

CHAPTER 46

PLEURAL EFFUSION AND EMPYEMA

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Introduction

In Africa, as elsewhere, the surgeon is often requested to insert a chest tube for the drainage of pleural fluid. The most common reason for such a request is a postpneumonic infected effusion, or empyema. A chest tube, however, is often an adequate solution to this problem; in some cases, more complicated therapy is required. It is therefore important that the paediatric surgeon appreciates all aspects of pleural space infections (PSIs) in children.

A pleural effusion (PE) is any collection of fluid in the pleural space. Parapneumonic exudative effusions occur in up to 50% of pneumonias. Empyema thoracis (ET) is the accumulation of pus in the pleural space. ET remains a very significant cause of childhood mortality and morbidity in the developing world. Poverty, ignorance, inappropriate antibiotic use, malnutrition, delay in seeking treatment, and lack of supportive care are major impediments to adequate treatment.¹⁻³

Empyema is an infected pleural effusion and is usually the result of uncontrolled pulmonary infection or pneumonia. Indiscriminate use of antibiotics and the emergence of antibiotic-resistant organisms have resulted in an increase in the frequency of empyema complicating pneumonia. ET has the reputation of being the worst treated of the common disorders of the chest. Empyema is often recognised after the patient has already received antibiotics, and culture and gram stain may be negative in up to 30% of patients. Reports of anaerobic bacteria isolated from pleural fluid have ranged from 38% to 76%.^{4,5} Current treatment of empyema in children is highly variable, due in part to both provider experiences and the variable clinical presentations.

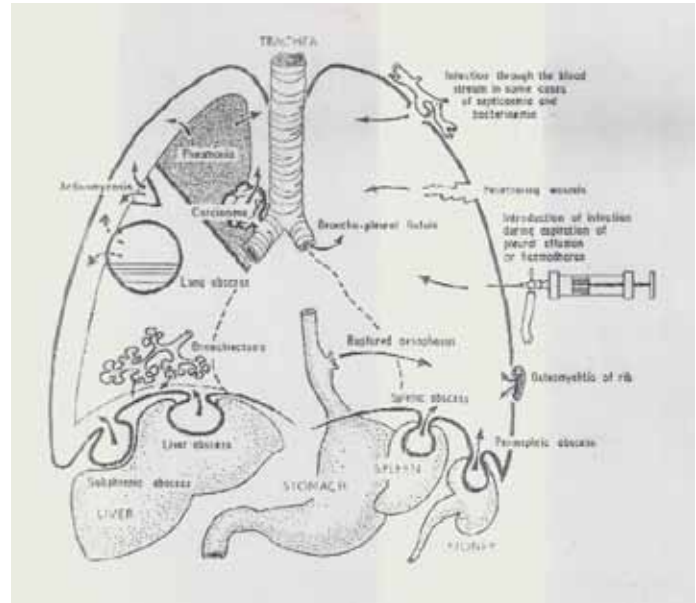
The management of ET in children has evoked considerable controversy.^{6,7} The literature provides many options but assists little in establishing the ideal treatment.⁶⁻¹⁵ Generally, recommendations have been based on institutional traditions, personal experience, and limited case reviews. Decisions about individual cases are further influenced by varying criteria, such as patient age, clinical status, antibiotic response, stage and duration of the empyema, and the organism cultured.¹⁶

Demographics

The incidence of empyema thoracis is unknown, although about 50–70% of children admitted with ET have pneumonia.¹⁷ ET affects both sexes equally.

Aetiology/Pathophysiology

A pleural effusion is either an exudate or a transudate, which are distinguished on the basis of protein content. An exudate is characterised by a protein content of >3 g/l. A lactate dehydrogenase (LDH) level of >200 is also diagnostic. Plasma/serum ratios of protein (>0.5) or LDH (>0.6) are more accurate but seldom available. A transudate is usually caused by medical conditions such as congestive heart failure, nephrotic syndrome, and liver cirrhosis; the pleural tap is generally clear and straw-coloured. Exudates are found in postinfective effusions, malignancy, tuberculosis (TB), and other conditions. ET is never a primary condition. A parapneumonic effusion is the most common cause of empyema in childhood.



Source: Adeloje A, ed. Companion to Surgery in Africa, 2nd ed. Churchill Livingstone, 1987.

