Empyema

Michael Singh and Dakshesh Parikh

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Abstract
The incidence of pediatric empyema is increasing globally. It is usually a complication of pneumonia, with *Streptococcus pneumoniae* the most common organism identified. If untreated, the effusion progresses through three stages: exudative, fibropurulent, and organization. Early medical management may halt the progression. Chest X-ray and ultrasound are useful initial investigations, with CT of the chest reserved for complicated patients. The mainstay of treatment includes intravenous antibiotics and effusion drainage. Intrapleural fibrinolysis has improved the outcome. A mini thoracotomy or thoracoscopic debridement can produce effective drainage and lung re-expansion with a low recurrence. Thoracotomy and decortication is reserved for an organized empyema, with or without a bronchopleural fistula.

Keywords
Empyema · Fibrinolysis · Decortication · Thoracoscopic · Thoracotomy

Synonyms
Empyema; Empyema thoracis; Parapneumonic effusion; Pleural empyema

Introduction
Empyema of the chest is the accumulation of pus in the pleural cavity. The most common etiology in childhood is secondary to an underlying pneumonia. The incidence is 3.3 per 100,000 children (Balfour-Lynn et al. 2005; Rees et al. 1997; Playfor et al. 1997; Hardie et al. 1996). Globally, there is an increasing incidence (Liese et al. 2019), with the under 5 year olds (53%) most commonly affected (Li and Tancredi 2010). While the mortality from empyema is low, the morbidity and burden on health care systems is significant.

Etiology
The majority of pediatric empyema is secondary to acute bacterial pneumonia. However, it can complicate viral infections (chicken pox and measles). Other predisposing factors include: chronic lung disease, steroid and immunosuppressive drugs, diabetes, transplantation, esophageal perforation, and peritonitis.

The most common causative bacteria is *Streptococcus pneumoniae*. Other associated bacteria include: Group A *Streptococcus*, *Streptococcus viridans*, *Streptococcus anginosus*, *Staphylococcus aureus*, *Haemophilus influenzae*, *Streptococcus milleri*, and the anaerobic *Peptostreptococcus*. However, due to prior antibiotic therapy, the yield from pleural fluid culture is low (17–42%) (Saglani et al. 2005; Bishay et al. 2009). The introduction of broad range polymerase chain reaction (PCR) has increased the ability to identify many species in a single assay. The advantages include: time and cost savings, identifying unexpected organisms, such as anaerobes, and improving targeted therapy. PCR combined with pleural fluid culture increases the bacterial identification rate up to 75% of patients (Saglani et al. 2005).

Pathology
The pathology of empyema is a continuum over three stages: stage 1 exudative, stage 2 fibropurulent, and stage 3 organization (Table 1)
Table 1 The different phases of an empyema and their characteristics

<table>
<thead>
<tr>
<th>Stage</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stage I Exudative phase</td>
<td>Initial post inflammatory response to an underlying pneumonia. Clear or cloudy fluid, high protein, low number of white cells, and sugar within the pleural space</td>
</tr>
<tr>
<td>Stage II Fibropurulent phase</td>
<td>Advanced inflammatory process results in the deposition of fibrin within the parapneumonic effusion causing loculations. The effusion becomes thicker containing gelatinous material and pus. The visceral and parietal pleura get covered with pyogenic material. As the process advances more fibroblast mature to form fibrosis</td>
</tr>
<tr>
<td>Stage III Organization phase</td>
<td>The fibrinous tissue matures and causes fibrosis which covers both visceral and parietal pleura. The consolidated lung gets trapped under this fibrous peel. Failure of re-expansion of the collapsed lung inevitably results in loss of function, a focus for a recurrent infection and bronchiectasis</td>
</tr>
</tbody>
</table>

(Balfour-Lynn et al. 2005; Parikh 2009). Its progression is influenced by: organism virulence, host resistance, antibiotic use, and drainage procedures. Inevitably, the disease progresses if inappropriately managed.

A large untreated empyema can spontaneously drain alongside a perforating vessel to the surface of the chest wall and is called empyema necessitans. If untreated, it can spontaneously drain externally and can cause an open pneumothorax (Pleuro-cutaneous fistula). Infection can cause a pericardial effusion or empyema. Spontaneous drainage into the airways or hematogenous spread to the bone and brain is possible.

