

# Sepsis in the Postpneumonectomy Space

## Pathogenesis, Recognition, and Management



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### KEYWORDS

- Postpneumonectomy sepsis • Empyema • Microbiology • Aerobic and anaerobic bacteria
- Bronchopleural fistula • Esophagopleural fistula

### KEY POINTS

- Factors predisposing to the formation of bronchopleural fistula and subsequent empyema.
- Bacteriology in postpneumonectomy empyema due to aerobic and anaerobic infection.
- Factors that are incriminated in the development of postpneumonectomy bronchopleural fistula.
- Investigations necessary in the management.
- Three phases in the pathogenesis of empyema and clinical findings in each phase.

### INTRODUCTION

Empyema may occur in the pleural space after pulmonary resection in the presence of bronchopleural fistula. This also is usually the result of a dead space within the pleural cavity after pneumonectomy, which is filled with blood or serosanguinous fluid. Subsequent bacterial contamination results in infection and the development of a frank empyema. It may be associated with a transient bronchopleural fistula that closed spontaneously and may occur any time after surgery, even years after a pneumonectomy.<sup>1</sup>

Pneumonectomy is the surgical removal of the entire lung.<sup>2</sup> Pneumonectomy is the treatment of choice for centrally located bronchogenic carcinoma, diffuse malignant mesothelioma, and chronic inflammatory lung diseases with destroyed lung from pulmonary tuberculosis, fungal infections, and bronchiectasis. It is considered to be a major chest operation, often elective and sometimes urgent. Uncomplicated, the postpneumonectomy space must be radiologically monitored with chest radiographs at 3-day intervals as it gradually fills up with serosanguinous fluid over 3 to 6 weeks.

The mediastinum shifts gradually toward the operated side as it decreases in volume from the expected physiologic changes. These changes are expected, compensatory expansion of the contralateral lung and decrease in the pneumonectomy space owing to the absorption of air and the gradual accumulation of pleural fluid, as well as the gradual development of pleural thickening and fibrosis from inflammatory organization. In the uncomplicated case, on the pneumonectomy side, the diaphragm becomes elevated as the air–fluid level decreases, there is chest wall deformation, and the hydrothorax gradually disappears.

The pneumonectomy space is at potential risk for getting infected from bacterial contamination and developing empyema. The accumulating serosanguinous fluid is a good bacterial culture medium. Bronchopleural fistula and esophagopleural fistula are the 2 major sources of infection in the in the postpneumonectomy space in the surgical patient. Another source of space infection is direct extension from infected thoracotomy incision or septicemia from urosepsis, subdiaphragmatic abscess, or peritonitis.<sup>3–9</sup>

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## UNCOMPLICATED POSTOPERATIVE COURSE AFTER PNEUMONECTOMY

As soon as the operation is completed and the diseased lung is removed, the integrity of the closed bronchial stump must be confirmed. Surgical division and closure of the bronchial stump must be tested for unexpected air leak. To do so, it requires that the pleural space be partially filled with normal saline solution and the anesthesiologist exerts a tracheal airway pressure of up to 45 cm H<sub>2</sub>O by manual “bagging” to identify any bronchial stump air leaks. After ensuring that the bronchial stump is completely secure and intact, thereafter the bronchial stump is covered and protected, and reinforced with viable tissue such as pedicled pericardial fat pad, a pedicled flap of the pericardium, intercostal muscle pedicled flap, proximal and distal ligation, and division of azygous–superior vena cava junction and filleted azygous vein pedicle surrounded by parietal pleura flap, or anterior transdiaphragmatic retrosternal route for omentum. After satisfactory bronchial stump reinforcement, the bronchial stump must be tested again for an air leak under positive pressure ventilation with an airway pressure of up to 45 cm H<sub>2</sub>O while submerged under saline solution. Without evidence of bronchial stump air leak, the integrity of the bronchial stump is now confirmed and the chest tube must then be clamped after the mediastinum is properly balanced by the responsible thoracic surgeon, permitting some shift of the mediastinum toward the pneumonectomy side by partial hyperinflation of the contralateral lung without excessive ipsilateral mediastinal shift. The chest tube must be left clamped overnight; it is removed the following day after radiologic assessment is confirmed to be satisfactory and the mediastinum is well-balanced with minor shift to the operated side.<sup>10</sup>

Postoperatively, the fluid balance must be maintained. Cardiac function and rhythm must be monitored. Daily body temperature and white blood cell count should be recorded. Daily chest radiographs are required to monitor the integrity of the postpneumonectomy space until the patient is ready to be discharged from the hospital. The white blood cell count is monitored daily for 7 days for leukocytosis. The thoracotomy incision is examined every day for unexpected infection.

