or non-expandable lung and the procedure should be stopped if these occur.

In light of this, 1.5 L is advised as a maximum drainage volume in one attempt; however, should the patient develop symptoms at a lower volume the aspiration should be stopped. Larger volumes may be aspirated under certain circumstances with monitoring by expert teams.

Postprocedure imaging

Whether to perform a CXR after a pleural aspiration depends on the clinical context.

For immediate safety reasons, if a patient develops symptoms which do not resolve promptly after aspiration, if the procedure is complicated or if multiple aspiration attempts are required, a CXR should be considered to evaluate for possible complications. However, if the procedure is straightforward and the patient is asymptomatic, a routine CXR is not required.

A CXR may, however, be useful in other circumstances; in those with MPE, a postprocedure CXR is useful to identify substantial non-expandable lung, which may alter future decisions regarding appropriateness of talc pleurodesis.[57] CXRs should be considered as a record of the post aspiration appearance, if ultrasound images are not available on PACS.

Clinical practice points

- Thoracentesis should be performed above a rib to minimise risk of damage to the neurovascular bundle.
- TUS must be used for aspiration of pleural effusion.
- Small bore needles are preferred to minimise the risk of complications from a thoracentesis.
- For therapeutic pleural aspiration >60 mL, a catheter should be used rather than a needle alone.
- Use of the Veress needle may reduce the risk of damaging underlying structures.
- Routine use of pleural fluid manometry does not help to reduce the risk associated with large volume pleural aspiration.
- Therapeutic pleural aspiration should be performed slowly using either manual syringe aspiration or gravity drainage. Vacuum bottles or wall suction should not be used.
- In general, a maximum of 1.5 L should be drained in one attempt
- The procedure should be stopped if symptoms of chest tightness, pain, persistent cough or worsening breathlessness develop

Research question

- Does the use of doppler ultrasound to identify intercostal vessels reduce the risk of puncture and reduce bleeding complications?

INTERCOSTAL DRAIN INSERTION

The size of intercostal (chest) drains is measured in 'French' units which equal one third of a mm[58] and thus a 12F drain has an outer diameter of 4 mm. Chest drains are traditionally described as small-bore if their calibre is 14F or less and large bore for larger sizes.[59]

The usual method for inserting small-bore drains is the Seldinger technique (ie, using a guidewire).[60] Large-bore drains (particularly >20F) are mainly inserted by means of blunt dissection. Some chest drains come equipped with a sharp-tipped metal trocar. This can be used as a scaffold to 'thrust' the drain into the pleural cavity without dissection, but this technique should be avoided as it can result in potentially fatal complications.[58 61 62]

The choice of type of chest drain should depend on indication, training/and expertise of the operator. Small-bore drains seem to be associated with less pain during insertion[63 64] while in situ,[63–65] requiring a smaller incision, and leaving a smaller scar which usually does not need a closing suture.[66] On the other hand, large-bore drains have less tendency to kink or block.[66] In a BTS audit of chest drain practices in more than 100 hospitals in the UK in 2011, 88% of chest drains inserted were Seldinger drains (6–16F).[49]

Indications

In general, there are no absolute contraindications for chest drain insertion especially in emergencies.[58] The indications for inserting a chest drain are listed in box 4.

Drain size

Seldinger drains of up to 12F bore are suitable for most indications. In certain situations such as post thoracic surgery, haemothorax in an unstable patient, or pneumothorax with substantial air leak (in trauma, secondary pneumothorax or ventilated patients) a large-bore drain is required.[59 67] In an ex vivo experiment using a model simulating drainage of a massive haemothorax, 28F drains offered the best balance between efficiency of flow rate, less tendency to block and smaller size.[68] Thus, in situations where a larger bore drain is required, sizes larger than 32F are unlikely to be necessary.[69] A consensus statement of four international societies of thoracic surgeons recommended the use of chest drains of 28–32F post thoracotomy.[70]

Spontaneous or iatrogenic pneumothorax[59 67] and pleural infection (including frank empyema[64]) can be managed with chest drains <14F. However, larger-bore drains are the preferred first choice by some operators for cases with secondary spontaneous pneumothorax who may have large air leaks. Patients with pneumothorax that occurs as a complication of barotrauma from mechanical ventilation may be better managed with larger bore drains, as smaller drains appear to have lower success rates.[71] The BTS Guideline for Pleural Disease 2023 can be consulted for specific guidance on the management of pneumothorax due to different aetiologies.[2]

Meta-analyses of studies on different chest drain sizes for pleurodesis show similar risks of procedure failure with large- and small-bore drains.[72 73] However, these meta-analyses combined results from observational and interventional studies. The only RCT with adequate sample size found small-bore drains to be non-inferior to large-bore drains in terms of pleurodesis efficacy.[65] Chest drains inserted with a view to talc slurry pleurodesis should be at least 12F (and probably of larger size to ensure

Box 4 Indications for chest drain insertion

⇒ Pneumothorax failing other treatments.
⇒ Simple drainage of large benign or malignant pleural effusions.
⇒ Symptomatic pleural effusions in patients on mechanical ventilation.
⇒ Talc pleurodesis.
⇒ Pleural infection.
⇒ Traumatic haemothorax and/or pneumothorax.
⇒ Post thoracic cavity procedures (ie, medical thoracoscopy, thoracic, oesophageal or cardiac surgery).

good quality pleurodesis, eg, 18F) as smaller drains may easily block with talc particles.

In trauma patients with haemothorax or pneumothorax, it is customary to insert large-bore drains which are less susceptible to blockage with blood clots and are better able to handle large air leaks.[59 74] While this is the case for unstable trauma patients, several studies have challenged this tradition for more stable patients. In cases of traumatic pneumothorax 14F drains were as effective as 28F drains with no increased complications.[63 75] Similarly, small-bore drains have been used to drain traumatic haemothorax in stable patients with no excess failure or complication rate.[74 75]

Procedure planning

Patient positioning, choice of insertion site and a brief procedure guide are covered in online supplemental appendix 4 (Intercostal drain insertion).

Complications

Despite being considered a generally safe procedure, chest drain insertion is associated with complications in 8%–20%.[76–79]

Mortality directly related to chest drain insertion is related to either the occurrence of RPO or organ puncture.[80] Fortunately, mortality is rare and has not been encountered in large series by Jackson *et al*[76] and Kong *et al*,[81] but a mortality rate of 0.1% was reported in the 2015 BTS Pleural procedures and patient safety audit.[49] Many of the serious complications involving organ damage have been reported in procedures where the 'trocar technique' was used.[58 61 62] Reported rates of organ puncture vary from 0% to 0.6%.[49 76 77 81] Complications are grouped as immediate, insertional or delayed and a table summarising the rates of different complications is shown in Appendix 2.

Post insertion care

The rate of fluid drainage after insertion should follow the advice above to avoid RPO. Regardless of volume, chest drains should be promptly clamped in any patient with repetitive coughing or chest pain to avoid complications.[62] Pneumothorax drainage, particularly when pneumothorax size is large, carries a risk of RPO which is evident radiologically in up to one third of cases, although a minority are symptomatic.[82] Therefore routine application of suction at the initial drainage of pneumothorax is not advised.[61] Management of RPO is detailed above.

An intercostal drain insertion report should mention details of sutures used, distance at which the drain was fixed, colour of fluid drained, instructions for when to clamp/unclamp the drain, follow-up imaging needed and who to contact in case of complications with the drain. In locked drains, instruction on how to release the lock prior to removal must be clearly documented. A follow-up chest radiograph should be conducted within a few hours of insertion to ensure appropriate drain position. It is good practice for the operator inserting the chest drain to prescribe appropriate analgesia, prophylactic anticoagulation, and 6–8 hourly 30 mL saline flushes (for small bore drains) to ensure this is not missed in handover.

Removal

The decision to remove a chest drain depends on the clinical situation. In pneumothorax, when there is full lung re-expansion and cessation of air leak, performing a 'clamping trial' (to unmask a less visible air leak) is not uniformly performed. In a 2001 American College of Chest Physicians panel on pneumothorax management, only half of panel members would conduct a clamping test before removing a chest drain for a patient with a primary (47% of the respondents) or secondary (59% of the respondents) pneumothorax.[83] Retrospective data from traumatic pneumothorax series show conflicting results on whether clamping trials reduce need for further ipsilateral invasive pleural procedures.[84 85] Notably, in one of the studies, a clamping trial unveiled a small air leak in two of 214 cases (<1%). Prospective studies are needed to inform practice and to explore the potential utility of digital suction devices in measuring extent of air leak prior to chest drain removal.

