Diseases of the pleura and pleural space are common and present a significant contribution to the workload of respiratory physicians. Despite their prevalence and clinical importance, there is limited consensus on their management. These guidelines attempt to integrate the available objective evidence with clinical experience relating to the investigation and treatment of these problems. The guidelines have been prepared using consistent methods and are presented in a broadly similar way.

STRUCTURE OF EACH GUIDELINE

The first section of each guideline consists of a brief introduction that sets an historical and clinical background for the management guidance itself.

The guidelines are then presented so that they can be read at three levels. The articles begin with a flow diagram that is intended to present a “thumbnail” sketch of management for the relevant area. These flow diagrams are brief enough to be used as a wall display in, for instance, an accident and emergency department or respiratory ward, or might be added to a junior doctor’s personal organiser.

At the next level, the reader can look at the bullet points presented after the flow diagram in each document. These are structured to follow the same order as the flow diagram and represent the “key facts” which underpin the flow diagram. These bullet points have been rated according to the strength of evidence that lies behind each recommendation. This grading is laid out in table 1 and ranges from grade A (based on good quality clinical trial evidence) to grade C (based on expert opinion alone).

Beneath each set of bullet points is a short paragraph detailing the literature and the rationale relating to that section’s bullet points. This text is intended to provide greater detail without requiring access to the primary literature. The text is referenced in detail and these references constitute the bibliography at the end of each guideline for the reader wishing to explore the data for themselves. This primary source literature has been individually graded for its methodology and the grading is given alongside each reference. The explanation of this grading system is presented in table 2.

METHODS USED IN GENERATING THE GUIDELINES

Each guideline was researched and drafted by a subgroup of the Pleural Diseases Group (itself a subcommittee of the BTS Standards of Care Committee). Members of the drafting subgroup of the Pleural Diseases Group are cited as the primary authors of each guideline. For each guideline area, a systematic search of the Medline database was performed using all identifiable key words relevant to the disease area of interest. Thereafter, a paper based exploration of the relevant literature was pursued from this core dataset. All English language literature including all clinical trials and all well formulated clinical case series were identified. Isolated case reports were excluded unless they seemed particularly relevant. Animal and basic science research was cited as needed, but no systematic review of this literature was performed. All identified publications were reviewed by the drafting subgroup of the Pleural Diseases Group.
Abstracted bullet points from each of the BTS guidelines for the management of pleural disease

In this section the “bullet points” from each of the BTS guidelines for the management of pleural disease are presented together so that they can be easily reproduced and used for teaching, training, A&E handbooks, etc.

INVESTIGATION OF A UNILATERAL PLEURAL EFFUSION IN ADULTS

Clinical assessment and history
- Aspiration should not be performed for bilateral effusions in a clinical setting strongly suggestive of a pleural transudate, unless there are atypical features or they fail to respond to therapy. [C]
- An accurate drug history should be taken during clinical assessment. [C]

Pleural aspiration
- A diagnostic pleural fluid sample should be gathered with a fine bore (21G) needle and a 50 ml syringe. The sample should be placed in both sterile vials and blood culture bottles and analysed for protein, lactate dehydrogenase (LDH, to clarify borderline protein values), pH, Gram stain, AAFB stain, cytology, and microbiological culture. [C]

Pleural fluid analysis
- The appearance of the pleural fluid and any odour should be noted. [C]
- A pleural fluid haematocrit is helpful in the diagnosis of haemothorax.
- The pleural protein should be measured to differentiate between a transudative and exudative pleural effusion. This will usually suffice if the patient’s serum protein level is normal and pleural protein is less than 25 g/l or more than 35 g/l. If not, Light’s criteria (see box 5, page ii11) should be used. [B]
- Pleural lymphocytosis is common in malignancy and tuberculosis.
- Eosinophilic pleural effusions are not always benign.
- pH should be performed in all non-purulent effusions. [B]
- In an infected effusion a pH of <7.2 indicates the need for tube drainage. [B]
- Amylase measurement should be requested if acute pancreatitis or rupture of the oesophagus is possible. [C]
- Iso-enzyme analysis is useful in differentiating high amylase levels secondary to malignancy or ruptured oesophagus from those raised in association with abdominal pathology.
- Malignant effusions can be diagnosed by pleural fluid cytology alone in only 60% of cases.
- If the first pleural cytology specimen is negative, this should be repeated a second time. [B]
- Both cell blocks and fluid smears should be prepared for examination and, if the fluid has clotted, it needs to be fixed and sectioned as a histological section. [B]

Diagnostic imaging
- PA and lateral chest radiographs should be performed in the assessment of suspected pleural effusion. [C]
- Ultrasound guided pleural aspiration should be used as a safe and accurate method of obtaining fluid if the effusion is small or loculated. [B]
- Fibrous septations are better visualised on ultrasound than on CT scans.
- CT scans for pleural effusion should be performed with contrast enhancement. [C]
- In cases of difficult drainage, CT scanning should be used to delineate the size and position of loculated effusions. [C]
- CT scanning can usually differentiate between benign and malignant pleural thickening.

Invasive investigations
- Pleural tissue should always be sent for tuberculosis culture whenever a biopsy is performed. [B]
- In cases of mesothelioma, the biopsy site should be irradiated to stop biopsy site invasion by tumour. [A]
- When using an Abrams’ needle, at least four biopsy specimens should be taken from one site. [C]
- When obtaining biopsies from focal areas of pleural nodularity shown on contrast enhanced CT scans, image guidance should be used. [C]
- Image guided cutting needle biopsies have a higher yield for malignancy than standard Abrams’ needle pleural biopsy.
- Thoracoscopy should be considered when less invasive tests have failed to give a diagnosis. [B]
- Routine diagnostic bronchoscopy should not be performed for undiagnosed pleural effusion. [C]
- Bronchoscopy should be considered if there is haemoptysis or clinical features suggestive of bronchial obstruction. [C]
Abstracted bullet points from each of the BTS guidelines for the management of pleural disease (continued)

**Special tests**
- If a chylothorax or pseudochylothorax is suspected, pleural fluid should be sent for measurement of triglyceride and cholesterol levels and the laboratory asked to look for the presence of cholesterol crystals and chylomicrons. [C]
- If a pneumothorax is suspected, the pleural fluid creatinine level should be measured and will be higher than the serum creatinine level. [C]
- When pleural biopsies are taken, they should be sent for both histological examination and culture to improve the diagnostic sensitivity for tuberculosis. [B]
- There are no specific pleural fluid characteristics to distinguish those caused by pulmonary embolism. This diagnosis should be pursued on clinical grounds.
- Suspected rheumatoid effusions should have a pleural fluid pH, glucose and complement measured. [C]
- Rheumatoid arthritis is unlikely to be the cause of an effusion if the glucose level in the fluid is above 1.6 mmol/l (29 mg/dl).
- The pleural fluid ANA level should not be measured as it mirrors serum levels and is therefore unhelpful. [C]
- In patients with HIV infection, the differential diagnosis of pleural effusion is wide and differs from the immunocompetent patient.

**Management of persistent undiagnosed pleural effusion**
- In persistently undiagnosed effusions, the possibility of pulmonary embolism and tuberculosis should be reconsidered since these disorders are amenable to specific treatment. [C]
- Undiagnosed pleural malignancy proves to be the cause of many “undiagnosed” effusions with sustained observation.

**MANAGEMENT OF PLEURAL INFECTION**

**Diagnostic pleural fluid sampling in parapneumonic pleural effusions**
- All patients with a pleural effusion in association with sepsis or a pneumonic illness require diagnostic pleural fluid sampling. [C]

**Sampling small parapneumonic pleural effusions**
- In the event of a small effusion or a failed previous attempt at pleural fluid sampling, an ultrasound scan and image guided fluid sampling is recommended. [C]
- Pleural effusions with maximal thickness <10 mm on ultrasound scanning can be observed, with pleural fluid sampling if the effusion enlarges. [C]

**When to use chest tube drainage in pleural infection**
- Patients with frankly purulent or turbid/cloudy pleural fluid on sampling should receive prompt pleural space chest tube drainage. [B]
- The presence of organisms identified by Gram stain or culture from non-purulent pleural fluid samples indicates that pleural infection is established and should lead to prompt chest tube drainage. [B]
- Pleural fluid pH should be assessed in all non-purulent, possibly infected effusions. [B]
- pH <7.2 indicates chest tube drainage is required. [B]
- Parapneumonic effusions that do not fulfil these criteria for chest tube drainage should be treated with antibiotics alone provided clinical progress is good. [B]
- Poor clinical progress during treatment with antibiotics alone should lead to prompt patient review and probably chest tube drainage. [B]

**Other indications for chest tube drainage**
- Patients with a loculated pleural collection should receive earlier chest tube drainage. [C]
- Large non-purulent effusions should be drained by chest tube for symptomatic benefit. [C]

**Referral to a respiratory specialist**
- A respiratory physician or thoracic surgeon should be involved in the care of all patients requiring chest tube drainage for a pleural infection. [C]

**Antibiotics**
- All patients should receive antibiotics. [B]
- Where possible, antibiotics should be guided by bacterial culture results. [B]
- Where cultures are negative, antibiotics should cover community acquired bacterial pathogens and anaerobic organisms. [B]
- Hospital acquired empyema requires broader spectrum antibiotic cover. [B]

**Chest tube drainage**
- There is no consensus on the size of the optimal chest tube for drainage.
- If a small bore flexible catheter is used, regular flushing and suction is recommended to avoid catheter blockage. [C]

**Cessation of chest tube drainage in the presence of a residual pleural fluid collection**
- If the chest tube becomes blocked or pus is unable to drain, it should be flushed with saline to ensure its patency. If poor drainage persists, a chest radiograph or CT scan should be performed to check drain position. [C]

**Intrapleural fibrinolytic drugs**
- Intrapleural fibrinolytic drugs (streptokinase 250 000 IU twice daily for 3 days or urokinase 100 000 IU once a day for 3 days) improve radiological outcome and, in children, hospital stay. Current best evidence favours their use [B], but it is not known if they reduce mortality and/or the need for surgery. Clinical trials are underway to address this question.
- Patients who receive intrapleural streptokinase should be given a streptokinase exposure card and should receive urokinase or tissue plasminogen activator (TPA) for subsequent indications. [C]

**Persistent sepsis and pleural collection**
- Patients with persistent sepsis and a residual pleural collection should undergo further radiological imaging. [C]
**Abstracted bullet points from each of the BTS guidelines for the management of pleural disease (continued)**

### Bronchoscopy
- Bronchoscopy should only be performed in patients where there is a high index of suspicion of bronchial obstruction. [C]

### Nutrition
- Clinicians should ensure adequate nutritional support commencing as soon as possible after pleural infection is identified. [C]

### Referral for surgical treatment
- Failure of chest tube drainage, antibiotics and fibrinolytic drugs should prompt early discussion with a thoracic surgeon. [C]
- Patients should be considered for surgical treatment if they have persisting sepsis in association with a persistent pleural collection, despite chest tube drainage and antibiotics. [C]

### Patients not considered fit for surgery and not improving with chest tube drainage and antibiotics
- In cases of ineffective chest tube drainage and persistent sepsis in patients unable to tolerate general anaesthesia, re-imaging the thorax and placement of further image guided small bore catheters, large bore chest tubes, or intrapleural fibrinolytic therapy should be considered. [C]
- Local anaesthetic surgical rib resection should be considered in patients unsuitable for general anaesthesia. [C]

### MANAGEMENT OF MALIGNANT PLEURAL EFFUSIONS

#### Clinical presentation
- Massive pleural effusions are most commonly due to malignancy. [B]

#### Management by observation alone
- Observation is recommended if the patient is asymptomatic or there is no recurrence of symptoms after initial thoracentesis. [C]
- Advice should be sought from the thoracic malignancy multidisciplinary team for symptomatic or recurrent malignant effusions. [C]

#### Therapeutic pleural aspiration
- Repeat pleural aspiration is recommended for the palliation of breathlessness in patients with a very short life expectancy. [C]
- Caution should be taken if removing more than 1.5 l on a single occasion. [C]
- The recurrence rate at 1 month after pleural aspiration alone is close to 100%. [B]
- Intercostal tube drainage without pleurodesis is not recommended because of a high recurrence rate. [B]

#### Size of intercostal tube
- Small bore (10–14 F) intercostal catheters should be the initial choice for effusion drainage and pleurodesis. [B]

#### Lung re-expansion, fluid drainage and suction
- Large pleural effusions should be drained in a controlled fashion to reduce the risk of re-expansion pulmonary oedema (RPO). [C]
- Suction to aid pleural drainage before and after pleurodesis is usually unnecessary but, if applied, a high volume, low-pressure system is recommended. [C]
- In patients where only partial pleural apposition can be achieved, chemical pleurodesis should still be attempted and may provide symptomatic relief. [B]
- Once effusion drainage and lung re-expansion have been radiographically confirmed, pleurodesis should not be delayed while the cessation of pleural fluid drainage is awaited. [B]

#### Analgesia and premedication
- Lignocaine (3 mg/kg; maximum 250 mg) should be administered intrapleurally just prior to sclerosant administration. [B]
- Premedication should be considered to alleviate anxiety and pain associated with pleurodesis. [C]

#### Selecting a sclerosing agent
- Talc is the most effective sclerosant available for pleurodesis. [B]
- A small number of patients (<1%) may develop acute respiratory failure following talc administration. [B]
- Tetracycline is modestly effective, has few severe side effects, and is the preferred sclerosant to minimise adverse event rates. [B]
- Bleomycin is an alternative sclerosant with a modest efficacy rate but is expensive. [B]
- Pleuritic chest pain and fever are the most common side effects of sclerosant administration. [B]

#### Rotation following pleurodesis
- Patient rotation is not necessary after intrapleural instillation of tetracycline class agents. [A]

#### Clamping of intercostal tube
- The intercostal tube should be clamped for 1 hour after sclerosant administration. [C]
- In the absence of excessive fluid drainage (>250 ml/day) the intercostal tube should be removed within 12–72 hours of sclerosant administration. [C]

#### Malignant seeding at intercostal tube or port site
- Patients with proven or suspected mesothelioma should receive prophylactic radiotherapy to the site of biopsy or chest drain insertion. [A]

#### Intrapleural fibrinolytics
- Intrapleural instillation of fibrinolytic drugs is recommended for the relief of distressing dyspnoea due to multiloculated malignant effusion resistant to simple drainage. [C]

#### Thoracoscopy in malignant pleural effusion
- Thoracoscopy should be considered for the diagnosis of suspected but unproven malignant pleural effusion. [B]
- Thoracoscopy should be considered for the control of recurrent malignant pleural effusion. [B]
- Thoracoscopy is a safe procedure with low complication rates. [B]
### Abstracted bullet points from each of the BTS guidelines for the management of pleural disease (continued)

#### Long term indwelling pleural catheter drainage
- Chronic indwelling pleural catheters are effective in controlling recurrent and symptomatic malignant effusions in selected patients. [B]

#### Pleuroperitoneal shunting
- Pleuroperitoneal shunts are an alternative and effective option in patients with a trapped lung or failed pleurodesis. [B]

#### MANAGEMENT OF SPONTANEOUS PNEUMOTHORAX

##### Smoking
- Strong emphasis should be placed on the relationship between the recurrence of pneumothorax and smoking in an effort to encourage patients to stop smoking. [B]

##### Clinical evaluation and imaging
- Expiratory chest radiographs should not be used for the routine diagnosis of pneumothorax. [B]
- A lateral chest or lateral decubitus radiograph should be performed if the clinical suspicion of pneumothorax is high, but a PA radiograph is normal. [B]
- CT scanning is recommended when differentiating a pneumothorax from complex bullous lung disease, when aberrant tube placement is suspected, and when the plain chest radiograph is obscured by surgical emphysema. [C]
- The clinical history is not a reliable indicator of pneumothorax size. [C]

##### Size of pneumothorax
- The previous classification of the size of a pneumothorax tends to underestimate its volume. In these new guidelines the size of a pneumothorax is divided into “small” or “large” depending on the presence of a visible rim of <2 cm or >2 cm between the lung margin and the chest wall.

##### Treatment by observation alone
- Observation should be the treatment of choice for small closed pneumothoraces without significant breathlessness. [B]
- Patients with small (<2 cm) primary pneumothoraces not associated with breathlessness should be considered for discharge with early outpatient review. These patients should receive clear written advice to return in the event of worsening breathlessness. [B]
- If a patient with a pneumothorax is admitted overnight for observation, high flow (10 l/min) oxygen should be administered, with appropriate caution in patients with COPD who may be sensitive to higher concentrations of oxygen. [B]
- Breathless patients should not be left without intervention regardless of the size of the pneumothorax on a chest radiograph. [C]

##### Simple aspiration
- Simple aspiration is recommended as first line treatment for all primary pneumothoraces requiring intervention. [A]
- Simple aspiration is less likely to succeed in secondary pneumothoraces and, in this situation, is only recommended as an initial treatment in small (<2 cm) pneumothoraces in minimally breathless patients under the age of 50 years. [B]
- Patients with secondary pneumothoraces treated successfully with simple aspiration should be admitted to hospital and observed for at least 24 hours before discharge. [C]

##### Repeat aspiration and catheter aspiration of simple pneumothorax
- Repeated aspiration is reasonable for primary pneumothorax when the first aspiration has been unsuccessful (i.e. patient still symptomatic) and a volume of <2.5 l has been aspirated on the first attempt. [B]
- Catheter aspiration of pneumothorax (CASP) can be used where the equipment and experience is available. [B]
- Catheter aspiration kits with an integral one way valve system may reduce the need for repeat aspiration. [C]

##### Intercostal tube drainage
- If simple aspiration or catheter aspiration drainage of any pneumothorax is unsuccessful in controlling symptoms, then an intercostal tube should be inserted. [B]
- Intercostal tube drainage is recommended in secondary pneumothorax except in patients who are not breathless and have a very small (<1 cm or apical) pneumothorax. [B]
- A bubbling chest tube should never be clamped. [B]
- A chest tube which is not bubbling should not usually be clamped. [B]
- If a chest tube for pneumothorax is clamped, this should be under the supervision of a respiratory physician or thoracic surgeon, the patient should be managed in a specialist ward with experienced nursing staff, and the patient should not leave the ward environment. [C]
- If a patient with a clamped drain becomes breathless or develops subcutaneous emphysema, the drain must be immediately unclamped and medical advice sought. [C]

##### Size of chest tube
- There is no evidence that large tubes (20–24 F) are any better than small tubes (10–14 F) in the management of pneumothoraces. The initial use of large (20–24 F) intercostal tubes is not recommended, although it may become necessary to replace a small chest tube with a larger one if there is a persistent air leak. [B]

##### Referral to respiratory specialists
- Pneumothoraces which fail to respond within 48 hours to treatment should be referred to a respiratory physician. [C]

##### Chest drain suction
- Suction to an intercostal tube should not be applied directly after tube insertion, but can be added after 48 hours for persistent air leak or failure of a pneumothorax to re-expand. [B]
- High volume, low pressure (~10 to ~20 cm H₂O) suction systems are recommended. [C]
- Patients requiring suction should only be managed on lung units where there is specialist medical and nursing experience. [C]
Abstracted bullet points from each of the BTS guidelines for the management of pleural disease (continued)

**Chemical pleurodesis**
- Chemical pleurodesis can control difficult or recurrent pneumothorax [A] but should only be attempted if the patient is either unwilling or unable to undergo surgery. [B]
- Medical pleurodesis for pneumothorax should be performed by a respiratory specialist. [C]

**Referral to thoracic surgeons**
- In cases of persistent air leak or failure of the lung to re-expand, the managing respiratory specialist should seek an early (3–5 days) thoracic surgical opinion. [C]
- Open thoracotomy and pleurectomy remains the procedure with the lowest recurrence rate for difficult or recurrent pneumothoraces. Minimally invasive procedures, thoracoscopy (VATS), pleural abrasion, and surgical talc pleurodesis are all effective alternatives.

**Surgical chemical pleurodesis**
- Surgical chemical pleurodesis is best achieved with 5 g sterile talc. Side effects such as ARDS and empyema are reported but rare. [A]

**Discharge and follow up**
- Patients discharged without intervention should avoid air travel until a chest radiograph has confirmed resolution of the pneumothorax. [C]
- Diving should be permanently avoided after a pneumothorax, unless the patient has had a surgical pleurectomy. [C]
- Primary pneumothorax patients treated successfully by simple aspiration should be observed for 4–6 hours before discharge. Secondary pneumothorax patients who are successfully treated with simple aspiration should be admitted for 24 hours before discharge to ensure no recurrence. [C]

**Pneumothorax and AIDS**
- Early and aggressive treatment of pneumothoraces in HIV patients, incorporating intercostal tube drainage and early surgical referral, is recommended. [B]

**Pneumothorax and cystic fibrosis**
- Early and aggressive treatment of pneumothoraces in cystic fibrosis is recommended. [C]
- Surgical intervention should be considered after the first episode, provided the patient is fit for the procedure. [C]

**Tension pneumothorax**
- If tension pneumothorax is present, a cannula of adequate length should be promptly inserted into the second intercostal space in the mid clavicular line and left in place until a functioning intercostal tube can be positioned. [B]

**INSERTION OF A CHEST DRAIN**

**Training**
- All personnel involved with insertion of chest drains should be adequately trained and supervised. [C]

**Pre-drainage risk assessment**
- Risk of haemorrhage: where possible, any coagulopathy or platelet defect should be corrected prior to chest drain insertion but routine measurements of platelet count and/or prothrombin time should only be performed in patients with known risk factors. [C]
- The differential diagnosis between a pneumothorax and bullous disease requires careful radiological assessment. Similarly, it is important to differentiate between the presence of collapse and a pleural effusion when the chest radiograph shows a unilateral “whiteout”.
- Lung densely adherent to the chest wall throughout the hemithorax is an absolute contraindication to chest drain insertion. [C]
- The drainage of a post pneumonectomy space should only be carried out by or after consultation with a cardiothoracic surgeon. [C]

**Consent and premedication**
- Prior to commencing chest tube insertion the procedure should be explained fully to the patient and consent recorded in accordance with national guidelines. [C]
- Unless there are contraindications to its use, premedication (benzodiazepine or opioid) should be given to reduce patient distress. [B]

**Confirming site of drain insertion**
- A chest tube should not be inserted without further image guidance if free air or fluid cannot be aspirated with a needle at the time of anaesthesia. [C]
- Imaging should be used to select the appropriate site for chest tube placement. [B]
- A chest radiograph must be available at the time of drain insertion except in the case of tension pneumothorax. [C]

**Drain size**
- Small bore drains are more comfortable for the patient than larger bore tubes, [B] but there is no evidence that either is therapeutically superior.
- Large bore drains are recommended for drainage of acute haemothorax to monitor further blood loss. [C]

**Aseptic technique**
- Aseptic technique should be employed during catheter insertion. [C]
- Prophylactic antibiotics should be given in trauma cases. [A]

**Anaesthesia**
- Local anaesthetic should be infiltrated prior to insertion of the drain. [C]
### Abstrated bullet points from each of the BTS guidelines for the management of pleural disease (continued)

#### Insertion of chest tube
- Chest drain insertion should be performed without substantial force. [C]
- Insertion of a small bore drain under image guidance with a guidewire does not require blunt dissection.
- Blunt dissection into the pleural space must be performed before insertion of a large bore chest drain. [C]

#### Incision
- The incision for insertion of the chest drain should be similar to the diameter of the tube being inserted. [C]

#### Position of tube tip
- The position of the tip of the chest tube should ideally be aimed apically for a pneumothorax or basally for fluid. However, any tube position can be effective at draining air or fluid and an effectively functioning drain should not be repositioned solely because of its radiographic position. [C]

#### Securing the drain
- Large and medium bore chest drain incisions should be closed by a suture appropriate for a linear incision. [C]
- “Purse string” sutures must not be used. [C]

#### Clamping of chest drains
- A bubbling chest tube should never be clamped. [C]
- Drainage of a large pleural effusion should be controlled to prevent the potential complication of re-expansion pulmonary oedema. [C]
- In cases of pneumothorax, clamping of the chest tube should usually be avoided. [B]
- If a chest tube for pneumothorax is clamped, this should be under the supervision of a respiratory physician or thoracic surgeon, the patient should be managed in a specialist ward with experienced nursing staff, and the patient should not leave the ward environment. [C]
- If a patient with a clamped drain becomes breathless or develops subcutaneous emphysema, the drain must be immediately unclamped and medical advice sought. [C]

#### Closed system drainage
- All chest tubes should be connected to a single flow drainage system e.g. under water seal bottle or flutter valve. [C]
- Use of a flutter valve system allows earlier mobilisation and the potential for earlier discharge of patients with chest drains.