## PATHOGENESIS OF SEPSIS IN THE POSTPNEUMONECTOMY SPACE

Pathophysiological changes that occur in the postpneumonectomy space are related to the following factors.

1. Infection in the thoracotomy incision with subsequent extension into the dead pleural space

within the pleural cavity resulting in empyema. This finding is particularly worrisome in the postpneumonectomy patient, and the infecting micro-organism is frequently *Staphylococcus aureus*. The other pathogenic bacterial infections causing empyema may be pneumococci (*Streptococcus pneumoniae*), beta-hemolytic streptococci (*S pyogenes*), gram-negative enteric bacilli such as *Escherichia coli*, *Pseudomonas aeruginosa*, *Proteus spp.*, *Klebsiella pneumoniae*, and *S milleri* (of the viridans streptococci group). Anaerobic infections (usually peptostreptococci, *Bacteroides fragilis*, and fusobacteria) are probably more common than is often reported. Mixed infections may occur, and microbiological study may record both aerobic and anaerobic organisms.

2. The postpneumonectomy space gradually fills up with a serosanguinous fluid. Bacterial contamination of the pleural fluid is harmful. The fluid is a good culture medium for contaminating bacteria resulting in empyema.
3. There are several causes of postpneumonectomy bronchopleural fistula resulting from impaired healing of the bronchial stump. The main causes of this complication are technical errors in the closure of the bronchus, closure of a diseased bronchus, and leaving an excessively long bronchial stump, technical factors caused by increased rigidity of the bronchial cartilaginous rings affecting satisfactory bronchial stump closure, increased tension and dehiscence of the bronchial staple line when the division of the closed main bronchus is too close to the rigid cartilaginous tracheal carina, residual cancer in the divided bronchus impairing healing process, preoperative lung and bronchial infection, preoperative radiation therapy resulting in bronchial ischemia owing to endarteritis obliterans, excessive devascularization of the bronchus owing to overzealous dissection, and intraoperative bacterial contamination. The bronchopleural fistula may be small in size, resulting in infection of the postpneumonectomy serosanguinous fluid and empyema, or it may be large in size resulting in transbronchial aspiration of postpneumonectomy fluid into the contralateral lung and infection, leading to respiratory failure. The diagnosis should be suspected by unsuspected decrease in the air–fluid level in the pneumonectomy space, by the presence of aspiration pneumonia in the contralateral lung, and by documentation of multiple loculated air pockets in the accumulating pleural fluid. The diagnosis of bronchopleural fistula should be suspected from clinical examination and

radiologic examination with chest radiographs and computed tomography scans. It may be confirmed by bronchoscopic visualization of the bronchial stump or by the instillation of contrast material (Omnipaque) into the appropriate bronchus and sinogram demonstration of communication with the pleural space. Sepsis developing in the postpneumonectomy space is a major serious complication and threat to life. Bronchopleural fistula occurring after pneumonectomy presents a significantly greater hazard than that following a lesser pulmonary resection with lobectomy, segmentectomy, or wedge resection.<sup>11,12</sup>

4. The postpneumonectomy space may change in configuration with the presence of multiple loculated air pockets and a decreasing air–fluid level owing to the bronchopleural fistula.
5. Gram-negative enteric bacilli such as *E coli*, *P aeruginosa*, *Proteus spp.*, and *K pneumoniae* are found most commonly in empyema complicating esophagopleural fistula caused by esophageal injury during pulmonary resection.
6. An esophagopleural fistula is an uncommon postoperative problem.<sup>4</sup> It is the result of esophageal injury at the time of pneumonectomy. Extensive extrapleural dissection, especially on the right, and extensive mediastinal lymph node dissection are probably the precipitating factors. Dumont and DeGraef<sup>8</sup> pointed out that the blood supply to the esophagus is segmental and that the part of the esophagus just below the carina has the poorest blood supply; this site of fistula formation is the commonest. The majority of fistulas after pneumonectomy occur on the right.<sup>12</sup>