The task of drain removal should be conducted by suitably trained individuals depending on setting. In some settings, nurses are trained in removal of Seldinger and large bore drains. The timing of removal (whether at the end of inspiration or expiration) does not seem to have a bearing on risks of a large residual pneumothorax[86 87] as long as a Valsalva manoeuvre has been performed.[88] The removal should occur using a steady continuous pull followed quickly by occlusion of the wound with a swab.[61] With large-bore drains, it may be useful to have an assistant to tie the closing suture,[89] however, this can be done by the person removing the drain after a few seconds of occluding the wound.

A post removal chest radiograph should be considered to check for complications, particularly re-accumulation or appearance of pneumothorax.

Troubleshooting

Surgical emphysema

The development of surgical (subcutaneous) emphysema following chest drain insertion for pneumothorax and thoracoscopic procedures[90] is common and is often of minimal clinical consequence. However, in certain instances, substantial amounts of air can progressively accumulate subcutaneously. Risk factors include drain blockage and poor drain placement or fixation (leading to migration of the side-holes subcutaneously) in the context of large air leak.[61 90] Figure 2 summarises the management of problematic surgical emphysema.

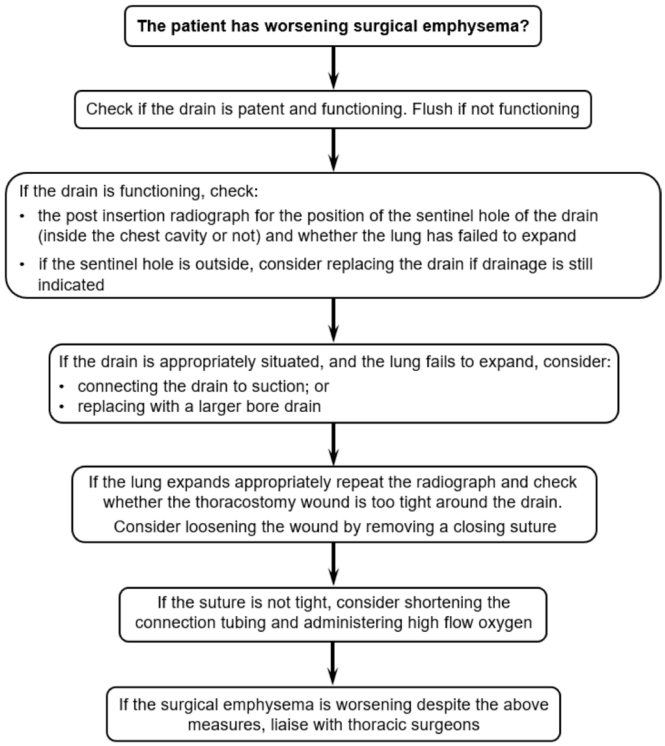

Figure 2 Management of problematic surgical emphysema.

Non-functioning drain

The cessation of swinging of liquid in the drain tubing is usually a manifestation of drain blockage which is often resolved with simple saline flushing. The full length of the drain and the tubing should be inspected to rule out any kinking as a cause of drain non-function.

The assessment of a non-functioning chest drain is summarised in figure 3. Where high flow oxygen is used, caution should be employed in those with chronic lung disease and an arterial blood gas considered after 30 min to ensure hypercapnia is not developing.

Malposition on follow-up radiology

As long as a chest drain is functioning and all side-holes are within the thoracic cavity, regardless of where the tip of the drain lies, changing the position of the drain or replacement should not be attempted. The exception is when the drain is too far in with symptoms suggesting irritation of the pleura, where withdrawing the drain to some degree is advised to relieve symptoms. For misplaced or poorly placed drains that are too far out, pushing the drain in is contraindicated as this carries a risk of introducing infection. In such a situation, or if a drain is completely dislodged, the need for further drainage should be considered carefully, and if deemed necessary, another site chosen[61] since the original wound will be challenging to appropriately anaesthetise or clean.

Thoracostomy wound leakage

Leakage of fluid from around the drain is seen with large volumes of pleural effusion with wide thoracostomy wounds and is usually exacerbated when the drain is clamped or blocked. In most instances the leakage ceases with thorough drainage of the effusion, but to avoid consistently wet dressings which may predispose to chest wall cellulitis, a simple interrupted suture may be required to narrow the aperture around the drain.

Clinical practice points

- Small-bore drains (<14F) are suitable for most indications including draining empyema.
- Larger bore drains should be considered in unstable trauma patients and pneumothorax complicating mechanical ventilation.
- Consider a larger bore drain (>14F) if pleurodesis is intended.
- Before drain insertion, aspiration of air or fluid with the needle applying the anaesthetic is necessary, and failure to do so should prompt further assessment.
- Where possible, using guards over the plastic dilators for Seldinger drains is advised to reduce the risk of insertion of unnecessary excessive lengths of the sharp-tipped dilators.

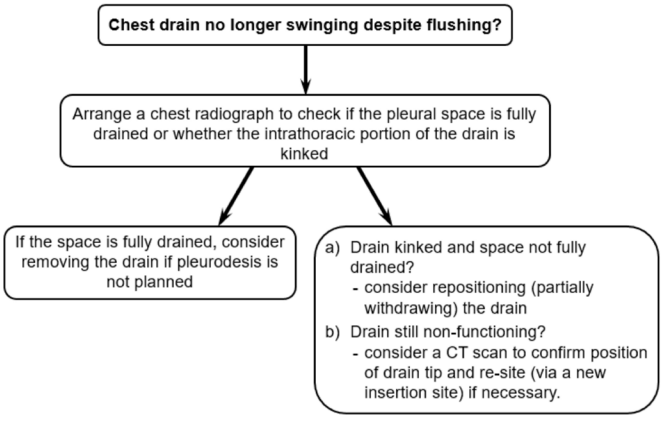

Figure 3 Assessment of a non-functioning chest drain.

- All chest drains should be fixed with a holding suture to prevent fall out.
- A chest drain inserted for managing pleural effusion should be clamped promptly in patients with repetitive coughing or chest pain to avoid RPO, which is a potentially fatal complication.
- A follow-up chest radiograph should be conducted within a few hours of insertion to ensure appropriate drain position inside the thorax.
- For pleural fluid, the volume to be drained over specific time periods should be specified in the procedure report and in handover (eg, 500 mL/hour).
- In cases of a non-functioning intercostal drain where another drain is required, the old track must be avoided when inserting the new drain.

Research questions

- What is the clinical utility of routine suction use in managing pleural infection, pneumothorax and pleurodesis?
- What is the utility of 'clamping trials' prior to removal of chest drains inserted for pneumothorax?

IPC INSERTION, MANAGEMENT AND REMOVAL

IPC insertion and removal

The procedures for IPC insertion and removal are detailed in online supplemental appendix 5 (IPC insertion technique).

Indications for IPC insertion

IPC insertion is indicated as first line for recurrent MPE according to patient choice (on the basis of two randomised trials), and in the setting of non-expandable lung (on the basis of small case series) or as second line after failed chemical pleurodesis (on the basis of clinical practice). IPCs may be considered in selected patients with recurrent non-MPEs.[91 92]

IPCs in patients undergoing systemic chemotherapy with possible neutropenic side effects

There is no robust evidence to suggest IPCs increase the risk of infection in those receiving chemotherapy. In a study of 262 IPCs for MPE and an overall IPC-related infection rate of 6%, there was no statistically significant difference in IPC-related complications comparing patients receiving chemotherapy and those not receiving chemotherapy (9/173 (5.2%) vs 7/89 (7.9%), respectively (p=0.4)) and no difference in pleural infection rates.[93] These findings have been replicated elsewhere.[94 95] An IPC should therefore not be a contraindication to chemotherapy; however, careful consideration of IPC insertion timing, and meticulous aseptic catheter care are advisable.

IPC duration in situ

IPCs are designed to be a permanent solution to recurrent pleural effusions and therefore have no defined limit on how long they can be kept in situ. The risk of IPC-related pleural infection increases with duration of IPC (4.9% of 1021 patients with IPC, after a median of 62 days after IPC insertion), highlighting the importance of patient and carer education regarding fastidious care of the IPC.[96] The polyester cuff stimulates granulation tissue formation and fibrosis which anchors the drain in place decreasing the chance of catheter fall out, and provides a barrier to infection.

Indications for IPC removal

Successful IPC-related pleurodesis is defined in several clinical trials as <50 mL drainage from the IPC on three

consecutive occasions, absence of symptoms of fluid re-accumulation, and absence of substantial residual pleural effusion on imaging.[97–99] It would be reasonable to use these same criteria in clinical practice when planning IPC removal. IPC-related spontaneous pleurodesis has previously been reported in around 45% of IPC insertions according to a systematic review published in 2011.[100] However, lower rates of 23%–24% have been reported with standard IPC drainage protocols in more recent and robust RCT studies, and this likely reflects the 'real' pleurodesis rate.[97 99]

Other reasons for IPC removal include intractable pain, IPC-related skin/pleural infection which do not resolve with antibiotics and fluid drainage alone, irreparable device damage, and irreversible IPC blockage with ongoing fluid formation.