Figure 46.1: Empyema. Sources of infection.

The causes of ET in children include (see Figure 46.1):

1. Pneumonia (usually caused by *Staphylococcus aureus*, *S. pneumoniae*, group A streptococci or *Haemophilus influenzae*). There may be anaerobic infections, infections secondary to aspiration, or infections with *Mycoplasma pneumoniae* and viruses.
2. Mycobacterial infections (especially in immunosuppressed patients) and fungal infections.
3. Ruptured lung abscess (usually caused by *S. aureus*).
4. Trauma (e.g., penetrating trauma to the lungs, fracture of ribs, or perforated oesophagus).
5. Amoebiasis (from amoebic abscess).
6. Contiguous infections of the oesophagus, mediastinum, or subdiaphragmatic region.
7. Spread of infections of the retropharyngeal, retroperitoneal, paravertebral, or subphrenic spaces.
8. Malignancy, including Kaposi sarcoma in children with human immunodeficiency virus (HIV) infection.

Host factors that contribute to alterations in pleural permeability, such as noninfectious inflammatory diseases, infection, trauma, or malignancy, may allow accumulation of a thin serous fluid (pleural effusion or parapneumonic effusion) in the pleural space, which may become secondarily infected. As the body attempts to fight off infection, the cavity starts filling up with pleural fluid, pus, and dead pleura cells.



Figure 46.2: Empyema with extension forming subcutaneous abscess and empyema necessitans.

The development of parapneumonic pleural effusions is gradual, and progression to empyema occurs in three phases:

1. *Exudative stage*, or acute phase: This stage is characterised by increased permeability and a small serous fluid collection. At this stage, the pleural cavity fills with an abnormal amount of pleural fluid containing some pus from the infectious condition, contains mostly neutrophils, and is often sterile.
2. *Fibrinopurulent stage*: This second phase is marked by a thickening of the fluid, the accumulation of fibrin—a fibrous, protein-based coagulant—in the cavity, and the formation of fibrin membrane deposition, which forms partitions or loculations within the pleural space.
3. *Organising stage*, or chronic phase: If left untreated, the chronic phase begins, during which a pleural peel is created by the resorption of fluid, forming a thick fibrous material that can entrap the lung parenchyma.

Left untreated, the ET burrows through the parietal pleura, usually into the chest wall, to form a subcutaneous abscess that eventually may rupture through the skin and discharge spontaneously, forming an empyema necessitans¹⁸ (Figure 46.2).

Clinical Features

For both pleural effusion and empyema, the most common preceding factor is pneumonia. The usual presenting symptoms are a general discomfort or uneasiness, with fever, cough, and dyspnoea with nasal flaring.

Depending on the underlying condition, there may also be haemoptysis, chest pain, night sweats, dehydration, and/or weight loss. The inflammation of the pleural space may cause abdominal pain and vomiting. Symptoms may be blunted, and fever may not be present in patients who are immunocompromised.

In more progressive cases, the patient might develop very foul breath or cough up bloody or offensive-looking sputum with a strong fetid odour. There may be a history of TB contact or treatment for other manifestations of Kaposi sarcoma.

Clinically, there is not much to differentiate a pleural effusion and empyema. The usual findings are dullness to percussion, decreased breath sounds, decreased vocal fremitus, and tracheal shift. These signs may vary, however, depending on the causative organism and the duration of the illness.

Auscultation may reveal crackles, decreased breath sounds, and possibly a pleural rub if the process is recognised before a large amount of fluid accumulates. Dullness to percussion and decreased breath sounds are likely findings, but they are difficult to elicit in the younger child, who, because of discomfort, may be less cooperative with the examination.

Failure to improve after pneumonia, the classical physical signs, and radiological evidence of pleural fluid are diagnostic.