The development of esophagopleural fistula were described by Dumont and De Graef in 1961,<sup>8</sup> by Takaro and colleagues in 1960,<sup>6</sup> and by Erikson<sup>7</sup> in 1964. Takaro reported 24 cases occurring after pneumonectomy for tuberculosis or suppurative pulmonary disease and the mortality rate was 49%; the cure rate was 21%.<sup>4</sup> Erikson reported 3 cases of esophagopleural fistula occurring after right pneumonectomy for carcinoma of the lung.<sup>5</sup> Benjamin and colleagues<sup>9</sup> reported 3 cases of esophagopleural fistula after right pneumonectomy for carcinoma. Two cases occurred early in the postoperative period, and one occurred 8 months later. They pointed out that the clinical picture may be confused with that of bronchopleural fistula and empyema, but that a diatrizoate (Gastrografin) radiographic study is diagnostic. Esophagoscopy and bronchoscopy were performed in each case to rule out the presence of tumor.

Benjamin and colleagues<sup>9</sup> recommended empyema drainage followed by direct closure of the fistula with protection by a flap of pleura. After the fistula healed, the empyema was treated by the Clagett method: making an open window thoracostomy, pleural cavity irrigation with antibiotic solution, and finally closing the window after complete secure healing of the fistula.<sup>13–15</sup> Engelman and associates<sup>10</sup> reported a case of postpneumonectomy esophagopleural fistula successfully treated with a 1-stage procedure of intercostal muscle pedicle flap closure of the fistula with thoracoplasty. The collapsed empyema space was then continuously irrigated with antibiotic solution.

The best treatment for this entity is prevention. A nasogastric tube permits location of the esophagus. If the esophagus is injured at the time of pneumonectomy, the esophageal tear should be repaired immediately in 2 layers—a mucosal repair first followed by esophageal muscle reapproximation. The repaired site should be covered with a pleural flap and methylene blue should be instilled into the esophagus to ensure it is secure in the repaired esophageal tear.

#### BRONCHOPLEURAL FISTULA AND POSTPNEUMONECTOMY EMPYEMA

The incidence of empyema after pneumonectomy should not exceed 3%.<sup>1</sup> In up to 10% of patients bronchopleural fistulae appear (disrupted healing of the main bronchus). The clinical signs of infection of the pleural space vary widely and may not appear for several months after the operation. Therefore, the possibility of empyema should be considered in any patient with signs of infection after pneumonectomy, no matter how far in the past they underwent the procedure. Unexplained fever, expectoration of serosanguineous fluid, drainage from the wound, or multiloculated air pockets or a decrease in the air–fluid level seen on a chest film should immediately arouse suspicion of an infected space and possibly a bronchopleural fistula.

The management of empyema has been radically changed by the contributions of Clagett and Geraci (1963).<sup>13–17</sup> It consisted of 1 or 2 segmental rib resections with intervening intercostal muscles and parietal pleura in the anterior portion of the thoracotomy incision and immediate pleurocutaneous fistula in the chest wall fenestration by suturing of the pleura to the skin with Vicryl sutures. Three times daily packing with sterile gauze and monitoring for sepsis is needed. Weekly monitoring of the bronchial stump by bronchoscopy is required and, when necessary, by esophagoscopy. The Clagett procedure has 3 components:

creating the chest wall window (fenestration), sterilizing the empyema cavity, and finally surgically closing the window. Stafford and Clagett (1972)<sup>15-17</sup> demonstrated obliteration of the empyema in 16 of 18 cases. Management consists of open drainage using a modification of the pleural flap operation of Eloesser (1969)<sup>4</sup> followed 4 to 8 weeks later by daily cleansing of the pleural space, bronchoscopy to monitor bronchial stump healing, filling the pleural space with dilute beta-dine solution, and tight closure of the incision.

Bronchopleural fistulas generally occur in the first operative week. Rarely do they occur months after a pneumonectomy. After a pulmonary resection and closed tube drainage, the persistence of a large air leak or the sudden appearance of a large leak of air followed by some fever and the development of purulent drainage may make one suspicious of a bronchopleural fistula. The presence of a fistula can be confirmed by bronchoscopy.