Talc can be instilled via IPC, allowing the option of chemical pleurodesis in an outpatient setting, and was associated with a 43% rate of pleurodesis vs 23% without talc at 35 days after IPC insertion.[97]

IPC care after insertion and advice to give patients

Baths, swimming

A waterproof dressing is usually applied after IPC insertion, and patients are advised to avoid swimming and having baths until the suture(s) are removed (usually after 7–10 for the closing suture, and 21 days for the holding suture (see figure 4), with the latter used in some centres to provide added security to the IPC while the cuff is granulating). Provided the IPC site is kept clean and dry, patients should be able to shower normally. After both sutures are removed, patients are usually advised that they can have a bath or swim, although ideally these activities would be undertaken in a way that allows the IPC site to be kept clean and dry such as with a waterproof dressing and prompt changing of the dressing should it get wet. Ideally, these activities should be timed with drainage so that a clean and dry dressing can be applied after the activity and IPC drainage.

Drainage frequency

The usual starting drainage frequency is three times per week, however, recent evidence suggests that daily drainage increases pleurodesis rates and shortens time to pleurodesis compared with alternate day drainage or symptom-guided drainage.[98 99] Daily drainage should be considered in patients with expandable lung and where pleurodesis is a priority, and where drainage does not cause undue patient discomfort. However, daily drainage frequency has cost and patient impact implications. Drainage can be performed by community nurses at the patients' home, or by the patient or relatives. If daily drainage is not possible, such as in the case where access to community healthcare staff may be limited, or if the patient does not tolerate this, drainage should be as frequent as possible as tolerated by the patient.

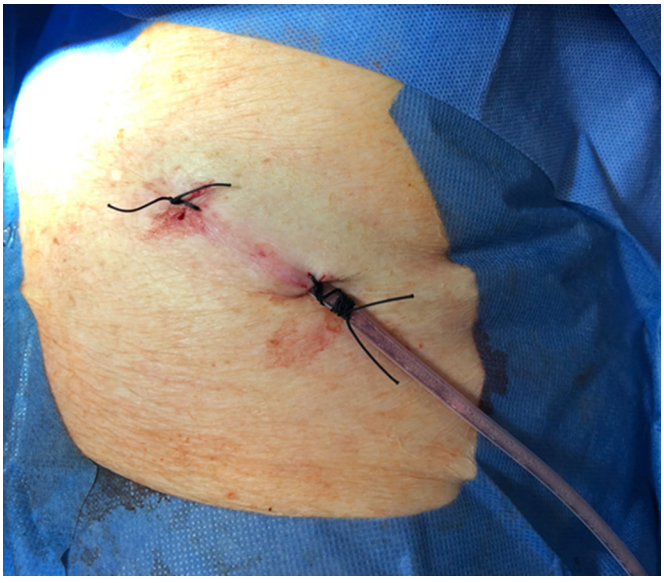

Figure 4 Image showing an IPC immediately after insertion, with a closing suture (left) and a holding suture (right) anchoring the IPC. IPC, indwelling pleural catheter.

Drainage volume

Usually around 500 mL are drained, but up to 1500 mL pleural fluid may be drained—the maximum recommended by guidelines (Grade C recommendation) although this is arbitrary and based on the fact that complications rarely arise when draining this volume at one go.[43] However, in practice, smaller volumes tend to be drained, as tolerated by patients, and drainage stopped if the patient develops chest discomfort or persistent cough.

IPC-related complications

IPC-related complications can be divided into:

1. Procedure-related complications
   These are similar to other pleural procedures (see above). Unsuccessful insertion occurs in 4%.[101] It is common for air to become entrained in the pleural cavity during the procedure, and appear as a small pneumothorax on the post procedure CXR. This usually resolves spontaneously or is drained from the pleural cavity during the first IPC fluid drainage. Larger collections of air, especially if associated with pain, should raise concern about underlying visceral injury, although may be indicative of underlying non-expandable lung. Subcutaneous emphysema has been reported after IPC insertion, although usually in the setting of IPC insertion post video-assisted thoracoscopic surgery (VATS).[102]
2. Complications associated with the IPC being in situ
   Pain or discomfort at the IPC insertion site for a few days after the procedure can be managed by simple analgesia. Other IPC-related complications are summarised in Appendix 3. IPC mechanical issues including failure or detachment of the one-way valve or detachment occur rarely. Makeshift solutions have been reported with valves from new IPC kits fitted onto the original IPC[103 104]; however, our advice is to replace the IPC to minimise the risk of infection or air entrainment through an open IPC end.
3. Complications associated with IPC removal.
   Inability to remove the IPC can occur if the intrapleural portion of the IPC has become enveloped and trapped by pleural tumour anchoring the intrapleural part of the catheter, or if the cuff is unable to be freed of extensive fibrous tissue, particularly if the IPC has been in situ for several months. The external portion of the IPC can be severed under tension, allowing the proximal intrapleural and subcutaneous portion of the IPC to retract into the pleural space, and the remaining portion cut flush with the skin. This results in a retained IPC fragment within the pleural space and subcutaneous tissue but does not seem to be associated with long-term complications such as pain or infection.[105]

Catheter fracture has been reported to occur on attempted IPC removal, although rare (n=1 of 202 (0.5%) IPC insertions) also leading to a retained IPC fragment.[106] In the presence of an IPC retained fragment, early review of the patient is advised to ensure no complications develop.

A table showing IPC-related complications, rates of occurrence and management is shown in Appendix 3.

IPC use in transudative non-MPE

IPCs were originally licensed for use in MPE in 1997, but were only approved for use in non-MPE in 2016.[107] Medical management is usually sufficient for non-MPE, however IPC may be considered in selected cases.

Using IPC in non-MPE has shown patient satisfaction and symptom benefit,[108–111] however, is less likely to lead to pleurodesis when compared with MPE.[108] IPC-related complication rates appear similar between MPE and non-MPE, with 5% empyema rate reported in most studies,[91 109] although reported in 16.1% (n=10) in a study of 62 IPC insertions in patients with hepatic hydrothorax.[112]

Since publication of the above case series (which suffer with inherent bias), the first RCT of IPC treatment vs standard care (pleural aspiration) has been published. The REDUCE trial randomised 33 patients to IPC treatment, and 35 to as needed pleural aspiration. There was no difference in overall breathlessness between the two groups, despite far greater fluid drainage in the IPC group (17.4 L vs 2.9 L over 12 weeks) with the aspiration group undergoing three aspirations on average in the trial period. There was, in addition, a statistically significant excess of adverse events in the IPC group compared with aspiration.[113]

On this basis, we do not in general endorse IPCs in the treatment of transudative effusion. Their use may be considered where repeated aspiration (>3 events) is required despite full optimisation of the cause of the effusion (eg, cardiac/liver/renal dysfunction), and where risks of complications of pleural interventions (eg, clotting abnormalities) are high, with full discussion of potential risks and benefits.

Successful IPC use in empyema has been reported in cases of failed surgical management or where surgical management was not possible due to patient frailty or comorbidities,[91 114]; however, there are no large studies or case series available in the literature. Routine use of IPC in acute empyema is not advised but there is a possible role in selected cases.

Fitness for technique

General contraindications to IPC insertion include those common to any pleural procedure (see above). Contraindications specific to IPC insertion include inability for the patient to tolerate the catheter, inability for the patient, relatives or healthcare services to manage and support the outpatient management of the IPC, cellulitis or significant malignant infiltration of the skin at the proposed IPC insertion site, and pleural infection with evidence of ongoing sepsis.

In general, IPC is considered in patients whose life expectancy is likely to be longer than a few weeks, during which time the pleural effusion is likely to reaccumulate. However, during the COVID-19 pandemic, IPC was often a preferred option to chest drain insertion and talc pleurodesis across many centres because of an attempt to keep patients, especially those with cancer and immunosuppression, out of hospital as much as possible. This is likely to have lowered the threshold for IPC insertion in preference to therapeutic aspiration in frail patients with a short life expectancy.

IPC removal

Indications

For indications of IPC removal, please see the 'IPC insertion, management and removal, Indications for IPC removal' section above

Catheter tract metastases

Pleural tumours, especially mesothelioma, can spread along instrumentation sites, leading to catheter tract metastases. This has been noted to occur in association with IPCs in 6.7% of cases, but usually does not necessitate IPC removal.[115] Two RCTs, one of which included IPCs, have not shown any patient benefit from prophylactic irradiation of pleural procedure sites.[116 117] Should pain develop from the chest wall metastases and is resistant to analgesia, localised radiotherapy may be considered.