#### Suction
- When chest drain suction is required, a high volume/low pressure system should be used. [C]
- When suction is required, the patient must be nursed by appropriately trained staff. [C]

#### Ward instructions
- Patients with chest tubes should be managed on specialist wards by staff who are trained in chest drain management. [C]
- A chest radiograph should be performed after insertion of a chest drain. [C]

#### Removal of a chest tube
- In cases of pneumothorax, the chest tube should not be clamped at the time of its removal. [B]
BTS guidelines for the investigation of a unilateral pleural effusion in adults

N A Maskell, R J A Butland, on behalf of the British Thoracic Society Pleural Disease Group, a subgroup of the British Thoracic Society Standards of Care Committee

1 INTRODUCTION

Pleural effusions, the result of the accumulation of fluid in the pleural space, are a common medical problem. They can be caused by several mechanisms including increased permeability of the pleural membrane, increased pulmonary capillary pressure, decreased negative intrathoracic pressure, decreased onotic pressure, and obstructed lymphatic flow. The pathophysiology of pleural effusions is discussed in more detail in the guideline on malignant effusions (page ii29).

Pleural effusions indicate the presence of disease which may be pulmonary, pleural, or extrapulmonary. As the differential diagnosis is wide, a systematic approach to investigation is necessary. The aim is to establish a diagnosis swiftly while minimising unnecessary invasive investigation. This is particularly important as the differential diagnosis includes malignant mesothelioma in which 40% of needle incisions for investigation are invaded by tumour.7 A minimum number of interventions is therefore appropriate. A diagnostic algorithm for the investigation of a pleural effusion is shown in fig 1.

2 CLINICAL ASSESSMENT AND HISTORY

• Aspiration should not be performed for bilateral effusions in a clinical setting strongly suggestive of a pleural transudate, unless there are atypical features or they fail to respond to therapy. [C]

• An accurate drug history should be taken during clinical assessment. [C]

The initial step in assessing a pleural effusion is to ascertain whether it is a transudate or exudate. Initially this is through the history and physical examination. The biochemical analysis of pleural fluid is considered later (section 5).

Clinical assessment alone is often capable of identifying transudative effusions. In a series of 33 cases, all 17 transudates were correctly predicted by clinical assessment, blind of the results of pleural fluid analysis. There are a multitude of causes of transudates and exudates and these are shown in boxes 2 and 3, together with a guide to their frequency.

4 PLEURAL ASPIRATION

• A diagnostic pleural fluid sample should be gathered with a fine bore (21G) needle and a 50 ml syringe. The sample should be placed in both sterile vials and blood culture bottles and analysed for protein, lactate dehydrogenase (LDH, to clarify borderline protein values), pH, Gram stain, AAFB stain, cytology, and microbiological culture. [C]

This is the primary means of evaluating pleural fluid and its findings are used to guide further investigation. Diagnostic taps are often performed in the clinic or by the bedside, although small

Box 1 Drugs known to cause pleural effusions

Over 100 reported cases globally*

• Amiodarone
• Nitrofurantoin
• Phenytoin
• Methotrexate

20–100 reported cases globally*

• Carbamazepine
• Procainamide
• Propylthiouracil
• Penicillamine
• GCSF
• Cyclophosphamide
• Bromocriptine

*pneumotox.com (2001)
Figure 1  Flow diagram of the investigation pathway for a unilateral pleural effusion of unknown aetiology.
effusions often require radiological guidance. A green needle (21G) and 50 ml syringe are adequate for diagnostic pleural taps. The 50 ml sample should be split into three sterile pots to be sent directly for microbiological, biochemical, and cytological analysis.

Microscopic examination of Gram stained pleural fluid sediment is necessary for all fluids and particularly when a parapneumonic effusion is suspected. If some of the microbiological specimen is sent in blood culture bottles the yield is greater, especially for anaerobic organisms.2

20 ml of pleural fluid is adequate for cytological examination and the fresher the sample when it arrives at the laboratory the better. If part of the sample has clotted, the cytologist must fix and section this and treat it as a histological section as it will increase the yield. SENDING the cytology sample in a citrate bottle will prevent clots and is preferred by some cytologists. If delay is anticipated, the specimen can be stored at 4°C for up to 4 days.7

5 PLEURAL FLUID ANALYSIS

5.1 Typical characteristics of the pleural fluid

• The appearance of the pleural fluid and any odour should be noted. [C]
• A pleural fluid haematocrit is helpful in the diagnosis of haemothorax.

After performing pleural aspiration, the appearance and odour of the pleural fluid should be noted. The unpleasant aroma of anaerobic infection may guide antibiotic choice. The appearance can be divided into serous, blood tinged, frankly bloody, or purulent. If the pleural fluid is turbid or milky it should be centrifuged. If the supernatant is clear, the turbid fluid was due to cell debris and empyema is likely. If it is still turbid, this is because of a high lipid content and a chylothorax or pseudochylothorax are likely.8 Table 1 lists the characteristics of the pleural fluid in certain pleural diseases.

If the pleural fluid appears bloody, a haematocrit can be obtained if there is doubt as to whether it is a haemothorax. If the haematocrit of the pleural fluid is more than half of the patient’s peripheral blood haematocrit, the patient has a haemothorax. If the haematocrit on the pleural fluid is less than 1%, the blood in the pleural fluid is not significant.9 Grossly bloody pleural fluid is usually due to malignancy, pulmonary embolus with infarction, trauma, benign asbestos pleural effusions, or post-cardiac injury syndrome (PCIS).10

5.2 Differentiating between a pleural fluid exudate and transudate

• The pleural protein should be measured to differentiate between a transudative and exudative pleural effusion. This will usually suffice if the patient’s serum protein is normal and pleural protein is less than 25 g/l or more than 35 g/l. If not, Light’s criteria (see box 5) should be used. [B]

The classical way of separating a transude from an exudate is by pleural fluid protein, with exudates having a protein level of >30 g/l and transudates a protein level of <30 g/l. Care should be taken in interpreting this result if the serum total protein is abnormal. Unfortunately, the protein level often lies very close to the 30 g/l cut off point, making clear differentiation difficult. In these cases, measurement of serum and pleural fluid lactate dehydrogenase (LDH) and total protein levels will allow the use of Light’s criteria to distinguish between these two more accurately (box 5).11

A considerable number of other biochemical markers have been compared with Light’s criteria. These include measuring pleural fluid cholesterol, albumin gradient, and serum/pleural fluid bilirubin ratio.12,13 The accuracy of these different indices

### Box 2 Causes of transudative pleural effusions

**Very common causes**
- Left ventricular failure
- Liver cirrhosis
- Hypoalbuminaemia
- Peritoneal dialysis

**Less common causes**
- Hypothyroidism
- Nephrotic syndrome
- Mitral stenosis
- Pulmonary embolism

**Rare causes**
- Constrictive pericarditis
- Urinothorax
- Superior vena cava obstruction
- Ovarian hyperstimulation
- Meigs’ syndrome

### Box 3 Causes of exudative pleural effusions

**Common causes**
- Malignancy
- Parapneumonic effusions

**Less common causes**
- Pulmonary infarction
- Rheumatoid arthritis
- Autoimmune diseases
- Benign asbestos effusion
- Pancreatitis
- Post-myocardial infarction syndrome

**Rare causes**
- Yellow nail syndrome
- Drugs (see box 1)
- Fungal infections

### Box 4 Key facts when investigating undiagnosed pleural effusions

- If the pleural fluid protein is between 25 and 35 g/l, then Light’s criteria are advised to differentiate accurately exudates from transudates.
- Pleural fluid pH should be performed in all non-purulent effusions if infection is suspected.
- When sending a pleural fluid specimen for microbiological examination, it should be sent in both a sterile tube (for Gram stain, AAFB and TB culture) and in blood culture bottles to increase the diagnostic yield.
- Only 60% of malignant effusions can be diagnosed by cytological examination.
- A contrast enhanced CT scan of the thorax is best performed with the fluid present. This will enable better visualisation of pleura and can identify the best site for pleural biopsy if cytological examination is unhelpful.

### Table 1 Appearance of pleural fluid

<table>
<thead>
<tr>
<th>Fluid</th>
<th>Suspected disease</th>
</tr>
</thead>
<tbody>
<tr>
<td>Putrid odour</td>
<td>Anaerobic empyema</td>
</tr>
<tr>
<td>Food particles</td>
<td>Oesophageal rupture</td>
</tr>
<tr>
<td>Bile stained</td>
<td>Cholethorax (biliary fistula)</td>
</tr>
<tr>
<td>Milky</td>
<td>Chylothorax/pseudochylothorax</td>
</tr>
<tr>
<td>&quot;Anchovy sauce&quot; like fluid</td>
<td>Ruptured amoebic abscess</td>
</tr>
</tbody>
</table>

Table 1 lists the characteristics of the pleural fluid in certain pleural diseases.
in differentiating exudates and transudates has been examined in a meta-analysis of 1448 patients from eight studies. Light's criteria performed best with excellent discriminative properties. Further analysis suggests a cut off value of LDH levels in pleural fluid of >0.66, the upper limits of the laboratory normal might be a better discriminator ("modified Light's criteria").

In summary, Light's criteria appear to be the most accurate way of differentiating between transudates and exudates. The weakness of these criteria is that they occasionally identify an effusion in a patient with left ventricular failure on diuretics as an exudate. In this circumstance, clinical judgement should be used.

5.3 Differential cell counts on the pleural fluid

• Pleural lymphocytosis is common in malignancy and tuberculosis.

• Eosinophilic pleural effusions are not always benign. When polymorphonuclear cells predominate, the patient has an acute process affecting the pleural surfaces. If there is concomitant parenchymal shadowing, the most likely diagnoses are parapneumonic effusion and pulmonary embolism with infarction. If there is no parenchymal shadowing, more frequent diagnoses are pulmonary embolism, viral infection, acute tuberculosis, or benign asbestos pleural effusion.

An eosinophilic pleural effusion is defined as the presence of 10% or more eosinophils in the pleural fluid. The presence of pleural eosinophilia is of little use in the differential diagnosis of pleural effusions. Benign aetiologies include parapneumonic effusions, tuberculosis, drug induced pleurisy, benign asbestos pleural effusions, Churg-Strauss syndrome, pulmonary infarction, and parasitic disease. It is often the result of air or blood in the pleural cavity. However, malignancy is also a common cause; 11 of a series of 45 eosinophilic effusions were due to cancer.

If the pleural fluid differential cell count shows a predominance of lymphocytes, the most likely diagnoses are tuberculosis and malignancy. Although high lymphocyte counts in pleural fluid raise the possibility of tuberculous pleurisy, as many as 10% of tuberculous pleural effusions are predominantly neutrophilic. Lymphoma, sarcoidosis, rheumatoid disease, and chylothorax can cause a lymphocytic pleural effusion.

Coronary artery bypass grafting (CABG) often causes pleural effusions which can usually be treated conservatively. Large symptomatic effusions can occur in up to 1% of patients in the postoperative period. These are predominantly left sided and the differential cell count can help to clarify the situation. Bloody effusions are usually eosinophilic, occur early, and are related to bleeding into the pleural cavity from the time of surgery. Non-bloody effusions tend to have small lymphocytes as their predominant cell type, occur later, and are generally more difficult to treat.

5.4 pH

• pH should be performed in all non-purulent effusions. [B]

• In an infected effusion a pH of <7.2 indicates the need for tube drainage. [B]

A pleural fluid pH of <7.2 with a normal blood pH is found in the same diagnoses as a low pleural fluid glucose. A pH of <7.2 represents a substantial accumulation of hydrogen ions, as normal pleural pH is about 7.6 because of bicarbonate accumulation in the pleural cavity. The main clinical use for the measurement of pleural pH is the identification of pleural infection. This is covered in detail in the guideline on pleural infection (page ii18). Other diseases causing an exudative pleural effusion with a low pH are collagen vascular diseases (particularly rheumatoid arthritis), oesophageal rupture, and malignancy.

A prospective study of the value of pH in malignant pleural effusions by Rodriguez and Lopez in 77 patients undergoing thoracoscopy showed that a pH of <7.3 was associated with more extensive malignancy, a 90% chance of positive cytology, and a 50% chance of failed pleurodesis. Sahin and Good showed that a reduced pH (<7.3) predicted poor survival in malignant pleural disease (pH >7.3, median survival 9.8 months; pH <7.3, survival 2.1 months).

5.5 Glucose

A pleural glucose level of less than 3.3 mmol/l is found in exudates, pleural effusions secondary to empyema, rheumatoid disease, lupus, tuberculosis, malignancy, or oesophageal rupture. The lowest glucose concentrations are found in rheumatoid effusions and empyema. In pleural infection, pH discriminates better than glucose. Rheumatoid arthritis is unlikely to be the cause of an effusion if the glucose level in the fluid is above 1.6 mmol/l (see section 8.6.1).

5.6 Amylase

• Amylase measurement should be requested if acute pancreatitis or rupture of the oesophagus is possible. [C]

• Iso-enzyme analysis is useful in differentiating high amylase levels secondary to malignancy or ruptured oesophagus from those raised in association with abdominal pathology.

Pleural fluid amylase levels can be useful in the evaluation of an exudative effusion. Pleural fluid amylase levels are elevated if they are higher than the upper limits of normal for serum or the pleural fluid/serum ratio is >1.0. This suggests acute pancreatitis, pancreatic pseudocyst, rupture of the oesophagus, ruptured ectopic pregnancy, or pleural malignancy (especially adenocarcinoma). Approximately 10% of malignant effusions have raised pleural amylase levels.

Iso-enzyme analysis can be useful in suspected cases of oesophageal rupture as this will show the amylase is of salivary origin. If the salivary amylase is raised and oesophageal rupture is not suspected, malignancy is most likely. Pleural effusions associated with pancreatic disease usually contain pancreatic amylase.

In a prospective study of 176 patients, 10 had an amylase rich effusion. Of these, four had pancreatitis which had not previously been suspected. The rest were due to non-pancreatic diseases of which lung cancer was predominant. The incidence of pleural effusion with acute pancreatitis exceeds 50%. Patients with acute pancreatitis and a pleural effusion tend to have more severe disease and a higher likelihood of subsequently developing a pseudocyst than those without effusions.

5.7 Cytology

• Malignant effusions can be diagnosed by pleural fluid cytology alone in only 60% of cases.

• If the first pleural cytology specimen is negative, this should be repeated a second time. [B]

• Both cell blocks and fluid smears should be prepared for examination and, if the fluid has clotted, it needs to be fixed and sectioned as a histological section. [B]
If malignancy is suspected, cytological examination of the pleural fluid is a quick and minimally invasive way to obtain a diagnosis. The results of the major series reporting the sensitivity of pleural cytology are shown in table 2. These sensitivities vary from 40% to 87%, with a mean of about 60%. Of 55 cases where malignancy was diagnosed on the basis of cytological examination, Garcia et al found 65% were established from the first specimen, a further 27% from the second, and only 5% from the third. A retrospective review of 414 patients between 1973 and 1982 compared the diagnostic efficacy of cytology alone and in combination with pleural biopsy. The final causes of the effusion were malignancy in 281 patients (68%). The presence of pleural malignancy was established by cytology in 162 patients (58%) and, with the addition of a blind pleural biopsy, a further 20 patients (7%) were classified as having malignancy. The yield depends on the skill and interest of the cytologist and on tumour type, with a higher diagnostic rate for adenocarcinoma than for mesothelioma, squamous cell carcinoma, lymphoma and sarcoma. The yield increases if both cell blocks and smears are prepared.

Immunocytochemistry, as an adjunct to cell morphology, is becoming increasingly helpful in distinguishing benign from malignant mesothelial cells and mesothelioma from adenocarcinoma. Epithelial membrane antigen (EMA) is widely used to confirm a cytological diagnosis of epithelial malignancy. When malignant cells are identified, the glandular markers for CEA, B72.3 and Leu-M1 together with calcitonin and cytokeratin 5/6 will often help to distinguish adenocarcinoma from mesothelioma.

### Table 2: Sensitivity of pleural fluid cytology in malignant pleural effusion

<table>
<thead>
<tr>
<th>Reference</th>
<th>No of patients</th>
<th>No caused by malignancy</th>
<th>% diagnosed by cytology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salyer et al</td>
<td>271</td>
<td>95</td>
<td>72.6</td>
</tr>
<tr>
<td>Prakash et al</td>
<td>414</td>
<td>162</td>
<td>57.6</td>
</tr>
<tr>
<td>Nance et al</td>
<td>385</td>
<td>109</td>
<td>71.0</td>
</tr>
<tr>
<td>Hirsch et al</td>
<td>300</td>
<td>117</td>
<td>53.8</td>
</tr>
<tr>
<td>Total</td>
<td>1370</td>
<td>371</td>
<td>61.6</td>
</tr>
</tbody>
</table>

#### 6.1 Plain radiography

- **PA and lateral chest radiographs should be performed in the assessment of suspected pleural effusion.**

The plain chest radiographic features of pleural effusion are usually characteristic. The PA chest radiograph is abnormal in the presence of about 200 ml pleural fluid. However, only 50 ml of pleural fluid can produce detectable posterior costophrenic angle blunting on a lateral chest radiograph. Lateral decubitus films are occasionally useful as free fluid gravitates to the most dependent part of the chest wall, differentiating decubitus films are occasionally useful as free fluid gravitates in a subpulmonic location. They are often transudates and can be difficult to diagnose on the PA radiograph and may require a lateral decubitus view or ultrasound. The PA radiograph will often show a lateral peaking of an apparently raised hemidiaphragm which has a steep lateral slope with gradual medial slope. The lateral radiograph may have a flat appearance of the posterior aspect of the hemidiaphragm with a step downward slope at the major fissure.

#### 6.2 Ultrasound findings

- **Ultrasound guided pleural aspiration should be used as a safe and accurate method of obtaining fluid if the effusion is small or loculated.**
- **Fibrinous septations are better visualised on ultrasound than on CT scans.**

Ultrasound is more accurate than plain chest radiography for estimating pleural fluid volume and aids thoracentesis. After unsuccessful thoracentesis or in a loculated pleural effusion, ultrasound guided aspiration yields fluid in 97% of cases. In a series of 320 patients, Yang et al found that pleural effusions with complex septated, complex non-septated, or homogeneously echogenic patterns are always exudates, whereas hypoechoic effusions can be either transudates or exudates. Ultrasound is also useful in demonstrating fibrous loculation and readily differentiates between pleural fluid and pleural thickening.

#### 6.3 CT findings

- **CT scans for pleural effusion should be performed with contrast enhancement.**
- **CT scanning can usually differentiate between benign and malignant pleural thickening.**

There are features of contrast enhanced thoracic CT scanning which can help differentiate between benign and malignant disease (fig 2). In a study of 74 patients, 39 of whom had malignant disease, Leung et al showed that malignant disease is favoured by nodular pleural thickening, mediastinal pleural thickening, parietal pleural thickening greater than 1 cm, and circumferential pleural thickening. These features have specificities of 94%, 94%, 88%, and 100%, respectively, and sensitivities of 51%, 36%, 56% and 41%. Scott et al evaluated these criteria in 42 patients with pleural thickening; 32 of the 33 cases of pleural malignancy were identified correctly on the basis of the presence of one or more of Leung's criteria. When investigating a pleural effusion a contrast enhanced thoracic CT scan should be performed before full drainage of the fluid as pleural abnormalities will be better visualised.

CT scanning has been shown to be superior to plain radiographs in the differentiation of pleural from parenchymal disease. It is particularly helpful in the assessment and management of loculated pleural effusions. Loculated effusions on CT scans tend to have a lenticular shape with smooth margins and relatively homogeneous attenuation. The role of magnetic resonance (MR) imaging is currently evolving, but generally does not provide better imaging than CT scanning.

#### 7 INVASIVE INVESTIGATIONS

#### 7.1 Percutaneous pleural biopsy

- **Pleural tissue should always be sent for tuberculosis culture whenever a biopsy is performed.**
- **In cases of mesothelioma, the biopsy site should be irradiated to stop biopsy site invasion by tumour.**

Percutaneous pleural biopsies are of greatest value in the diagnosis of granulomatous and malignant disease of the...
pleura. They are performed on patients with undiagnosed exudative effusions, with non-diagnostic cytology, and a clinical suspicion of tuberculosis or malignancy. Occasionally, a blind pleural biopsy may be performed at the same time as the first pleural aspiration if clinical suspicion of tuberculosis is high.

All aspiration and biopsy sites should be marked with Indian ink as the site(s) will need local radiotherapy within 1 month if the final diagnosis is mesothelioma. This is based on a small randomised study showing tumour seeding in the biopsy track in about 40% of the patients who did not receive local radiotherapy. Other clinical trials continue to recruit to clarify this area.

7.1.1 Blind percutaneous pleural biopsies

**When using an Abrams’ needle, at least four biopsy specimens should be taken from one site. [C]**

The Abrams’ pleural biopsy needle is most commonly used in the UK with the Cope needle being less prevalent. Marrone et al. compared these two needles in a small randomised study of 24 patients; the diagnostic yield was similar but samples were larger with an Abrams’ needle. The yield compared with pleural fluid cytology alone is increased by only 7–27% for malignancy. At least four samples need to be taken to optimise diagnostic accuracy, and these should be taken from one site as dual biopsy sites do not increase positivity. The biopsy specimens should be placed in 10% formaldehyde for histological examination and sterile saline for tuberculosis culture. A review of the pleural biopsy yield from 2893 examinations performed between 1958 and 1985 (published in 14 papers) showed a diagnostic rate of 75% for tuberculosis and 57% for carcinoma. In tuberculous effusions, when fluid AAFB smear, culture, biopsy histology, and culture are performed in concert, the diagnostic yield is 80–90%. Complications of Abrams’ pleural biopsy include site pain (1–15%), pneumothorax (3–15%), vasovagal reaction (1–5%), haemothorax (<2%), site haematoma (<1%), transient fever (<1%) and, very rarely, death secondary to haemorrhage. If a pneumothorax is caused, only 1% require chest drainage.

7.1.2 Image guided cutting needle pleural biopsies

**When obtaining biopsies from focal areas of pleural nodularity shown on contrast enhanced CT scans, image guidance should be used. [C]**

**Image guided cutting needle biopsies have a higher yield for malignancy than standard Abrams’ needle pleural biopsy.**

The contrast enhanced thoracic CT scan of a patient with a pleural effusion will often show a focal area of abnormal pleura. An image guided cutting needle biopsy allows that focal area of abnormality to be biopsied. It has a higher yield than that of blind pleural biopsy in the diagnosis of malignancy. This technique is particularly useful in patients who are unsuitable for thoracoscopy. Pleural malignant deposits tend to predominate close to the midline and diaphragm, which are areas best avoided when performing an Abrams’ biopsy. However, it is possible to take biopsy specimens safely from these anatomical regions under radiological imaging. In a recent prospective study 33 patients with a pleural effusion and pleural thickening, demonstrated on contract enhanced CT scanning, underwent percutaneous image guided pleural biopsy. Correct histological
diagnosis was made in 21 of 24 patients (sensitivity 88%, specificity 100%) including 13 of 14 patients with mesothelioma (sensitivity 93%). In a larger retrospective review of image-guided pleural biopsy in one department by a single radiologist, 18 of 21 mesothelioma cases were correctly identified (sensitivity 86%, specificity 100%). The only published complications to date are local haematoma and minor haemoptysis.

7.2 Thoracoscopy

- Thoracoscopy should be considered when less invasive tests have failed to give a diagnosis. [B]

Thoracoscopy is usually used when less invasive techniques (thoracentesis and percutaneous closed pleural biopsy) have not been diagnostic. Harris et al. described 182 consecutive patients who underwent thoracoscopy over a 5 year period and showed it to have a diagnostic sensitivity of 95% for malignancy. Malignancy was shown by thoracoscopy in 66% of patients who had previously had a non-diagnostic closed pleural biopsy and in 69% of patients who had had two negative pleural cytological specimens. A similar sensitivity for malignant disease was described by Page et al. in 121 patients with undiagnosed effusion.

In addition to obtaining a tissue diagnosis, several litres of fluid can be removed during the procedure and the opportunity is also provided for talc pleurodesis. Thoracoscopy may therefore be therapeutic as well as diagnostic. Complications of this procedure appear to be few. The most serious, but rare, is severe haemorrhage caused by blood vessel trauma. In a series of 566 examinations by Viskum and Enk the most common side effect was subcutaneous emphysema (6.9%), with cardiac dysrhythmia occurring in 0.33%, one air embolism, and no deaths.

7.3 Bronchoscopy

- Routine diagnostic bronchoscopy should not be performed for undiagnosed pleural effusion. [C]

- Bronchoscopy should be considered if there is haemoptysis or clinical features suggestive of bronchial obstruction. [C]

Heaton and Roberts reviewed the case records of 32 patients who had bronchoscopy for undiagnosed pleural effusion. In only six did it yield a diagnosis and in four of these the diagnosis was also established by less invasive means. The other two had radiographic abnormalities suggestive of bronchial neoplasm. Upham et al. studied 245 patients over 2 years and Feinsilver et al. studied 70. Both also found positive yields of <5% in patients with a pleural effusion, but no haemoptysis or pulmonary abnormality on the chest radiograph. Chang et al. performed bronchoscopy, thoracentesis, and pleural biopsy on 140 consecutive patients with pleural effusion. In the patient group with an isolated pleural effusion, with no haemoptysis or pulmonary abnormality on the chest radiograph, the yield from bronchoscopy was only 16% whereas pleural investigation yielded a positive diagnosis in 61%. If bronchoscopy is deemed necessary, it should be performed after pleural drainage in order to perform adequate bronchoscopy without extrinsic airway compression by pleural fluid.