Clinical Presentation

The initial clinical presentation is of pneumonia: cough, fever, tachypnea, and anorexia. Empyema should be suspected when there is worsening or recurrence of the fever and tachypnea, despite appropriate antibiotic therapy. An older child may complain of pleuritic chest pain or abdominal pain. Examination of the chest will reveal poor air entry and stony dullness over the affected area. In advanced cases, there is reduced movement, loss of volume, and scoliosis on the affected side of the chest. A large effusion will result in marked tachypnea and mediastinal shift with a deviated trachea.

Investigation

Blood Investigations

The following tests are indicated: full blood count, C reactive protein, and blood cultures. Serial measurements of the inflammatory parameters can be useful in monitoring the response to therapy.

Radiology

A chest x-ray will give the typical appearance of an effusion with the meniscus sign (Fig. 1). There will also be signs of lung consolidation. In complicated cases, the presence of an air fluid level could indicate a lung abscess or bronchopleural fistula (Fig. 2).

Ultrasound

Chest ultrasonography can provide very useful information about the nature of the effusion, avoiding the need for Computed Tomography (CT) scan and unnecessary irradiation. An ultrasound can identify if the effusion is clear, contains debris, and fibrin septation consistent with a loculated effusion (Fig. 3a, b). An ultrasound is superior to CT in identifying pleural septation. It can also be used to mark the site of chest drain insertion (Kurian et al. 2009). One advantage of ultrasound is that it is portable and can be done at the patient’s bedside without sedation. The disadvantages of ultrasound include: poor identification of mediastinal and lung pathology as well as
tumors. Homogenous solid lesions may be misdiagnosed as advanced empyema (Sharif et al. 2006). The extent of necrotizing pneumonia is also difficult to quantify on ultrasound.

Computed Thermography (CT)

Although CT scans of the chest offers no real advantage over ultrasound in the management of uncomplicated empyema, it gives better anatomical definition to a surgeon. The use of CT with intravenous contrast can be selective where surgery is considered (Balfour-Lynn et al. 2005). It can image the lung parenchyma and therefore has a role in persisting pyrexia following a drainage procedure, lung abscess, pneumatocele, bronchopleural fistula, and necrotizing pneumonia. Parenchymal necrosis appears as low-density areas within consolidated lung, with reduced enhancement relative to the adjacent parenchyma (Kurian et al. 2009). CT is particularly useful for patients who have had a poor response to fibrinolysis or complications following surgery, including recurrence (Fig. 4a, b).

Management

The management of early empyema should be aimed at achieving adequate drainage and full expansion of the lung (Flowchart 1). Failure of management should be recognized early and prompt referral to a specialized pediatric thoracic surgery center.

The aims of both the medical and surgical management of empyema are as follows:

- Control of sepsis with appropriate antibiotics
- Encourage lung expansion: chest drain, fibrinolysis, or surgery
- Manage complications: conservative or surgery

Supportive Medical Therapy

Supportive medical therapy includes: oxygen, rehydration with intravenous fluids, analgesia, antipyretics, physiotherapy, and nutritional supplementation.
Antibiotics

In the early exudative phase, high doses of appropriate antibiotics can result in improvement. However, in the fibrinopurulent phase, antibiotics alone are unlikely to result in improvement. The antibiotics used should ideally follow the local antibiotic policy and known sensitivities but must cover *S. pneumoniae*, *S. pyogenes*, and *S. aureus*. For community-acquired pneumonia, the following antibiotics will be appropriate: Co-amoxiclav, Cefuroxime, Penicillin and Flucloxacillin, Amoxicillin and Flucloxacillin, and Clindamycin. Gram negative and anaerobic cover should be included if the empyema is as a result of hospital-acquired infection, aspiration, peritonitis, or surgery. If the patient has a small effusion and has had a good clinical response to 48 h of intravenous antibiotics, then conservative management should continue. Oral antibiotics should be continued for up to 4 weeks post discharge to allow for complete resolution (Balfour-Lynn et al. 2005). A recent study of pleural tap-guided 14 day antimicrobial treatment yielded excellent results in children with empyema (Meyer Sauteur et al. 2019).

**Fig. 3** (a) Ultrasound of the right chest showing a clear effusion. The arrow is pointing to the diaphragm. (b) The empyema has progressed to the Fibropurulent Phase.