Investigations

Imaging

- Plain chest radiography (upright views) should show obliteration of the diaphragmatic margins (costophrenic angles) with pleural fluid collections (Figure 46.3). Because up to 400 ml may be required before these costophrenic angles are obscured in older children and adolescents, further diagnostic imaging may be needed.
- The erect chest x-ray may show an air fluid level (Figure 46.4) if there is lung collapse, an associated pneumothorax, and/or infection with anaerobic bacteria.
- Indistinct diaphragmatic contours merit lateral decubitus views of the chest. This may show layering of fluid. The absence of free layering on the decubitus films does not exclude the possibility of a loculated pleural effusion.
- In moderate effusion, the radiograph may demonstrate displacement of the mediastinum to the contralateral hemithorax, as well as scoliosis.
- Free-flowing pleural effusions suggest less complicated parapneumonic processes, which may not require extensive diagnostic and therapeutic interventions.
- An ultrasound scan is a sensitive test and can also be used to localise loculated effusions and to guide targeted drainage.
- Computed tomography (CT) may identify the presence of consolidated lung or fibrinous septations. In situations of complex fluid collections, chest CT imaging is the study of choice because it can detect and define pleural fluid and image the airways, guide interventional procedures, and discriminate between pleural fluid and chest consolidation.
- Viewing the pleural space by using a thoracoscope to examine its characteristics may also help the diagnosis in complex cases.

Other Investigations

- Thoracentesis is the standard diagnostic test. Aspirated pus or fluid should always be cultured; in a febrile patient, blood cultures should be done also. Where the cause of the pleural effusion is not clear or if the fluid is bloodstained, cytological investigation should also be done.
- Blood culture is obtained to assist in the identification of the offending organism. In paediatric patients, where sputum production is uncommon, identifying the cause of the pulmonary symptoms early in the course of a pulmonary infection is difficult. However, with parapneumonic effusions, the patient may become bacteraemic as the organism invades the pleural space, and a blood culture may reveal the organism.
- Total serum protein.
- Total white cell blood count.
- Culture and serologic studies of the aspirated pleural fluid, which may reveal bacterial, mycobacterial, and fungal isolates.
- Cell count and differential of aspirated pleural fluid are taken. Although the pleural fluid obtained at thoracentesis is typically purulent, with an elevated white blood count (WBC) count and a predominance of leucocytes, an effusion evaluated early in the infectious process may well be more transudative, with a less cellular WBC and a differential that has fewer leucocytes predominant. Regardless of the cell count and differential, the treatment should be based on clinical course, pending the culture results. Cytokine analyses of pleural fluid have been performed in experi-

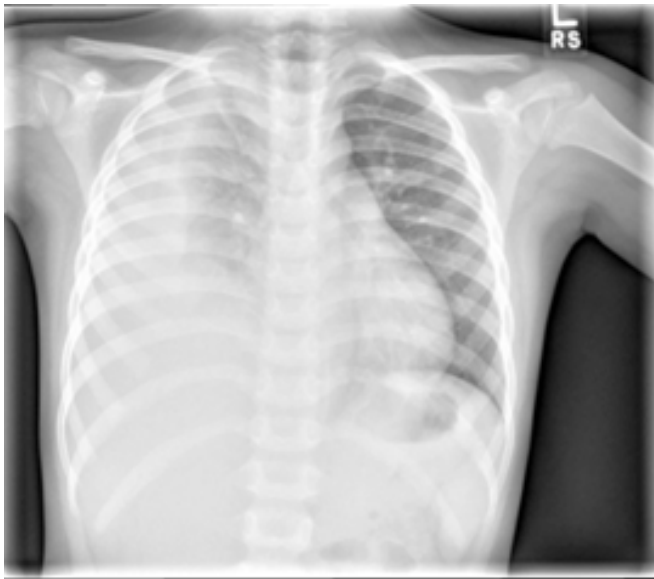


Figure 46.3: Empyema with lung entrapment.



Figure 46.4: Empyema with air fluid levels.

mental settings and may prove to add prognostic value on the degree of inflammation present; these may be beneficial in determining treatment course in the near future.

- Where malignant effusion is suspected, cytological investigation is mandatory. Rarely, a pleural biopsy may be indicated.
- Pleural fluid latex agglutination (or counterimmunoelectrophoresis (CIE) for specific bacteria) may be helpful if the cause of the infection cannot be ascertained from the usual culture results.

Management

There is contention regarding the management of empyema in children. The greatest discrepancies occur between nonsurgical and surgical specialists. The most controversial area in the management of empyema concerns which patients would benefit from pleural drainage and the selection of the appropriate drainage intervention. For uncomplicated free-flowing empyema, surgical intervention is rarely needed; however, surgery is usually indicated for the multiloculated persistent empyema for which initial therapy may have been delayed or failed.