A bronchopleural fistula developing after a pneumonectomy is generally heralded by the sudden coughing up of a thin, bloody fluid. This fluid may be so copious as to flood the opposite lung and cause pneumonia and death. The patient should immediately reassume a position that will make the intrapleural fluid gravitate away from the opening in the bronchus, that is, sitting up or lying down with the side operated on dependent. All the pleural fluid that can be obtained should be aspirated promptly by thoracentesis. This treatment takes care of the immediate emergency. Closed tube drainage of the pleural space is then recommended. Intravenous broad-spectrum antibiotics after Gram stain and culture should be administered. When the mediastinum has stabilized, open drainage with chest wall fenestration, a pleural flap, and an immediate pleurocutaneous fistula should be performed. Pleural cavity packing is started 3 times daily and sepsis is monitored. If the patient is old and debilitated, open pleural drainage may be used indefinitely.<sup>18</sup> Subsequently, the fistula may close. If it closes, the infected pleural space can then be managed in the method described by Clagett.<sup>13,15,17,18</sup> If the fistula does not close spontaneously, a tailoring thoracoplasty<sup>19</sup> or closure of the fistula using an intercostal muscle flap, or pectoral muscular flap, or omentum should be performed.

### FACTORS PREDISPOSING TO BRONCHOPLEURAL FISTULA

1. Common etiologic factors are believed to be endobronchial tuberculosis, drug-resistant organisms, and concomitant illness.
2. Preoperative radiation therapy interfering with bronchial microcirculation and endarteritis obliterans.

3. Improper surgical technique with stapled closure of the bronchus very close to the tracheal carina, creating tension in the bronchial stump closure.
4. Overzealous peribronchial dissection and consequent devascularization of the bronchus.
5. Presence of cancer at the bronchial resection margin.
6. Long bronchial stump resulting in the pooling of bronchial secretions and infection.
7. Disrupted bronchial blood circulation.
8. Faulty technique of bronchial stump closure.
9. Preexisting empyema.
10. Extended carinal resections.
11. Preoperative thoracic radiation.
12. Postoperative need for mechanical ventilation.
13. Right versus left pneumonectomy.
14. Poor nutritional status.
15. Diabetes.
16. Sepsis.
17. Age older than 70 years.
18. Underlying lung disease, including pulmonary tuberculosis, chronic infection, and chronic obstructive lung disease.
19. Preoperative immunosuppression and steroid therapy.
20. Postoperative sputum positive for acid-fast bacilli.

### ESOPHAGOPLEURAL FISTULA AND EMPYEMA

This complication is an uncommon postoperative problem. It is the result of esophageal injury at the time of pneumonectomy. Extensive extrapleural dissection, especially on the right, and extensive lymph node dissection are probably the precipitating factors. Dumont and DeGraef<sup>8</sup> pointed out that the blood supply to the esophagus is segmental and that the part of the esophagus just below the carina has the poorest blood supply; this site of fistula formation is the commonest. The majority of fistulas after pneumonectomy occur on the right.

Takaro and colleagues<sup>6</sup> found 24 cases of esophagopleural fistula after pneumonectomy in 1960 occurring for tuberculosis or suppurative pulmonary disease with mortality rate of 49%. Erikson<sup>7</sup> in 1964 reported 3 cases of esophagopleural fistula occurring after right pneumonectomy for carcinoma of the lung. Benjamin and others<sup>9</sup> reported 3 cases of esophagopleural fistula after right pneumonectomy for carcinoma. Two cases occurred early in the postoperative period, and one occurred 8 months later.

Esophagoscopy and bronchoscopy were performed in each case to rule out the presence of tumor. Benjamin and colleagues<sup>9</sup> recommended empyema drainage followed by direct closure of the fistula with protection by a flap of pleura. After the fistula healed, the empyema was closed by the Clagett method. Engelman<sup>10</sup> and others reported a case of postpneumonectomy esophagopleural fistula successfully treated with a 1-stage procedure of intercostal pedicle flap closure of the fistula with an extensive thoracoplasty. The collapsed empyema space was then treated continuously irrigated with antibiotics.

The best treatment for this entity is prevention. A nasogastric tube will permit location of the esophagus. If the esophagus is injured at the time of pneumonectomy, the esophageal defect should be repaired and covered with a viable pleural flap and methylene blue should be instilled into the esophagus to determine leakage.

## INVESTIGATIONS REQUIRED

The investigations that are required for diagnosis and management of postpneumonectomy sepsis are as follows.

Daily blood sampling for measuring white cell count and assessment of leukocytosis.

Daily serial chest radiographs to assess the postpneumonectomy space, air-fluid level, loculated air pockets in the pleural fluid, and contralateral lung for pneumonia.