Septations can be seen on the ultrasound (arrow). EFF is effusion

**Fig. 4** (a, b) CT showing a recurrent effusion and abscess cavity (+) in the right middle lobe post thoracoscopic debridement
**Flowchart 1** A flowchart illustrating the management of a parapneumonic effusion or empyema

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**Intercostal Drainage and Fibrinolysis**

Drainage of the effusion should be considered if there is persistent pyrexia, worsening respiratory signs or a loculated empyema. The intrapleural instillation of a fibrinolytic agent has been shown to improve the outcome in pediatric empyema (Islam et al. 2012). A randomized trial of intrapleural urokinase versus saline for pediatric empyema showed a shorter hospital stay in the urokinase group (Table 2). The patients who had urokinase and a small size 10 (1.7 Fr) chest drain had a shorter hospital stay. The only adverse event reported was discomfort on instillation of both urokinase and saline. Five of the 60 patients required surgical debridement (3 placebo, 2 urokinase) (Balfour-Lynn et al. 2005).

It is recommended that the chest drain should be inserted by someone who is appropriately trained, preferably under ultrasound guidance. A small-size drain can be just as effective as a large one. The small-size drain can be easily inserted...
under ultrasound guidance with a Seldinger technique (Laws et al. 2003). In children, a small-size Seldinger chest drain can be inserted under sedation and local anesthesia. The procedure should preferably be done during normal working hours when adequate help is available if the child’s condition deteriorates. It is important that these children are appropriately monitored during the procedure.

**Fibrinolysis Versus Thoracoscopic Debridement of Empyema**

Two randomized studies, (UK, USA) comparing fibrinolysis (urokinase, tPA) with thoracoscopic debridement for pediatric empyema, showed no difference in: days on oxygen, duration of pyrexia, analgesic requirements, and length of hospital stay. However, thoracoscopic debridement was more expensive in both studies. Both studies found the failure of fibrinolysis to be 16% (St Peter et al. 2009; Sonnappa et al. 2006). In none randomized studies, thoracoscopic debridement has resulted in a reduced length of stay and low recurrence (Bishay et al. 2009).

**Decortication**

Decortication is a demanding operation and involves the sharp dissection of the thick fibrous peel, in order to release the trapped lung (organization phase) (Parikh 2009). This is difficult to achieve effectively without open surgery. A high morbidity is associated with this surgery including: excessive bleeding and air leak. Mortalities have also been reported following decortication.

**Thoracoscopic (Video-Assisted Thoracoscopic VATS) Debridement**

Thoracoscopic debridement of the empyema, as the primary intervention, can produce good results in experienced hands. Bishay reported on 114 patients who underwent thoracoscopic debridement of the empyema with a low failure rate of 7%. This figure included five conversions to a thoracotomy (dense adhesions, bleeding, poor view, and inadequate lung expansion) and three with recurrent empyema (thoracotomy) following inadequate thoracoscopic debridement. Seven (6%) had surgical complications which were managed conservatively: five minor air leaks and one minor lung injury. They argue that thoracoscopic debridement should be the primary intervention as in experienced hands the failure rate was much lower than that reported by Sonnappa and St Peter (16%) (St Peter et al. 2009; Sonnappa et al. 2006; Bishay et al. 2009).

Thoracoscopic debridement is unlikely to be successful in the following scenarios as there will be a dense fibrous peel causing lung trapping:

- Chronic, organized empyema
- Previous intrapleural fibrinolysis
- Pneumatocele or bronchopleural fistula
- Recurrent empyema
Operative Procedure for Thoracoscopic Debridement (Parikh 2009)
The aim of debridement surgery is to drain the effusion, release the trapped lung, and allow re-expansion.

Preoperative Checks
- Hemoglobin, blood cross match
- Mark side of surgery (confirm with x-ray)

Operation Room Setup
- Lateral decubitus position with affected side up
- Axillary roll under dependent side
- Video monitor positioned to patients head or foot depending on location of empyema. For diffuse empyema, the monitor will have to be moved around
- Surgeon stands either to the back or front of the patient
- Assistant and scrub nurse stands opposite the surgeon
- Instruments: 5 mm laparoscopy ports × 3, 5 mm 0 or 30° laparoscope, 5 mm straight grasper, suction, and irrigation device.