Clinical practice points

- IPCs have a well-defined role in MPE management.
- The role of IPCs in transudative non-MPE remains controversial and there is currently insufficient evidence to advocate routine use in transudative non-MPE, although they may have a role in selected patients with very frequent therapeutic aspiration requirements despite optimisation of treatment of the underlying pathology.
- An IPC should not be a contraindication to chemotherapy, although judicious IPC insertion timing, and meticulous aseptic catheter care is advisable.
- After both sutures are removed, patients can have a bath and swim, although care should be taken to keep the IPC site clean and dry, such as with a waterproof dressing and prompt changing of the dressing should it get wet.
- There is a lack of robust data on treatment of non-draining septated IPC-related effusions (see Appendix 3), however, a trial of intrapleural fibrinolytics may be considered in selected patients.
- Consider removal of IPCs when <50 mL are drained on three consecutive occasions and there is absence of symptoms of fluid reaccumulation and no substantial residual pleural effusion on imaging.
- Drainage frequency should be guided by patient symptoms, unless aiming for pleurodesis in those with expansile lungs, in which case IPC drainage should be as frequent as possible (daily) as tolerated by the patient.

Research questions

- Studies to investigate the role of fibrinolytic treatment in septated effusion related to IPC use in MPE patients.
- Studies addressing the use of single or dual stiches after IPC insertion.

ULTRASOUND-GUIDED PLEURAL BIOPSY

Introduction

In circumstances where local anaesthetic thoracoscopy (LAT) is not feasible, physician-based ultrasound-guided cutting needle pleural biopsy provides a less invasive modality of pleural tissue sampling (please refer to the BTS Guideline for Pleural Disease 2023, 'What is the diagnostic accuracy of pleural biopsy?' section[2]).

Traditionally, ultrasound-guided pleural biopsy (UGBx) has been the domain of specialised radiologists. However, in 2004, Diacon *et al* reported one of the first experiences of a pleural biopsy service led by respiratory physicians where lesions >20 mm in diameter were biopsied under US guidance with

a 14G cutting needle in 91 patients. They reported an overall sensitivity for malignancy of 85.5% with a low complication (4%).[118] Since then, with the increasing use of TUS, the practice has extended to more centres, although is still far from commonplace. More recently, a retrospective review of physician-led UGBx in a UK pleural service obtained sufficient sample for a histological diagnosis in 47 of 50 pleural biopsy procedures (overall sensitivity 94%). Both studies demonstrate yields and complication rates comparable to those reported by radiologists for image-guided pleural biopsies using ultrasound and CT guidance,[119 120] and similar to LAT.

In a study by Hallifax *et al*, 13 UGBx were conducted in patients after failed LAT attempt as an 'on table' conversion (prior consent was obtained for both procedures) with high diagnostic yield, meaning there was no delay to their diagnostic pathway and preventing the need for a further admission and intervention. There were no immediate or delayed complications.[121]

Comparative diagnostic yields between USGBx, LAT and CT-guided biopsies are addressed in the BTS Guideline for Pleural Disease 2023, 'What is the diagnostic accuracy of pleural biopsy?' section[2].

Pleural USGBx consent considerations

When consenting a patient for pleural USGBx, potential risks and complications (box 5) should be considered.

Indicative radiology: is parietal pleural thickening a prerequisite to USGBx?

Although it seems logical that pleural thickening would increase the diagnostic yield in USGBx, the literature suggests the presence of pleural thickening is not mandatory for a diagnostic pleural biopsy. In an observational study from Koegelenberg *et al*, 100 consecutive patients undergoing USGBx of the pleura had an overall diagnostic yield of 88%. Of the 100 patients, 65 had no demonstrable pleural thickening on ultrasound and this group specifically had an overall sensitivity of 58/65 (89.2%). Specifically for malignancy, the sensitivity was 24/27 (88.9%) in the absence of pleural thickening comparable to the 18/20 (90%) sensitivity when pleural thickening was present.[122] In the study from Hallifax *et al,* despite the high overall sensitivity of 47/50 (94%), 12 patients had no significant pleural thickening on CT scan in the mid-axillary line.[121] In the AUDIO study, evidence of pleural thickening was not a prerequisite to pleural biopsy for microbiology.[123]

Overview of cutting needles

Blind or 'closed' pleural biopsy with an Abrams or Cope needle has been in use since it was proposed as a less invasive option to 'open' pleural biopsy (via thoracoscopy) in 1958.[124] Since the use of ultrasound has become standard practice, blind techniques such as this are diminishing, except in the context of TB in areas with high prevalence where closed pleural biopsy may still have a role.

Cutting needle biopsy devices (eg, Temno or Tru-cut) have been a relatively more recent addition.[125] They are designed for manual capture of high-quality tissue samples, including a core biopsy device and sometimes a removable stylet to enable multiple sampling. An ultrasound example is shown in figure 5.

Cutting needles can usually be obtained in a range of sizes from 14G to 21G. There is no high-quality evidence as to whether size affects diagnostic yield. In one small study, the use of a larger cutting needle (18G vs 14G) was not shown to be of any diagnostic benefit.[126] Most radiological studies tend to favour mid-range 16–18G needle sizes.[120]

Advantages of UGBx

- Image-guided biopsy using US guidance is safe with a lower overall rate of adverse events (3%) in comparison to CT (7%).
- In contrast to LAT, patient sedation is not usually required.
- US-guided biopsy facilitates real time visualisation of the needle with no radiation risk to the patient.
- Patient movement due to heavy breathing in a dyspneic patient can be compensated for in real time.
- US-guided biopsy is cheap, relatively accessible and requires minimal consumables (see figure 6).
- While it is helpful to have an assistant to process samples in between biopsies and provide sterile supplies as required, there is minimal additional need for support staff.

Limitations of the US-guided approach

1. Areas inaccessible to ultrasound (eg, behind ribs) cannot be biopsied.
2. Pleural lesions/areas of pleural thickening smaller than 1 cm result in lower diagnostic yields.

In both these circumstances, CT-guided biopsy may be preferred as studies have shown lesions as small as 5 mm can be effectively biopsied.[126]

Contraindications

See the 'Safety and preparation for pleural procedures' section.

Box 5 Pleural ultrasound-guided pleural biopsy consent considerations

⇒ Failure to make a diagnosis.
⇒ Pain.
⇒ Wound infection (3%).
⇒ Pleural infection (empyema) (<1%).
⇒ Pneumothorax (4%).
⇒ Organ puncture; mainly lung but liver/spleen also possible when targeting basal lesions.
⇒ Bleeding requiring treatment.
⇒ Low blood pressure/vasovagal syncope.

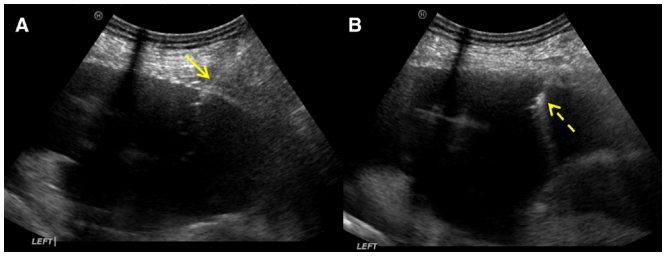

Figure 5 Cutting needle traversing skin to pleura during an US-guided pleural biopsy. The cutting needle (solid arrow) (A) is an example of a semiautomated biopsy device that requires manual advancement of the trocar to expose the side notch (dashed arrow) (B). With pressure on its plunger, an automated biopsy action rapidly advances the cutting cannula over the specimen-containing side notch of the trocar. US, ultrasound.

Complications

A recent systematic review and meta-analysis addressing safety of image-guided pleural biopsy contained data on complications from 18 studies included 1342 patients who had undergone USGBx. The overall probability of developing major complications was 1% (95% CI 0.00% to 0.01%) and minor complications 2% (95% CI 0.01% to 0.03%).[127] Complication rates as high as 10% have been reported in individual studies.[126 128]

Clinical practice points

- The preferred patient position is lateral decubitus and biopsies should be targeted along the mid-axillary line to minimise complications.[6]
- A real-time, freehand technique (figure 6) is advocated whereby a suitable site is identified using a low frequency probe (2–5 MHz) and the biopsy performed while the patient remains in the same position. Doppler ultrasound screening of the intercostal vessels using the same probe can be conducted to avoid vessels.[7]
- Inferior biopsy sites closer to the diaphragm have shown to be more likely to elicit positive biopsy samples due to the anatomical predilection of secondary metastases to this area.[8]
- A biopsy site with underlying pleural effusion to act as a buffer is preferable to reduce the risk of lung perforation and subsequent pneumothorax. If pleural fluid is not present it is preferable for the procedure to be performed under CT guidance.
- When preparing the cutting biopsy needle, it is helpful to demonstrate the 'firing' mechanism of the needle to the patient outside their chest so as not to cause alarm when they first hear the sound.
- The cutting needle should be angled in a way to ensure that the core of tissue obtained will contain the full thickness of the pleura and the needle tip ends in the pleural fluid creating an oblique biopsy tract (figure 7).
- While an assistant releases the tissue cores into a cytolyte container (with saline for samples for microbiology) and rinses the needle in a small pre-prepared tray of saline between biopsies, it is useful for the operator to intermittently check for any evidence of bleeding by looking for echogenic material gathering in the pleural space, or use of Doppler.[9]
- Usually at least six cores are obtained (extrapolated from TB practice[10]). If the pleura is not very thickened, it may be judicious to perform more (as the number of passes increases, be aware that the introduction of air with each biopsy may negatively impact the quality of the real-time ultrasound image).