### Box 6 Causes of chylothorax and pseudochylothorax

**Chylothorax**
- Neoplasm: lymphoma, metastatic carcinoma
- Trauma: operative, penetrating injuries
- Miscellaneous: tuberculosis, sarcoidosis, lymphangioleiomyomatosis, cirrhosis, obstruction of central veins, amyloidosis

**Pseudochylothorax**
- Tuberculosis
- Rheumatoid arthritis
- Poorly treated empyema

In summary, bronchoscopy has a limited role in patients with an undiagnosed pleural effusion. It should be reserved for patients whose radiology suggests the presence of a mass, loss of volume or when there is a history of haemoptysis or possible aspiration of a foreign body.

#### 8 SPECIAL TESTS

### 8.1 Chylothorax and pseudochylothorax

- If a chylothorax or pseudochylothorax is suspected, pleural fluid should be sent for measurement of triglyceride and cholesterol levels and the laboratory asked to look for the presence of cholesterol crystals and chylomicrons. [C]

True chyrous effusions result from disruption of the thoracic duct or its tributaries. This leads to the presence of chyle in the pleural space. Approximately 50% are due to malignancy (particularly lymphoma), 25% trauma (especially during surgery), and the rest are miscellaneous causes such as tuberculosis, sarcoidosis, and amyloidosis (box 6). Chylothorax must be distinguished from pseudochylothorax or “cholesterol pleurisy” which results from the accumulation of cholesterol crystals in a long standing pleural effusion. In these cases the pleura is usually markedly thickened and fibrotic. In the past, the most common causes of a pseudochyrous effusion were tuberculosis and artificial pneumothorax. Chronic rheumatoid pleurisy is now the usual cause.

Chylothorax and pseudochylothorax can be discriminated by lipid analysis of the fluid. A true chylothorax will usually have a high triglyceride level, usually >1.24 mmol/l (110 mg/dl), and can usually be excluded if the triglyceride level is <0.56 mmol/l (50 mg/dl). The biochemistry laboratory should be asked to look for the presence of chylomicrons between these values. In a pseudochylothorax the cholesterol level is >5.18 mmol/l (200 mg/dl), chylomicrons are not found, and cholesterol crystals are often seen at microscopy (table 3).

Occasionally an empyema can be unusually milky and confused with chylothorax. They can be distinguished by bench centrifugation which leaves a clear supernatant in empyema as the cell debris is separated. The chyrous effusion remains milky.

#### Table 3 Laboratory differentiation of chylothorax and pseudochylothorax

<table>
<thead>
<tr>
<th>Feature</th>
<th>Pseudochylothorax</th>
<th>Chylothorax</th>
</tr>
</thead>
<tbody>
<tr>
<td>Triglycerides</td>
<td>&lt;0.56 mmol/l (50 mg/dl)</td>
<td>&gt;1.24 mmol/l (110 mg/dl)</td>
</tr>
<tr>
<td>Cholesterol</td>
<td>&gt;5.18 mmol/l (200 mg/dl)</td>
<td>&lt;5.18 mmol/l (200 mg/dl)</td>
</tr>
<tr>
<td>Cholesterol crystals</td>
<td>Often present</td>
<td>Absent</td>
</tr>
<tr>
<td>Chylomicrons</td>
<td>Absent</td>
<td>Present</td>
</tr>
</tbody>
</table>

www.thoraxjnl.com
8.2 Urinothorax

- If urinothorax is suspected, the pleural fluid creatinine level should be measured and will be higher than the serum creatinine level. [C]

Urinothorax is a rare complication of an obstructed kidney. The urine is thought to move through the retroperitoneum to enter the pleural space, with the effusion occurring on the same side as the obstructed kidney. The pleural fluid smells like urine and resolves when the obstruction is removed. The diagnosis can be confirmed by demonstrating that the pleural fluid creatinine level is greater than the serum creatinine level. The pleural fluid is a transudate and has a low pH. 

8.3 Tuberculous pleurisy

- When pleural biopsies are taken, they should be sent for both histological examination and culture to improve the diagnostic sensitivity for tuberculosis. [B]

Smears for acid fast bacilli are only positive in 10–20% of tuberculous effusions and are only 25–50% positive on pleural fluid culture. The adenosine deaminase (ADA) level in pleural fluid tends to be higher with tuberculosis than in other exudates. However, ADA levels are also raised in empyema, rheumatoid pleurisy, and malignancy, which makes the test less useful in countries with a low prevalence of tuberculosis. Importantly, ADA levels may not be raised if the patient has HIV and tuberculosis. 

8.4 Pleural effusion due to pulmonary embolism

- There are no specific pleural fluid characteristics to distinguish those caused by pulmonary embolism.

This diagnosis should be pursued on clinical grounds. Small pleural effusions are present in up to 40% of cases of pulmonary embolism. Of these, 80% are exudates and 20% transudates; 80% are bloodstained. A pleural fluid red blood cell count of more than 100 000/mm³ is suggestive of malignancy, pulmonary infarction, or trauma. Lower counts are unhelpful. Effusions associated with pulmonary embolism have no specific characteristics and the diagnosis should therefore be pursued on clinical grounds with the physician retaining a high index of suspicion for the diagnosis. 

8.5 Benign asbestos pleural effusion

Benign asbestos pleural effusions are commonly diagnosed in the first two decades after asbestos exposure. The prevalence is dose related with a shorter latency period than other asbestos related disorders. The effusion is usually small and asymptomatic, often with pleural fluid which is haemorrhagic. There is a propensity for the effusion to resolve within 6 months, leaving behind residual diffuse pleural thickening. As there are no definitive tests, the diagnosis can only be made with certainty after a prolonged period of follow up.

8.6 Connective tissue diseases

8.6.1 Rheumatoid arthritis associated pleural effusions

- Suspected cases should have a pleural fluid pH, glucose and complement measured. [C]

- Rheumatoid arthritis is unlikely to be the cause of an effusion if the glucose level in the fluid is above 1.6 mmol/l (29 mg/dl).

Pleur al involvement occurs in 5% of patients with rheumatoid arthritis. The majority of patients with rheumatoid pleural effusions are men, even though the disease generally affects more women. Pleural fluid can be serous, turbid, yellow green, milky, or haemorrhagic. Rheumatoid arthritis is unlikely to be the cause of an effusion if the glucose level in the fluid is above 1.6 mmol/l, so this serves as a useful screening test. 80% of rheumatoid pleural effusions have a pleural fluid glucose to serum ratio of <0.5 and a pH <7.30. However, in acute rheumatoid pleurisy the glucose level and pH may be normal. Measurement of C4 complement in pleural fluid may be of additional help, with levels below 0.04 g/l in all cases of rheumatoid pleural disease and in only two of 118 controls reported in one study. Rheumatoid factor can be measured on the pleural fluid and often has a titre of >1:320. However, it can be present in effusions of other aetiology and often mirrors the serum value, adding little diagnostically. 

8.6.2 Systemic lupus erythematosus

- The pleural fluid ANA level should not be measured as it mirrors serum levels and is therefore unhelpful. [C]

Up to 50% of patients with systemic lupus erythematosus (SLE) will have pleural disease at some time in the course of their disease. The presence of LE cells in pleural fluid is diagnostic of SLE. However, ADA levels are raised in empyema, rheumatoid pleurisy, and malignancy, which makes the test less useful in countries with a low prevalence of tuberculosis. Importantly, ADA levels may not be raised if the patient has HIV and tuberculosis.

8.7 Pleural effusions in HIV infection

- In patients with HIV infection, the differential diagnosis of pleural effusion is wide and differs from the immunocompetent patient. 

A pleural effusion is seen in 7–27% of hospitalised patients with HIV infection. Its three leading causes are Kaposi’s sarcoma, parapneumonic effusions, and tuberculosis. In one prospective study of 58 consecutive patients with HIV infection and radiographic evidence of a pleural effusion, the causes of the effusion were Kaposi’s sarcoma in one third of the cases, parapneumonic effusion in 28%, tuberculosis in 14%, Pneumocystis carinii pneumonia in 10%, and lymphoma in a further 7%.

In a large prospective series of 999 HIV infected patients over 3 years, 160 had a pleural effusion during an inpatient admission; 65% were small effusions, 23% moderate, and 13% large. In this series the most common cause was bacterial pneumonia and the overall in-hospital mortality was high at 10%.

9 MANAGEMENT OF PERSISTENT UNDIAGNOSED PLEURAL EFFUSION

- In persistently undiagnosed effusions the possibility of pulmonary embolism and tuberculosis should be reconsidered since these disorders are amenable to specific treatment. [C]

- Undiagnosed pleural malignancy proves to be the cause of many “undiagnosed” effusions with sustained observation. 

The cause of the pleural effusion is undetermined after repeated cytology and pleural biopsy in around 15% of cases.
Thoracoscopy is advised. Specific pleural fluid tests for pulmonary embolism so, if the examination of a positive tuberculin skin test and an exudative pleural effusion containing predominantly lymphocytes is sufficient to justify empirical antituberculous therapy.

R J A Butland, et al.


Hirsch A. Pleural effusion: laboratory tests in 300 cases. Thorax 1979; 34:106–12. [III]


null
BTS guidelines for the management of pleural infection

C W H Davies, F V Gleeson, R J O Davies, on behalf of the BTS Pleural Disease Group, a subgroup of the BTS Standards of Care Committee

There is great variation worldwide in the management of patients with pleural infection, and approaches differ between physicians. In the UK up to 40% of empyema patients come to surgery due to failed catheter drainage and, overall, 20% of patients with empyema die. The process of rapid evaluation and therapeutic intervention appears to reduce morbidity and mortality, as well as health care costs.

This paper presents the results of a peer reviewed systematic literature review, combined with expert opinion, of the preferred management of pleural infection. The clinical guidelines generated from this process are shown in fig 1. The guidelines are aimed predominantly at physicians involved in general and respiratory medicine, and specifically do not cover in detail the complex areas of surgical management or the management of post pneumonectomy empyema.

1 HISTORICAL PERSPECTIVE, PATHOPHYSIOLOGY AND BACTERIOLOGY OF PLEURAL INFECTION

This section provides background information for reference, interest, and to set the management guidelines in context.

1.1 Historical perspective

Pleural infection was first described by Hippocrates in 500BC. Open thoracic drainage was the only treatment for this disorder until the 19th century when closed chest tube drainage was first described but not adopted. This technique became widely practised during an influenza epidemic in 1917–19 when open surgical drainage was associated with a mortality rate of up to 70%. This high mortality was probably due to respiratory failure produced by the large open pneumothorax left by open drainage. This was particularly true of Streptococcus haemolyticus infections which produce streptokinase and probably reduce adhesion formation. A military commission investigated this high mortality rate and produced recommendations that remain the basis for treatment today. They advocated adequate pus drainage with a closed chest tube, avoidance of early open drainage, obliteration of the pleural space, and proper nutritional support. These changes reduced the mortality rate to 3.4% during the later stages of the epidemic.

The introduction of antibiotics both reduced the incidence of empyema and changed its bacteriology. Before antibiotics 60–70% of cases were caused by Streptococcus pneumoniae, which now accounts for about 10% of culture positive cases. The prevalence of Staphylococcus aureus rose and the development of staphylococcal resistance in the 1950s increased complications and mortality. More recently, the reported prevalence of anaerobic infections and Gram negative organisms has risen. Intrapleural fibrinolytic therapy was first introduced in 1949, but the impure agents used caused adverse reactions. Most recently, thoracoscopic surgery has introduced the early use of video assisted thoracoscopic (VATS) pleural debridement.

1.2 Pathophysiology of pleural infection

Pneumonia leads to about 50 000 hospital admissions each year in the UK. Up to 57% of patients with pneumonia develop pleural fluid and there are about 60 000 cases of pleural infection in the USA per year. A significant proportion of cases are related to community and hospital acquired pneumonia, or are secondary to iatrogenic causes. Pleural infection may also develop without evidence of pneumonia—so called primary empyema. Most forms of pleural infection represent a progressive process that transforms a fluid self-resolving parapneumonic pleural effusion into a complicated multiloculated fibrotic and purulent collection which significantly impairs respiratory reserve and is only amenable to surgical drainage.

1.3 Normal pleural fluid physiology

In health, the volume of pleural fluid in humans is small (<1 ml), forming a film about 10 μl thick between the visceral and parietal pleural surfaces. Pleural fluid contains protein at concentrations similar to the interstitial fluid, a small number of cells (predominantly mesothelial cells, macrophages and lymphocytes), and some large molecular weight proteins such as lactate dehydrogenase (LDH). Compared with serum, pleural fluid in health also contains higher levels of bicarbonate, lower levels of sodium, and similar levels of glucose. These parameters change when disease processes affecting the adjacent lung or vascular tissue activate an immune response.

Water and small molecules pass freely between mesothelial cells, while larger particles may be transported by cytoplasmic transport mechanisms or via the pleurolymphatic communication. The pleurolymphatic communication is poorly documented but probably consists of a series of stomas in selected areas of pleura overlying connective tissue and a series of dilated lymphatic channels with regulatory valves.

1.4 Pleural effusion development with pneumonia

The development of empyema in association with pneumonia is a progressive process that moves from a simple exudate to a fibrinopurulent stage and later to an organising stage with scar tissue formation. The stage when the pleural fluid is a straightforward exudate is often called a “simple parapneumonic effusion”. The early fibrinopurulent stage when the pleural fluid has developed...
Figure 1 Flow diagram describing the management of pleural infection.
features of infection but is not yet overtly purulent is termed a “complicated parapneumonic effusion”. Frank pus is termed “empyema”. The features of these three stages are summarised in table 1.

In the early exudative stage there is fluid movement into the pleural space due to increased capillary vascular permeability, accompanied by the production of proinflammatory cytokines. These produce active changes in the pleural mesothelial cells to facilitate fluid entry into the pleural cavity. Initially the fluid is a free flowing exudate characterised by a pH of 7.2 and proteases. This combination of events leads to increased vascular permeability, as a solid fibrous pleural peel replaces the soft fibrin, the re-expansion of lung is prevented, impairing lung function and creating a persistent pleural space with continuing potential for infection.

1.6 Bacteriology of pleural infection

Currently, aerobic organisms are those most frequently identified from empyemas. Gram positive organisms from the streptococcal species, including the S milleri group of organisms, and Staphylococcus aureus are most commonly found. Most patients with S aureus have postoperative or nosocomial empyemas or are immunocompromised. S aureus is seen frequently in patients following trauma and surgery. Gram negative organisms are also the most commonly found aerobic bacteria in pleural infection, including Escherichia coli, Pseudomonas spp., Haemophilus influenzae, and Klebsiella spp. These organisms are commonly part of mixed growths with other Gram negative organisms or with anaerobes and rarely occur in isolation.

The frequency of anaerobic isolates is rising and anaerobes may be present in up to 76% of cases. However, most series report anaerobes in 12–34% of positive pleural fluid cultures. Anaerobes may cause empyema without other aerobic co-pathogens in about 14% of culture positive cases. Infections with anaerobes are more likely to have an insidious clinical onset, with less fever, greater weight loss, and are more common following possible aspiration pneumonia and with poor dental hygiene.

2 IDENTIFICATION AND RADIOLOGICAL ASSESSMENT OF PNEUMONIA ASSOCIATED PLEURAL EFFUSION

This section presents the detail of the literature evidence and expert opinion behind the guideline presented in fig 1.

2.1 Identification

A pleural effusion may be obvious on the chest radiograph and the co-existence of pulmonary infiltrates and fluid should alert the clinician to the possibility of a parapneumonic collection. Empyema should be suspected in patients who are failing to respond to appropriate antibiotic therapy. Lateral chest radiographs may confirm pleural fluid not suspected on the posteroanterior chest radiograph. Ultrasound scanning, which is now readily available, is the preferred investigation and enables exact location of any fluid collection and allows guided diagnostic aspiration if required.

Occasionally, pleural sepsis is caused by oesophageal rupture and this diagnosis should be suspected in patients who develop a pleural effusion soon after significant retching or vomiting. Oesophageal imaging and the detection of an oesophageal leak should prompt immediate referral to a surgeon with expertise in the management of oesophageal rupture.

2.2 Radiological assessment

Ultrasound may help to identify exudative pleural effusions; in a study of 320 cases of pleural effusion all echogenic effusions were caused by exudates and homogeneous echogenic effusions were due to either empyema or haemorrhage. In a review of both ultrasound and computed tomographic (CT) appearances in a group of patients with parapneumonic effusion requiring drainage, the appearances at ultrasound (septations, echogenicity, fig 2) did not correlate with the length of history, presence or absence of purulence, or the biochemical staging of pleural infection, but pleural thickness on contrast enhanced CT scanning was greater in those with frankly purulent effusions.

In cases of diagnostic difficulty, contrast enhanced CT scanning may help to differentiate pleural empyema from a parenchymal lung abscess. Empyemas are usually lenticular in shape and compress the lung parenchyma, while lung abscesses often have an indistinct boundary between the lung parenchyma and collection. The “split pleura” sign, caused
by enhancement of both parietal and visceral pleural surfaces (fig 3), and their separation in empyema is characteristic of a pleural collection. Pleural thickening is seen in 86–100% of empyemas and 56% of exudative parapneumonic effusions. In patients with pneumococcal pneumonia the development of parapneumonic effusions may be associated with a longer duration of symptoms and the presence of bacteraemia, but the majority of these patients will have a “simple parapneumonic effusion” and will not require chest tube drainage. Similarly, there are no reliable clinical or radiological characteristics that will predict which patients with pleural infection will come to surgery.

Pleural fluid characteristics remain the most reliable diagnostic test to guide management, and diagnostic pleural fluid sampling is therefore recommended in all patients with a pleural effusion in association with a pneumonic illness or recent chest trauma or surgery. Patients in an intensive care (ICU) setting frequently develop pleural effusions that are not caused by pleural infection. It is probably safe to observe such patients with hypoalbuminaemia, heart failure, or atelectasis who are at low risk of infection while treating the underlying condition. Pleural fluid should be sampled if there are features of sepsis, possibly under ultrasound guidance if patients are receiving positive pressure ventilation.

2.4 Patients with a small pleural effusion or who have failed diagnostic pleural fluid sampling

• In the event of a small effusion or a failed previous attempt at pleural fluid sampling, an ultrasound scan and image guided fluid sampling is recommended. [C]

• Pleural effusions with maximal thickness <10 mm on ultrasound scanning can be observed, with pleural fluid sampling if the effusion enlarges. [C]

In the event of a small effusion, failure of an attempt to gather a pleural fluid sample, or an inexperienced operator, an ultrasound scan and image guided pleural fluid sampling is simple and will reduce patient discomfort. Small effusions of
<10 mm thickness on a decubitus chest radiograph will usually resolve with antibiotics alone. As ultrasound is used in preference to decubitus chest radiography in the UK, it seems reasonable to observe any effusion where maximal thickness is <10 mm on ultrasound scanning. An increase in the size of the effusion should warrant re-evaluation and a diagnostic pleural fluid sample if clinically indicated.

2.5 When to use chest tube drainage in pleural infection

- Patients with frankly purulent or turbid/cloudy pleural fluid on sampling should receive prompt pleural space chest tube drainage. [B]
- The presence of frankly purulent or turbid/cloudy fluid on pleural aspiration indicates the need for prompt chest tube drainage. Purulent fluid is more frequent in patients who fail chest tube drainage and require surgery or in those who die. The presence of organisms identified by Gram stain or culture from non-purulent pleural fluid samples indicates that pleural infection is established and should lead to prompt chest tube drainage. [B]
- Pleural fluid pH should be assessed in all non-purulent, possibly infected effusions. [B]
- pH <7.2 indicates chest tube drainage is required. [B]
- Parapneumonic effusions that do not fulfil these criteria for chest tube drainage should be treated with antibiotics alone provided clinical progress is good. [B]
- Poor clinical progress during treatment with antibiotics alone should lead to prompt patient review and probably chest tube drainage. [B]

Parapneumonic pleural effusions are inflammatory exudates dominated by polymorphonuclear leucocytes. The absolute protein values are of no value in determining the likelihood of spontaneous resolution of the effusion or chest tube drainage requirements. The pleural fluid leucocyte count shows a wide variation in values between simple effusions and frankly purulent empyemas, and a predominance of lymphocytes in an exudate should raise the possibility of malignancy or tuberculosis. Some non-purulent collections will show biochemical evidence of infection and are likely to need chest tube drainage for resolution of sepsis. The development of a pleural fluid acidosis associated with a rising pleural fluid pH is specific in predicting the need for pleural drainage, it is less than 100% sensitive and does not accurately predict eventual need for surgery. Unsatisfactory clinical progress therefore indicates the need for repeated pleural fluid sampling and possible chest tube drainage. When needle aspiration is straightforward, it may occasionally be possible to remove all the fluid at initial thoracocentesis. In some cases the fluid will not then return and no further intervention will be required.

2.6 Other indications for chest tube drainage

- Patients with a loculated pleural collection should receive earlier chest tube drainage. [C]
- Large non-purulent effusions should be drained by chest tube for symptomatic benefit. [C]
- The presence of loculation on the chest radiograph or ultrason is associated with a poorer outcome and may be an additional indication for early chest tube drainage. Larger pleural collections (>40% of the hemithorax) may be more likely to require surgery, and non-purulent effusions without acidosis can be drained with a chest tube if indicated for symptomatic benefit.

2.7 Respiratory specialist

- A respiratory physician or thoracic surgeon should be involved in the care of all patients requiring chest tube drainage for a pleural infection. [C]

In view of the substantial mortality associated with pleural infection, the small number of cases seen annually in a single centre and the need for prompt effective treatment, it is appropriate to focus the care of this disorder in specialist hands. Delay to chest tube drainage of the pleural space is probably associated with increased morbidity and duration of hospital stay, misdiagnosis, inappropriate antibiotics, and inappropriate chest tube placement have been cited as important factors contributing to the progression of pleural infection.

An appropriate physician requires the skills to identify patients for surgery and experience in assessing thoracic surgical risk as well as expertise in managing the substantial co-morbidity in these patients. A respiratory physician best combines these skills as well as having the advantage of an established liaison with a thoracic surgeon. In centres with thoracic surgery immediately available, care may be under a surgeon and a surgical opinion is appropriate after approximately 7 days in any patient not settling with drainage and antibiotics.
2.8 Antibiotics

- All patients should receive antibiotics. [B]
- Where possible, antibiotics should be guided by bacterial culture results. [B]
- Where cultures are negative, antibiotics should cover community acquired bacterial pathogens and anaerobic organisms. [B]
- Hospital acquired empyema requires broader spectrum antibiotic cover. [B]

All patients should receive antibiotic therapy as soon as pleural infection is identified, and where possible, antibiotics should be chosen based on the results of pleural fluid culture and sensitivities. A significant proportion of both aerobes and anaerobes isolated from pleuropulmonary infections may be resistant to penicillin, but beta-lactams remain the drugs of choice for pneumococcal and the S. milleri group infections. Both penicillins and cephalosporins show good penetration of the pleural space, and there is no need to administer antibiotics directly into the pleural space. Aminoglycosides should be avoided as they have poor penetration into the pleural space and may be inactive in the presence of pleural fluid acidosis.

In the absence of positive culture results, antibiotics should be chosen to cover the likely organisms that may cause pleural infection. There are a considerable number of reasonable drug combinations and the chosen regimen should reflect whether the infection was contracted in the community or in hospital. The actual regimen choice should reflect local hospital policy.

In community acquired infection, empirical treatment with a second generation cephalosporin (e.g. cefuroxime) or an aminopenicillin (e.g. amoxycillin) will cover expected organisms such as Pneumococcus, Staphylococcus aureus, and Haemophilus influenzae. A beta-lactamase inhibitor or metronidazole should also be given because of the frequent co-existence of penicillin resistant aerobes and anaerobes. Clindamycin can combine this spectrum into a single agent. Intravenous benzyl penicillin combined with a quinolone also has an appropriate spectrum and may be associated with a reduced incidence of Clostridium difficile diarrhoea.

There is evidence for a probable synergistic role of anaerobes with the S. milleri group of organisms and patients with these mixed infections have a higher mortality from empyema. Patients with an allergy to penicillin can be treated by clindamycin alone or in combination with a cephalosporin. Chloramphenicol, carbapenems such as meropenem, third generation cephalosporins, and broad spectrum antipseudomonal penicillins such as piperacillin also have good anti-anaerobic activity and are alternative agents.

Pleural effusions may occur in patients with Legionella pneumonia and are usually self-resolving. Legionella has rarely been reported as a cause of empyema and a macrolide should only be added in suspected cases. Similarly, pleural effusions may occur in 5–20% of patients with pneumonia due to Mycoplasma pneumoniae, but these are usually small reactive effusions. Most will resolve with suitable antibiotics such as a macrolide, but diagnostic pleural fluid sampling should be performed to ensure that a complicated parapneumonic effusion is not present. In all cases antibiotic regimens should be adjusted according to the results of subsequent culture results (while remembering that anaerobic pathogens are difficult to grow).

In hospital acquired empyema, usually secondary to nosocomial pneumonia, trauma or surgery, the antibiotics should be chosen to treat both Gram positive and Gram negative aerobes and also anaerobes. Postoperative and trauma related empyema requires antistaphylococcal cover. Recommended antibiotics include antipseudomonal penicillins (piperacillin-tazobactam and ticarcillin-clavulanic acid), carbapenems (meropenem), or third generation cephalosporins.