Regular computerized chest computed tomography scan to assess the postpneumonectomy space and contralateral lung.

Regular fiberoptic bronchoscopy to assess the bronchial stump for impaired healing and defect.

Omnipaque bronchography and sinogram to assess for the bronchial stump leak.

Thoracentesis and chest tube drainage for bacteriologic examination of the pleural fluid in the postpneumonectomy space.

Omnipaque swallow and barium swallow to assess for postoperative esophagopleural fistula.

Esophagoscopy to assess esophagus for tear.

## DEFINITION OF AND INTRODUCTION TO EMPYEMA THORACIS

The word empyema is used to denote the presence of pus in a natural body cavity. In thoracic medicine, that space is the empty pleural cavity created after a whole lung is removed by pneumonectomy. After pneumonectomy, the space is filled with serosanguinous fluid, which is a good

bacterial culture medium. The infecting bacteria causing empyema after pulmonary resection are often pneumococci (*S pneumoniae*), beta-hemolytic streptococci (*S pyogenes*), and *S aureus*. Anaerobic infections owing to peptostreptococci, Bacteroides, and fusobacteria are probably more common than is often reported. Mixed infections may occur, recording both anaerobic and aerobic organisms. It is clear that both anaerobic and aerobic cultures should be carried out routinely when infected fluid is obtained from the pleural cavity.

Gram-negative rods are found most commonly in empyema complicating esophagopleural fistula from esophageal trauma during pulmonary resection.

## Clinical Manifestations

The clinical manifestation of postpneumonectomy empyema may be highly variable, depending both on the nature of the infecting organism and the competency of the patient's immune system. The spectrum ranges from an almost complete absence of symptoms to a severe illness with all the usual manifestations of systemic toxicity. The manner in which the empyema has arisen is also clearly relevant to the presenting findings, that is, whether it has followed pneumonia, surgical or other trauma or whether it is associated with mediastinitis or subdiaphragmatic sepsis.

Postpneumonectomy sepsis in the pleural space may develop for a variety of reasons. It may be related to intraoperative contamination from a lung abscess during surgical dissection. Bronchopleural fistula is another cause owing to unrecognized bronchial stump leak and bacterial contamination by infected bronchial secretions in the accumulating postpneumonectomy serosanguinous fluid, which is a good culture medium for the bacteria. Postoperative wound infection in the thoracotomy incision may extend into the pleural space and cause empyema. A subphrenic abscess may extend through the diaphragm and infect the postpneumonectomy pleural space. Poorly performed postoperative chest thoracentesis by needle or chest tube insertion has the potential to infect the pleural space.

Fever is common, although if the empyema cavity is well walled off or the patient is elderly, this symptom need not be present. General malaise and loss of weight are common features, as is pleuritic pain, which may take the form of dull chest wall discomfort. Dyspnea may result from compression of the contralateral lung from sympathetic pleural effusion, pulmonary embolism, atrial fibrillation, or cardiac tamponade owing to septic

pericarditis and an associated pericardial effusion. A cough is frequently present, and, in the presence of a large bronchopleural fistula, large volumes of purulent sputum may be expectorated.

The suppurative process, if undrained and uncontrolled by appropriate antibiotics, may extend beyond the pleural cavity, with pointing occurring in an intercostal space often in the thoracotomy incision or often close to the sternum where the chest wall is thinnest. The term empyema necessitatis may be used to denote any such lesion that has ruptured through the skin surface to form a discharging sinus.

### **Diagnosis**

The possibility of a complicating postpneumonectomy empyema should always be borne in mind in a patient who is running a febrile postoperative course. Whereas the clinical history and physical findings may be suggestive, the diagnosis can only be made with confidence when suspicious chest radiographic findings lead to thoracentesis.

The chest radiographic appearances of postpneumonectomy empyema may, in the early stages, be identical to those of an uncomplicated pleural effusion. The air–fluid level may have decreased, raising the possibility of bronchopleural fistula. The presence of loculated bubbles of air in the pleural fluid may raise suspicion for bronchopleural fistula.

A computed tomography scan of the thorax is similarly helpful. The pericardium should be assessed for pericardial effusion. The pneumonectomy space needs to be assessed for an air–fluid level and loculated air pockets. The contralateral lung should be assessed for aspirated fluid. A sample of pleural fluid must be obtained at thoracentesis to confirm the diagnosis.