Intraoperative Steps
- Central endotracheal intubation
- Local anesthetic infiltration to port sites or paravertebral blocks
- 1, 5 mm port inserted anterior to the inferior angle of the scapula (optical) (Fig. 5a)
- The empyema fluid can be aspirated at this stage and a specimen sent for culture and PCR
- Pneumothorax of 5–6 mmHg with flows of 1.5–2 L/min
- Second working port inserted under direct vision so as to provide good access to the empyema
- Third working port is not necessary most times but can be used to gain better access
- The loculations are broken down and the peel removed from the surface of the lung and interlobar fissures. The thick pus is evacuated. The base of the lung should be separated from the diaphragm (Fig. 5b).
- The pneumothorax is released and the anesthetist is asked to ventilate manually to reinflate the lung under direct thoracoscopic vision.
- A 16 Fr chest drain is inserted via the first anterior port site and the wounds closed

Postoperative Management
- Appropriate analgesia (morphine infusion and oral analgesia)
- Chest drain on free drainage, suction unnecessary
- Chest X-ray the following day
- Mobilization and Chest physiotherapy
- Hemoglobin check
- Intravenous antibiotics for 5 days
- Drain removed when output is minimal (<1 ml/kg/day) and chest X-ray shows good lung expansion with minimal effusion
- Oral antibiotics for 4 weeks post discharge

Complications, Prevention, and Their Management
- Bleeding
  - Usually small and stops with lung expansion
  - Avoid sharp dissection on the mediastinal structures
  - Air leak
    - Usually minor from lung surface and stops with lung expansion
    - Always insert a chest drain
- Injury to lung
  - Always create a pleural window to avoid injury to the lung with open first port insertion
  - Working ports inserted under direct vision
  - Gentle separation of peel from lung
- Recurrent effusion/empyema
  - Small asymptomatic effusions can be managed conservatively
  - Larger symptomatic effusions can be managed by re-do surgery or drainage
- Inadequate lung expansion
  - Small degrees of asymptomatic, inadequate expansion can be managed conservatively
• Pneumothorax
  – Small asymptomatic pneumothorax should be managed conservatively
  – Larger pneumothorax with lung collapse should be investigated for a pneumatocele or bronchopleural fistula with a chest CT.
• Recurrent empyema
  – Consider early thoracoscopy or thoracotomy as prolonged delay will allow for dense peel formation

**Mini Thoracotomy and Debridement**

Mini thoracotomy and debridement can be a very effective procedure when thorascopic surgery is not available. It facilitates evacuation of the effusion, debridement of the fibrin septations, and lung expansion.

**Operative Procedure for Mini thoracotomy and Debridement (Parikh 2009)**

**Preoperative Checks**

• As for thoracoscopy

**Operation Room Setup**

• Lateral decubitus position with affected side up
• Axillary roll under dependent side
• Surgeon stands to the back of the patient
• Assistant and scrub nurse stands opposite the surgeon
• Instruments: Periosteal elevators, Finochietto retractor (rib spreader), lung retractor, Duval lung grasping forceps, suction

**Intraoperative Steps**

• Incision from the posterior to anterior axillary line along the 5th or 6th intercostal space
• Muscle cutting incision: dividing the latissimus dorsi and serratus anterior
• Muscle sparing incision: mobilizing the anterior border of the latissimus dorsi and retracting it posteriorly. The serratus anterior is split.
• The chest can be entered via the 5th or 6th intercostal space or through the bed of the 5th rib following subperiosteal resection
• The loculations are broken down and pleural cavity debrided
• Chest drains inserted and chest closed in layers
Postoperative Management

- Appropriate analgesia (morphine infusion and oral analgesia)
- Monitoring of SpO₂; keep above 95%
- Chest drain on free drainage, suction unnecessary
- Hemoglobin check
- Chest X-ray the following day
- Chest physiotherapy
- Intravenous antibiotics for 5 days
- Drain removed when output is minimal (<1 ml/kg/day) and chest X-ray shows good lung expansion with minimal effusion
- Oral antibiotics for 4 weeks post discharge

Thoracotomy and Decortication (Parikh 2009)

Thoracotomy and decortication is indicated in advanced and complicated empyema. A thick fibrous peel with a trapped lung can be a result of inadequate management of empyema.

Operative Procedure for Lateral or Posteriolateral Thoracotomy and Decortication

Preoperative Checks

- Hemoglobin, blood cross match with blood available in the theatre.
- Mark side of surgery (confirm with X-ray)
- Team briefed that significant blood loss is likely

Operation Room Setup

- As for mini thoracotomy

Intraoperative Steps

- Lateral or Posteriolateral incision with either muscle sparring or cutting the latissimus dorsi and serratus anterior.