The duration of treatment for pleural infection has not been assessed in detailed clinical trials and remains controversial. Antibiotics are often continued for several weeks, based on the experience of clinicians managing this and other purulent pulmonary diseases such as lung abscess but, providing there is adequate pleural drainage, long term treatment may not be necessary. Treatment for about 3 weeks is probably appropriate. When prolonged treatment is used, the antibiotic regimen is usually changed to an oral combination after the fever and sepsis syndrome has settled.

Suggested antibiotic regimens for the initial treatment of culture negative community and hospital acquired pleural infections are shown in Table 2.

### Table 2: Illustrative antibiotic regimens for the initial treatment of culture negative pleural infection

<table>
<thead>
<tr>
<th>Origin of infection</th>
<th>Intravenous antibiotic treatment</th>
<th>Oral antibiotic treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Community acquired culture negative pleural infection</td>
<td>Cefuroxime 1.5 g tds iv + metronidazole 400 mg tds orally or 500 mg tds iv</td>
<td>Amoxicillin 1 g tds + clavulanic acid 125 mg tds</td>
</tr>
<tr>
<td></td>
<td>Benzyl penicillin 1.2 g qds iv + ciprofloxacin 400 mg bd iv</td>
<td>Amoxicillin 1 g tds + metronidazole 400 mg tds</td>
</tr>
<tr>
<td></td>
<td>Meropenem 1 g tds iv + metronidazole 400 mg tds orally or 500 mg tds iv</td>
<td>Clindamycin 300 mg qds</td>
</tr>
<tr>
<td>Hospital acquired culture negative pleural infection</td>
<td>Piperacillin + tazobactam 4.5 g qds iv</td>
<td>Not applicable</td>
</tr>
<tr>
<td></td>
<td>Cefazidine 2 g tds iv</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Meropenem 1 g tds iv ± metronidazole 400 mg tds orally or 500 mg tds iv</td>
<td></td>
</tr>
</tbody>
</table>

No particular regimen is the single “ideal” choice. Drug doses should be appropriately adjusted in the presence of renal or hepatic failure.

2.9 Chest tube drainage

- There is no consensus on the size of the optimal chest tube for drainage.
- If a small bore flexible catheter is used, regular flushing and suction is recommended to avoid catheter blockage. [C]

Chest tube drainage is usually performed in one of three ways: tube insertion under radiological guidance, tube insertion without radiological guidance, and tube insertion at time of surgical debridement. Traditionally, the closed chest tube drainage of pus from the pleural cavity has been via the insertion of a large bore chest tube, inserted without radiological guidance. More recently, flexible small bore catheters which seem less traumatic to insert and more comfortable for the patient have been employed. These smaller catheters are usually inserted under ultrasound or CT guidance.

There are no controlled trials comparing the use of traditional large bore chest tubes with smaller catheters and no clinical consensus on the optimal choice. Most of the published data relate to the use of image guided small bore catheters and suggest these can have a good outcome as a primary drainage procedure, or as a rescue treatment when larger tubes have failed. There is no evidence that 10–14 Fr catheters are popular in these series and have a low complication rate. There is
also a substantial body of opinion that considers large bore tubes to be more effective for draining thick pus, based on clinical experience. Sound clinical trials are needed to clarify the optimal size of chest tube.

There is no controlled evidence about optimal drain management regarding issues such as drain flushing and drain suction. In most of the studies with small bore catheters, both catheter flushing and suction were used in the belief it improves large drains and it is therefore not recommended routinely. Suction (20 cm H₂O) is employed in the belief it improves drainage but there is no sound evidence or clinical consensus on which to base specific guidelines in this area.⁷⁹ ⁹⁹

2.10 Management of cessation of chest tube drainage in the presence of a residual pleural fluid collection

- If the chest tube becomes blocked or pus is unable to drain, it should be flushed with saline to ensure its patency. If poor drainage persists, a chest radiograph or CT scan should be performed to check drain position. [C]

In the event that the chest tube should become blocked or pus is unable to drain, it may be flushed with 20–50 ml normal saline to ensure its patency. If poor drainage persists, imaging should be performed to check chest tube position and tube distortion and to look for undrained locules. Kinks may occur at the skin with smaller drains which can be repositioned and redressed. A number of commercial dressings are now available to prevent small drains to reduce kinking and which have a low fall out rate. If the chest tube is permanently blocked, it should be removed and a further chest tube inserted if indicated.

Contrast enhanced CT scanning is the most useful imaging modality in patients failing chest tube drainage to provide anatomical detail such as locules and to ensure accurate chest tube placement. Pleural thickening seen on contrast enhanced CT scanning represents a “fibrous” peel, which may prevent lung re-expansion despite adequate drainage of the pleural space.⁶⁶ Contrast enhanced CT scanning cannot accurately differentiate early and late fibrinopurulent stage disease,⁷⁷ and pleural thickening on the CT scan does not appear to predict the outcome of tube drainage.⁷⁷ Pleural peel may resolve over several weeks in patients spared surgery.¹⁰¹ Residual calcification,¹⁰² thickening of extrapleural tissues,¹⁰³ and pleural scarring¹⁰⁴ may persist long after empyema treatment. Both ultrasound and chest radiography may also be useful in patients failing to drain.

2.11 Intrapleural fibrinolytic drugs

- Intrapleural fibrinolytic drugs (streptokinase 250 000 IU twice daily for 3 days or urokinase 100 000 IU once a day for 3 days) improve radiological outcome and current best evidence recommends their use. [B] It is not known if they reduce mortality and/or the need for surgery and clinical trials are underway to address this question.

- Patients who receive intrapleural streptokinase should be given a streptokinase exposure card and should receive urokinase or tissue plasminogen activator (TPA) for subsequent indications. [C]

Intrapleural fibrinolytic therapy was first used in 1949.¹¹ The agents used initially were impure and produced side effects due to immunological events such as fever, leucocytosis and general malaise,¹² and these agents fell out of use. More recently, intrapleural fibrinolytic drugs have been reassessed. Several observational series suggest improved pleural drainage with these agents.²¹ ¹³⁻¹⁴ and these reports have been supplemented by small controlled trials.¹¹⁸⁻¹¹⁹⁻¹²⁰

There are four small randomised trials of intrapleural fibrinolytic agents. The first¹¹⁹ reported 24 patients randomised to streptokinase or saline placebo. Pleural drainage was improved on radiographic criteria. The study was not large enough to address surgery rates, mortality or safety. The second study¹¹¹ compared urokinase and a saline placebo in 31 patients with pleural infection. Patients were randomised after failed chest tube drainage alone. Successful pleural drainage was significantly more frequent in those receiving urokinase, but again the study was not powered for mortality, surgery rates or safety. The third study¹¹² is currently only reported in abstract form and included 128 patients with loculated parapneumonic pleural effusion randomised to receive either intrapleural urokinase, streptokinase, or control flushes. As with the other studies,¹¹¹ ¹¹² groups who received fibrinolytic therapy drained more fluid and had improved radiology. The fourth study is in children and shows that urokinase reduces hospital stay compared with placebo. Again it was not powered to assess the main clinical end points of mortality and surgery frequency.¹¹²

In these studies, drained pleural fluid volume is uninterpretable since intrapleural streptokinase increases pleural fluid production.¹²² The current literature is therefore encouraging but does not establish benefit for the primary end points of clinical interest: patient mortality, surgery rates, and residual lung function. The Medical Research Council and British Thoracic Society are currently recruiting to a multicentre study to assess definitively the efficacy of intrapleural streptokinase.

Most reported adverse events due to intrapleural fibrinolytic agents are immunological and occur with intrapleural streptokinase. Fever has been noted,¹¹¹ ¹¹² ¹²³⁻¹²⁵ but only in subjects receiving fibrinolytics for pneumonic associated pleural infection where the varying fever of the primary illness makes it difficult to quantify this effect reliably. Systemically administered streptokinase generates a systemic antibody response that can neutralise later administration of streptokinase.¹³⁰⁻¹³¹ It is not yet known whether intrapleurally administered fibrinolytic agents produce a similar response. In the absence of such data it is advisable to manage patients as if they had received their initial fibrinolytic systemically, with urokinase or tissue plasminogen activator (TPA) being used for later myocardial infarction or pulmonary embolism.

Two studies of small patient groups suggest that intrapleural streptokinase does not produce systemic fibrinolysis up to a total cumulative dose of 1.5 million IU.¹³² There are isolated reports of local pleural haemorrhage¹³²⁻¹³³ and systemic bleeding¹³⁴ associated with intrapleural fibrinolytic use. There have also been reports of nose bleeds,¹³⁵ pleural pain,¹³⁶⁻¹³⁷ and transient disorientation (without evidence of intracerebral bleeding on CT brain scan).¹³⁷ Urokinase is non-antigenic but may still cause acute reactions (due to immediate hypersensitivity and histamine release) with fever¹³⁸ and cardiac arrhythmia.¹³⁹ There is a report of adult respiratory distress syndrome (ARDS) in a patient who received both streptokinase and urokinase for empyema drainage.¹⁴⁰ The true incidence of these occasional but major side effects is not known and will be clarified by the currently recruiting MRC/BTS trial.

Streptokinase 250 000 IU daily,¹¹¹ ¹¹²⁻¹¹⁹ ¹²⁰ or 250 000 IU 12 hourly,¹²⁵ or urokinase 100 000 U daily¹³¹ ¹³² retained for 2–4 hours in the pleural space are the usual regimens. Their use may be most beneficial in high risk patients of an older age or with co-morbidity where surgery has a greater risk.

Currently, there has been interest in other intrapleural agents including combination drugs consisting of streptokinase and streptodornase-α, DNase.¹⁴¹⁻¹⁴³ In an experimental
setting in which fluid viscosity was assessed, this combination reduced the amount of non-liquefied material and therefore viscosity compared with streptokinase alone. These in vitro studies suggest that it is the DNA content of pus that determines the viscosity and that, if it is effective, streptokinase may work predominantly by breaking down loculations and not by changing pus viscosity. Clinical trials will be required to assess whether DNase compounds are effective adjuncts in pleural drainage, and their use in patients cannot yet be recommended.

2.12 Persistent sepsis and pleural collection

- Patients with persistent sepsis and a residual pleural collection should undergo further radiological imaging. [C]

In patients who do not respond to medical treatment and who have sepsis in association with a persistent pleural collection, the diagnosis should be reviewed and a further chest radiograph performed. Thoracic CT scanning will identify chest tube position, pleural thickening, and anatomy of the effusion, and may also identify endobronchial obstruction of the bronchi by malignancy or foreign body, and pathology in the mediastinum when there is inadequate resolution of pleural sepsis following drainage.

2.13 Bronchoscopy

- Bronchoscopy should only be performed in patients where there is a high index of suspicion of bronchial obstruction. [C]

The role of bronchoscopy in patients with empyema has not been addressed specifically by any studies, but it is clear from the BTS empyema series that British chest physicians consider bronchoscopy an important investigation in patients with pleural infection. In this series, 43 of 119 patients (40%) underwent bronchoscopy, usually to exclude a tumour predisposing to empyema; tumour was only found in five patients, less than 4% of the total sample. Bronchoscopy is usually performed at the time of surgery by most thoracic surgeons, but only a small number of these patients have obstructing tumour predisposing to empyema. In view of the small number of patients in whom bronchoscopy is helpful, it is only recommended where there is a high index of suspicion for bronchial obstruction. Features that should raise this suspicion include a mass or loss of volume on radiographic imaging or a history of possible aspiration/inhalation.

2.14 Nutrition

- Clinicians should ensure adequate nutritional support commencing as soon as possible after pleural infection is identified. [C]

Poor nutrition was identified during the First World War as one of the important determinants of outcome from pleural empyema, but is still sometimes overlooked. Patients with empyema suffer the catabolic consequences of chronic infection who are suitable for general anaesthesia to receive immediate VATS or intrapleural streptokinase for 3 days and intensive medical treatment. Wait et al randomised 20 patients with pleural infection who were suitable for general anaesthesia to receive immediate VATS or intrapleural streptokinase for 3 days instilled into a chest tube. Chest tubes were not inserted under radiological guidance in the medical group and were inserted by junior resident medical staff. The surgical group had higher primary treatment success (10/11 patients) and all medical failures (5/9 patients) were salvaged by surgery without requiring thoracotomy. Surgical patients required shorter drainage time (5.8 days, 95% confidence interval 4.5–7.1) compared with the medical group (6.8 days, 95% confidence interval 5.8–8.0) but the difference was not statistically significant. Pathology in the small sample size and the unusually high failure rate in the control limb (55%) suggests that bronchoscopy is an important investigation in patients with pleural empyema.

2.15 Referral for surgical treatment

- Failure of chest tube drainage, antibiotics and fibrinolytic drugs should prompt early discussion with a thoracic surgeon. [C]

- Patients should be considered for surgical treatment if they have persisting sepsis in association with a persistent pleural collection, despite chest tube drainage and antibiotics. [C]

The decision to operate to achieve empyema drainage is subjective, and there are no established objective criteria to define the point at which a patient should proceed to surgery. Patients with purulent fluid and/or loculations at presentation are more likely to require surgical drainage, although many patients settle without surgery. Patients should be considered for surgery if they have a residual sepsis syndrome in association with a persistent pleural collection, despite drainage and antibiotics. Failure of sepsis to begin resolution within 7 days is suggested as an appropriate period after which a surgical opinion should be sought.

A number of surgical approaches are available including video assisted thorascopic surgery (VATS), open thoracic drainage, or thoracotomy and decortication. The type of procedure performed will depend on many factors including patient age and co-morbidity, and surgical preference including the local availability of video assisted surgical techniques. The choice of surgical procedure is beyond the remit of these guidelines and is not considered further.

One small trial has directly compared surgical and medical treatment. Wait et al randomised 20 patients with pleural infection who were suitable for general anaesthesia to receive immediate VATS or intrapleural streptokinase for 3 days instilled into a chest tube. Chest tubes were not inserted under radiological guidance in the medical group and were inserted by junior resident medical staff. The surgical group had higher primary treatment success (10/11 patients) and all medical failures (5/9 patients) were salvaged by surgery without requiring thoracotomy. Surgical patients required shorter drainage time (5.8 days, 95% confidence interval 4.5–7.1) compared with the medical group (6.8 days, 95% confidence interval 5.8–8.0) but the difference was not statistically significant. Pathology in the small sample size and the unusually high failure rate in the control limb (55%). Further appropriately powered studies are needed.

2.16 Patients not considered fit for surgery and not improving with chest tube drainage and antibiotics

- In cases of ineffective chest tube drainage and persistent sepsis in patients unable to tolerate general anaesthesia, re-imaging the thorax and placement of further image guided small bore catheters, large bore chest tubes, or intrapleural fibrinolytic therapy should be considered. [C]
• Local anesthetic surgical rib resection should be considered in patients unsuitable for general anaesthesia. [C]

Ineffective chest tube drainage and persistent sepsis in patients unfit for general anaesthesia can be tried for “thick” pus. Alternatively, patients may proceed to surgical rib resection and open drainage under local anaesthesia.

..............................

Authors’ affiliations
C W H Davies, Department of Respiratory Medicine, Battle and Royal Berkshire Hospitals, Oxford Road, Reading RG3 1AG, UK
F V Gleeson, Department of Radiology, Churchill Hospital Site, Oxford Radcliffe Hospitals NHS Trust, Oxford OX3 7JU, UK
R J O Davies, Oxford Centre for Respiratory Medicine, Churchill Hospital Site, Oxford Radcliffe Hospital, Headington, Oxford OX3 7JU, UK

REFERENCES

1 Berger HA. Morgansoth ML. Immediate drainage is not required for all patients with complicated parapneumonic effusions. Chest 1990; 97:731–5. [II]


Fears R, Ferres H, Glasgow E, et al. Monitoring of streptokinase resistance titre in acute myocardial infarction patients up to 30 months after giving streptokinase or anistreplase and related studies to measure specific antistreptokinase IgG. Br Heart J 1992; 68:167–70. [IIb]

Lee HS, Cross S, Davidson R, et al. Raised levels of antistreptokinase antibody and neutralization titres from 4 days to 54 months after administration of streptokinase or anistreplase. Eur Heart J 1993; 14:64–9. [IIb]


Lee HS, Cross S, Davidson R, et al. Raised levels of antistreptokinase antibody and neutralization titres from 4 days to 54 months after administration of streptokinase or anistreplase. Eur Heart J 1993; 14:64–9. [IIb]


Woodring JH. Determining the cause of pulmonary atelectasis: a comparison of plain radiography and CT. AJR 1988; 150:757–63. [III]

1 INTRODUCTION
The discovery of malignant cells in pleural fluid and/or parietal pleura signifies disseminated or advanced disease and a reduced life expectancy in cancer patients. Median survival following diagnosis ranges from 3 to 12 months and is dependent on the stage and type of the underlying malignancy. The shortest survival time is observed in malignant effusions secondary to lung cancer and the longest in ovarian cancer, while malignant effusions due to an unknown primary have an intermediate survival time.  

Currently, lung cancer is the most common metastatic tumour to the pleura in men and breast cancer in women. Together, both malignancies account for approximately 50–65% of all malignant effusions (table 1). Lymphomas, tumours of the genitourinary tract and gastrointestinal tract as a group account for a further 25%, 5–7. Pleural effusions from an unknown primary are responsible for 7–15% of all malignant pleural effusions.  

An algorithm for the management of malignant pleural effusions is shown in fig 1.

2 PATHOPHYSIOLOGY
The pleura consists of five main anatomical compartments (fig 2): the parietal systemic circulation (branches of the intercostal and internal mammary arteries), the parietal interstitial space, the pleural space lined on either side by mesothelial cells, the pulmonary interstitium, and the visceral circulation (bronchial and pulmonary arteries).

Pleural fluid is filtered in the parietal pleural compartment from the systemic capillaries down a small pressure gradient into the pleural space. Under normal conditions the visceral pleura plays an insignificant role in pleural fluid turnover.  

Experiments using radioactive albumin and other labelled proteins have shown that pleural fluid secretion is greatest at the apex and absorption is increased towards the diaphragm and mediastinum. Pleural fluid is drained out of the pleural space predominantly through the stomata of the parietal lymphatics lying between the parietal mesothelial cells. The number of parietal lymphatics is greatest at the diaphragm and mediastinum. These stomata merge into small lymphatic channels which, in turn, form larger vessels ultimately draining into the mediastinal lymph nodes.

Any disruption or obstruction by tumour cells along this intricate lymphatic network may result in a pleural effusion. This mechanism for pleural fluid accumulation has been confirmed by necropsy studies which reveal that involvement of the regional lymph nodes is usually associated with the presence of a pleural effusion. Typically, adenocarcinoma of the lung spreads to the parietal pleura from the visceral pleura along existing pleural adhesions. This is preceded by migration of tumour cells to the visceral pleura from underlying pulmonary capillaries—that is, haematogenous spread. Pleural metastases from a primary site other than the lung result from haematogenous or lymphatic spread. Malignant effusions secondary to breast cancer arise either through chest wall lymphatics or via hepatic metastases resulting in either contralateral or bilateral effusions. Haemorrhagic malignant effusions usually result from invasion of blood vessels directly and/or tumour induced angiogenesis. Vascular endothelial growth factor (VEGF), a cytokine possessing potent angiogenic activity and promoting endothelial permeability, may play a significant role in the formation of malignant effusions and local tumour growth.

3 CLINICAL PRESENTATION
- Massive pleural effusions are most commonly due to malignancy. [B]  
- The majority of malignant effusions are symptomatic. [C]

Massive pleural effusions, defined as complete or almost complete opacification of a hemithorax on
Figure 1  Algorithm for the management of malignant pleural effusions.
the chest radiograph, are more commonly associated with a malignant aetiology. However, a modest number of patients (up to 25%) are asymptomatic at presentation—that is, they are found incidentally with physical examination or by chest radiography. Dyspnoea is the most common presenting symptom and is occasionally accompanied by chest pain and cough. Dyspnoea is due to a combination of reduced compliance of the chest wall, depression of the ipsilateral diaphragm, mediastinal shift, and reduction in lung volume due to involvement of the parietal pleura, ribs, and other intercostal structures. Constitutional symptoms including weight loss, malaise, and anorexia also generally accompany respiratory symptoms. The diagnosis of a malignant pleural effusion is discussed in the section on the investigation of a unilateral pleural effusion (page 8).

4 MANAGEMENT OPTIONS
Treatment options for malignant pleural effusions are determined by several factors: symptoms and performance status of the patient, the primary tumour and its response to treatment, and lung re-expansion following pleural fluid evacuation (Table 2). Although small cell lung cancer, lymphoma, and breast cancer usually respond to chemotherapy, associated secondary pleural effusions may require intervention during the course of treatment. Common and less common management options will be discussed below.

4.1 Observation
• Observation is recommended if the patient is asymptomatic or there is no recurrence of symptoms after initial thoracentesis. [C]
• Advice should be sought from the thoracic malignancy multidisciplinary team for symptomatic or recurrent malignant effusions. [C]
The majority of these patients will become symptomatic in due course and require further intervention. There is no evidence that initial thoracentesis carried out according to standard technique will reduce the chances of subsequent effective pleurodesis.

4.2 Therapeutic pleural aspiration
• Repeat pleural aspiration is recommended for the palliation of breathlessness in patients with a very short life expectancy. [C]
• Caution should be taken if removing more than 1.5 l on a single occasion. [C]
• The recurrence rate at 1 month after pleural aspiration alone is close to 100%. [B]
• Intercostal tube drainage without pleurodesis is not recommended because of a high recurrence rate. [B]
Repeated therapeutic pleural aspiration provides transient relief of symptoms and avoids hospitalisation for patients with limited survival expectancy and poor performance status. This option is appropriate for frail or terminally ill patients but individual patient preference may also dictate its use in patients who have had a previous failed intercostal tube and pleurodesis. The amount of fluid evacuated will be guided by patient symptoms (cough, chest discomfort) and should be limited to 1–1.5 l (see section 4.3.2). Pleural aspiration alone and intercostal tube drainage without instillation of a sclerosant are associated with a high recurrence rate and a small risk of iatrogenic pneumothorax and empyema.

4.3 Intercostal tube drainage and intrapleural instillation of sclerosant
Pleurodesis requires a diffuse inflammatory reaction and local activation of the coagulation system with fibrin deposition. Antony and colleagues have demonstrated increased growth factor-like activity in mesothelial cells exposed to tetracycline leading to fibroblast proliferation. This activity gradually decays once the tetracycline is removed. Increased pleural fibrinolytic activity is associated with failure of pleurodesis. Rodriguez-Panadero showed that rapid reduction in fibrinolytic activity within 24 hours using pleural D-dimer levels was

<table>
<thead>
<tr>
<th>Table 2 Treatment options for malignant pleural effusions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Management approach</td>
</tr>
<tr>
<td>-----------------------------</td>
</tr>
<tr>
<td>Commonly used options</td>
</tr>
<tr>
<td>Observation</td>
</tr>
<tr>
<td>Therapeutic thoracentesis</td>
</tr>
<tr>
<td>Chest tube insertion with intrapleural sclerosant</td>
</tr>
<tr>
<td>Thoracoscopy with talc poudrage</td>
</tr>
<tr>
<td>Less commonly used options</td>
</tr>
<tr>
<td>Long term indwelling catheter drainage</td>
</tr>
<tr>
<td>Pleuroperitoneal shunt</td>
</tr>
<tr>
<td>Pleurectomy</td>
</tr>
</tbody>
</table>

www.thoraxjnl.com

Figure 2 Schematic diagram of pleural anatomy; s.c.=systemic capillary; p.c.=pulmonary capillary. Modified from Misericchi with permission.
associated with good outcome of talc pleurodesis. In contrast, the group in whom the n-dimer level took longer to return to baseline (>24 hours) had a greater number of treatment failures.\(^\text{25}\n\)

In animals the effectiveness of pleurodesis may be reduced by concomitant use of corticosteroids. Recent evidence in rabbits has shown reduced pleural inflammatory reaction and, in some cases, prevention of pleurodesis with administration of corticosteroids at the time of talc pleurodesis.\(^\text{34}\n\) The administration of non-steroidal anti-inflammatory agents at the time of pleurodesis is more contentious and, at present, evidence against their use is lacking.

Belani and colleagues, using a simulation model, compared the cost effectiveness of intercostal tube insertion and chemical pleurodesis (tetracycline, doxycyline and bleomycin) with operative talc poudrage. The cost of symptom free days was used to determine cost effectiveness. Intercostal tube insertion and chemical pleurodesis was found to be more cost effective than talc poudrage where theatre time and personnel contributed significantly to the extra cost.\(^\text{35}\n\) The method of chemical pleurodesis will be discussed below and is summarised in box 1.

### 4.3.1 Size of intercostal tube

- **Small bore (10–14 F) intercostal catheters should be the initial choice for effusion drainage and pleurodesis. [B]**

Conventional large bore intercostal tubes (24–32 F) have been employed in most studies involving sclerosing agents.\(^\text{36}\) They have traditionally been used because they are thought to be less prone to obstruction by clots, but there is little published evidence to confirm this. The placement of large bore tubes is perceived to be associated with significant discomfort\(^\text{37}\) and this has led to the assessment of smaller bore tubes (10–14 F) for the drainage and administration of sclerosing agents. Studies using small bore intercostal tubes with commonly used sclerosants have reported similar success rates to large bore tubes.\(^\text{38,39}\) The small bore tubes in these studies were inserted either at the patient’s bedside by a physician or under radiological guidance.