Because many of the infections that cause empyema are indolent, a physician often sees patients after their empyema has already reached the fibrino-purulent or organising stage. These patients often are subjected to multiple surgical procedures and long hospital stays before the empyema is successfully treated.

Thoracentesis, tube thoracostomy, intrapleural thrombolytics (urokinase), thoracoscopic drainage, open drainage, and decortication all have success rates ranging from 10 to 90%.^{23,24} The variability in the success rates of these procedures can be attributed, in part, to the stage of the empyema at presentation. In the initial exudative stage, an exudative effusion forms during the first 72 hours; this will usually resolve as the pneumonia clears up following antibiotics therapy.

Antibiotic therapy and drainage of fluid collection are the mainstays of treatment. Broad-spectrum intravenous antibiotic cover should be commenced as soon as pus is aspirated from the chest and before culture results are available. For a simple pleural effusion, aspiration of the pleural space by thoracentesis is usually adequate but may be repeated as required. A malignant pleural effusion, such as that found in Kaposi sarcoma, should be treated with repeated aspirations and chemotherapy.

The initial treatment of ET is medical. Appropriate antibiotic selection should be based on the gram stain and culture of the pleural fluid; however, because a large number of patients may have already received antibiotics at the time of thoracentesis, an empiric selection of the most appropriate antibiotics is necessary.¹⁹ The choice of antibiotics should be based on the most common pathogens that cause pneumonia within the patient's age range and geographic location. When the organism is identified, the antibiotics may be changed to most specifically cover for the pathogen.

The duration of treatment is determined by the response to therapy; a patient usually receives 10–14 days of intravenous antibiotics and receives treatment until he or she responds appropriately to therapy, with pyrexia reduced and supplemental oxygen no longer required. Continuation of oral antibiotics may be recommended for 1–3 weeks after discharge.

Surgical Management

Treatment of parapneumonic effusions aims to control the infection and effect drainage of the pleural fluid to achieve full re-expansion of the affected lung tissue.^{1,20} Optimal treatments include antibiotics alone (for small effusions or empyemas) or in combination with surgical procedures. Numerous surgical options include thoracentesis,¹⁶ tube thoracostomy, fibrinolytics,^{7,13} thoracoscopy,^{10,21,22} minithoracotomy,¹⁵ open window drainage,¹⁶ or formal thoracotomy and decortication,^{14,22} which are described in the following sections.

Thoracentesis and Simple Tube Thoracostomy

Thoracentesis or chest tube placements may be required to effect a cure. In the second, fibrino-purulent stage, antibiotics with properly positioned chest tube drainage usually resolve the empyema thoracis. Failures may be due to an improperly positioned tube, pleural loculations, high fluid viscosity, or early peel on the lung. Failures are managed with open drainage involving rib resection, decortications, intrapleural thrombolytics, or thoracoscopic drainage. Prompt drainage of a free-flowing effusion prevents the development of loculations and a fibrous peel. The tube is removed when the lung re-expands and drainage ceases. If the fluid is not free flowing, further radiologic imaging is undertaken to better define the pleural space disorder.

In addition to the benefit of CT and ultrasonographic imaging to characterise loculated pleural effusions, the radiologist has become significantly involved in the treatment of empyema. The ability of the interventional radiologist to assist in the placement of small-bore catheters, specifically localised to loculated pleural fluid collections, has helped to facilitate drainage. Furthermore, with smaller-diameter tubes, patients have tolerated tube placement better, with less associated morbidity. In addition, radiologists can lyse adhesions directly by using

imaging during the tube placement. Finally, interventional radiologists, using fibrinolytics, have further improved the care of complicated empyema by improved management of loculations and amelioration of fibrous peel formation and fibrin deposition. Numerous studies have documented the effectiveness of intrapleural fibrinolytics (e.g., urokinase or tissue plasminogen activator (TPA)) to treat obstructed thoracostomy tubes, increase drainage in multiloculated effusions, and lyse adhesions. Cost may limit its more widespread use.

Open Drainage

Thoracotomy or minithoracotomy (with decortications) to remove the pleural peel and lyse the adhesions (in advanced empyema) if the patient does not respond promptly to treatment is very effective, with a reported 95% success rate for patients with fibrinopurulent empyema.