Postprocedural care

- Ensure no oozing from biopsy site or no chest wall haematoma and apply mepore dressing.
- See 'General aftercare applicable to all pleural procedures' section.
- At the end of the routine observation period and prior to discharge, a chest radiograph is advised to document absence of a pneumothorax and haemothorax.

Research questions

- Can contrast-enhanced US improve diagnostic yield from USGBx through differentiating benign and malignant pleural disease?
- Can US elastography reliably allow non-invasive differentiation between benign (soft) and malignant (hard) tissue to guide USGBx?

MEDICAL THORACOSCOPY

For the purposes of this statement, the term LAT is intended to describe the thoracoscopic procedure undertaken by respiratory physicians, which is commonly also referred to in the literature as medical thoracoscopy or pleuroscopy. The practice of VATS or any other forms of surgeon-led thoracoscopy are beyond the scope of this document, even when using a single port and/or local anaesthetic instead of general anaesthetic.

Current UK LAT service provision

The number of UK sites offering LAT increased dramatically in the early 2000s, from a handful of specialist sites to approximately 17.[97 129] By 2018, a survey of UK practice suggested that approximately 50 centres were offering LAT.[130] At present, most regions of the UK have access to LAT services or are able to offer these themselves.

Indications for LAT

Although LAT has been used to access the pleural cavity for a wide variety of reasons, in the majority of cases LAT is undertaken with

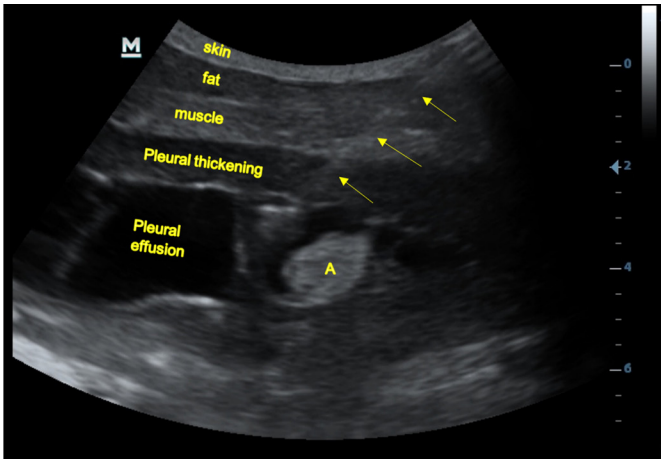

Figure 6 Ultrasound anatomy during cutting needle biopsy. Yellow arrows=biopsy needle track; A=meshwork of closely interlaced septations.

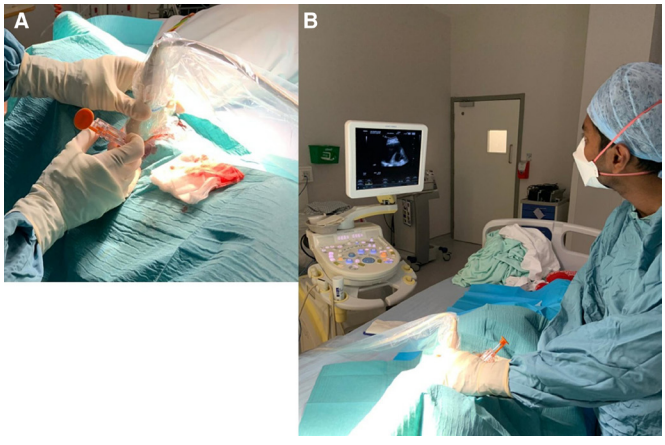

Figure 7 Real-time free-hand technique demonstrated with dominant hand controlling the cutting needle (A). Operator should be positioned facing the ultrasound machine with patient in lateral decubitus position in between (B).

a view to obtaining parietal pleural biopsies in order to confirm or refute a diagnosis of pleural malignancy (figure 8).[131] This is almost always undertaken in the context of a pleural effusion. For patients with confirmed MPE, a LAT may be performed specifically with a view to rapid maximal drainage (± septation breakdown), followed by some form of definitive MPE intervention (usually talc poudrage with or without IPC insertion) to achieve pleurodesis. A rare, but previously described indication for LAT, also includes drainage (± adhesiolysis, ± irrigation) of pleural infection.[132–135] In cases where pleural tuberculosis is suspected, pleural biopsies obtained at LAT have been shown to have an extremely high sensitivity for diagnosis.[136]

Patient selection

Patients should be able to lie in the proposed procedure position (usually on their side) for up to 1 hour and be able to tolerate moderate sedation. It is advised that patients have a WHO performance status of 3, or better when the LAT is undertaken. Box 6 lists absolute contraindications to LAT. Although the presence of heavy fluid septation/loculation is not an absolute contraindication, this finding may mean some operators choose to pursue an alternative procedure.

Complications and consent

Overall, LAT is a safe procedure. In data obtained from 47 studies, death occurred in 0.3% of cases, although, in the 28 of these studies reporting on diagnostic LAT without talc, no deaths occurred. Other major reported complications, occurring in 1.8% of patients, included pleural infection, significant haemorrhage, port site or tract metastasis, bronchopleural fistula, pneumothorax or air leak, and pneumonia. Thirty-one of these studies reported minor complications in 7.3%, including non-significant bleeding, hypotension, fever, atrial fibrillation, wound infection and subcutaneous emphysema.[137] When taking consent for LAT, it is prudent to mention the possibility of intra and postprocedural pain and cough.

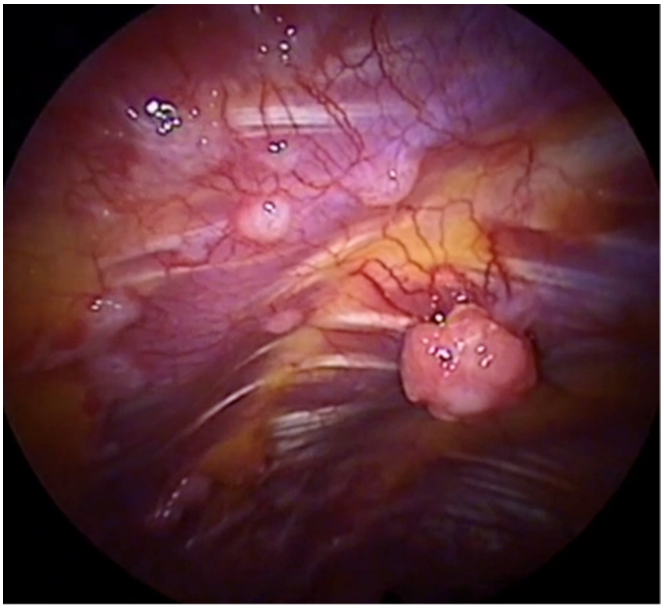

Figure 8 Thoracoscopic view of the parietal pleura, demonstrating multiple small nodules and single larger nodule, which when biopsied demonstrated lung adenocarcinoma.

Peri-procedural analgesia, local anaesthesia and sedation

Patients should be encouraged to take simple analgesia prior to their attendance at the hospital. Preparation of a prescription chart containing simple analgesia and basic opiates (eg, oral liquid morphine) before the procedure is advised to avoid unnecessary discomfort in the recovery period/area.

In the UK, management of sedation is usually the responsibility of the thoracoscopist, although in select centres a dedicated anaesthetist may be available, which may in turn allow for a more complex sedation regimen.[138]

During the procedure, 20 mL of 1% lidocaine (± adrenaline) is advised for skin and tract anaesthesia. In the UK, LAT is usually undertaken under light to moderate sedation using incremental doses of an intravenous benzodiazepine (eg, midazolam 0.5–5 mg). This may be combined with an intravenous opiate (eg, fentanyl 25–100 μg) for control of pain and cough. Additional doses should be available during the procedure in case of pain or agitation.

