Pus in the thorax: management of empyema and lung abscess

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Key points
Thoracic ultrasound before pleural procedures reduces attempts and complications.
The cornerstones of empyema management are fluid drainage, antibiotics, and nutrition.
A broncho-pleural fistula should be assumed when empyema occurs after thoracic surgery.
A thoracotomy is very painful. Postoperative analgesia should include either a paravertebral catheter + patient-controlled analgesia or a thoracic epidural.
Life-threatening airway compromise can occur with apparently small-volume haemoptysis.

Empyema
Pleural infection is a common clinical problem that is associated with a high mortality and morbidity. In the UK, the mortality is 20% with ∼20% requiring surgery.1

The development of an empyema associated with pneumonia is a progressive process classified in three stages. Initially, there is a free-flowing exudate with a normal pH termed a simple parapneumonic effusion. This progresses to a fibrinopurulent stage with increasing fluid and bacterial invasion causing a decrease in pH. If the fluid is clear but the pH <7.2, this is termed a complicated parapneumonic effusion while frank pus is termed an empyema. The third stage is an organizing stage with the formation of a solid fibrous peel.

Pleural infection can also occur after pleural interventions, thoracic or oesophageal surgery, trauma, or oesophageal rupture.

Bacteriology
Pleural fluid culture remains negative in ∼40% of aspirates. Streptococcal species account for 50% of positive cultures with the other 50% comprising Staphylococcus species, anaerobes, and gram-negative organisms. Anaerobes are identified by positive cultures in 35% of cases but identified by DNA amplification in up to 76% of cases.

In hospital-acquired infections, methicillin-resistant Staphylococcus aureus (MRSA) may account for up to 66% of cases. Gram-negative organisms such as Escherichia coli, Enterobacter species, and Pseudomonas species account for the majority of the remainder, although higher rates of gram-negative aerobes are reported in those requiring intensive care admission.

Investigation
Deciding which patients to investigate for possible empyema is difficult in the intensive care unit (ICU) as both signs of sepsis and pleural effusions are common. One study of a medical ICU found that 62% of patients had an effusion on chest radiograph, but only seven were parapneumonic and only one an empyema.2

The British Thoracic Society (BTS) guidelines state that features of ongoing sepsis in patients with pneumonia, after 3 or more days, may indicate progression to pleural infection.1 A failure of the C-reactive protein to decrease by 50% is also associated with an increased incidence of empyema. The possibility of an empyema should also be explored in patients who have an effusion with signs of sepsis where no source is apparent or where the patient is unresponsive to treatment from sepsis of a known source.

Aspiration
Aspiration allows diagnosis of an empyema and differentiation between simple parapneumonic effusions and those requiring drainage. The investigations to request are listed in Table 1. Fluid for pH measurement should be collected in a heparinized syringe and not one containing lidocaine, as this is acidic. Extensive clinical practice has shown that putting pleural fluid through a blood gas analyser is safe if a heparinized syringe is used and pus or turbid fluid is not processed. (As this alone is an indication for a chest drain, pH measurement is not required for these samples.)

Ultrasound
Thoracic ultrasound (TUS) is a simple bedside investigation that can be used to assess the presence and size of an effusion more accurately than a plain chest radiograph. The echogenicity

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pus in the thorax

Table 1 Investigations to be requested from pleural aspiration. LDH, lactate dehydrogenase; MC+S, microscopy, culture and sensitivity; AFB, acid-fast bacilli; TB, tuberculosis

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<thead>
<tr>
<th>Investigations that should always be requested</th>
<th>Investigations to consider sending</th>
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<tbody>
<tr>
<td>Protein</td>
<td>pH (non-purulent fluid)</td>
</tr>
<tr>
<td>LDH</td>
<td>AFB (if TB suspected)</td>
</tr>
<tr>
<td>MC+S</td>
<td></td>
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<td>Cytology</td>
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Table 2 Indications for pleural fluid drainage

<table>
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<th>Indication</th>
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<td>Frankly purulent or turbid/cloudy fluid</td>
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<tr>
<td>Presence of organisms identified by gram stain + culture in non-purulent pleural fluid pH&lt;7.2 with suspected infection</td>
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<tr>
<td>Loculated pleural collection</td>
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<td>Poor clinical progress with antibiotics alone</td>
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of the fluid and the presence of loculations aid in diagnosing an empyema and deciding whether insertion of a chest drain is necessary.