**Comparison between small bore and large bore intercostal tubes has been considered in two studies.** Clementsen et al.\(^\text{40}\) in a randomised study using tetracycline as a sclerosing agent, compared a small bore tube (10 F) placed at bedside with a large bore tube (24 F). Although no significant difference in success rate was observed between the two groups, the small bore catheter was associated with less discomfort. Small bore tubes (10 F) were also considered more successful than large bore tubes (32–38 F) in a non-randomised study.\(^\text{41}\) Both studies recruited only a small number of patients and larger randomised studies are necessary to support these findings.

Small bore tubes have been used for ambulatory or outpatient pleurodesis. Patz et al.\(^\text{42}\) used a fluoroscopically placed tube (10 F) connected to a closed gravity drainage bag for this purpose. Bleomycin was the preferred sclerosing agent and the pleurodesis success rate approached 80%. Six patients complained of mild chest pain during insertion of the intercostal tube. Two of the intercostal tubes became blocked but were successfully cleared with a guidewire.

In view of the potential advantages (reduced patient discomfort, ease of placement, and comparable pleurodesis success rates), small bore tubes (10–14 F) should be considered initially for the drainage of malignant effusions.

### 4.3.2 Lung re-expansion, fluid drainage, and suction

- **Large pleural effusions should be drained in a controlled fashion to reduce the risk of re-expansion pulmonary oedema (RPO). [C]**

- **Suction to aid pleural drainage before and after pleurodesis is usually unnecessary but, if applied, a high volume, low pressure system is recommended. [C]**

- **In patients where only partial pleural apposition can be achieved, chemical pleurodesis should still be attempted and may provide symptomatic relief. [B]**

- **Once effusion drainage and lung re-expansion have been radiographically confirmed, pleurodesis should not be delayed while the cessation of pleural fluid drainage is awaited. [B]**

The most important requirement for successful pleurodesis is satisfactory apposition of the parietal and visceral pleura, confirmed radiologically.\(^\text{43}\) Incomplete lung re-expansion may be due to a thick visceral peel (“trapped lung”), pleural loculations, proximal large airway obstruction, or a persistent air leak. Most studies indicate that the lack of a response following instillation of a sclerosant is predominantly due to incomplete lung expansion.\(^\text{44,45}\) Where complete lung re-expansion or pleural apposition is not achieved and the patient is unsuitable for surgical intervention, pleurodesis should still be attempted. Robinson and colleagues,\(^\text{46}\) in a study using doxycycline as a sclerosing agent, reported a favourable response in nine out of 10 patients with partial re-expansion of the lung.

The amount of pleural fluid drained per day before the instillation of a sclerosant (<150 ml/day) is less relevant for successful pleurodesis than radiographic confirmation of fluid evacuation and lung re-expansion. In a randomised study, a shorter period of intercostal tube drainage and hospital stay was seen in the group in whom sclerotherapy was undertaken as soon as complete lung re-expansion was documented (majority <24 hours) than in the group in whom pleurodesis was attempted only when the fluid drainage was <150 ml/day. The success rate in both groups approached 80%.\(^\text{47}\)

Large pleural effusions should be drained in a controlled fashion avoiding evacuation of more than 1–1.5 l at one time or slowed to about 500 ml/hour, and aspiration discontinued if the patient develops chest discomfort, persistent cough, or vasovagal symptoms. Re-expansion pulmonary oedema (RPO) is a well described but rare complication following rapid expansion of a collapsed lung through evacuation of large amounts of pleural fluid at a single time and the use of early and excessive pleural suction.\(^\text{48,49}\) Putative pathophysiological mechanisms include reperfusion injury of the underlying hypoxic lung, increased capillary permeability, and local production of neutrophil chemotactic factors such as interleukin (IL)-8.\(^\text{50}\) Suction may be required for incomplete lung expansion and a persistent air leak. When suction is applied, the use of high volume, low pressure systems is recommended with a gradual increment in pressure to about –20 cm H₂O.

### 4.3.3 Analgesia and premedication

- **Lignocaine (3 mg/kg; maximum 250 mg) should be administered intrapleurally just prior to sclerosant administration. [B]**

---

**Box 1 Chemical pleurodesis**

1. Insert small bore intercostal tube (10–14 F).
2. Controlled evacuation of pleural fluid.
3. Confirm full lung re-expansion and position of intercostal tube with chest radiograph.
4. Administer premedication prior to pleurodesis.
5. Instill lignocaine solution (3 mg/kg; maximum 250 mg) into pleural space followed by sclerosant of choice (for sclerosants, see text).
6. Clamp tube for 1 hour and consider patient rotation for talc slurry.
7. Remove intercostal tube within 12–72 hours if lung remains fully re-expanded and there is satisfactory evacuation of pleural fluid.
transient paraesthesia in a single patient. Within the therapeutic range. Side effects were limited to those than those given 200 mg, while serum levels remained receiving 250 mg lignocaine had more frequent pain-free episode to achieve acceptable levels of local anaesthesia. The patients study of 20 patients larger doses of lignocaine were necessary nervous system side effects (that is >3 µg/ml). In an earlier study of 20 patients larger doses of lignocaine were necessary to achieve acceptable levels of local anaesthesia. The patients receiving 250 mg lignocaine had more frequent pain-free episodes than those given 200 mg, while serum levels remained within the therapeutic range. Side effects were limited to transient paraesthesia in a single patient. The reason for the significant difference in analgesia between the two groups with only a small increment in the lignocaine dose was unclear.

In the context of pleurodesis, premedication and sedation is poorly studied and no evidence based guidelines exist. Pleurodesis is an uncomfortable procedure and is associated with anxiety for the patient. The use of sedation may be helpful to allay such fears and induce amnesia. The level of sedation using either an opioid (with a suitable anti-emetic) or benzodiazepine should be appropriate—that is, maintenance of verbal communication and cooperation. Sedation employed before pleurodesis should be conducted with continuous monitoring with pulse oximetry and in a setting where resuscitation equipment is available.

<table>
<thead>
<tr>
<th>Table 3 Sclerosing agents available in UK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sclerosing agent</td>
</tr>
<tr>
<td>------------------</td>
</tr>
<tr>
<td>Tetracycline</td>
</tr>
<tr>
<td>Sterile talc</td>
</tr>
<tr>
<td>Bleomycin</td>
</tr>
<tr>
<td>Doxycycline</td>
</tr>
</tbody>
</table>

ARDS = adult respiratory distress syndrome.
*Produced in Germany and available via international wholesalers.
†Produced under manufacturer’s licence in UK.
‡Not available or licensed for use in the UK.

**Premedication should be considered to alleviate anxiety and pain associated with pleurodesis.**

Intrapleural administration of sclerosing agents is associated with chest pain and the incidence varies from 7% in the case of talc to 40% with doxycycline. Lignocaine is the best studied local anaesthetic for intrapleural administration. The onset of action of lignocaine is almost immediate and it should therefore be administered just before the sclerosant. The issue of safety has been highlighted in two studies. Wooten et al. showed that the mean peak serum concentration of lignocaine following 150 mg of intrapleural lignocaine was 1.3 µg/ml, well below the serum concentration associated with central nervous system side effects (that is >3 µg/ml). In an earlier study of 20 patients larger doses of lignocaine were necessary to achieve acceptable levels of local anaesthesia. The patients receiving 250 mg lignocaine had more frequent pain-free episodes than those given 200 mg, while serum levels remained within the therapeutic range. Side effects were limited to transient paraesthesia in a single patient. The reason for the significant difference in analgesia between the two groups with only a small increment in the lignocaine dose was unclear.

In the context of pleurodesis, premedication and sedation is poorly studied and no evidence based guidelines exist. Pleurodesis is an uncomfortable procedure and is associated with anxiety for the patient. The use of sedation may be helpful to allay such fears and induce amnesia. The level of sedation using either an opioid (with a suitable anti-emetic) or benzodiazepine should be appropriate—that is, maintenance of verbal communication and cooperation. Sedation employed before pleurodesis should be conducted with continuous monitoring with pulse oximetry and in a setting where resuscitation equipment is available.

**4.3.4 Selecting a sclerosing agent**

**Talc is the most effective sclerosant available for pleurodesis.**

A small number of patients (<1%) may develop acute respiratory failure following talc administration.

**Tetracycline** is modestly effective, has few severe side effects, and is the preferred sclerosant to minimise adverse event rates.

**Bleomycin** is an alternative sclerosant with a modest efficacy rate but is expensive.

**Pleuritic chest pain and fever are the most common side effects of sclerosant administration.**

Despite the evaluation of a wide variety of agents, to date no ideal sclerosing agent exists. Comparison of sclerosing agents is hampered by the lack of comparative randomised trials, different eligibility criteria, and disparate criteria for measuring response and end points. A complete response is usually defined as no re-accumulation of pleural fluid after pleurod-
gamma radiation. It may be administered in two ways: at thoracoscopy using an atomiser termed “talc poudrage” or via an intercostal tube in the form of a suspension termed “talc slurry.”

Success rates (complete and partial response) for talc slurry range from 88% to 100% with a mean of 90%. The majority of studies have used talc slurry alone and only a limited number of comparative studies have been published. A truncated randomised study by Lynch and colleagues compared talc slurry (5 g) with bleomycin (60 units) and tetracycline (750 mg). Although the study was terminated early because of the removal of tetracycline from the US market, analysis of the data to that point revealed no differences between the three treatment groups 1 month after pleurodesis. In a recent randomised trial between talc slurry (5 g) and bleomycin (60 units), 90% of the talc group achieved a complete response at 2 weeks compared with 79% of the bleomycin group, which was statistically insignificant. Yim et al. compared talc slurry (5 g) with talc poudrage (5 g) and found no significant difference between the two groups with respect to complete response rate (both over 90%), chest drainage duration, length of hospital stay, and complication rate. Talc slurry is usually well tolerated and pleuritic chest pain and mild fever are the most common side effects observed. A serious complication associated with the use of talc is adult respiratory distress syndrome (ARDS) or acute pneumonitis leading to acute respiratory failure. The mechanism of acute talc pneumonitis is unclear and has been reported with both talc poudrage and slurry. The dose of talc and the physical characteristics (size and type) appear to be the most important determinants for the development of this complication. In a case series reported by Kennedy et al., five patients developed respiratory failure with talc slurry pleurodesis (10 g). Three patients required mechanical ventilation but were later successfully extubated. Studies using lower doses (2–5 g) have reported excellent complete response rates with a lower incidence of serious adverse effects including acute respiratory failure. The diagnosis of talc pneumonitis is made after exclusion of other possible mechanisms for pulmonary infiltrates and respiratory failure—that is, re-expansion pulmonary oedema and lymphangitis carcinomatosa.

**Bleomycin**

Bleomycin is the most widely used antineoplastic agent for the management of malignant pleural effusions. Its mechanism of action is predominantly as a chemical sclerosant similar to talc and tetracycline. Although 45% of the administered bleomycin is absorbed systemically, it has been shown to cause minimal or no myelosuppression. Bleomycin is an effective sclerosant with success rates after a single administration ranging from 58% to 85% with a mean of 61%. Large comparative trials have found it to be superior to tetracycline. It has an acceptable side effect profile with fever, chest pain, and nausea being the most common adverse effects. The recommended dose is 60 units mixed in normal saline. Bleomycin has also been used in studies evaluating small bore intercostal tubes placed under radiological guidance with similar efficacy rates. The major disadvantages of bleomycin are the cost per treatment compared with other sclerosants and that it needs to be performed by trained personnel familiar with the administration of cytotoxic drugs (table 3).

**Rarely used and historical agents**

(1) Doxycycline: Although doxycycline is widely used in the US and is available in Continental Europe, it is not available or licensed for intrapleural administration in the UK. It has been evaluated in several small trials with success rates varying from 65% to 100% with a mean of 76%. All but one of the trials used a dose of 500 mg mixed in normal saline. Prevost et al. used doses in excess of 2 g with a reported success rate of 82%. Side effects are similar to those with tetracycline—that is, fever (30%) and mild to moderate pleuritic chest pain (up to 60%). Doxycycline has been used with small bore tubes in two studies. Patz et al. in a large randomised study compared bleomycin with doxycycline (500 mg) in 106 patients. The complete response rate at 1 month for doxycycline was 79%. In a similar study, Seaton et al. reported a complete response rate of 81% with a low incidence of side effects. The major disadvantage of doxycycline is the need for repeated instillations to obtain a satisfactory success rate. This may lead to prolonged catheter or intercostal tube indwelling times with a potential increase in infection, patient discomfort, and overall cost in treatment.

(2) Minocycline: Minocycline has been used as a sclerosing agent but experience in humans is limited to a single small and uncontrolled study. A recent study in rabbits suggests that it may be as effective as tetracycline at inducing pleurodesis. Minocycline is not available or licensed for intrapleural administration in the UK.

(3) Other sclerosants: Corynebacterium parvum extract, interferons (interferon-α and -β), interleukins (IL-2), and several chemotherapeutic drugs (cisplatin, cytosine arabinoside, interferons (α, β, γ)) have been used for pleurodesis with variable and usually disappointing efficacy rates. Most of the trials have been uncontrolled and recruited small numbers of patients. Corynebacterium parvum, interferons, and interleukins require multiple administrations, while significant toxicity is encountered with the use of the chemotherapeutic drugs.

### 4.3.5 Rotation following pleurodesis

- **Patient rotation is not necessary after intrapleural instillation of tetracycline class agents. [A]**

Rotation of the patient following intrapleural administration of a sclerosing agent is described in most pleurodesis studies in order to achieve adequate distribution of the agent over the pleura. However, patient rotation is time consuming and may cause further discomfort for these patients. A study using radiolabelled tetracycline has shown that tetracycline is dispersed throughout the pleural space within seconds and rotation of the patient did not influence the distribution of the agent. A subsequent randomised trial using tetracycline, minocycline, and doxycycline revealed no significant difference in the success rate of the procedure or duration of fluid drainage between the rotation and non-rotation groups. Patient rotation is still required when using talc slurry until further evidence is available.

### 4.3.6 Clamping of intercostal tube

- **The intercostal tube should be clamped for 1 hour after sclerosant administration. [C]**

Clamping of the intercostal tube following intrapleural administration of the sclerosant should be brief (1 hour). This will prevent the sclerosant from immediately draining back out of the pleural space, although this may not be important. Intercostal tube removal has been recommended when fluid drainage reached less than 150 ml/day, but there is a lack of evidence to support this action. In the absence of any evidence that protracted drainage is beneficial, and given the discomfort associated with prolonged drainage, we arbitrarily recommend removal of the intercostal tube within 12–72 hours after the instillation of the sclerosant provided the lung remains fully re-expanded and there is satisfactory evacuation of small fluid on the chest radiograph. Where excessive fluid drainage persists (>250 ml/day), repeat pleurodesis may be attempted with an alternative sclerosant. In

www.thoraxjnl.com
the event of incomplete lung expansion any treatable cause for this should be excluded and the drain may then be removed as pleurodesis is unlikely to succeed.

4.3.7 Malignant seeding at intercostal tube or port site

- Patients with proven or suspected mesothelioma should receive prophylactic radiotherapy to the site of biopsy or chest drain insertion. [A]

Local tumour recurrence or seeding following diagnostic and therapeutic pleural aspiration, pleural biopsy, intercostal tube insertion, and thoracoscopy is uncommon in non-mesothelioma malignant effusions. However, in mesothelioma 40% of patients may develop malignant seeding at the site of diagnostic pleural procedures. In a randomised study Boutin et al found that local metastases were prevented in patients who received radiotherapy to the thoracoscopic tract site. All the patients received radiotherapy within 2 weeks of thoracoscopy. It should be noted that further clinical trials of procedure site radiotherapy in mesothelioma are currently recruiting. The role of prophylactic radiotherapy following pleural procedures in non-mesothelioma malignant effusions has not been established and therefore cannot be recommended.

4.3.8 Intrapleural fibrinolytics

- Intrapleural instillation of fibrinolytic drugs is recommended for the relief of distressing dyspnoea due to multiloculated malignant effusion resistant to simple drainage. [C]

The use of fibrinolytic agents represents an advance in the management of multiloculated malignant effusions. Immune mediated or haemorrhagic complications have rarely been described with the administration of intrapleural fibrinolytics in contrast to systemic administration of these agents. Jerjes-Sanchez et al administered intrapleural streptokinase (250 000 IU) in an open study to four patients with multiloculated malignant effusions not considered suitable for pleurodesis at the time. In three of the four patients fibrinolytic administration allowed radiographic improvement and led to successful pleurodesis. A more recent study found that intrapleural streptokinase increased pleural fluid drainage and led to radiographic improvement and amelioration of symptoms in 10 patients with multiloculated or septated malignant effusions. Intrapleural streptokinase was well tolerated and no allergic or haemorrhagic complications were reported. Gilkeson et al preferred urokinase in their prospective but non-randomised study. Twenty two malignant pleural effusions were treated with urokinase resulting in substantial increase in pleural fluid output in patients both with and without radiographic evidence of loculations. The majority then underwent pleurodesis with doxycycline resulting in a complete response rate of 56%. Similarly, no allergic or haemorrhagic complications were encountered.

None of these studies is large enough to accurately describe the safety profile of fibrinolytic drugs in this setting. The physician should therefore use these agents with caution, carefully considering the risk/benefit balance for the individual patient. An appropriately experienced specialist should be involved in the care of all patients receiving this treatment.

4.4 Thoracoscopy in malignant pleural effusion

- Thoracoscopy should be considered for the diagnosis of suspected but unproven malignant pleural effusion. [B]
- Thoracoscopy should be considered for the control of recurrent malignant pleural effusion. [B]
- Thoracoscopy is a safe procedure with low complication rates. [B]

Thoracoscopy (under sedation or general anaesthesia) has grown in popularity as a diagnostic and therapeutic tool for malignant effusions. The thoracoscopic appearance of pleural malignancy and a thoracic CT scan from the same patient are shown in fig 3. The diagnostic yield and accuracy of thoracoscopy for malignant effusions is greater than 90%. Patients with exudative pleural effusions of unknown aetiology after pleural fluid cytological and microbiological examination should proceed to pleural tissue biopsy (see guideline on the investigation of pleural effusions, page ii8).

The therapeutic role of thoracoscopy has been evaluated extensively. Talc poudrage is an effective method for controlling malignant effusions with a mean pleurodesis success rate of more than 90%. Patient selection for thoracoscopy and talc poudrage is important in view of the invasive nature of the procedure and cost. The role of surgical thoracoscopy in patients with trapped lung is less clear. The procedure can facilitate breaking up of loculations and release of adhesions...
and thereby aid lung re-expansion and apposition of the pleura for talc poudrage.\textsuperscript{1,2}

Thoracoscopy is a safe and well tolerated procedure with a low perioperative mortality rate (<0.5%).\textsuperscript{11,12} The most common major complications are empyema and acute respiratory failure secondary to infection or re-expansion pulmonary oedema.\textsuperscript{11,12}

4.5 Long term indwelling pleural catheter drainage

• Chronic indwelling pleural catheters are effective in controlling recurrent and symptomatic malignant effusions in selected patients. [B]

Insertion of a long term tunnelled pleural catheter is an alternative method for controlling recurrent and symptomatic malignant effusions including patients with trapped lung. A specific catheter has been developed for this purpose and the published studies employing this catheter have reported encouraging results.\textsuperscript{124,125}

In the only randomised and controlled study to date, Putnam and colleagues\textsuperscript{126} compared a long term indwelling pleural catheter with doxycycline pleurodesis via a standard intercostal tube. The length of hospitalisation for the indwelling catheter group was significantly shorter (1 day) than that of the doxycycline pleurodesis group (6 days). Spontaneous pleurodesis was achieved in 42 of the 91 patients in the indwelling catheter group. A late failure rate (defined as reaccumulation of pleural fluid after initial successful control) of 13% was reported compared with 21% for the doxycycline pleurodesis group. There was a modest improvement in the quality of life and dyspnoea scores in both groups. The complication rate was higher (14%) in the indwelling catheter group and included local cellulitis (most common) and, rarely, tumour seeding of the catheter tract.

An indwelling pleural catheter is therefore an effective option for controlling recurrent malignant effusions when length of hospitalisation is to be kept to a minimum (reduced life expectancy) and expertise and facilities exist for outpatient management of these catheters.

4.6 Pleuroperitoneal shunting

• Pleuroperitoneal shunts are an alternative and effective option in patients with a trapped lung or failed pleurodesis. [B]

In selected patients with trapped lung and large effusions refractory to chemical pleurodesis, pleuroperitoneal shunting is an acceptable palliative option. The shunt consists of a valved chamber (containing two unidirectional valves) with fenestrated pleural and peritoneal catheters attached at either end. The device is pressure activated but spontaneous flow will also occur when the pressure gradient between the pleural and peritoneal space is more than 1 cm H\textsubscript{2}O. More often the pressure gradient is low and requires manual compression of the pump chamber percutaneously, sometimes over 400 times per day.\textsuperscript{127} The insertion of the shunt is facilitated by thoracoscopy or a mini-thoracotomy and the duration of hospital stay varies between 4 and 6 days. The procedure is usually well tolerated and postoperative morbidity and mortality are low.\textsuperscript{128,129}

Complications include shunt occlusion, infection, and tumour seeding or implantation into the peritoneal cavity. Shunt occlusion rates vary from 12% to 25% and normally requires replacement of the shunt.\textsuperscript{130,131} The presence of pleural infection, multiple pleural loculations, and inability to compress the pump chamber are contraindications to pleuroperitoneal shunting.

4.7 Pleurectomy

Pleurectomy is an effective but invasive method for treating malignant pleural effusions. Complications may include empyema, haemorrhage, and cardiorespiratory failure (operative mortality rates of 10–13%). Patient selection is therefore important and this method should be reserved for those who have failed to respond to other forms of treatment.\textsuperscript{132} The advent of video assisted thoracic surgery (VATS) has enabled parietal pleurectomy to be performed without a formal thoracotomy. A study of 19 patients (13 with mesothelioma, six with metastatic adenocarcinoma) found this thoracoscopic method to be safe and associated with an effusion recurrence rate of 10%. The median postoperative stay was 5 days and all patients were discharged home.\textsuperscript{133}

Audit points

• Performance status at time of chemical pleurodesis.
• Use of small bore catheters in the management of malignant pleural effusions.
• Assessment of lung re-expansion prior to pleurodesis.
• Assessment of pain during and after pleurodesis using a pain scale or score.
• Complete and partial response rates of sclerosing agents.
• Surgical referral rates for the management of malignant pleural effusions.

Future potential areas for research

• Large prospective randomised trials comparing small bore catheters and large bore intercostal tubes for pleural fluid drainage and pleurodesis in malignant pleural effusions.
• Role of premedication before pleurodesis in malignant pleural effusion.
• Clinical trials of promising new sclerosants such as transforming growth factor beta (TGF\textbeta) and iodopovidone.
• Place of suction after pleurodesis in terms of duration of fluid drainage and length of hospital stay.

Authors’ affiliations

G Antunes, Department of Respiratory Medicine, James Cook University Hospital, Middlesborough TS4 3BW, UK

E Neville, Respiratory Centre, St Mary’s Hospital, Portsmouth PO3 6AD, UK

J Duffy, Cardiothoracic Surgery Department, Nottingham City Hospital, Nottingham NG5 1PB, UK

N Ali, Kings Mill Centre, Sutton in Ashfield, Nottingham NG17 4JJ, UK

REFERENCES


Sahn SA
Lorch DG
Yim AP
Gleichmann E
Hatta T
Wilkins HE
McLeod DT
Heffner JE
Lissoni P
Light RW
Webb HE
Bilaceroglu S
Masotti A
Viallat JR
Oncol 1992; 15:1163–70. [IIb]
45
110
104
105
106
107
109
111
116
117
119
120
122
123
124
125
126
127
129
130
131
132
133
134
135
136
137
138
139
140
141
142
www.thoraxjnl.com
BTS guidelines for the management of spontaneous pneumothorax

M Henry, T Arnold, J Harvey, on behalf of the BTS Pleural Disease Group, a subgroup of the BTS Standards of Care Committee

1 INTRODUCTION
Pneumothorax is defined as air in the pleural space—that is, between the lung and the chest wall. Primary pneumothoraces arise in otherwise healthy people without any lung disease. Secondary pneumothoraces arise in subjects with underlying lung disease. The term pneumothorax was first coined by Itard, a student of Laennec, in 1803, and Laennec himself described the clinical picture of pneumothorax in 1819. He described most pneumothoraces as occurring in patients with pulmonary tuberculosis, although he recognised that pneumothoraces also occurred in otherwise healthy lungs, a condition he described as “pneumothorax simple”. The modern description of primary spontaneous pneumothorax occurring in otherwise healthy people was provided by Kjaergard in 1932. Primary pneumothorax remains a significant global problem, occurring in healthy subjects with a reported incidence of 18–28/100 000 per year for men and 1.2–6/100 000 per year for women. Secondary pneumothorax is associated with underlying lung disease, whereas primary pneumothorax is not. By definition, there is no apparent precipitating event in either. Hospital admission rates for combined primary and secondary pneumothorax are reported in the UK at between 5.8/100 000 per year for women and 16.7/100 000 per year for men. Mortality rates in the UK were 0.62/million per year for women and 1.26/million per year for men between 1991 and 1995. This guideline describes the management of spontaneous primary and secondary pneumothorax. It excludes the management of trauma. Algorithms for the management of spontaneous primary and secondary pneumothorax are shown in figs 1 and 2.