Rigid versus semi-rigid LAT

The majority of UK LAT operators use a rigid system, with fewer than 10% opting solely for a semi-rigid system (currently only manufactured by Olympus).[130] Previous comparative data have shown biopsy samples obtained using the semi-rigid system to be consistently smaller than those obtained with rigid scopes, however, this does not appear to translate into meaningfully lower diagnostic rates.[139–142] Benefits of the semi-rigid system may include: a more natural learning curve for respiratory physicians who are already trained in bronchoscopy, as the devices are similar in design; ability to access and visualise a greater proportion of the thoracic cavity; and the scope being autoclavable. Disadvantages of the semi-rigid system include considerably greater scope cost compared with rigid systems, smaller volume biopsies[142] and less lateral stability when taking biopsies, which may lead to difficulty obtaining samples, especially in cases where the visceral pleura is firmer. A comparison of rigid and semi-rigid scopes is shown in figure 9.

Additional techniques during LAT

The scope of activity for physicians in the UK is usually limited to parietal pleural biopsies (as above), talc poudrage, and limited manual (ie, without electrocautery) adhesiolysis. Although more advanced procedures are technically possible, these are usually only undertaken as part of research studies or in a very small number of individual centres with particular expertise and are thus beyond the scope of this document.

Identifying non-expandable lung

For patients undergoing surgical thoracoscopy with the assistance of mechanical ventilation, it may be feasible to selectively inflate the

Box 6 Absolute contraindications to local anaesthetic thoracoscopy

- ⇒ Uncorrectable bleeding tendency.
- ⇒ Significant (associated with symptoms or heart failure) pulmonary hypertension.
- ⇒ Cutaneous infection, metastasis or rib fracture around port insertion site.
- ⇒ Uncorrectable type 1 respiratory failure.
- ⇒ Ongoing type 2 respiratory failure.
- ⇒ Cardiovascular instability.
- ⇒ Complete absence of a pleural space due to adhesions.

collapsed lung at the end of the procedure to make an informed estimate as to likelihood of re-expansion.[102] However, although certain visual features may be suggestive (eg, visceral pleural rind, limited diaphragmatic movement), recent data have shown that NEL (or its extent) cannot be reliably or consistently identified during LAT using visual appearances alone.[143]

Talc as part of a LAT

Talc in the context of LAT is almost exclusively used to treat known or suspected MPE. In the UK, a standard dose is 3–4 g, given in graded form as this is proven to be significantly safer than the ungraded form.[144] Talc may be delivered during LAT as poudrage (a dry powder sprayed directly onto the pleural surfaces), or shortly after LAT in the form of slurry via the chest drain which is placed postprocedure (once lung expansion is confirmed). Robust RCT data has confirmed that there is no significant difference in pleurodesis or health economic outcomes when comparing the use of poudrage with slurry (in patients with known MPE), with both leading to approximately 75% 'success' rates at 3 months postprocedure.[145]

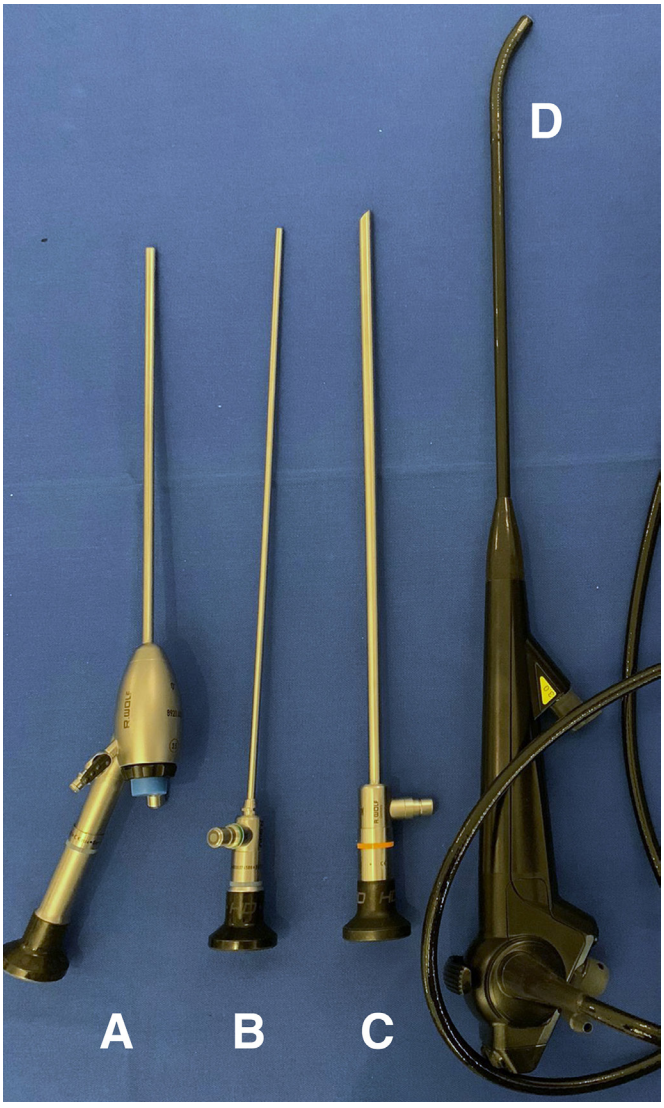

Figure 9 Comparison of medical thoracoscopes (left-to-right, (A)). 0° rigid scope with working channel and in-line suction port; (B) standard 0° rigid scope; (C) standard 50° rigid scope; and (D) semi-rigid thoracoscope with working channel and in-line suction port.

Common perceived benefits of poudrage at LAT include the ability to apply talc under direct vision, ensuring even pleural spread; and, where applicable, the added convenience of combining diagnostic and therapeutic procedures. Conversely, compared with a solely diagnostic LAT, poudrage usually extends the duration of a patient's procedure and their hospital stay; introduces the risk of talc-related side effects and complications; and often has to be given before non-expandable lung can be excluded.[137]

Post LAT chest tube

The size of chest tube to be inserted at the end of a LAT should be determined by taking into consideration:

1. The size of port used to access the pleural space, ensuring that the tube chosen is slightly larger than the diameter of the access tract.
2. The width of the patient's rib space.

The typical range of tube size for UK operators is 16F–24F. Any tube should be secured in line with the guidance detailed in online supplemental appendix 4 (Intercostal drain insertion). If a tube is expected to remain in place (eg, so that talc slurry can be given once lung expansion is confirmed), then a three-way tap should be added into the drainage circuit. This may require an additional connector (figure 10).

IPC in combination with LAT

There is currently no consensus regarding when placement of an IPC should be combined with LAT. Accordingly, patient selection should be made based on individualised discussions, taking into consideration factors such as rapidity of prior fluid accumulation; previous failed pleurodesis attempts; knowledge of pre-existing non-expandable lung and symptomatic improvement with thoracentesis; and geographical location, which may influence the ability for patients to return for additional procedures. If being undertaken, procedural consent should be extended to include potential complications relating to the IPC insertion specifically. Limited evidence suggests that the combination of LAT, poudrage and IPC may confer benefits in terms of duration of post procedure stay and pleurodesis success.[146]

Should an IPC be placed as part of a LAT procedure, it is advised that the IPC normally be inserted into the pleural cavity at least one rib space either above or below the LAT port site. However, if a small introducer is used for the LAT, then it may also be feasible to use the existing tract to place the IPC.

Post LAT drainage and imaging

As the thoracic cavity will be largely empty immediately post LAT, it is advised that the chest tube circuit be left 'open' to allow free

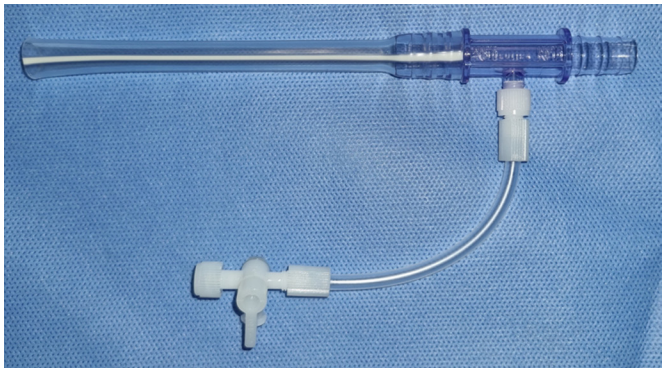

Figure 10 Example of a connector which allows the easy installation of pleural agents (eg, talc slurry or saline flush) into a large chest drain.

drainage of air and any remaining fluid. It is common for patients to experience coughing and some transient chest discomfort as the lung re-expands initially. Pilot data have suggested that the use of 'digital' suction devices, which are able to quantify air leak, may predict the presence of non-expandable lung which may not have been diagnosed pre LAT.[147]

A chest radiograph performed approximately 1-hour post-procedure will usually be sufficient to identify the degree of initial lung expansion. For most, complete expansion would be expected to happen almost immediately. However, for those with a degree of underlying NEL, or who had a significant degree of atelectasis, a more prolonged period of chest drainage and observation may be required. For those not attached to digital suction, a CXR should be obtained every 24–48 hours to assess for degree of lung expansion. For those who continue to exhibit incomplete expansion or ongoing air leak, on a case-by-case basis, thoracic suction may be considered, although there are no robust data to support or oppose its use at present. It is advised that a maximum pressure of −20 cm H_2O be applied, as tolerated.