Bronchoscopy and esophagogastrosocopy are necessary. The bronchial stump needs to be examined for healing and fistula. The esophagus should be examined for injury.

A bronchogram is necessary by contrast study is using Omnipaque bronchography and sinogram to assess the bronchial stump.

### **Pathogenesis of Postpneumonectomy Empyema**

Causes of nontraumatic pneumonectomy space sepsis include the following.<sup>15</sup>

#### **Underlying thoracic disease**

1. Pulmonary
  - a. Lung abscess
  - b. Bronchiectasis
  - c. Tuberculosis

- d. Pneumonia
- e. Resection of lung cancer
- f. Iatrogenic esophageal tear during pulmonary resection
- g. Intraoperative errors
2. Osteomyelitis
  - a. Sternum
  - b. Ribs
  - c. Vertebrae
3. Extrathoracic sepsis
  - a. Subphrenic abscess extending through the diaphragm
  - b. Transdiaphragmatic erosion of liver abscess
4. Preoperative chest injury from stabbings and gunshot wounds
5. Preoperative mediastinitis from complications during mediastinoscopy and esophageal tear

### **Investigation of empyema**

1. Gross examination of the pleural fluid.
  - a. Thin pus
  - b. Thick pus
  - c. Infected watery fluid
2. Pleural fluid aspiration for microscopic examination of the pleural fluid.
  - a. White blood cells
  - b. Bacteria
3. Microbiological examination.
  - a. Type of bacteria
  - b. Aerobic and anaerobic
  - c. Bacterial culture
4. Complete blood sample measuring hemoglobin and white blood cell count every day.
5. Broad spectrum antibiotics selected from bacteriologic examination.
6. Bronchoscopy to assess healing of the bronchial stump.
7. Esophagoscopy to rule out esophageal iatrogenic injury during pulmonary resection.
8. Daily chest radiograph to assess the air–fluid level, a decrease in the fluid level, and the presence of multiloculated air pockets in the pneumonectomy fluid.
9. Assessment of the contralateral lung for aspiration pneumonitis from the infected postpneumonectomy space with a large bronchopleural fistula.
10. Chest computed tomography scan.
11. Two-dimensional echocardiogram to assess the pericardial space for pericarditis and pericardial effusion.

## MANAGEMENT OF POSTPNEUMONECTOMY EMPYEMA

1. Preferred by most thoracic surgeons; the initial treatment is closed-tube thoracostomy with intent to cure.<sup>16,17</sup>
2. Bronchoscopy before discharge from the hospital.
3. The patient is fit for thoracotomy and bronchopleural fistula is evident without occurrence of pleural sepsis. The patient needs a bronchoscopy to assess the bronchus and to exclude persistent cancer in the bronchial margin. A thoracotomy should be undertaken to repair the bronchus and use vascularized pedicle to support bronchial repair. The choices are the intercostal muscle pedicle, pericardial fat pad, parietal pericardium pedicle, azygous vein flap by mobilization, ligation, and division of the proximal end at the azygous vein–superior vena cava junction, after which it is fileted open to cover the bronchus, and vascularized pedicle of omentum through upper laparotomy incision delivered into the chest through the retrosternal route.
4. Appropriate broad-spectrum antibiotic coverage must be continued for 4 weeks on the basis of bacteriologic examination.

### ***Extent of Pneumonectomy and Postoperative Complications***

Complications of pneumonectomy are classified as follows.

1. Standard pneumonectomy is a less demanding procedure, and the operative risk is less than 3%.
2. Carinal pneumonectomy is performed when the lung cancer has extended into the tracheal carina, requiring resection of the carina and the lung, and contralateral tracheobronchial anastomosis; the operative risk is increased to just higher than 5%.
3. Vocal cord dysfunction occurs when pneumonectomy is on the left side and the left recurrent laryngeal nerve is vulnerable to injury.
4. Cardiac arrhythmias are frequent complication of thoracotomy and pneumonectomy.
5. Postpneumonectomy pulmonary edema and evolving hypoxia.
6. Chylothorax is recognized by the rapid accumulation of fluid in the pneumonectomy space and from fluid analysis for chylomicrons.
7. Pulmonary thromboembolism.
8. Bronchopleural fistula and empyema.
9. Esophagopleural fistula and empyema.
10. Postpneumonectomy syndrome is a rare complication after pneumonectomy. It