Customarily, rib resection has been required to manage the organised empyemas. Empyemas that have reached the organised phase are characterised by the presence of thick pleural peel, causing varying degree of pulmonary parenchymal entrapment. Limited thoracoplasty and muscle flap rotation are also needed in some instances to obliterate the pleural space problem.

Video-Assisted Thoracoscopic Surgery

Video-assisted thoracoscopic surgery (VATS) has proven to be an effective and less-invasive replacement for the limited decortication procedure. Thoracoscopic debridement closely imitates open thoracotomy and drainage. Mechanical removal of purulent material and the breakdown of adhesions can be easily accomplished via this route. VATS results in more rapid relief of symptoms, earlier hospital discharge, and significantly less discomfort and morbidity. For the paediatric population of many developed centres, VATS is the preferred method to alternative procedures such as rib resection and open drainage or pleural obliteration.

The Eloesser Procedure

The Eloesser procedure and its modification are important options in the surgical treatment of chronic, complicated ET.

Postoperative Complications

To encourage lung re-expansion, adequate analgesics are administered, and the patient is encouraged to take deep breaths and undergo basic chest physiotherapy including, where possible, blowing up (inflating) balloons.

Specific postoperative complications include:

- *Air leak* (bronchopleural fistula). This may spontaneously or it may require pneumonectomy (lung resection).

- *Persistence and chronicity* (from inadequate drainage due to the premature removal of the drainage tube or failure to establish drainage at the dependent position of the empyema cavity). Management may involve open drainage by rib resection, pneumonectomy (if there is associated lung disease, such as bronchopleural fistula), or obliteration of the pleural space by collapsing the chest wall to meet the lung by performing thoracoplasty.

Prognosis and Outcomes

Mortality-related prognostic factors of empyema thoracis in children include age, causative bacteriological agents such as *Streptococcus milleri*, concomitant disease, and history of operation.^{25,26} Morbidity and mortality may be reduced through early diagnosis and therapy.^{23,24,27,28}

A significant proportion of children with chronic disease develop a thoracic scoliosis, which is always directed towards the side of the effusion. This is thought to be due to pleuritic pain from the infection/inflammation and discomfort from the chest drainage tube.

Empyema necessitans is another long-term complication of poorly or uncontrolled empyema thoracis. The pus collection bursts and communicates with the exterior, forming a fistula between the pleural cavity and the skin.

The main determinants of outcome of empyema thoracis are early and adequate treatment, access to proper care, nutritional status of the patient, and the causative agent (tuberculous empyema).

Prevention

Early, aggressive, and adequate treatment of pneumonia; good hygiene; and adequate nutrition are imperative to preventing empyema thoracis in children in Africa. Public education and management of patients at risk by medical experts and specialists will play a crucial role in this regard.

Evidence-Based Research

In the literature of the last 10 years, only two reports are available in English from Africa on the treatment of postpneumonic pleural space infection.^{29,30} Both reports are of descriptive studies. The mean age at presentation of the patients is 5 years. Fever, cough, and dyspnoea are the standard presentations, together with radiologic evidence of pleural effusion. Pneumococci and staphylococci were the most common organisms isolated. In the Ethiopian study, no patient required thoracotomy and decortication, and in the Nigerian study, only one patient did. Mortality ranged from 7% to 16%.

Key Summary Points

1. Pleural effusion is aspirated and protein content is measured; exudates are cultured, and have cell count, gram staining, and acid-fast staining evaluated.
2. *Streptococcus pneumoniae* and *Staphylococcus aureus* are the major pathogens in children; antibiotic treatment should be started before culture results are available.
3. Tuberculous pleurisy needs to be distinguished from TB empyema.
4. Tube thoracostomy (with antibiotics) is the treatment of choice for empyema; and it must be carried out as soon as the diagnosis is made.
5. If an empyema does not resolve promptly with tube drainage, an ultrasound examination should be done and a new drain inserted if necessary.
6. In children, thoracotomy is rarely necessary and is a last resort.
7. The failure of an empyema to resolve is a good indication for VATS.
8. In areas with high HIV prevalence, a bloodstained pleural effusion is usually caused by Kaposi sarcoma.

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Suggested Reading

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