For those patients in whom talc has been administered, it is advised that the chest drain be left in situ until drain output has reduced to 200–250 mL in the preceding 24-hour period, although evidence for this target volume is weak. As an alternative, a recent RCT demonstrated that the use of serial, 9-point, TUS scans (using lack of visible lung sliding as a surrogate for pleurodesis) post talc reduced the duration of hospital stay by 1 day when compared with standard monitoring.[148]

For those with persistent high fluid output, regardless of prior talc use, consideration should be given to removing the tube and discharging the patient, with a view to later placement of an IPC as an outpatient. For those with persistent air leak or poor lung expansion despite the above strategies, consideration should be given to ambulatory management/discharge with a Heimlich device.

LAT as a day-case

Previous data have suggested that between 24% and 46% of UK LATs are performed as day case procedures (ie, no in patient overnight stay), although this is now likely to be inaccurate in light of pressures placed on diagnostic services during the COVID-19 pandemic.[130] The majority of practitioners will limit day-case LAT to diagnostic biopsies±IPC insertion, omitting talc pleurodesis. However, there are a limited number of UK centres who choose to undertake LAT, talc poudrage, and IPC insertion as a single day-case procedure.

LAT service emergency support

Recent data suggest only 27% of UK LAT centres have access to on-site thoracic surgical support.[130] It is strongly endorsed that all LAT practitioners develop lines of communication with local thoracic surgical colleagues/centre for advice and/or assistance in the event of rare LAT complications such as diaphragmatic, visceral or major vessel injury. Intercostal artery injury and subsequent haemothorax may require assistance from thoracic surgical colleagues, however, this complication may also be managed by interventional radiology colleagues, who may be available locally.

In addition to the above, it is strongly advised that sites undertaking LAT develop pathways for common emergency scenarios both during and post LAT. These will likely involve protocols for urgent liaison with back-up services as above. Scenarios may include major haemorrhage due to intercostal injury; cardiovascular instability due to sedation and/or biopsies; or suspected RPO.

LAT troubleshooting

A guide to LAT troubleshooting is shown in Appendix 4.

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Contributors All authors drafted the manuscript and approved the final version. NMR was lead author responsible for final approval.

Funding The authors have not declared a specific grant for this research from any funding agency in the public, commercial or not-for-profit sectors.

Competing interests Declarations of interest were completed in line with the BTS Policy and are available from the BTS Office on request

Patient consent for publication Consent obtained directly from patient(s).

Provenance and peer review Commissioned; externally peer reviewed.

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APPENDIX 1: SUMMARY OF STUDIES EVALUATING THORACENTESIS-RELATED COMPLICATIONS IN THE LAST 6 YEARS

(please note that Appendix references are listed as a separate list at the end of the appendices)

Author	Study type	Main finding	Overall risk estimate for consent
Pneumothorax			<5%
Cavanna 2014[1]	Retrospective cohort	Decreased risk of PTX with ultrasound guidance used for 445 cancer patients. 3.37% incidence of PTX, 0.97% with ultrasound guidance, 8.89% without.	
Perazzo 2014[2]	Prospective study	Decreased risk of PTX with ultrasound guidance (1.25% vs 12.5%)	
Ault 2015[3]	Prospective cohort	9230 thoracenteses. 0.61% PTX rate; PTX associated with>1500 mL removed, unilateral procedure, more than one pass through skin and low BMI (<18). 0.18% bleeding episodes, 0.01% RPO.	
Cho 2017[4]	Retrospective cohort	0.62% PTX rate. PTX associated with low BMI (<18.5)	
Shechtman 2020[5]	Retrospective cohort	12% PTX rate. PTX associated with higher rate of congestive heart failure, smaller depth of pleural fluid, larger volume of fluid drained and bilateral procedures.	
Touray 2017[6]	Retrospective cohort	Iatrogenic PTX rate 1.38% with use of ultrasound.	
Hooper 2015[7]	National Audit (BTS)	15/1162 (1.3%) patients developed an iatrogenic pneumothorax.	
Bleeding complications			<1%
Ault 2015[3]	Prospective study	0.18% bleeding complications, 0.01% haemothorax, 0.05% rate of haemothorax without correction of bleeding risk; no association of bleeding risk with patient or laboratory parameters.	
Touray 2017[6]	Retrospective cohort	Bleeding complication rate 0.4%	
Perl 2020[8]	Retrospective case control	No increased bleeding risk in clopidogrel treated patients. 2.2% vs 1.2%	
Hooper 2015[7]	National Audit (BTS)	13/1162 (1.1%) patients developed a haemothorax and 12/1162 (1%) developed a chest wall haematoma.	
Re-expansion pulmonary oedema (RPO)			<1%
Ault 2015[3]	Prospective cohort	10/9320 (0.01%) incidence of RPO; association with volume of fluid removed and non-inflammatory conditions.	
Senitko 2019[9]	Prospective randomised study	Vacuum aspiration associated with increased risk of complications (5/51 vs 0/49 p=0.03), PTX n=3, surgically treated haemothorax and death (n=1), RPO causing respiratory failure (n=1)	
Failed procedure / dry tap			4%
Hooper 2015[7]	National Audit (BTS)	43/1162 (3.7%) had a failed procedure or dry tap.	
Pain			5%
Hooper 2015[7]	National Audit (BTS)	112/1162 (5%) developed pain.	
Symptomatic hypotension			<1%
Hooper 2015[7]	National Audit (BTS)	7/1162 (0.6%) developed symptomatic hypotension.	
Ault 2015[3]	Prospective cohort	6/9320 (0.1%) had a vasovagal reaction.	
Organ puncture			<1%
Hooper 2015[7]	National Audit (BTS)	3/1162 (0.3%) had an organ puncture.	
Ault 2015[3]	Prospective cohort	1/9320 (0.01%) splenic rupture.	

BMI, body mass index; PTX, pneumothorax; RPO, re-expansion pulmonary oedema

APPENDIX 2: SUMMARY OF THE RATES OF DIFFERENT COMPLICATIONS RELATED TO INTERCOSTAL DRAINS

(please note that Appendix references are listed as a separate list at the end of the appendices)

Complication	Study type	Study details	Risk of complication per study	Overall risk estimate for consent
Immediate complications				
Pain				8%
Hooper 2015[7]	UK National Audit (BTS)	1394 procedures, 88% 6–16F intercostal drains.	8%	
Inappropriate placement				1% (small-bore drains) 6% (large-bore drains)
Vilkki 2020[10]	Retrospective cohort	1169 procedures, more than half were small-bore drain insertions.	0.43%	
Hooper 2015[7]	UK National Audit (BTS)	See above	2%	
Kong 2014[11]	Retrospective cohort	1050 drain insertions for trauma patients, 32F or larger.	6%	
Maritz 2009[12]	Local audit at a tertiary hospital	273 drain insertions for trauma patients, no information on drain sizes.	6.9%	
Symptomatic hypotension				2%
Hooper 2015[7]	UK National Audit (BTS)	See above	1.9%	
Iatrogenic haemothorax				<1%
Jackson 2021[13]	Retrospective cohort	879 small-bore drain insertions.	0.1%	
Kong 2014[11]	Retrospective cohort	See above	0.2%	
Hooper 2015[7]	UK National Audit (BTS)	See above	1.3%	
Organ Puncture				<1%
Vilkki 2020[10]	Retrospective cohort	See above	0%	
Jackson 2021[13]	Retrospective cohort	See above	0%	
Kong 2014[11]	Retrospective cohort	See above	0.4%	
Hooper 2015[7]	UK National Audit (BTS)	See above	0.6%	
Delayed complications				
Pain				16%
Hooper 2015[7]	UK National Audit (BTS)	See above	15.6%	
Drain blockage				8%
Hooper 2015[7]	UK National Audit (BTS)	See above	8.2%	
Drain displacement				5%
Kong 2014[11]	Retrospective cohort	See above	1.3%	
Jackson 2021[13]	Retrospective cohort	See above	3.9%	
Hooper 2015[7]	UK National Audit (BTS)	See above	9.2%	
Surgical emphysema				5%
Hooper 2015[7]	UK National Audit (BTS)	See above	4.2%	
Jackson 2021[13]	Retrospective cohort	See above	4.6%	
Skin infection				1%
Hooper 2015[7]	UK National Audit (BTS)	See above	1%	
Re-expansion pulmonary oedema				<1%
Jackson 2021[13]	Retrospective cohort	See above	0%	
Hooper 2015[7]	UK National Audit (BTS)	See above	0.6%	
Pleural space infection				<1%
Jackson 2021[13]	Retrospective cohort	See above	0.4%	
Hooper 2015[7]	UK National Audit (BTS)	See above	0.4%	
Death				<1%
Kong 2014[11]	Retrospective cohort	See above	0%	
Jackson 2021[13]	Retrospective cohort	See above	0%	
Hooper 2015[7]	UK National Audit (BTS)	See above	0.1%	