consists of an excessive mediastinal shift, resulting in the compression and stretching of the tracheobronchial tree and the esophagus. The aim of this study was to give a comprehensive overview of diagnosis, variety of symptoms and evaluation of surgical treatment of postpneumonectomy syndrome. Six women with a median age of 56.5 years (range, 49–65 years) developed postpneumonectomy syndrome after pneumonectomy for the treatment of lung cancer. Four presented with a right postpneumonectomy syndrome and 2 with a left postpneumonectomy syndrome. Symptoms consisted of shortness of breath in all patients and dysphagia as well as heartburn in 2 patients. Correction of postpneumonectomy syndrome required reexploration of the pneumonectomy space, reposition of the mediastinum followed by the insertion of single silicone prosthesis in 5 patients or fixation of the mediastinum with a xenopericardial graft in 1 patient.

### ***Extent of Pneumonectomy, Clinical Manifestations, and Presentation of Postoperative Empyema***

In Mearns Kirk Hospital in Glasgow, 29 patients with postpneumonectomy empyema were treated by fenestration over a 12-year period.<sup>20</sup> This series was reported by Goldstraw.<sup>20</sup> Peter Goldstraw is Honorary Consultant Thoracic Surgeon to the Royal Brompton Hospital and Emeritus Professor of Thoracic Surgery at Imperial College London, UK. Seven of these patients were not considered fit enough for definitive closure and died of continuing disease or respiratory infection. Twenty-two patients went on to closure of their fenestra, and in 17 (77%) the pneumonectomy space was rendered permanently sterile. If the empyema recurred, treatment was repeated but proved less successful. Fenestration is an effective method of dealing with postpneumonectomy empyema, but also has several other advantages, particularly if the empyema is associated with a bronchopleural fistula (Tables 1 and 2).

### ***Clinical Features of Empyema***

#### Systemic features

- Pyrexia, usually high and remittent
- Rigors, sweating, malaise, and weight loss
- Polymorphonuclear leukocytosis

#### Local features

- Pleural pain, breathlessness, cough and infected sputum usually because of underlying lung disease, and copious purulent sputum owing to bronchopleural fistula

Clinical signs of fluid in the pleural space: dullness on percussion and absent breath sounds

## EXTENT OF PNEUMONECTOMY AND POSTOPERATIVE COMPLICATIONS

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Vocal cord dysfunction occurs when pneumonectomy is on the left side and the left recurrent laryngeal nerve is vulnerable to injury.

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Chylothorax is recognized by the rapid accumulation of fluid in the pneumonectomy space and from fluid analysis for chylomicrons.

Pulmonary thromboembolism.

Bronchopleural fistula and empyema.

Esophagopleural fistula and empyema.

### Postpneumonectomy Syndrome

Postpneumonectomy syndrome is a rare complication after pneumonectomy. It consists of an

excessive mediastinal shift resulting in compression and stretching of the tracheobronchial tree and the esophagus. The aim of this study was to give a comprehensive overview of diagnosis, variety of symptoms and evaluation of surgical treatment of postpneumonectomy syndrome. Six women with a median age of 56.5 years (range, 49–65 years) developed postpneumonectomy syndrome after pneumonectomy for the treatment of lung cancer. Four presented with a right postpneumonectomy syndrome and 2 with a left postpneumonectomy syndrome. Symptoms consisted of shortness of breath in all patients and dysphagia as well as heartburn in 2 patients. Correction of postpneumonectomy syndrome required reexploration of the pneumonectomy space, reposition of the mediastinum followed by the insertion of single silicone prosthesis in 5 patients or fixation of the mediastinum with a xenopericardial graft in 1 patient.

### SUMMARY

#### ***Natural History of Empyema Thoracis: Definition and Introduction of Empyema Thoracis***

The word 'empyema' is used to denote the presence of pus in a natural body cavity. In thoracic medicine that space is the empty pleural cavity created after whole lung is removed by pneumonectomy. After pneumonectomy, the space becomes filled with serosanguinous fluid which is a good bacterial culture medium. The infecting bacteria causing empyema after pulmonary resection are often pneumococci (*S pneumoniae*), beta-hemolytic streptococci (*S pyogenes*), and *S aureus*. Anaerobic infections owing to