TUS improves success and reduces complications of pleural procedures. A National Patient Safety Agency Rapid Response Report stated that ultrasound guidance is strongly advised when inserting a drain for fluid. BTS guidelines recommend TUS for all pleural procedures, particularly in those mechanically ventilated, where a pneumothorax is a serious complication. A study of 232 pleural aspirations in mechanically ventilated patients performed by intensivists using ultrasound guidance reported pneumothorax as a complication in 1.3%. A previous study without ultrasound guidance reported pneumothorax in 9.7%.

Computed tomography (CT) is not as accurate as ultrasound in detecting septations and requires transferring the patient. However, it is better able to detect underlying abnormalities such as oesophageal perforation or bronchial carcinoma. It also aids in the differentiation between empyema and lung abscess. This is important, as the former always requires external drainage whereas the latter usually resolves with medical management and insertion of a chest drain may result in the formation of a broncho-pleural fistula (BPF). Empyemas are usually lenticular in shape, compress the lung, and create obtuse angles as they follow the contour of the chest wall. There is usually an indistinct border between lung par enchyma and a lung abscess, which forms an acute angle where contact with the chest wall is made. The ‘split pleura’ sign, where both parietal and visceral pleura enhance showing their separation, can be present in an empyema.

Management

The mainstay of treatment for pleural infection remains appropriate antibiotics, pleural fluid removal, and adequate nutrition. Indications for pleural fluid drainage are listed in Table 2.

Antibiotic therapy

Where no culture results are available, the antibiotic regimen should include anaerobic cover and reflect the high level of penicillin-resistant organisms. In hospital-acquired infections, MRSA should be covered and also gram-positive and gram-negative aerobes and anaerobic organisms. Aminoglycosides poorly penetrate the pleural space and should not be used.

Size of chest drain

There is no consensus on, or randomized controlled trials comparing, the optimal size for a chest drain in the context of pleural infection. Surgeons tend to suggest the more traditional approach of using large-bore drains (>28 Fr), whereas physicians tend to suggest the use of smaller drains (10–14 Fr), placed under US or CT guidance. With smaller drains, regular flushing is recommended to avoid blockage. A subset analysis of a large, multicentre, randomized controlled trial (investigating intrapleural fibrinolytics) found no difference in mortality or numbers referred to surgery between different drain sizes, but there was a significant increase in pain scores in patients receiving larger drains, normally inserted with blunt dissection. There have been trials showing good outcomes from image-guided small-bore drains both as an initial and as a rescue therapy.

Intrapleural fibrinolytics

Fibrinolytics such as streptokinase and urokinase have been widely used in the treatment of pleural infection, especially with small-bore drains, to break down loculations and the viscous, fibrin-rich fluid that commonly blocks drains. A large, randomized, controlled trial showed that their routine use did not improve mortality or reduce the number of patients requiring surgery. However, this trial was devised before the advent of bedside pleural ultrasound and therefore did not differentiate between simple and loculated effusions. All patients with a pleural fluid pH <7.2 or pus were given a fibrinolytic, irrespective of whether the fluid drained easily or not. The BTS guidelines recommend their use in large, loculated fluid collections resistant to chest tube drainage where thoracic surgery is not considered an immediate alternative or is not available.

Surgery

There is no consensus as to the optimum timing of surgery for pleural infection secondary to pneumonia. The BTS guidelines suggest discussing with a surgeon if there are ongoing signs of sepsis with a persistent pleural collection after 5–7 days and that repeat imaging with either CT or US should be requested. If the cause is iatrogenic or following trauma, then earlier discussion is needed.

There are a number of surgical options available (Table 3). The choice will depend on the availability of equipment and surgeon’s preference and also the co-morbidities of the patient. The most commonly performed procedures are rib resection and drainage,
video-assisted thoracoscopic surgery (VATS), and open thoracotomy with decortication. The first option is the simplest and has the advantage that the anaesthetic can be performed with a single-lumen tube or, in extreme cases, under regional anaesthesia. VATS is being used with increasing frequency. In the UK, when used for pleural infection, it remains within the remit of thoracic surgeons, performed under general anaesthesia. In other European countries, it is increasingly performed by respiratory physicians using sedation (medical thoracoscopy) and this practice may become more common in the UK. When performed under general anaesthesia, it requires one-lung ventilation with either a double-lumen tube (DLT) or a bronchial blocker.

Decortication can lead to extensive bleeding and may cause significant air leaks. While decortication is possible with VATS, it is more time-consuming and if the pleural peel is difficult to remove, conversion to open thoracotomy may be required.

Anaesthetic management

This can be difficult as the patient may have significant co-morbidity, be acutely unwell, and have underlying severe chronic lung disease, but the surgery may be potentially life saving with any significant delay only leading to a worsening of the patient’s condition.