Postoperative Management

- The chest can be entered via the fourth or fifth intercostal space or through the bed of the fifth rib following subperiosteal resection.
- The thick fibrous parietal pleura is incised to enter the pleura cavity.
- The pus and effusion is evacuated.
- The next step is dissection of the fibrous visceral pleura in order to release the trapped lung.
- If the peel is very thick and fibrous, it may be necessary to cut through the peel with a knife onto the surface of the lung in order to find the plane of dissection. Stripping off the peel produces punctate bleeding and peripheral air leakage from the lung surface which stops when the lung re-expands.
- It is important to decorticate the interlobar fissures and separate the lung from the diaphragm.
- Superficial injury to the lung surface does not require suturing.
- At the end of the procedure, there should be adequate lung re-expansion.
- At least 2, 16, or 20 Fr chest drains are inserted as necessary.

Complicated Empyema Management

Fortunately, the outcome of the majority of children with empyema is good if treatment is prompt. However, a minority go on to have a complicated course.
Empyema, in association with necrotizing pneumonitis, pneumatocele, lung abscess, bronchopleural fistula, and recurrent empyema, results in a prolonged complicated course (Parikh 2009). Persistent symptoms, prolonged bubbling from the chest drain, persistent lung collapse, pneumothorax or effusion should prompt further investigation for these complications (Flowchart 2). A CT scan with intravenous contrast is the investigation of choice in these circumstances.

### Necrotizing Pneumonia

Necrotizing pneumonia is an uncommon complication of pneumonia. However, there is an increasing incidence globally (Wong et al. 2000; Sawicki et al. 2008). There is progressive lung necrosis which results in multiple small cavities with the parenchyma. Historically, *Staphylococcus aureus* was the main cause. Recently, *Streptococcus pneumoniae* has emerged as the main causative organism. Other identified bacteria include: *Haemophilus influenzae* type B, *Mycoplasma pneumoniae*, methicillin-sensitive *Staphylococcus aureus*, methicillin-resistant *Staphylococcus aureus* (MRSA), *Fusobacterium*, *Pseudomonas* aeruginosa and *Streptococcus milleri* (Wong et al. 2000; Sawicki et al. 2008). These patients have a longer duration of pyrexia, a higher incidence of bronchopleural fistula (55%), more days with a chest drain, and a longer hospital stay (Hacimustafaoglu et al. 2004; Sawicki et al. 2008). If no pneumothorax is present on initial presentation, then the empyema could be managed with intrapleural fibrinolysis or gentle thoracoscopic debridement. If there is a pyopneumothorax (air fluid level) and lung collapse, then a bronchopleural fistula is present and a thoracotomy is indicated. These patients can have profound respiratory failure and may require intensive care support. Most necrotizing pneumonia recovers with early intervention, namely, adequate drainage of empyema, appropriate antibiotics, and monitoring. Most pediatric respiratory physicians follow these children for long-term respiratory morbidity.

### Pneumatocele

A pneumatocele can result from localized parenchymal necrosis leading to a breakdown of alveoli and an air leak into the interstitial space of the consolidated lung. A thin-walled intraparenchymal cyst is visible on a chest x-ray and CT (Fig. 6). Imamoğlu reported on a series of 134 children with empyema of whom 58 (43%) developed a pneumatocele (Imamoğlu et al. 2005). Thirty-seven (63.7%) asymptomatic patients showed spontaneous resolution over 2 months and a further 13 resolved over 13 months. Eight patients had

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**Flowchart 2** This flowchart illustrates the management of complicated empyema
Complications as a result of a large pneumatocele: tension with respiratory compromise and infection. They performed a radiologic guided catheter insertion into the pneumatocele in seven patients with resolution (3–19 days) in five patients. Two patients required surgery for resection of a persistent thick-walled cyst.

**Bronchopleural Fistula**

The term bronchopleural fistula in the presence of infection is a misnomer as the communication is generally distal to the segmental bronchi with the pleural cavity. In the modern era, the most common bacteria associated with this is *Streptococcus pneumonia*, serotype 1. The mechanism of formation is due to parenchymal necrosis as a result of either an abnormal inflammatory cytokine response or vascular thrombosis secondary to the infection. The peripheral necrosis and abscess formation then ruptures through the visceral pleura. The pyopneumothorax causes lung collapse and the lung becomes trapped by the organizing peel.