• Strong emphasis should be placed on the relationship between the recurrence of pneumothorax and smoking in an effort to encourage patients to stop smoking. [B]

Despite the absence of underlying pulmonary disease in patients with primary pneumothorax, subpleural blebs and bullae are likely to play a role in the pathogenesis since they are found in up to 90% of cases of primary pneumothorax at thoracoscopy or thoracotomy and in up to 80% of cases on CT scanning of the thorax. The aetiology of such bullous changes in otherwise apparently healthy lungs is unclear. Undoubtedly, smoking plays a role; the lifetime risk of developing a pneumothorax in healthy smoking men may be as much as 12% compared with 0.1% in non-smoking men. This trend is also present, though to a lesser extent, in women. There does not appear to be any relationship between the onset of pneumothorax and physical activity. Small airway obstruction, mediated by an influx of inflammatory cells, often characterises pneumothorax and may become manifest in the smaller airways of men at an earlier stage. Patients with primary pneumothoraces tend to be taller than control patients. The gradient in pleural pressure increases from the lung base to the apex, thus alveoli at the lung apex in tall individuals are subject to significantly greater distending pressure than those at the base of the lung and, theoretically, are more predisposed to the development of subpleural blebs. Strong emphasis should be placed on the relationship between smoking and pneumothorax in an effort to deter those smokers who have developed a pneumothorax from smoking. Despite the apparent relationship between smoking and pneumothorax, 80–86% of young patients continue to smoke after their first primary pneumothorax.

The risk of recurrence of primary pneumothorax is 54% within the first 4 years, with isolated risk factors including smoking, height in male patients, and age over 60 years. Risk factors for secondary pneumothorax recurrence include age, pulmonary fibrosis, and emphysema.

In an effort to standardise treatment of primary and secondary pneumothoraces, the British Thoracic Society (BTS) published guidelines for the treatment of both in 1993. Several studies suggest that compliance with the 1993 guidelines, though improving, remains at only 20–40% among non-respiratory and A&E staff. Clinical guidelines have been shown to improve clinical practice and compliance with guidelines is related to the complexity of practical procedures that are described and is strengthened by an evidence base. Steps in the 1993 guidelines which may need clarification include: (1) simple aspiration (thoracocentesis) versus intercostal tube drainage (tube thoracostomy) as the first step in the management of primary and secondary pneumothoraces, (2) treatment of elderly pneumothorax patients or patients with underlying lung disease, (3) when to refer patients with a difficult pneumothorax to a chest physician or thoracic surgeon for persistent air leak or failure of re-expansion of the lung, and (4) treatment of the recurrent pneumothorax. This guideline addresses these issues. Its purpose is to provide a comprehensive evidence based review of the epidemiology, aetiology, and treatment of pneumothorax to complement the summary guidelines for diagnosis and treatment.

2 CLINICAL EVALUATION AND IMAGING
• Expiratory chest radiographs are not recommended for the routine diagnosis of pneumothorax. [B]
Figure 1  Recommended algorithm for the treatment of primary pneumothorax.
Figure 2  Recommended algorithm for the treatment of secondary pneumothorax.
A lateral chest or lateral decubitus radiograph should be performed if the clinical suspicion of pneumothorax is high, but a PA radiograph is normal.\[B\]

CT scanning is recommended when differentiating a pneumothorax from complex bullous lung disease, when aberrant tube placement is suspected, and when the plain chest radiograph is obscured by surgical emphysema. [C]

The clinical history is not a reliable indicator of pneumothorax size. [C]

Clinical history and physical examination usually suggest the presence of a pneumothorax, although clinical manifestations are not reliable indicators of size.\[7\] In general, the clinical symptoms associated with secondary pneumothoraces are more severe than those associated with primary pneumothoraces, and most patients with a secondary pneumothorax complain of breathlessness which is out of proportion to the size of the pneumothorax.\[11,12\] Many patients, particularly those with primary pneumothoraces, do not seek medical advice for several days, 46% waiting more than 2 days with symptoms. This feature is important because the occurrence of re-expansion pulmonary oedema (RPO) after re-inflation may be related to the length of time the lung has been collapsed (see section 4.4.1).\[13,16\]

Arterial blood gas measurements are frequently abnormal in patients with pneumothorax with the arterial oxygen tension (Pao2) being less than 10.9 kPa (80 mm Hg) in 75% of patients. The presence of underlying lung disease along with the size of pneumothorax predicts the degree of hypoxaemia.\[15\] Arterial PaO2 was below 7.5 kPa (55 mm Hg) and PacO2 above 6.9 kPa (50 mm Hg) in 16% of cases of secondary pneumothorax in the largest reported series. Pulmonary function tests are weakly sensitive measures of the presence or size of pneumothorax and are not recommended. [6]

In both primary and secondary spontaneous pneumothorax the diagnosis is normally established by plain chest radiograph. In general, expiratory radiographs add little and are not indicated as a routine investigation, even in the case of a suspected small apical pneumothorax.\[17,18\] When a pneumothorax is suspected but not confirmed by standard postero-anterior (PA) chest radiographs, lateral radiographs provide added information in up to 14% of cases. The lateral decubitus radiograph is superior to the erect or supine chest radiograph and is felt to be as sensitive as CT scanning in pneumothorax detection. The upright lateral or lateral decubitus radiograph is clinically helpful where findings on the upright PA radiograph are unclear. While such small pneumothoraces may not have much clinical relevance in patients without underlying lung disease, in patients with suspected secondary pneumothoraces, even small pneumothoraces may have significant implications and here lateral or lateral decubitus radiographs are probably valuable. In patients with severe bullous lung disease CT scanning will differentiate emphysematous bullae from pneumothoraces and save the patient an unnecessary and potentially dangerous aspiration.\[41\]

3 SIZE OF PNEUMOTHORAX

The previous classification of the size of a pneumothorax tends to underestimate its volume. In these new guidelines the size of a pneumothorax is divided into “small” or “large” depending on the presence of a visible rim of <2 cm or ≥2 cm between the lung margin and the chest wall.

The plain PA radiograph is a poor method of quantifying the size of a pneumothorax as it usually underestimates it. Exact methods of estimating size from PA chest radiographs are cumbersome and generally used only as a research tool.\[19\] The size of a pneumothorax, in terms of volume, is difficult to assess accurately from a chest radiograph which is a two dimensional image. In the 1993 guidelines\[20\] pneumothoraces were classified into three groups:

- “small”: defined as a “small rim of air around the lung”;
- “moderate”: defined as lung “collapsed halfway towards the heart border”;
- “complete”: defined as “airless lung, separate from the diaphragm”.

This attempt to quantify a pneumothorax tends to underestimate the volume of anything greater than the smallest of pneumothoraces.\[3\] Since the volume of a pneumothorax approximates to the ratio of the cube of the of the lung diameter to the hemithorax diameter, a pneumothorax of 1 cm on the PA chest radiograph occupies about 27% of the hemithorax volume if the lung is 9 cm in diameter and the hemithorax 10 cm: \( (10^3 - 9^3)/10^3 = 27% \). Similarly, a 2 cm radiographic pneumothorax occupies 49% of the hemithorax on the same basis (fig 3).

In view of the proximity of the lung surface to the chest wall in a pneumothorax of <1 cm, aspiration using a sharp needle may not be advisable. However, given that the actual volume of a 2 cm pneumothorax approximates to a 50% pneumothorax, this should be considered large in size and can be treated safely by aspiration when circumstances dictate. For the purposes of these new guidelines, “small” is therefore regarded as a pneumothorax of <2 cm and “large” as a pneumothorax of ≥2 cm.

If accurate size estimates are required, CT scanning is the most robust approach.\[42\] Otherwise, it is only recommended for difficult cases such as patients in whom the lungs are obscured by overlying surgical emphysema, or to differentiate a pneumothorax from a suspected bulla in complex cystic lung disease.\[43\] The routine use of CT scans preoperatively in patients with pneumothorax and suspected emphysema or isolated bullae adds little to the plain PA chest radiograph from the point of view of management of the patient.\[44\]

4 TREATMENT OPTIONS FOR SPONTANEOUS PNEUMOTHORAX

4.1 Observation

- Observation should be the treatment of choice for small closed pneumothoraces without significant breathlessness. [B]
- Patients with small (<2 cm) primary pneumothoraces not associated with breathlessness should be considered for discharge with early outpatient review. These patients should receive clear written advice to return in the event of worsening breathlessness. [B]

![Figure 3](www.thoraxjnl.com) Quantitation of size of pneumothorax: 1993 versus 2003 guidelines.
• If a patient with a pneumothorax is admitted overnight for observation, high flow (10 l/min) oxygen should be administered, with appropriate caution in patients with COPD who may be sensitive to higher concentrations of oxygen. [B]

• Breathless patients should not be left without intervention regardless of the size of the pneumothorax on a chest radiograph. [C]

4.1 Primary pneumothoraces, minimal symptoms
Observation alone is advised for small, closed, mildly symptomatic spontaneous pneumothoraces. 31 32 48–50 70–80% of pneumothoraces estimated at smaller than 15% have no persistent air leak and recurrence in those managed with observation alone is less than in patients treated with intercostal tube drainage. 51 Patients with small primary pneumothoraces and minimal symptoms do not require hospital admission, but it should be stressed before discharge that they should return directly to hospital in the event of developing breathlessness. Most patients in this group who fail this “treatment” and require intercostal tube drainage have secondary pneumothoraces. 52

4.1.1 Primary pneumothoraces, minimal symptoms
Observation alone is only recommended in patients with small secondary pneumothoraces of less than 1 cm depth or isolated apical pneumothoraces in asymptomatic patients. Hospitalisation is recommended in these cases. All other cases will require active intervention (aspiration or chest drain insertion, see later sections).

4.1.3 Symptomatic pneumothoraces, primary or secondary
Observation alone is inappropriate and active intervention is required. Marked breathlessness in a patient with a small (<2 cm) primary pneumothorax may herald tension pneumothorax. 51 If a patient is hospitalised for observation, supplemental high flow (10 l/min) oxygen should be given where feasible. 53 Inhalation of high concentrations of oxygen may reduce the total pressure of gases in pleural capillaries by reducing the partial pressure of nitrogen. This should increase the pressure gradient between the pleural capillaries and the pleural cavity, thereby increasing absorption of air from the pleural cavity. The rate of resolution/reabsorption of spontaneous pneumothoraces is 1.25–1.8% of the volume of hemithorax every 24 hours. 55 In a group of 11 patients with pneumothoraces ranging in size from 16% to 100%, the mean rate of re-expansion was 1.8% per day and full re-expansion occurred at a mean of 3.2 weeks. 55 A 15% pneumothorax would therefore take 8–12 days to resolve fully. The addition of high flow oxygen therapy has been shown to result in a four-fold increase in the rate of pneumothorax reabsorption during periods of oxygen supplementation. 56

4.2 Simple aspiration
• Simple aspiration is recommended as first line treatment for all primary pneumothoraces requiring intervention. [A]

• Simple aspiration is less likely to succeed in secondary pneumothoraces and, in this situation, is only recommended as an initial treatment in small (<2 cm) pneumothoraces in minimally breathless patients under the age of 50 years. [B]

• Patients with secondary pneumothoraces treated successfully with simple aspiration should be admitted to hospital and observed for at least 24 hours before discharge. [C]

The 1993 BTS guidelines 57 recommended simple aspiration as first line treatment in all primary pneumothoraces where there is complete collapse of the lung, and in smaller primary pneumothoraces in which patients complain of significant breathlessness. Simple aspiration was also recommended as initial treatment in secondary pneumothoraces where there is moderate or complete collapse of the lung and in smaller secondary pneumothoraces where significant breathlessness is present. Small was defined as a “small rim of air around the lung”, moderate as “lung collapsed halfway towards the heart border”, and complete as “airless lung, separate from the diaphragm”.

A study describing treatment practices for pneumothoraces after the 1993 guidelines showed that only 17 of 43 decisions to aspirate pneumothoraces by A&E staff, perhaps because of unfamiliarity with the technique, and nine of 26 similar decisions made by medical staff seemed appropriate. 58 A similar study undertaken in Scotland and completed before the publication of the 1993 guidelines reported that only three of 38 spontaneous pneumothoraces (one primary, two secondary) were treated initially by aspiration alone and all three were successful. 59 It would seem, therefore, that many medical staff are unaware of the guidelines in this respect, or are unwilling or unable to aspirate.

Successful re-expansion of the lung is less likely after simple aspiration in secondary pneumothorax (33–67%) than in primary (59–83%). 51–53 However, several larger series which used this technique found that 59–73% of all pneumothoraces requiring intervention could be successfully aspirated. 51 52 54–56 Successful aspiration in these series depended on age (under 50 years: 70–81% success, over 50 years: 19–31% success), the presence of chronic lung disease (27–67% success), and the size of the pneumothorax (<3 l aspirated: 89% success, >3 l: no success; >50% on chest film: 62% success, <50% on chest film: 77% success). In a prospective randomised trial to compare simple aspiration and tube drainage of pneumothoraces, Andrivert and colleagues 57 found a 20% recurrence rate at 3 months after simple aspiration of primary pneumothoraces and a 28% recurrence rate after tube drainage demonstrating that simple aspiration is no less effective from the point of view of recurrence than the more invasive intercostal tube drainage. In a more recent randomised controlled trial Noppen and coworkers 60 showed that simple aspiration was as successful in treating first primary pneumothoraces as immediate intercostal tube drainage (59% versus 63%). In treated with simple aspiration were less likely to be hospitalised and less likely to suffer a recurrence of the pneumothorax over the next 12 months. Harvey and Prescott, 61 on behalf of the British Thoracic Society, confirmed that simple aspiration of primary pneumothoraces is as effective as tube drainage when recurrence of pneumothorax at 12 months was taken as an end point. Further advantages of simple aspiration over intercostal tube drainage are a reduction in total pain scores during hospitalisation and shorter hospital stays. 54 In centres where the experience and equipment is available, consideration should be given to using small bore catheter aspiration kits (CASP, see below) to aspirate pneumothoraces as the catheter may be left in place until full re-expansion of the lung is confirmed. Otherwise, repeat aspiration or connection to an underwater seal system may be facilitated through these indwelling small bore catheters.

Large secondary pneumothoraces (≥2 cm), particularly in patients over the age of 50, should be considered a high risk of failure for simple aspiration and recurrence and therefore tube drainage is recommended as appropriate initial treatment. If simple aspiration is considered in patients with secondary pneumothoraces, admission for observation for at least 24 hours should be undertaken, with prompt progression to tube drainage if needed. Active treatment of the underlying lung disorder will also be necessary.
4.2.1 Repeat aspiration and catheter aspiration of simple pneumothorax

- Repeated aspiration is reasonable for primary pneumothorax when the first aspiration has been unsuccessful (i.e., patient still symptomatic) and a volume of <2.5 l has been aspirated on the first attempt. [B]
- Catheter aspiration of pneumothorax (CASP) can be used where the equipment and experience is available. [B]
- Catheter aspiration kits with an integral one way valve system may reduce the need for repeat aspiration. [C]

Failure to re-expand a primary pneumothorax with aspiration can be successfully corrected by a second aspiration in over one third of cases, particularly where the initial attempt failed because of a kinked or displaced catheter. Despite this, the tendency is to treat aspiration failures with tube drainage. A second attempt at simple aspiration of the pneumothorax should be considered unless >2.5 l was aspirated during the unsuccessful first attempt. Catheter aspiration of simple pneumothorax (CASP) involves a small (8 F) catheter being passed over a guidewire into the pleural space. A three way stopcock is attached and air may be aspirated via a 50 ml syringe. This controls up to 50% of all pneumothoraces. Addition of a Heimlich valve and suction may improve success rates further.

4.3 Intercostal tube drainage

- If simple aspiration or catheter aspiration drainage of any pneumothorax is unsuccessful in controlling symptoms, then an intercostal tube should be inserted. [B]
- Intercostal tube drainage is recommended in secondary pneumothorax except in patients who are not breathless and have a very small (<1 cm or apical) pneumothorax. [B]
- A bubbling chest tube should never be clamped. [B]
- A chest tube which is not bubbling should not usually be clamped. [B]
- If a chest tube for pneumothorax is clamped, this should be under the supervision of a respiratory physician or thoracic surgeon, the patient should be managed in a specialist ward with experienced nursing staff, and the patient should not leave the ward environment. [C]
- If a patient with a clamped drain becomes breathless or develops subcutaneous emphysema, the drain must be immediately unclamped and medical advice sought. [C]

Underwater seal drainage using a chest tube was introduced in 1873. Widespread closed tube drainage as first adopted during the 1917 influenza epidemic. Intercostal tube drainage or underwater seal drainage in its modern form has been in use since 1916 when Kenyon described a “siphon” method of draining traumatic haemothorax. This treatment, despite being extremely effective, has many potential disadvantages ranging from chest and abdominal visceral trauma from sharp trocars in the hands of inexperienced operators to the bulkiness of the underwater seal bottle system which must be kept upright.

Likewise it may be hazardous to clamp a chest drain that is still bubbling, thereby potentially converting simple pneumothoraces into life threatening tension pneumothoraces. Such instances are anecdotal, and there is no evidence of which we are aware that clamping the tube improves success rates or prevents recurrence. Almost identical success rates have been recorded for the maintenance of full re-expansion of the lung after 24 hours whether the tube is clamped or not before removal. However, many experienced physicians still support the use of clamping of chest drains before their removal to detect small air leaks not immediately obvious at the bedside. By clamping the chest drain for several hours and performing a chest radiograph, a minor or intermittent air leak may be detected, potentially avoiding the need for chest tube reinsetion. In the ACCP Delphi consensus statement about half the consensus group supported clamping and half did not, and this seems similar to the UK spread of opinion. Drain clamping is therefore not generally recommended for safety reasons, but is acceptable under the supervision of nursing staff who are trained in the management of chest drains and who have instructions to unclamp the chest drain in the event of any clinical deterioration. Patients with a clamped chest drain inserted for pneumothorax should not leave the specialist ward area.

Despite these risks, tube drainage remains an effective treatment for pneumothorax although it is not proven that tube drainage should be performed as the initial treatment in any pneumothorax. Simple aspiration should be considered as the primary treatment for all primary pneumothoraces requiring intervention but not considered to be under tension. In secondary pneumothoraces in patients over 50 years with pneumothorax >50%, primary failure rates for aspiration are estimated at >50%. Age alone is a strong predictor of failure of simple aspiration (>50 years, success 27–67%), although in those over the age of 50 years with no evidence of pre-existing lung disease there is no evidence that tube drainage should be recommended before simple aspiration as primary treatment.

Analgesic use during the insertion of intercostal tubes remains poorly studied. The injection of intrapleural local anaesthetic (20–25 ml = 200–250 mg, 1% lignocaine) given as a bolus and at eight hourly intervals as necessary after the insertion of the drain significantly and safely reduced pain scores without affecting blood gas measurements, either with or without chemical pleurodesis. There are no data detailing the incidence of pleural infection with this technique.

Chest tubes frequently (59%) end up in fissures, but these tubes seem to retain their effectiveness. Step by step guidelines to chest drain insertion are described elsewhere in these guidelines (page i53).

4.3.1 Complications of intercostal tube drainage

The complications of intercostal tube drainage include penetration of the major organs such as lung, stomach, spleen, liver, heart and great vessels, and are potentially fatal. These complications occur more commonly when a sharp metal trocar is inappropriately applied during the procedure.

In the largest series reviewing complications of tube drainage in recent times, Chan and colleagues identified complications in 18% of chest drain insertions for all indications; 64% of these chest tubes (n=373) were inserted for treatment of pneumothorax. However, 15% of the “complications” identified involved failure of resolution of the pneumothorax and only 4% involved aberrant tube placement. Notably, complications related to tube placement occurred most commonly on medical wards. CT assessment suggests a higher rate of incorrect tube placement. Baldt and colleagues identified 3% of tubes placed extravasatorically and 6% placed within the lung during the treatment of pneumothoraces. This highlights the need for correct training in chest tube placement. In some circumstances, thoracic CT scanning is valuable for assessing chest tube position—for example, when displacement is suspected but not confirmed on plain radiograph.

Pleural infection is another complication of intercostal tube drainage. The rate of empyema after chest tube insertion has...
been estimated as 1%. Other series have reported an incidence of up to 6% of chest tube related empyema in trauma cases and suggested that the administration of prophylactic antibiotics should be considered, particularly where a prolonged period of chest tube drainage might be anticipated. This highlights the need for full aseptic technique in the insertion or manipulation of any chest drainage system. Finally, surgical emphysema is a well recognised complication of intercostal tube drainage. This is generally of cosmetic importance only, subsiding after a few days. The development of surgical emphysema associated with pneumothorax involves an air filled space, not formerly in communication with the subcutaneous tissue, being brought into communication with the subcutaneous tissues. This may occur in the presence of a malpositioned, kinked, blocked, or clamped tube. Likewise, a small tube in the presence of a very large leak may potentially cause surgical emphysema. Occasionally, the resulting acute airway obstruction or thoracic compression may lead to respiratory compromise. The treatment is usually conservative but, in life threatening situations, tracheostomy, skin incision decompression, and insertion of large bore modified subcutaneous chest drains have all been used.

4.3.2 Size of tube

- There is no evidence that large tubes (20–24 F) are any better than small tubes (10–14 F) in the management of pneumothoraces. The initial use of large (20–24 F) intercostal tubes is not recommended, although it may become necessary to replace a small chest tube with a larger one if there is a persistent air leak. [B]

Although one study suggested that success rates for the treatment of pneumothoraces with small chest tubes (13 F) were poor and that larger sized catheters should be used, subsequent studies have not confirmed this and suggest that smaller calibre chest tubes are just as effective. Primary success rates of 84–97% were recorded in these studies using drains of 7–9 F gauge. Recent technical developments have allowed the addition of a Heimlich flutter valve to small tubes exceeding 48 hours duration should prompt referral to a respiratory physician. Such patients may require sustained chest drainage with complex drain management (suction, chest drain repositioning) and thoracic surgery decisions. These issues will be better managed by physicians with specific training and experience in these problems and established relationships with a thoracic surgeon. Drain management is also best delivered by nurses with substantial experience in this area.

4.4 Referral to respiratory specialists

- Pneumothoraces which fail to respond within 48 hours to treatment should be referred to a respiratory physician. [C]

Failure of a pneumothorax to re-expand or a persistent air leak exceeding 48 hours duration should prompt referral to a respiratory physician. Such patients may require sustained chest drainage with complex drain management (suction, chest drain repositioning) and thoracic surgery decisions. These issues will be better managed by physicians with specific training and experience in these problems and established relationships with a thoracic surgeon. Drain management is also best delivered by nurses with substantial experience in this area.

4.4.1 Chest drain suction

- Suction to an intercostal tube should not be applied directly after tube insertion, but can be added after 48 hours for persistent air leak or failure of a pneumothorax to re-expand. [B]
- High volume, low pressure (–10 to –20 cm H₂O) suction systems are recommended. [C]
- Patients requiring suction should only be managed on lung units where there is specialist medical and nursing experience. [C]

There is no evidence to support the routine initial use of suction applied to chest drain systems in the treatment of spontaneous pneumothorax. A persistent air leak, with or without incomplete re-expansion of the pneumothorax on a chest radiograph, is the usual reason for applying suction to an intercostal tube system. A persistent air leak is usually arbitrarily defined as a continued air bubbling through an intercostal tube 48 hours after insertion. Mathur and colleagues retrospectively reviewed 142 cases of spontaneous pneumothorax requiring chest drain insertion. The median time to resolution was 8 days (19 days in those with underlying lung disease), which was not related to the initial size of the pneumothorax. Most of the patients (30/43) with a persistent air leak had suction applied, but without standardisation of the degree of suction or of the point of initiation (the first 4 days in the majority). Normal intrapleural pressures are –8 cm H₂O during inspiration and –3.4 cm H₂O during expiration. During intercostal tube drainage various factors influence the amount of suction applied to the pleural space. It has been suggested that, because the magnitude of these physiological factors varies, it is desirable to apply –10 to –20 cm H₂O suction to all pneumothoraces which are slow to re-expand, and the system used should have the capacity to increase the suction with an air flow volume of 15–20 l/min. Over 40 years ago Roe stressed the importance of high volume vacuums to drain the pleural space during pneumothoraces. The use of high pressure, high volume suction is not, however, recommended because of the ease with which it can generate high air flow suction which may lead to air stealing, hypoxaemia, or the perpetuation of persistent air leaks. Likewise, high pressure, low volume systems should be avoided. High volume, low pressure systems such as a Vernon-Thompson pump or wall suction with an adaptor to reduce pressure are recommended. Unfortunately, due to the lack of more recent randomised controlled trials examining the role of suction with intercostal tube systems, evidence based recommendations cannot be applied. The best practice from previous studies to date, as above, suggests that suction should be applied after 48 hours, but that surgical referral for a persistent air leak in those without pre-existing lung disease should be made at 5–7 days. Significantly, earlier referral (2–4 days) should be considered in those with underlying disease, a large persistent air leak, or failure of the lung to re-expand. If suction is to be applied to a chest drain, it is recommended that the patient should be situated in an area where specialist nursing experience is available.