Pulmonary function tests and cardiopulmonary exercise testing may be available if the patient was reviewed previously at a respiratory clinic or in pre-assessment for elective thoracic surgery. These results may, however, be misleading if the patient has acutely deteriorated. Problems encountered with lung isolation should have been documented if the patient has undergone thoracic surgery previously.

The main questions that need answering during the assessment are:

- Is there a BPF?
- Will lung isolation facilitate surgery?
- What are the options for analgesia?

Answering these requires good communication with the surgeon and an understanding of the possible options for surgery.

Is there a BPF?

The potential presence of a BPF is very important. If the pleural fluid is in communication with the airways, this can cause two problems. First, positive pressure ventilation may result in failure to ventilate the unaffected lung and potentially cause a tension pneumothorax around the affected lung. Secondly, soiling of the unaffected lung is a real risk causing a significant morbidity. A good rule of thumb is that any patient who has had recent thoracic surgery has a BPF unless proved otherwise. Lung isolation before positive pressure ventilation is an absolute indication in BPF. Techniques to secure the unaffected lung are widely debated and include gas induction, awake fibreoptic intubation, and, most commonly, rapid sequence induction. A DLT rather than a bronchial blocker is preferred as suctioning is easier and large volumes of pus can dislodge a blocker, particularly during surgical manipulation.

Will lung isolation facilitate surgery?

Single-lung ventilation (in the absence of a BPF) to facilitate surgery is a relative indication for lung isolation. Surgical access is usually improved if the operative lung is deflated and not moving. However, this is not always the case with empyema due to adhesions and pleural thickening. Importantly, single-lung ventilation will result in a shunt, compromising oxygenation, compound lung abscess drainage DLT Yes Yes PVC and PCA or epidural*

Lobectomy DLT Yes Yes PVC and PCA or epidural*

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analgesia is the ‘gold standard’ for post-thoracotomy pain relief, but paravertebral blocks, with the insertion of a paravertebral catheter (PVC), are gaining in popularity. PVCs have the advantage that they only cause a unilateral block. This means that arterial pressure is maintained due to less sympathetic block, urinary catheters can be avoided, and motor weakness is minimized, allowing early mobilization. Avoiding hypotension prevents the inevitable fluid boluses and associated risk of pulmonary oedema. It has been shown in the elective post-thoracotomy patients that peak expiratory flow rates are significantly better with PVCs when compared with thoracic epidurals. This may be because the unilateral block of PVCs better preserves both intercostal muscle function of the unaffected chest wall and the function of the abdominal muscles. The disadvantage of PVCs is that they often do not provide sufficient analgesia alone and require the addition of opiates, usually in the form of a patient-controlled analgesia (PCA) device. The anterior boundary of the paravertebral space is the parietal pleura. Paravertebral block, therefore, is not suitable when the parietal pleura has been (or will be) removed (decortication).

Epidural abscess after thoracic epidurals is a rare but serious complication. As patients with empyemas have a high probability of systemic sepsis, risk–benefit analysis must be given due consideration for each individual patient before insertion of a thoracic epidural. Intercostal blocks and a PCA are an alternative.

### Lung abscess

A lung abscess is a localized area of lung suppuration, leading to necrosis of the lung parenchyma with or without cavity formation. These are now rare in the developed world but still carry a mortality of ~10%. This can be increased up to 75% in the presence of underlying pneumonia, neoplasm, altered consciousness, anaemia (haemoglobin <10 g dl⁻¹), immunocompromise, or infection with *Pseudomonas aeruginosa*, *S. aureus*, or *Klebsiella pneumoniae*. They are most common in alcoholic men over the age of 50 and usually occur in patients with altered consciousness, as most are the result of aspiration. Other risk factors include dental disease, bronchial carcinoma, pneumonia (occurs in 16% of those with *S. aureus* pneumonia), and septic embolization (e.g. right heart endocarditis secondary to *S. aureus* in i.v. drug users). Although most commonly secondary, lung abscesses can be primary and also single or multiple, acute or chronic.

The presentation is often of an insidious onset with fever, weight loss, and respiratory symptoms such as chest pain and a cough that can be productive of foul-smelling sputum or haemoptysis, which can be massive and life threatening.

### Bacteriology

There is a mixed flora in at least 50%, with anaerobes being present in 30–50%. Because of the association with aspiration, the most common organisms seen are those colonizing the oral cavities and the gingival crevices that include *Peptostreptococcus*, *Prevotella*, *Bacteroides*, and *Fusobacterium* species. Aerobic organisms seen are *Streptococcus milleri*, *S. aureus*, *Klebsiella* species, *Streptococcus pyogenes*, and *Haemophilus influenzae*.