APPENDIX 3: IPC-RELATED COMPLICATIONS, RATES OF OCCURRENCE AND MANAGEMENT

(please note that Appendix references are listed as a separate list at the end of the appendices)

Complication	Outcomes	Risk of complication per study	Overall risk estimate for consent
Pain necessitating IPC removal			<1%
Asciak 2019[14] Tremblay 2006[15]	Severe or persistent pain should raise concern for intercostal nerve irritation, and IPC removal should be considered.	0.4%–0.5%	
Pain towards the end of the drainage procedure			Not quantified in literature, but commonly encountered in clinical practice
	May indicate the presence of underlying non-expandable lung. Routine pre-drainage analgesia may help reduce discomfort, or a revised drainage protocol may be required, with less frequent or smaller volumes of fluid drainage.	Fairly common	
IPC-related infection			5%
Asciak 2019[14] Fysh 2013[16] Tremblay 2006[15]	IPC related pleural infections carry a 0.29% mortality rate, but the majority (94%) respond to antibiotics treatment. Some may require intravenous antibiotics and continuous IPC drainage (by attaching the IPC to an underwater seal).[16] The majority do not require the IPC to be removed.[17]	Superficial (cellulitis): 1.6%–2.5% Pleural infection: 3.2%–5%	
Non-draining septated IPC-related pleural effusion			<15%
Asciak 2019[18] Thomas 2015[19]	Treatment with intrapleural fibrinolytics. A small study showed a single dose of fibrinolytic agent (majority given 4–10 mg tissue plasminogen activator (TPA)) was associated with an increased volume of drainage and decreased symptoms but was also associated with a 3% risk of non-fatal pleural bleed.[19] There is a lack of robust data on the right treatment but often there is a lack of alternatives in patients who are not suitable candidates for surgery, thus intrapleural fibrinolytics can be considered in select patients.	4%–14%	
IPC blockage			4%
Van Metre 2011[20]	Usually due to fibrinous debris. A catheter flush with sterile saline often clears any catheter obstruction, however, fibrinolytic therapy (eg, 4 mg alteplase in 20 mL sterile saline instilled through the IPC (similar to the method used for central line unblocking), repeated a second time if inadequate drainage (<150 mL)), may be considered for more resistant occlusion, although this carries considerable cost and re-obstruction may occur.[21 22 23]	4%	
IPC fall out or dislodgement			1%
Tremblay 2006[15]	May require new IPC insertion if ongoing pleural effusion re-accumulation.	1%	

IPC-related complications, rates of occurrence and management

APPENDIX 4: LAT TROUBLESHOOTING GUIDANCE

(please note that Appendix references are listed as a separate list at the end of the appendices)

Situation	Potential approach
No fluid / small fluid volume in lateral decubitus position	It is common for fluid to "fall" away anteriorly and posteriorly with the patient lying on their side, thus it is advised that patients be scanned in clinic prior to listing for LAT to avoid this situation. However, if encountered, a per-patient decision needs to be made as to whether to: 1. Abandon the procedure (perhaps with a view to re-listing after further fluid accumulation), 2. Attempt an on-table induced pneumothorax (usually with direct US guidance of a needle into fluid), or 3. Proceed with a 'dry' LAT, whereby a careful surgical dissection method is used to access the pleural space and allow air to entrain. Recent data suggest 78% of UK LAT sites would induce a pneumothorax for LAT if needed.[24] As above, the procedure can be undertaken whilst on the table (with thoracic US to check for absence of sliding and seashore sign) or shortly prior to LAT (with a lateral decubitus CXR to check for sufficient lung collapse).
Inability to aspirate fluid during anaesthesia or collapse lung following blunt dissection	This situation is likely to occur when fluid is heavily loculated or septated, perhaps due to chronicity or infection, and may not be appreciable until pleural access is attempted on table. As above, a per-patient decision needs to be made to either: 1. Abandon the procedure with a view to considering alternative pleural biopsy techniques at a later date (eg, VATS or image-guided), or 2. Proceed to on-table US-guided parietal pleural biopsy.
Unable to advance trochar through rib space	This may occur in patients who have intrinsically narrow rib spaces or in those who have been positioned on the table in such a way as to promote 'rib crowding'. For the former, an alternative rib space/location may be required, although due consideration should be given to whether the likely risk of pain and/or injury to sub-costal structures may be excessive. In all cases, it may be possible to widen the chosen rib space by placing a folded pillow or blanket between the patient and the bed, creating a gentle convex arch in their spine.
Difficulty penetrating pleural layer (especially with trochar)	It is common for the dissection tract to collapse due to pressure from surrounding tissues, impeding passage of instruments. This is more likely to occur in larger or obese patients, in whom there may be a significant distance from the skin to the parietal pleural layer. This can be accurately measured using US prior to beginning dissection. However, this situation can usually be overcome by slow, methodical, repeated dissection along the same tract. However, this may increase the risk of pain, subsequent local surgical emphysema post procedure, and delayed tract healing.
Unable to visualise ribs on inspection	This is common in patients with significant or chronic pleural inflammation, fibrosis, or malignant infiltration. Using a rigid instrument (usually a 0 degree scope with closed biopsy forceps attached), it may be possible to press against the posterior thoracic wall and slide from side to side, thus allowing the operator to 'feel' where the rib spaces are. In rare circumstances, external transillumination may also be an option.
Unable to visualise posterior thoracic wall due to adhesions or loculations	In some instances of severe septation, it may be necessary to abandon the LAT±convert to an on-table US-guided biopsy. However, if free-flowing fluid is present, it is usually possible to undertake careful, methodical dissection of adhesions and septations to create a tract to the posterior thoracic wall. This is typically done using a blunt instrument, such as closed biopsy forceps. Where feasible, electrocautery may also be considered but should only be used by those with adequate experience and training.
Pain during biopsies	The parietal pleural layer is highly innervated and thus a degree of discomfort during pleural biopsies is to be expected, with these occasionally being extremely painful. Direct application of local anaesthesia is usually impractical. If biopsies are limited by pain, then additional boluses of opiate (eg, fentanyl 25 µg) should be considered. Accordingly, care should be taken to ensure sufficient intravenous analgesia is available and that it can be administered by a non-sterile member of the team during LAT.
Vasovagal syncope during talc poudrage	This complication can arise due to severe pain, acute local inflammatory effects of talc or, with some aerosol talc preparations, cold gas hitting the pleural surface. Treatment is supportive and, although symptoms are usually transient, they may be extreme enough to require early termination of LAT to allow rapid drain insertion and for the patient to be nursed on their back. Occasionally, bolus intravenous fluids are required.
Suspected intercostal artery damage	This usually occurs because of biopsies and should prompt planned diagnostic and therapeutic treatments to be immediately abandoned in favour of emergency procedures. Intercostal artery laceration is usually visually distinct from the expected post-biopsy pleural ooze, which is typically self-limiting. As above, it is strongly endorsed that all LAT centres adopt a site-specific standardised protocol for management of this scenario and that this be prepared in line with local major haemorrhage pathways. Intercostal artery bleeds may also present post-LAT if laceration occurred during initial dissection but was concealed by the trochar causing tamponade during the procedure. As well as abandoning diagnostic procedures, actions should include: 1. Application of external pressure over the suspected bleeding site. 2. Insertion of at least two large-bore venous cannulas. 3. Urgent venous sampling for full blood count, renal function, clotting screen, group and screen, and crossmatch (four units). Venous blood gas analysis should also be performed to obtain immediate values for haemoglobin and lactate. 4. Intravenous fluid resuscitation. 5. Frequent, regular measurement of observations (pulse, blood pressure, respiratory rate, peripheral saturations) 6. Insertion of large bore chest tube via LAT tract. 7. Portable chest x-ray and arranging contrast-enhanced CT thorax to identify bleeding vessel. 8. As per local policy, contacting either thoracic surgical colleagues or interventional radiology colleagues. 9. Moving the patient to a high-care area with continuous monitoring.
Complications during post procedure lung expansion	Rapid lung expansion following insertion of the chest drain post LAT can lead to severe pain, coughing, and/or vasovagal syncope. Although such symptoms usually settle rapidly once complete expansion is achieved, they may require the chest tube to be opened to atmosphere to allow the lung to partially collapse once more, particularly if the patient has a degree of non-expandable lung. It is strongly advised that the chest drain be sutured and secured prior to connecting to the drainage circuit, to avoid symptoms while interventions are still taking place.

CXR, chest X-ray; LAT, local anaesthetic thoracoscopy; US, ultrasound; VATS, video-assisted thoracic surgery

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