The addition of suction too early after the insertion of a chest tube, particularly in the case of a primary pneumothorax which may have been present for a few days, may precipitate re-expansion pulmonary oedema (RPO) and is
contraindicated. RPO is probably caused by the increased permeability of capillaries damaged during a pneumothorax. This becomes manifest as oedema during re-expansion due to further mechanical stresses applied to the already “leaky” capillaries. Clinically, these patients manifest symptoms of coughing and breathlessness or chest tightness after insertion of the chest tube. In those whose symptoms persist, a repeat chest radiograph after 24 hours will often show pulmonary oedema in the treated lung, although pulmonary oedema may also develop in the contralateral lung. The incidence of RPO may be up to 14% and is higher in those with larger primary pneumothoraces and in younger patients (<30 years), although in most cases RPO does not progress beyond a radiological phenomenon. However, the clinical relevance of RPO must not be understated as the outcome has been reported as fatal in 20% of 53 reported cases who developed a clinical deterioration as part of an RPO syndrome in one series. Particular caution should therefore be exercised in treating young patients with large pneumothoraces and suction should not be used immediately in the treatment of a spontaneous pneumothorax. Even when employed later and it is suspected that the pneumothorax has been present for a considerable period of time, the potential development of RPO should be considered.

4.4.2 Chemical pleurodesis

- **Chemical pleurodesis can control difficult or recurrent pneumothorax [A] but should only be attempted if the patient is either unwilling or unable to undergo surgery. [B]**

- **Medical pleurodesis for pneumothorax should be performed by a respiratory specialist. [C]**

Chemical pleurodesis has generally been advocated by chest physicians experienced in thoracoscopy. The instillation of substances into the pleural space should lead to an aseptic inflammation with dense adhesions, leading ultimately to pleural symphysis. There is a high rate of recurrence of primary and secondary pneumothoraces, and efforts to reduce these rates by instillation of various sclerosants—or via chest drains or by surgical means—are regularly undertaken without clear guidelines to direct physicians in their use. In the majority of cases, when appropriate, the prevention of further pneumothoraces should be undertaken by surgical means. The rate of recurrence of pneumothoraces after surgical intervention either by thoracotomy or VATS, with or without surgical pleurodesis, is far less than after medical pleurodesis. A small number of individuals are either too frail or are unwilling to undergo any definitive surgical treatment to prevent recurrence of their pneumothoraces and, in these instances, medical chemical pleurodesis may be appropriate.

During the last decade many sclerosing agents have been studied. Tetracycline is recommended as the first line sclerosant therapy in both primary and secondary pneumothoraces. It was initially proposed as it proved to be the most effective sclerosant in animal models. Recently, parenteral tetracycline for pleurodesis has become more difficult to obtain due to problems with the manufacturing process. The parenteral preparation is currently available in Germany and may be imported via international wholesalers. The parenteral preparation is considered to be reasonable alternatives as sclerosants in animal models. The rate of recurrence of pneumothorax is the primary indicator of success for any sclerosant. Although tetracycline has been shown significantly to reduce the incidence of early recurrence, the incidence of late recurrence is 10–20% which is unacceptably high compared with surgical methods of pleurodesis. Large randomised controlled studies comparing the use of tetracycline as a sclerosant with standard management in primary pneumothorax did not provide sufficient evidence to determine whether or not tetracycline should be used after treatment of a first uncomplicated primary pneumothorax to prevent recurrence. Tetracycline can, however, be recommended for recurrent primary pneumothorax and secondary pneumothorax when surgery is not an option, and talc may be used on the grounds that it is the most effective agent in malignant effusion. There is conflicting evidence as to whether tetracycline is effective for the treatment of fully expanded pneumothorax with persistent air leak. The largest of these studies, the Veterans Administration Study, did not support the use of intrapleural tetracycline to facilitate the closure of a persistent air leak. Macowiak and colleagues suggest that intrapleural tetracycline can facilitate the closure of a persistent air leak provided that the lung can be kept expanded so that sympyosis can occur. Likewise, there is conflicting evidence as to whether intrapleural tetracycline shortens the length of stay in hospital with pneumothorax.

The dosage of intrapleural tetracycline requires clarification. Almind et al found a reduction in the incidence of recurrence in a group receiving 300 mg tetracyline via chest drains compared with those treated by tube drainage alone. This reduction was not significant. The Veterans Administration Study, which used 1500 mg tetracyline, showed a significant reduction in the incidence of recurrence of pneumothorax without significant extra morbidity. This dose of intrapleural tetracycline is therefore recommended as the standard dose for medical pleurodesis. While pain was reported more frequently in the group treated with tetracyline at a dose of 1500 mg, others have reported no increase in pain with tetracyline at a dose of 500 mg provided adequate analgesia is given. Adequate analgesia may be achieved with administration of intrapleural local anaesthesia. Standard doses (200 mg (20 ml) 1% lignocaine) are significantly less effective than larger doses (250 mg (25 ml) 1% lignocaine). The higher doses have been shown to increase the number of pain free episodes from 10% to 70% with no appreciable toxicity.

Medical and surgical pleurodesis using talc remain effective alternatives to tetracycline pleurodesis. There are no controlled trials comparing talc and tetracycline as sclerosants in the treatment of pneumothorax. The issue of talc pleurodesis will be dealt with later in the surgical section of this review as most trials using talc tend to focus on surgical talc pleurodesis. Since medical pleurodesis is recognised to be “second best” care and its use will imply a “difficult” case, it is recommended that medical pleurodesis be undertaken only by respiratory specialists or thoracic surgeons.

4.5 Referral to thoracic surgeons

- **In cases of persistent air leak or failure of the lung to re-expand, the managing respiratory specialist should seek an early (3–5 days) thoracic surgical opinion. [C]**

- **Open thoracotomy and pleurectomy remains the procedure with the lowest recurrence rate for difficult or recurrent pneumothoraces. Minimally invasive procedures, thoracoscopic (VATS), pleural abrasion, and surgical talc pleurodesis are all effective alternative strategies.**

The timing of surgical intervention for pneumothorax has recently been challenged and remains contentious. There is no evidence based justification for the arbitrary but widely advocated cut off point of 5 days for surgery for a persistent air leak. Chee and colleagues showed that 100% of primary pneumothoraces treated by tube drainage with persistent air leaks for more than 7 days had resolved their air leaks by 14 days and 79% of those with secondary pneumothoraces and
persistent air leaks had resolved their air leaks by 14 days with no mortality. However, considering the efficacy and relatively low levels of morbidity and recurrence associated with surgery for pneumothorax,20–22 earlier surgical intervention has been advocated for persistent air leak or failure of re-expansion, particularly in cases of secondary pneumothorax.21,22 Several authors have recommended operative referral/intervention as early as 3 days for a persistent air leak. However, these studies were not controlled.21,22 Despite the reduction in the incidence of late recurrence of pneumothorax in many of these studies, surgical referral for a persistent air leak in a first primary pneumothorax within the first 4–5 days is not supported by the literature. However, best practice suggests that protracted chest tube drainage is not in the patient’s interest. It is therefore recommended that patients with difficult pneumothoraces should receive care from a respiratory physician and that a thoracic surgical opinion will be an early part of management.

According to the statistical and perceived risk of recurrence, accepted indications for operative intervention are as follows:

- Second ipsilateral pneumothorax
- First contralateral pneumothorax
- Bilateral spontaneous pneumothorax
- Persistent air leak (>5–7 days of tube drainage; air leak or failure to completely re-expand)
- Spontaneous haemothorax
- Professions at risk (e.g. pilots, divers)108 110 114–116

4.5.1 Surgical strategies

There are two objectives in the surgical management of a pneumothorax. The first widely accepted objective is resection of blebs or the suture of apical perforations to treat the underlying defect. The second objective is to create a pleural symphysis to prevent recurrences. There is debate between those who favour surgical pleurodesis or pleural abrasion versus those who favour partial or total pleurectomy as a definitive treatment to prevent recurrence of pneumothorax,109–117 118 although a relatively recent comprehensive review of this area suggests a slight advantage of pleurectomy over pleural abrasion with a recurrence rate of 0.4% after pleurectomy (n=752) and 2.3% after pleural abrasion (n=301).109 Operative techniques have tended towards minimally invasive procedures over the last few years. In order to be considered effective, these techniques should yield results comparable to the “gold standard” open thoracotomy procedure—that is, the operative morbidity should be less than 15% and the pneumothorax recurrence rate should be less than 1%.109

Open thoracotomy

In 1941 Tyson and Crandall119 described pleural abrasion as a treatment for pneumothorax and in 1956 Gaensler120 introduced parietal pleurectomy for recurrent pneumothorax. This procedure produces uniform adhesions between the pleura and the chest wall. Both of these techniques are designed to obliterate the pleural space by creating symphysis between the two pleural layers or between the visceral pleura and subpleural plane, in the case of parietal pleurectomy. In order to prevent recurrence, however, an appropriate closure at the site of the pleural air leak is essential either by cauterisation, ligation, or suture of accompanying blebs.120 Open thoracotomy yields the lowest postoperative recurrence results. Bulla ligation/excision, thoracotomy with pleural abrasion, and either apical or total parietal pleurectomy all have failure rates under 0.5%.46,109 Morbidity from thoracotomy for pneumothorax has an overall incidence of 3.7%, mostly in the form of sputum retention and postoperative infection.109 Open thoracotomy is generally performed using single lung ventilation, a limited posterolateral thoracotomy allowing parietal pleurectomy, excision, or stapling of bullae or pleural abrasion.120 Isolated lung ventilation during open thoracotomy facilitates full visualisation of the visceral pleura. This may not be possible during a VATS procedure, increasing the risk of missing a leaking bulla.120–122 Open thoracotomy may be associated with increased postoperative respiratory dysfunction and hospital stay compared with VATS procedures.120 It is suggested that the success rates with the open procedure are higher.124 Thus, surgical authorities suggest open thoracotomy in patients with secondary pneumothoraces who may have extensive pleural disease requiring more extensive pleurectomy, subpleural bullectomy, or pleural abrasion.110 114 115

Surgical chemical pleurodesis

- Surgical chemical pleurodesis is best achieved with 5 g sterile talc. Side effects such as ARDS and empyema are reported but rare. [A]

The use of talc pleurodesis is now a subject of renewed interest because of the potential unavailability of tetracycline, its low cost, and a record of successful pleurodesis (85–92%) that is similar to alternative thoracoscopic techniques for complicated pneumothorax.114 116–117 While talc slurry inserted under medical supervision via intercostal tube drainage tends to be less favoured than thoracoscopic talc poudrage, both methods have been shown to be effective. The overall success rate for talc pleurodesis reviewed by meta-analysis is 91%.118 Surgical pleurodesis with tetracycline is not generally felt to be a satisfactory alternative, with recurrence rates of 16% in a series of 390 patients who underwent surgical pleurodesis using tetracycline.125 There are no controlled trials comparing pain during talc pleurodesis with that using other agents, although it is suggested that talc pleurodesis is no more difficult or painful a procedure than tetracycline pleurodesis.128–132 Dosages of talc ranging from 2 g to 10 g have been used, but the suggestion that higher dosages have more effective has not been established by controlled trials. On the basis of a meta-analysis of uncontrolled data, 5 g talc by VATS is recommended with a success rate of 87%, which is very close to the success rates using more extensive operative approaches.126 Side effects reported with talc pleurodesis include five cases of adult respiratory distress syndrome (ARDS), although it is suggested that ARDS may be related to the size of talc particles used136; empyema, although this is rare when properly sterilised talc is used126 134 135; pneumonia; and respiratory failure.118 In view of these potential side effects, standard first line usage of talc poudrage or talc slurry pleurodesis should be approached with caution since surgery not dependent on introducing a foreign agent is usually an option. Lower dosages of 2–5 g should be used until dosage schedules and effectiveness have been clarified. Long term safety does not appear to be an issue if asbestos-free talc is used. The success rates with talc poudrage and talc slurry pleurodesis are similar, so either approach can be recommended. Because of the relatively high failure rates of over 9% with talc pleurodesis compared with surgical pleural stripping procedures, talc pleurodesis should not be considered as initial treatment for primary spontaneous pneumothorax requiring surgical intervention. In those patients who are either unwilling or too unwell to undergo general anaesthesia, medical pleurodesis with either tetracycline or talc (via an intercostal tube) is recommended.

Transaxillary minithoracotomy

Becker and Munro136 pioneered this technique in the 1970s. The procedure is considered a minimally invasive procedure. The incision in the axillary margin measures 5–6 cm. Apical pleurectomy or abrasion may be performed and the apex carefully inspected for pleural blebs or bullae which may be stapled. The largest series examining this technique reported a mean hospital stay of 6 days, a recurrence rate of 0.4%, and a complication rate of 10%, most of which were minor.138 These results make this procedure a realistic alternative to open
thoracotomy for the treatment of complicated spontaneous pneumothorax.

Video assisted thoracoscopic surgery (VATS)
The evaluation of VATS for spontaneous pneumothorax is limited by the small number of randomised trials comparing it with alternative surgical approaches. To date, there have only been two randomised studies which have attempted to define the role of VATS in the treatment of spontaneous pneumothorax. In a comprehensive review, Massard and colleagues have suggested that the impression that VATS is superior to open procedures in terms of morbidity, time in hospital, and cost may not be wholly correct. Minimally invasive surgery may have a complication rate similar to open procedures at about 8–10%. Recurrence rates of pneumothorax after VATS are 5–10%, which are higher than the 1% rates reported after open procedures.

While bullectomy, pleurectomy, pleural abrasion, and surgical pleurodesis have all been shown to have reasonable success rates when carried out thoracoscopically, there are concerns associated with VATS performed under local anaesthetic supplemented by nitrous oxide inhalation. These arise from the inability to obtain isolated single lung ventilation and include difficulties in inspecting the entire visceral pleural surface, increasing the risk of missing a leaking bleb or bulla. It is also suggested that a less intense pleural inflammatory reaction is induced by VATS procedures leading to a less effective pleurodesis. Several authors suggest that VATS offers significant advantages over open thoracotomy including a shorter postoperative hospital stay, significantly less postoperative pain, and better pulmonary gas exchange in the postoperative period. However, Kim and colleagues in their randomised controlled trial did not confirm a shorter postoperative stay in the VATS groups. Further randomised trials comparing VATS with transaxillary and open thoracotomies are required and, until these data are available, VATS cannot be considered to be established as being superior to thoracotomy.

4.6 Discharge and follow up

- Patients discharged without intervention should avoid air travel until a chest radiograph has confirmed resolution of the pneumothorax.
- Diving should be permanently avoided after a pneumothorax, unless the patient has had bilateral surgical pleurectomy.
- Primary pneumothorax patients treated successfully by simple aspiration should be observed to ensure clinical stability before discharge. Secondary pneumothorax patients who are successfully treated with simple aspiration should be admitted at least overnight and preferably for 24 hours before discharge to ensure no recurrence. The mortality rate associated with secondary pneumothorax is 10%, and many of these patients die after the pneumothorax has resolved. Patients with secondary pneumothorax will require a more protracted admission, including treatment of their underlying lung disorder. All patients discharged after active treatment or otherwise should be given verbal and written advice to return to the Accident and Emergency department immediately should they develop further breathlessness.

5 PNEUMOTHORAX AND AIDS

- Early and aggressive treatment of pneumothoraces in HIV patients, incorporating intercostal tube drainage and early surgical referral, is recommended.

There is evidence that the clinical spectrum of spontaneous pneumothorax is shifting away from the predominant subpleural bleb disease as emphasised by most reports since Kjaergard. There are several reports that up to 25% of spontaneous pneumothoraces in large urban settings with a high prevalence of HIV infection are AIDS related; 2–5% of AIDS patients will develop a pneumothorax. Pneumocystis carinii pneumonia (PCP) is associated with a severe form of necrotising alveolitis in which the subpleural pulmonary parenchyma is replaced by necrotic thin walled cysts and pneumatoceles. AIDS related spontaneous pneumothorax is complicated by the refractory nature of air leaks which tend to occur with the necrotising subpleural pneumonitis of PCP infection. Such is the relationship between AIDS related pneumothorax and the presence of P carinii that the occurrence of pneumothorax in AIDS patients is considered an indicator of treatment for active P carinii infection. AIDS related spontaneous pneumothorax carries a higher hospital mortality, a higher incidence of bilateral (40%) and recurrent pneumothoraces, and more prolonged air leaks. Treatment failures may also reflect the degree of immunocompromise of the impaired host as reflected by the CD4 counts. It has also been suggested that systemic corticosteroids used to treat PCP may increase the risk of morbidity from AIDS related pneumothorax. Because of the high rate of primary treatment failures and associated short survival times reported for such patients, early and...
aggressive treatment of AIDS related spontaneous pneumothorax—incorporating early tube drainage and talc pleurodesis, early VATS assisted talc poudrage, unilateral or bilateral pleurectomy—is recommended.\textsuperscript{151, 152, 153, 154, 155, 156}

6 PNEUMOTHORAX AND CYSTIC FIBROSIS

- Early and aggressive treatment of pneumothoraces in cystic fibrosis is recommended. [C]

- Surgical intervention should be considered after the first episode, provided the patient is fit for the procedure. [C]

The treatment of pneumothorax for patients with cystic fibrosis (CF) is similar to that for non-CF patients. A pneumothorax is associated with more severe disease and can be life threatening. Median survival after pneumothorax in patients with CF is 30 months and the occurrence reflects the severity of the underlying disease rather than being an independent risk factor.\textsuperscript{157, 158} Contralateral pneumothoraces occur in up to 40% of patients.\textsuperscript{159, 160} A small pneumothorax without symptoms can be observed or aspirated. Larger pneumothoraces require treatment with intercostal tube drainage. The leak is usually from the upper lobes and it is important to site the tube in the correct place. The collapsed lung can be stiff and take a long time to re-expand. It is important to commence intravenous antibiotics at the same time to prevent sputum retention, which can delay re-expansion of the collapsed lung. Pleurectomy, pleural abrasion, and talc pleurodesis all have markedly lower reported recurrence rates than observation or tube thoracostomy alone, which has an unacceptably high recurrence rate of 50%.\textsuperscript{161-163} Partial pleurectomy has a success rate of 95% with little reduction in pulmonary function associated with surgery, and it is generally felt to be the treatment of choice in CF patients with recurrent pneumothoraces who are fit to undergo surgery.\textsuperscript{164} In those patients who are too ill to undergo surgery, it can take 2–3 weeks for the lung to re-expand with intubation and suction. In this group, talc instillation or repeated instillation of the patient’s own blood are effective alternatives.\textsuperscript{165} Although not an absolute contraindication to transplantation, sclerosants can make transplantation more difficult. It takes longer to remove the lungs, prolonging the ischaemic time for the donor lungs, and is associated with excessive bleeding.\textsuperscript{166}

7 TENSION PNEUMOTHORAX

- If tension pneumothorax is present, a cannula of adequate length should be promptly inserted into the second intercostal space in the mid clavicular line and left in place until a functioning intercostal tube can be positioned. [B]

Tension pneumothorax occurs when the intrapleural pressure exceeds the atmospheric pressure throughout inspiration as well as expiration. It is thought to result from the operation of a one way valve system, drawing air into the pleural space during inspiration and not allowing it out during expiration. The development of tension pneumothorax is often, but not always, heralded by a sudden deterioration in the cardiopulmonary status of the patient related to impaired venous return, reduced cardiac output, and hypoxaemia.\textsuperscript{167, 168} The development of tension in a pneumothorax is not dependent on the size of the pneumothorax and the clinical scenario of tension pneumothorax may correlate poorly with chest radiographic findings. The clinical status is striking. The patient rapidly becomes distressed with rapid laboured respiration, cyanosis, sweating, and tachycardia. It should be particularly suspected in those on mechanical ventilators or nasal non-invasive ventilation who suddenly deteriorate or develop EMD arrest, and is frequently missed in the ICU setting.\textsuperscript{169} If a tension pneumothorax occurs, the patient should be given high concentration oxygen and a cannula should be introduced into the pleural space, usually in the second anterior intercostal space mid clavicular line. Air should be removed until the patient is no longer compromised and then an intercostal tube should be inserted into the pleural space as previously described. Advanced Trauma Life Support guidelines recommend the use of a cannula 3–6 cm long to perform needle thoracocentesis for life threatening tension pneumothorax.\textsuperscript{170} However, in 57% of patients with tension pneumothorax the thickness of the chest wall has been found to be greater than 3 cm. It is therefore recommended that a cannula length of at least 4.5 cm should be used in needle thoracocentesis of tension pneumothoraces.\textsuperscript{171, 172} The cannula should be left in place until bubbling is confirmed in the underwater seal system to confirm proper function of the intercostal tube.\textsuperscript{173}

8 IATROGENIC PNEUMOTHORAX

The incidence of iatrogenic pneumothorax is high, out numbering spontaneous pneumothoraces in several large review series.\textsuperscript{174, 175} Transtracheal needle aspiration (24%), subclavian vessel puncture (22%), thoracocentesis (22%), pleural biopsy (8%), and mechanical ventilation (7%) are the five leading causes.\textsuperscript{176} The two primary risk factors related to the development of pneumothorax with transtracheal needle aspiration are the depth of the lesion and the presence of COPD.\textsuperscript{177} To date, no method has been found to prevent pneumothorax following needle aspiration/thoracocentesis. While it was hoped that positioning the patient so that the area to be biopsied was dependent might reduce the incidence of such events, this has not been shown to be the case.\textsuperscript{178} The treatment of iatrogenic pneumothorax tends to be simple as there is less likelihood of recurrence. The majority will resolve with observation alone. If required, treatment should be by simple aspiration. Delius and coworkers\textsuperscript{179} aspirated up to 89% without resorting to tube drainage using a small 8 F f I enon catheter. Patients with COPD who develop an iatrogenic pneumothorax are more likely to require tube drainage,\textsuperscript{180} and patients who develop a pneumothorax while on positive pressure ventilation should be treated with a chest drain unless immediate weaning from positive pressure ventilation is possible, as positive pressure ventilation maintains the air leak.\textsuperscript{181}

9 CONCLUDING REMARKS

The 1993 BTS pneumothorax guidelines emphasised the place of simple observation and aspiration, reminded junior doctors of the potential hazards of chest drain insertion, and encouraged shorter, safer and less painful treatment paths for many patients. Despite their usefulness, recent evidence suggests that adherence to these guidelines may be suboptimal. This revision-endorses the main thrust of these guidelines, with observation for the least severe cases, simple aspiration as the initial treatment choice, and chest drain insertion as a last resort. Recently, the American College of Chest Physicians (ACCP) has published its own guidelines which were arrived at by the Delphi consensus method.\textsuperscript{182} These guidelines are similar to our proposed guidelines in many respects, although there are differences such as the emphasis placed on the value of simple aspiration in the treatment of primary pneumothorax. Both sets of guidelines will undoubtedly stimulate debate. The evidence for the current BTS recommendations is incorporated and its weaknesses described. This revision alters the threshold for aspiration in primary pneumothorax and suggests a place for re-aspiration. The limitations of aspiration in secondary pneumothorax are acknowledged, and initial chest drain insertion is recommended for categories of patients where aspiration is unlikely to succeed. These issues are already being revisited as the new “pneumothorax kits” are already being revisited as the new “pneumothorax kits”
they will prove to be as successful and possibly replace simple aspiration followed by immediate removal of the catheter as recommended in these guidelines.

Several aspects of management that were not previously covered are now included. These include the place of CT scanning in diagnosis, which patients to refer for surgery, a discussion of surgical techniques, and issues such as intercostal tube size and the place of suction and pleurodesis. Complex scenarios including tension pneumothorax, subcutaneous emphysema, pneumothorax in HIV disease and adult CF are also discussed. It is hoped that these changes build on the clinical benefits produced by the first set of guidelines which—if adhered to—should, we calculate, prevent approximately 7000 unnecessary chest drain insertions every year in the UK.

References

10 Jansveld C, Dijkman JH. Primary spontaneous pneumothorax and smoking. BMJ 1975;4:559–60. [II]
15 West JB. Distribution of mechanical stress in the lung, a possible factor in localisation of pulmonary disease. (lancet 1971;i:839–43. [II]

www.thoraxjnl.com


Henry, Arnold, Harvey


Tocino IM, Miller MH, Fairfax WR. Distribution of pneumothorax in the supine and semi-recumbent critically ill adult. AJR 1985; 144:901–4. [III]


BTS guidelines for the insertion of a chest drain

D Laws, E Neville, J Duffy, on behalf of the British Thoracic Society Pleural Disease Group, a subgroup of the British Thoracic Society Standards of Care Committee

1 BACKGROUND
In current hospital practice chest drains are used in many different clinical settings and doctors in most specialities need to be capable of their safe insertion. The emergency insertion of a large bore chest drain for tension pneumothorax following trauma has been well described by the Advanced Trauma and Life Support (ATLS) recommendations in their instructor’s manual and there have been many general descriptions of the step by step method of chest tube insertion.