Bronchopleural fistula can develop in an inadequately managed empyema, or postoperatively in the presence of necrotizing pneumonia. Surprisingly, some of these patients can remain asymptomatic as the infection would have been cleared by antibiotics and drainage. If the rate of air leak is small, there may not be bubbling from the chest drain and the pneumothorax, and lung collapse would have been picked up on chest X-ray. Other signs on the chest X-ray are loss of thoracic volume and scoliosis on the affected side (Fig. 7). A CT with intravenous contrast will identify any intraparenchymal abscess cavity (Fig. 4a, b). Ramphul reported on 75 children with empyema, of which 15 (20%) developed a cavitary lesion and 3 developed a bronchopleural fistula (Ramphul et al. 2006). McKee showed that there is an increase in the incidence of bronchopleural fistula complicating empyema from 1% to 33% in 307 children over a 7-year period (2002–2009). They also reported that the bronchopleural fistula could be managed by insertion of a large chest drain. However, the duration of chest drainage was prolonged; median 21.5 days (range 7–46) (McKee et al. 2011).

Because the recovery is prolonged with chest drainage alone, a muscle spearing thoracotomy and serratus anterior digitation muscle flap onto the fistula with limited decortication is favored by Hallow and Parikh (2005) (Fig. 8). This approach brings a well-vascularized muscle flap onto the ruptured, necrotic abscess cavity. A thoracotomy also allows for a thorough decortication and
releases the trapped lung. Jester assessed the efficacy of this approach in his report of 20 children with complicated empyema and bronchopleural fistula. All 20 underwent a serratus anterior digitation muscle flap interposition to the leaking bronchopleural fistula and limited decortication. In all cases, this resulted in closure of the leaking fistula and lung expansion. The median postoperative duration of chest drainage was 7 days (range 5–15 days). The median postoperative hospital stay was 9 days (range 7–28 days). There were no long-term complications (Fig. 9) (Jester et al. 2012).

**Fig. 8** (a) One of the digitations of the serratus anterior muscle is mobilized from its anterior attachment (SAM-serratus anterior muscle, L-lung). (b) The muscle flap (+) is brought in to the pleural cavity via an adjacent intercostal space over the abscess cavity (A). (c) The muscle flap (SAM) is loosely sutured into the abscess cavity

**Operative Procedure for Serratus Muscle Digitation Flap**

**Preoperative Checks**
- As for thoracotomy and decortication

**Intraoperative Steps**
- The chest is opened through a lateral incision preferably muscle split. The old incision can be opened.
- The digitations of the serratus anterior muscle are preserved and the latissimus dorsi muscle is either cut or retracted posteriorly.
- The chest is entered through the bed of the fifth rib. By doing a subperiosteal resection of the fifth rib, the width of two intercostal spaces can be used to gain excellent access to the lung and pleura.
- The pleural cavity is debrided.
- In the majority of cases, the affected lobe is rigidly trapped by a dense fibrous peel.
- The decortication is performed as described previously so there is adequate lung expansion. In addition, a limited parietal pleurectomy adjacent to the abscess cavity is performed to allow the lung to adhere to the chest wall.
The fistula is generally visibly leaking air and a loud hissing sound is heard. The necrotic parenchyma around the opening of the fistula is very friable and should be gently handled. If there is some bleeding from an end artery that can be oversewn.

No attempt is made to oversew the fistula and temporary control of the air leak can be achieved by compression.

A digitation of the serratus anterior adjacent to the thoracotomy is mobilized by detaching it from its anterior rib attachment. This produces a posteriorly based muscle flap (Fig. 8a).

The muscle flap is brought inside the chest either through the thoracotomy or through a small adjacent intercostal space incision (Fig. 8b).

The end of the muscle flap is laid into the cavity and absorbable monofilament sutures are placed between the flap and surrounding healthy lung (Fig. 8c). This keeps the flap in position inside the fistula.

1 or 2, 16 or 20 Fr or chest drains are inserted and the chest is closed.

Postoperative Management

As for thoracotomy and decortication

Conclusion and Future Directions

The epidemiology of pediatric empyema is changing globally. There is an increasing incidence, with *Streptococcus pneumoniae* emerging as the most important cause of complicated empyema. There is an emerging resistance to antibiotics which is a cause for concern. Early recognition of a community acquired pneumonia and its appropriate management with antibiotics use in bacterial infection may prevent bacterial resistance and its progression to empyema.

Early and adequately managed empyema in children results in a good outcome, regardless of the intervention used (fibrinolysis or surgery). Three randomized studies with fibrinolysis showed good results. The failure of any management strategy should be recognized early and referral should be made to a center offering pediatric thoracic surgery. Complicated empyema is best managed in a tertiary center with pediatric thoracic surgery expertise.

Cross-References

▶ Esophageal Perforation in the Newborn
▶ Esophageal Replacement
▶ Respiratory Physiology
▶ Tumor of the Lung and Chest Wall

References