It is important not to forget mycobacteria and fungi such as aspergillus.

### Investigation

**Microbiology**

Sufficient samples are usually obtained with blood and sputum cultures. Sputum should be sent for microscopy, culture and sensitivity and acid-fast bacilli (AFB). Ideally, three early morning sputum samples should be sent for AFB’s. Bronchoscopy should be considered if there is difficulty expectorating sputum or if there is a failure of treatment. Bronchoscopy is also useful if other pathologies such as malignancy are suspected.

Sometimes percutaneous biopsies are required to obtain samples, usually performed under CT guidance.

### Imaging

The chest radiograph may not be sensitive enough to detect a lung abscess, especially if the film is taken in the semi-recumbent position in less than ideal circumstances such as the emergency department or the ICU. It may look normal or simply show areas of consolidation. Classically, it will show cavitation with an air-fluid level. The differential diagnosis of a cavitating lesion is listed in Table 4.

If the diagnosis is not clear or other pathologies are suspected, then a CT can be useful to show the extent of the disease and identify whether a cause of the abscess such as an inhaled foreign body or obstructing tumour is present.

Looking for a cause of the abscess, particularly if multiple should not be forgotten and more extensive CTs and an echocardiogram should be considered.

### Management

The mainstay of treatment is antibiotics plus physiotherapy to aid drainage. A prolonged course of antibiotics (4–6 weeks depending on clinical and radiological response) is required. Where treatment is successful, it is with medical management in the majority of cases. When treating without an organism having been identified,
initial therapy needs to include anaerobic cover and have a wide spectrum to cover bacteria commonly found.

When antibiotic treatment fails, percutaneous drainage has been shown to avoid surgery in 84% with complications such as BPFs, haemothorax, and empyema infrequent. Drains are commonly inserted under either CT or ultrasound guidance.

**Surgery**

Surgery is rarely necessary but may be required if the abscess is large (>6 cm), resistant to medical treatment, or if there is significant haemorrhage. The surgical options are varied but involve either external drainage or lobectomy for large abscesses that have destroyed a significant part of the lobe already. The approach for drainage can be through VATS or a thoracotomy. These cases should be treated as a BPF as there is the potential for soiling of the unaffected lung and a significant air leak once the abscess is drained.

**Haemoptysis**

This may be the presenting symptom and can be life threatening. The definition of massive haemoptysis is variable, ranging from 100 to 1000 ml day⁻¹ with a more practical definition being of a volume sufficient to be life threatening by virtue of blood loss or airway obstruction.¹³ As the anatomical dead space is 100–200 ml, airway compromise can occur with apparently small-volume haemoptysis, especially if expectoration is impaired, and before any signs of haemodynamic compromise.

Establishing the site of the haemoptysis is important, particularly if ongoing haemorrhage requires unilateral lung intubation, and early bronchoscopy should be considered.

If there is no airway compromise, initial management should be aimed at volume resuscitation and correction of coagulopathy and the patient positioned with the bleeding side down to prevent aspiration to the unaffected lung.

If there is ongoing haemorrhage with airway compromise, then lung isolation with a DLT is necessary. This is preferable to a bronchial blocker as both lungs can be isolated, suctioned, and ventilated which is particularly important if it is unknown which lung is bleeding. If no DLT is available (or no anaesthetist available with the skills to place the DLT), then a single-lumen tube can be advanced into the unaffected main bronchus (ideally over a bronchoscope) or a bronchial blocker placed in the affected main bronchus. The presence of blood in the airways makes this very difficult in practice and attempting to intubate the right main bronchus can lead to occlusion of the right upper lobe.

The definitive treatment for ongoing haemoptysis would be surgery or bronchial artery embolization, both of which require stabilization and transfer to a specialist centre.

**Conclusion**

Pleural effusions are common and deciding whom to investigate for empyema should be based on the clinical presentation. When in doubt, a diagnostic aspiration of a sample of pleural fluid is recommended. Treatment is with antibiotics, adequate nutrition, and the evacuation of infected fluid. An empyema requires surgery in ~20% cases. If there has been recent thoracic surgery, it should be assumed there is a BPF.

Lung abscesses are rare but carry a significant mortality. They can normally be managed without the need for surgery. If required, surgery can cause soiling or a significant BPF.

Both conditions are challenging to the anaesthetist if they require surgery as they often require one-lung ventilation and commonly occur in patients with significant co-morbidities.

**Conflict of interest**

None declared.

**References**


Please see multiple choice questions 25–28.