It has been shown that physicians trained in the method can safely perform tube thoracostomy with 3% early complications and 8% late. In these guidelines we discuss the safe insertion of chest tubes in the controlled circumstances usually encountered by physicians. A summary of the process of chest drain insertion is shown in fig 1.

2 TRAINING
• All personnel involved with insertion of chest drains should be adequately trained and supervised. [C]

Before insertion of a chest drain, all operators should have been adequately trained and have completed this training appropriately. In all other circumstances, insertion should be supervised by an appropriate trainer. This is part of the SHO core curriculum training process issued by the Royal College of Physicians and trainees should be expected to describe the indications and complications. Trainees should ensure each procedure is documented in their log book and signed by the trainer. With adequate instruction, the risk of complications and patient pain and anxiety can be reduced.

These guidelines will aid the training of junior doctors in the procedure and should be readily available for consultation by all doctors likely to be required to carry out a chest tube insertion.

3 INDICATIONS
Chest tubes may be useful in many settings, some of which are listed in box 1.

4 PRE-DRAINAGE RISK ASSESSMENT
• Risk of haemorrhage: where possible, any coagulopathy or platelet defect should be corrected prior to chest drain insertion but routine measurement of the platelet count and prothrombin time are only recommended in patients with known risk factors. [C]

• The differential diagnosis between a pneumothorax and bullous disease requires careful radiological assessment. Similarly it is important to differentiate between the presence of collapse and a pleural effusion when the chest radiograph shows a unilateral “whiteout”.

• Lung densely adherent to the chest wall throughout the hemithorax is an absolute contraindication to chest drain insertion. [C]

• The drainage of a post pneumonectomy space should only be carried out by or after consultation with a cardiothoracic surgeon. [C]

There is no published evidence that abnormal blood clotting or platelet counts affect bleeding complications of chest drain insertion. However, where possible it is obvious good practice to correct any coagulopathy or platelet defect prior to drain insertion. Routine pre-procedure checks of platelet count and/or prothrombin time are only required in those patients with known risk factors. For elective chest drain insertion, warfarin should be stopped and time allowed for its effects to resolve.

5 EQUIPMENT
All the equipment required to insert a chest tube should be available before commencing the procedure and are listed below and illustrated in fig 2.

• Sterile gloves and gown
• Skin antiseptic solution, e.g. iodine or chlorhexidine in alcohol
• Sterile drapes
• Gauze swabs
• A selection of syringes and needles (21–25 gauge)
• Local anaesthetic, e.g. lignocaine (lidocaine) 1% or 2%
• Scalpel and blade
• Suture (e.g. “1” silk)
• Instrument for blunt dissection (e.g. curved clamp)
Guidewire with dilators (if small tube being used)  
Chest tube  
Connecting tubing  
Closed drainage system (including sterile water if underwater seal being used)  
Dressing  
Equipment may also be available in kit form.

6. CONSENT AND PREMEDICATION  

- Prior to commencing chest tube insertion the procedure should be explained fully to the patient and consent recorded in accordance with national guidelines. [C]
- Unless there are contraindications to its use, premedication (benzodiazepine or opioid) should be given to reduce patient distress. [B]

Consent should be taken and recorded in keeping with national guidelines. The General Medical Council (GMC) guidelines for consent state that it is the responsibility of the doctor carrying out a procedure, or an appropriately trained individual with sufficient knowledge of a procedure, to explain its nature and the risks associated with it. It is within the rights of a competent individual patient to refuse such treatment. In the case of an emergency, when the patient is unconscious and the treatment is lifesaving, treatment may be carried out but must be explained as soon as the patient is sufficiently recovered to understand. If possible, an information leaflet should be given before the procedure.

Chest drain insertion has been reported to be a painful procedure with 50% of patients experiencing pain levels of 9–10 on a scale of 10 in one study,\(^1\) and therefore premedication should be given. Despite the apparent common sense of this approach, there is little established evidence of the effect from these medications. Premedication could be an intravenous anxiolytic—for example, midazolam 1–5 mg titrated to achieve adequate sedation—given immediately before the procedure or an intramuscular opioid given 1 hour before, although neither drug has been shown to be clearly superior. Both these classes of drugs may cause respiratory depression and patients with underlying lung disease such as COPD should be observed as reversal agents—for example, naloxone or flumazenil—are occasionally necessary.

While the use of atropine as part of premedication for fiberoptic bronchoscopy has been assessed, no controlled trial of its use in chest tube insertion has been identified, although it is advocated in some centres. Case reports of vasovagal reactions\(^1\) and a death due to vagal stimulation following tube insertion\(^1\) may support its use as premedication.
7 PATIENT POSITION
The preferred position for drain insertion is on the bed, slightly rotated, with the arm on the side of the lesion behind the patient’s head to expose the axillary area. An alternative is for the patient to sit upright leaning over an adjacent table with a pillow or in the lateral decubitus position. Insertion should be in the “safe triangle” illustrated in fig 3. This is the triangle bordered by the anterior border of the latissimus dorsi, the lateral border of the pectoralis major muscle, a line superior to the horizontal level of the nipple, and an apex below the axilla.

8 CONFIRMING SITE OF DRAIN INSERTION
• A chest tube should not be inserted without further image guidance if free air or fluid cannot be aspirated with a needle at the time of anaesthesia. [C]
• Imaging should be used to select the appropriate site for chest tube placement. [B]
• A chest radiograph must be available at the time of drain insertion except in the case of tension pneumothorax. [C]

Immediately before the procedure the identity of the patient should be checked and the site and side for insertion of the chest tube confirmed by reviewing the clinical signs and the chest radiograph. Fluoroscopy, ultrasonography, and CT scanning can all be used as adjunctive guides to the site of tube placement. Before insertion, air or fluid should be aspirated; if none is forthcoming, more complex imaging than a chest radiograph is required.

The use of ultrasonography guided insertion is particularly useful for empyema and effusions as the diaphragm can be localised and the presence of loculations and pleural thickening defined. Using real time scanning at the time of the procedure can help to ensure that the placement is safe despite the movement of the diaphragm during respiration. The complication rate following image guided thoracocentesis is low with pneumothoraces occurring in approximately 3% of cases. Success rates of image guided chest tube insertion are reported to be 71–86%. If an imaging technique is used to indicate the site for drain insertion but the procedure is not carried out at the time of imaging, the position of the patient at the time must be clearly documented to aid accurate insertion when the patient returns to the ward. It is recommended that ultrasound is used if the effusion is very small or initial blind aspiration fails.

9 DRAIN INSERTION SITE
The most common position for chest tube insertion is in the mid axillary line, through the “safe triangle” illustrated in fig 3 and described above. This position minimises risk to underlying structures such as the internal mammary artery and avoids damage to muscle and breast tissue resulting in unsightly scarring. A more posterior position may be chosen if suggested by the presence of a locule. While this is safe, it is not the preferred site as it is more uncomfortable for the patient to lie on after insertion and there is a risk of the drain kinking.

For apical pneumothoraces the second intercostal space in the mid clavicular line is sometimes chosen but is not recommended routinely as it may be uncomfortable for the patient and may leave an unsightly scar. Loculated apical pneumothoraces are not uncommonly seen following thoracotomy and may be drained using a posteriorly sited (suprascapular) apical tube. This technique should be performed by an operator experienced in this technique—for example, a thoracic surgeon. If the drain is to be inserted into a loculated pleural collection, the position of insertion will be dictated by the site of the locule as determined by imaging.

10 DRAIN SIZE
• Small bore drains are recommended as they are more comfortable than larger bore tubes [B] but there is no evidence that either is therapeutically superior.
• Large bore drains are recommended for drainage of acute haemothorax to monitor further blood loss. [C]

The use of large bore drains has previously been recommended as it was felt that there was an increase in the frequency of drain blockage, particularly by thick malignant or infected fluid. The majority of physicians now use smaller catheters (10–14 French (F)) and studies have shown that these are often as effective as larger bore tubes and are more comfortable and better tolerated by the patient. There remains intense debate about the optimum size of drainage catheter and no large randomised trials directly comparing small and large bore tubes have been performed.

In pneumothoraces 9 F catheters have been used with success rates of up to 87%, although in a few patients the air leak seems to exceed the capacity of this small catheter. In the event of failure to drain a pneumothorax due to excessive air leakage, it is recommended that a larger bore tube be inserted. There is no evidence to suggest that surgical emphysema rates vary between the size of drains. Ultrasonographically guided insertion of pigtail catheters for treatment of malignant pleural effusions has been particularly well studied with good effect. The use of small bore pigtail catheters has allowed outpatient treatment of malignant pleural effusions which have not responded to chemotherapy. Empyemas are often successfully drained with ultrasonically placed small bore tubes with the aid of thrombolytic agents.

In the case of acute haemothorax, however, large bore tubes (28–30 F minimum) continue to be recommended for their dual role of drainage of the thoracic cavity and assessment of continuing blood loss.

11 ASEPTIC TECHNIQUE
• Aseptic technique should be employed during catheter insertion. [C]
• Prophylactic antibiotics should be given in trauma cases. [A]

As a chest drain may potentially be in place for a number of days, aseptic technique is essential to avoid wound site infection or secondary empyema. Although this is uncommon, estimations of the empyema rate following drain insertions for trauma are approximately 2.4%. While the full sterile technique afforded by a surgical theatre is usually unnecessary, sterile gloves, gown, equipment and the use of sterile towels after effective skin cleansing using iodine or chlorhexidine are recommended. A large area of skin cleansing should
be undertaken. In a study of chest tubes inserted in trauma suites using full aseptic technique, there were no infective complications in 80 cases. Studies of the use of antibiotic prophylaxis for chest tube insertion have been performed but have failed to reach significance because of small numbers of infectious complications. However, a meta-analysis of these studies has been performed which suggested that, in the presence of chest trauma (penetrating or blunt), the use of prophylactic antibiotics reduces the absolute risk of empyema by 5.5–7.1% and of all infectious complications by 12.1–13.4%. The use of prophylactic antibiotics in trauma cases is therefore recommended. The antibiotics used in these studies were cephalosporins or clindamycin.

The use of prophylactic antibiotics is less clear in the event of spontaneous pneumothorax or pleural effusion drainage as no studies were found which addressed these circumstances. In one study only one infectious complication (in the chest tube track) occurred in a series of 39 spontaneous pneumothoraces treated with chest tubes.

12 ANAESTHESIA

- Local anaesthetic should be infiltrated prior to insertion of the drain. [C]

Local anaesthetic is infiltrated into the site of insertion of the drain. A small gauge needle is used to raise a dermal bleb before deeper infiltration of the intercostal muscles and pleural surface. A spinal needle may be required in the presence of a thick chest wall.

Local anaesthetic such as lignocaine (up to 3 mg/kg) is usually infiltrated. Higher doses may result in toxic levels. The peak concentration of lignocaine was found to be <3 µg/ml (that is, a low risk of neurotoxic effects) in 85% of patients given 3 mg/kg intrapleurally. The volume given is considered to be more important than the dose to aid spread of the effective anaesthetic area. The use of adrenaline to aid haemostasis and localise the anaesthesia is used in some centres but is not evidence based.

13 INSERTION OF CHEST TUBE

- Chest drain insertion should be performed without substantial force. [C]

Insertion of a chest tube should never be performed with any substantial force since this risks sudden chest penetration and damage to essential intrathoracic structures. This can be avoided either by the use of a Seldinger technique or by blunt dissection through the chest wall and into the pleural space before catheter insertion. Which of these approaches is appropriate depends on the catheter size and is discussed below.

13.1 Small bore tube (8–14 F)

- Insertion of a small bore drain under image guidance with a guidewire does not require blunt dissection.

Small bore chest tubes are usually inserted with the aid of a guidewire by a Seldinger technique. Blunt dissection is unnecessary as dilators are used in the insertion process. After infiltration with local anaesthesia, a needle and syringe are used to localise the position for insertion by the identification of air or pleural fluid. A guidewire is then passed down the hub of the needle, the needle is removed, and the tract enlarged using a dilator. A small bore tube can then be passed into the thoracic cavity along the wire. These have been successfully used for pneumothorax, effusions, or loculated empyemas.

13.2 Medium bore tube (16–24 F)

Medium sized chest drains may be inserted by a Seldinger technique or by blunt dissection as outlined below. As the incision size should afford a snug fit around the chest tube, it is not possible to insert a finger to explore the pleura when inserting this size of tube. Exploration with a finger is felt to be unnecessary for the elective medical insertion of these medium sized chest tubes.

13.3 Large bore tube (>24 F)

- Blunt dissection into the pleural space must be performed before insertion of a large bore chest drain. [C]

13.3.1 Incision

- The incision for insertion of the chest drain should be similar to the diameter of the tube being inserted. [C]

Once the anaesthetic has taken effect an incision is made. This should be slightly bigger than the operator’s finger and tube. The incision should be made just above and parallel to a rib.

13.3.2 Blunt dissection

Many cases of damage to essential intrathoracic structures have been described following the use of trocars to insert large bore chest tubes. Blunt dissection of the subcutaneous tissue and muscle into the pleural cavity has therefore become universal and is essential. In one retrospective study only four technical complications were seen in 447 cases using blunt dissection. Using a Spencer-Wells clamp or similar, a path is made through the chest wall by opening the clamp to separate the muscle fibres. For a large chest drain, similar in size to the finger, this track should be explored with a finger through into the thoracic cavity to ensure there are no underlying organs that might be damaged at tube insertion. The creation of a patent track into the pleural cavity ensures that excessive force is not needed during drain insertion.

13.3.3 Position of tube tip

- The position of the tip of the chest tube should ideally be aimed apically for a pneumothorax or basally for fluid. However, any tube position can be effective at draining air or fluid and an effectively functioning drain should not be repositioned solely because of its radiographic position. [C]

In the case of a large bore tube, after gentle insertion through the chest wall the trocar positioned a few centimetres from the tube tip can afford support of the tube and so help its positioning without incurring organ damage. A smaller clamp can also be used to direct the tube to its desired position. If possible, the tip of the tube should be aimed apically to drain air and basally for fluid. However, successful drainage can still be achieved when the drain is not placed in an ideal position, so effectively functioning tubes should not be repositioned simply because of a suboptimal radiographic appearance.

13.3.4 Securing the drain

- Large and medium bore chest drain incisions should be closed by a suture appropriate for a linear incision. [C]

- “Purse string” sutures must not be used. [C]

Two sutures are usually inserted—the first to assist later closure of the wound after drain removal and the second, a stay suture, to secure the drain.

The wound closure suture should be inserted before blunt dissection. A strong suture such as “1” silk is appropriate. A “mattress” suture or sutures across the incision are usually employed and, whatever closure is used, the stitch must be of a type that is appropriate for a linear incision (fig 4). Complicated “purse string” sutures must not be used as they convert
The drain should be secured after insertion to prevent it falling out. Various techniques have been described, but a simple technique of anchoring the tube has not been the subject of a controlled trial. The chosen suture should be stout and non absorbable to prevent breaking (e.g. “1” silk), and it should include adequate skin and subcutaneous tissue to ensure it is secure (fig 4).

Large amounts of tape and padding to dress the site are unnecessary and concerns have been expressed that they may restrict chest wall movement or increase moisture collection. A transparent dressing allows the wound site to be inspected by nursing staff for leakage or infection. An omental tag of tape has been described which allows the tube to lie a little away from the chest wall to prevent tube kinking and tension at the insertion site (fig 5).

14 MANAGEMENT OF DRAINAGE SYSTEM

14.1 Clamping drain

- A bubbling chest tube should never be clamped. [C]
- Drainage of a large pleural effusion should be controlled to prevent the potential complication of re-expansion pulmonary oedema. [C]
- In cases of pneumothorax, clamping of the chest tube should usually be avoided. [B]
- If a chest tube for pneumothorax is clamped, this should be under the supervision of a respiratory physician or thoracic surgeon, the patient should be managed in a specialist ward with experienced nursing staff, and the patient should not leave the ward environment. [C]
- If a patient with a clamped drain becomes breathless or develops subcutaneous emphysema, the drain must be immediately unclamped and medical advice sought. [C]

There is no evidence to suggest that clamping a chest drain prior to its removal increases success or prevents recurrence of a pneumothorax and it may be hazardous. This is therefore generally discouraged. Clamping a chest drain in the presence of a continuing air leak may lead to the potentially fatal complication of tension pneumothorax. A bubbling drain therefore should never be clamped. However, many experienced specialist physicians support the use of the clamping of non-bubbling chest drains inserted for pneumothorax to detect small air leaks not immediately obvious at the bedside. By clamping the chest drain for several hours, followed by a chest radiograph, a minor air leak may be detected, avoiding the need for later chest drain reinsertion. In the ACCP Delphi consensus statement about half the consensus group supported clamping and half did not, and this seems similar to the UK spread of opinion. Drain clamping is therefore not generally recommended for safety reasons, but is acceptable under the supervision of nursing staff who are trained in the management of chest drains and who have instructions to unclamp the chest drain in the event of any clinical deterioration. Patients with a clamped chest drain inserted for pneumothorax should not leave the specialist ward area.

There have been reports of re-expansion pulmonary oedema following rapid evacuation of large pleural effusions as well as in association with spontaneous pneumothorax. This has been reported to be fatal in some cases (up to 20% of subjects in one series of 53 cases). In the case of spontaneous pneumothorax this is a rare complication with no cases of re-expansion pulmonary oedema reported in two large studies of 400 and 375 patients, respectively. It is usually associated with delayed diagnosis and therefore awareness of its potential occurrence is sufficient.

Milder symptoms suggestive of re-expansion oedema are common after large volume thoracentesis in pleural effusion, with patients experiencing discomfort and cough. It has been suggested that the tube be clamped for 1 hour after draining 1 litre. While there is no evidence for actual amounts, good practice suggests that no more than about 1.5 litres should be drained at one time, or drainage should be slowed to about 500 ml per hour.

14.2 Closed system drainage

- All chest tubes should be connected to a single flow drainage system e.g. under water seal bottle or flutter valve. [C]
- Use of a flutter valve system allows earlier mobilisation and the potential for earlier discharge of patients with chest drains.

The chest tube is then attached to a drainage system which only allows one direction of flow. This is usually the closed underwater seal bottle in which a tube is placed under water at a depth of approximately 3 cm with a side vent which allows escape of air, or it may be connected to a suction pump. This enables the operator to see air bubble out as the lung re-expands in the case of pneumothorax or fluid evacuation rate in empyemas, pleural effusions, or haemothorax. The continuation of bubbling suggests a continued visceral pleural air leak, although it may also occur in patients on suction when the drain is partly out of the thorax and one of the tube holes is open to the air. The respiratory swing in the fluid in the chest tube is useful for assessing tube patency and confirms the position of the tube in the pleural cavity. The disadvantages of the underwater seal system include obligatory inpatient management, difficulty of patient mobilisation, and the risk of knocking over the bottle.
The use of integral Heimlich flutter valves has been advocated in patients with pneumothoraces, especially as they permit ambulatory or even outpatient management which has been associated with a 85–95% success rate. In 176 cases of pneumothorax treated with small chest tubes and a Heimlich flutter valve there were only eight failures (hospital admissions for problems with tube function or placement). The mean length of inpatient stay has been quoted at 5 hours with a thoracic vent and 144 hours with an underwater seal, with a cost saving US$5660. Case reports of incorrect use (wrong direction of flow) of such valves have been described, however, with tension pneumothorax as a result. Flutter valves cannot be used with fluid drainage as they tend to become blocked. However, in the UK a similar short hospital stay is achieved by initial aspiration of pneumothoraces (see guidelines on pneumothorax, page ii39).

The use of a drainage bag with an incorporated flutter valve and vented outlet has been successfully used postoperatively. A randomised trial of 119 cases following elective thoracotomy compared the use of an underwater seal with the flutter bag and found no difference in drainage volumes, requirement for suction, or complications with the added advantage of earlier mobilisation with drainage bags. In cases of malignant pleural effusion drainage a closed system using a drainage bag or aspiration via a three way tap has been described to aid palliation and outpatient management. One report of a modified urinary collecting bag for prolonged underwater chest drainage has been described for use with empyemas, bronchopulmonary fistula, and pneumothorax associated with emphysema with no complications in the 12 patients studied.

14.3 Suction
• When chest drain suction is required, a high volume/low pressure system should be used. [C]
• When suction is required, the patient must be managed by appropriately trained staff. [C]

The use of high volume/low pressure suction pumps has been advocated in cases of non-resolving pneumothorax or following chemical pleurodesis, but there is no evidence to support its routine use in the initial treatment of spontaneous pneumothorax. If suction is required, this may be performed via the underwater seal at a level of 10–20 cm H₂O. A high volume pump (e.g. Vernon-Thompson) is required to cope with a large leak. A low volume pump (e.g. Roberts pump) is inappropriate as it is unable to cope with the rapid flow, thereby effecting a situation similar to clamping and risking formation of a tension pneumothorax. A wall suction adaptor may also be effective, although chest drains must not be connected directly to the high negative pressure available from wall suction.

In the management of pleural infection, the use of suction is less clear. Most studies are observational and have used suction applied via the chest tube after flushing to prevent blockage and have reported success, but this has not been compared with cases without suction. This is discussed further in the guideline on pleural infection (page ii18). There is no evidence that briefly disconnecting a drain from suction used for spontaneous pneumothorax or pleural effusion is disadvantageous. Therefore, as long as adequate instruction is given to patient, portering and nursing staff with regard to keeping the underwater seal bottle below the level of the chest, it is acceptable to stop suction for short periods such as for radiography.

14.4 Ward instructions
• Patients with chest tubes should be managed on specialist wards by staff who are trained in chest drain management. [C]

Audit points
• The presence and use of an appropriate nursing chest drain observation chart should be noted.
• The frequency of chest drain complications should be recorded.
• The use of premedication and analgesics and patient pain scores relating to chest drain insertion should be recorded.
• The duration of chest tube drainage should be recorded.

14.5 Removal of the chest tube
• In cases of pneumothorax, the chest tube should not be clamped at the time of its removal. [B]

In cases of pneumothorax, there is no evidence that clamping a chest drain at the time of its removal is beneficial. The chest tube should be removed either while the patient performs Valsalva’s manoeuvre or during expiration with a brisk firm movement while an assistant ties the previously placed closure suture. The timing of removal is dependent on the original reason for insertion and clinical progress (see guidelines for management of pneumothorax (page ii39), malignant pleural effusions (page ii29), and pleural infections (page ii18)).

In the case of pneumothorax, the drain should not usually be removed until bubbling has ceased and chest radiography demonstrates lung reflation. Clamping of the drain before removal is generally unnecessary. In one study the removal of chest tubes after continuous suction was compared with the removal after a period of disconnection from suction to an underwater seal. No significant difference was seen between these two methods with only two of 80 cases (2.5%) requiring reinseration of a chest tube.

15 PATIENTS REQUIRING ASSISTED VENTILATION
During the insertion of a chest tube in a patient on a high pressure ventilator (especially with positive end expiratory pressure (PEEP)), it is essential to disconnect from the ventilator at the time of insertion to avoid the potentially serious
complication of lung penetration, although as long as blunt dissection is carried out and no sharp instruments are used, this risk is reduced.

ACKNOWLEDGEMENTS

The authors are grateful to Dr Richard Holmes for figs 3, 4, and 5.

Authors’ affiliations

The authors are grateful to Dr Richard Holmes for figs 3, 4, and 5.

REFERENCES

2 Miller KS, Sahn S, Helfner JE. Interstitial empyema: technique, management, and complications. Chest 1987; 91:258–64. [IV]
5 Westaby S, Brayley N. Thoracic trauma – I. BMJ 1990; 300:1639–44. [IV]
17 Hare WD, Hedges JR, Jones A. Clamping may be appropriate to prevent discomfort of the pleura with small-caliber chest tubes. Chest 1997; 111:1437–40. [IV]
31 Haggie JA. Management of pneumothorax: chest drain trocar is unsafe and unnecessary. BMJ 1993; 307:443. [IV]
34 Trapnell DH, Thurston JGB. Unilateral pulmonary oedema after pleural aspiration. Lancet 1970;i:1367–9. [IV]
40 Hall M, Jones A. Clamping may be appropriate to prevent discomfort and reduce risk of oedema of the pleural space. BMJ 1991; 305:153. [IV]
43 Mainini SE, Johnson FE. Tension pneumohorax complicating small-caliber chest tube insertion. Chest 1990; 97:759–60. [IV]
44 Matthews HR, Mcgugan JA. Closed chest drainage without an underwater seal. Thorax 1988; 41:804–IV.
48 So SY, Yu DY. Catheter drainage of spontaneous pneumothorax: suction or no suction, early or late removal? Thorax 1982; 37:46–8. [IV]
49 Williams T. To clamp or not to clamp. Nursing Times 1992;88:33. [IV]
52 Main A. As few sharp objects as possible should be used on entering pleural space (letter). BMJ 1998;316:68. [IV]

www.thoraxjnl.com