**Table 1**  
Three phases of empyema pathogenesis – 3 phases

Phase of Empyema	Early Phase I – 1st Week	Intermediate Phase II – 2nd Week	Late Phase III – 3rd Week
Early acute exudative →	Acute septic pleurisy; free serous infected fluid, thin and watery	–	–
Intermediate subacute "fibrinopurulent"	→	Subacute suppurative effusion gradually thickens, becomes more purulent; limiting adhesions develop with multiple loculations	–
Chronic "true purulent empyema" 4–6 weeks later	→		Localized abscess is formed with its walls lined by fibrinous deposit



**Table 2**  
Symptoms and signs of empyema: clinical findings

Phase of Empyema		
Early - Phase I Acute Pleurisy, Exudative	Intermediate -Phase II Fibrinopurulent	Late - Phase III Empyema Pyopneumothorax
Sharp stabbing pain, aggravated by chest movements	General toxemia, dyspnea, fever, malaise, fatigue, and sweating episodes	General, toxemia, fever, malaise, loss of appetite, loss of weight
Pleural rub	Local – chest pain worsened by breathing	Local – chest pain
Chest movements and breath sounds are decreased by conscious efforts to decrease chest pain		
Moderate fever and dry cough usually accompany chest pain		

peptostreptococci, Bacteroides, and fusobacteria are probably more common than is often reported. Mixed infections may occur, recording both anaerobic and aerobic organisms. It is clear that both anaerobic and aerobic cultures should be carried out routinely when infected fluid is obtained from the pleural cavity.<sup>21</sup> Gram-negative rods are found most commonly in empyema complicating esophagopleural fistula from esophageal trauma during pulmonary resection.

### **Clinical Manifestations**

The clinical manifestation of postpneumonectomy empyema may be highly variable, depending both on the nature of the infecting organism and the competency of the patient's immune system. The spectrum ranges from an almost complete absence of symptoms to a severe illness with all the usual manifestations of systemic toxicity. The manner in which the empyema has arisen is also clearly relevant to the presenting findings, whether it has followed pneumonia, surgical or other trauma, or whether it is associated with mediastinitis or subdiaphragmatic sepsis.

Postpneumonectomy sepsis in the pleural space may develop for a variety of reasons. It may be related to intraoperative contamination from a lung abscess during surgical dissection. Bronchopleural fistula is another cause owing to an unrecognized bronchial stump leak and bacterial contamination by infected bronchial secretions in the accumulating postpneumonectomy serosanguinous fluid, which is a good culture medium for the bacteria. Unrecognized postoperative wound infection in the thoracotomy incision may extend into the pleural space and cause empyema. Subphrenic abscess may extend through the diaphragm and infect the postpneumonectomy pleural space. A poorly performed postoperative

chest thoracentesis by needle or chest tube insertion has the potential to infect the pleural space.

Fever is common, although if the empyema cavity is well walled off or the patient is elderly this symptom need not be present. General malaise and loss of weight are common features, as is the pleuritic pain, which may take the form of dull chest wall discomfort. Dyspnea may result from compression of the contralateral lung from sympathetic pleural effusion, pulmonary embolism, atrial fibrillation, or cardiac tamponade owing to septic pericarditis and associated pericardial effusion. A cough is frequently present, and, in the presence of a large bronchopleural fistula, large volumes of serosanguinous fluid or frank purulent sputum may be expectorated (Tables 1 and 2).

The suppurative process, if undrained and uncontrolled by appropriate antibiotics, may extend beyond the pleural cavity, with pointing occurring in an intercostal space, often in the thoracotomy incision or often close to the sternum where the chest wall is thinnest. The term empyema necessitatis may be used to denote any such lesion that has ruptured through the skin surface to form a discharging sinus.

### **Diagnosis**

The possibility of a complicating postpneumonectomy empyema should always be borne in mind in a patient who is running a febrile postoperative course. Whereas the clinical history and physical findings may be suggestive, the diagnosis can only be made with confidence when suspicious chest radiographic findings leads to thoracentesis and analysis of pleural fluid.

The chest radiographic appearances of postpneumonectomy empyema may, in the early stages, be identical to those of an uncomplicated pleural effusion. An air-fluid level may have decreased,

raising the possibility of bronchopleural fistula. The presence of loculated bubbles of air in the pleural fluid may raise suspicion of bronchopleural fistula.

A computed tomography scan of the thorax is similarly helpful in establishing the diagnosis. The pericardium should be assessed for pericardial effusion. The pneumonectomy space needs to be assessed for the air–fluid level and loculated air pockets. The contralateral lung should be assessed for aspirated fluid. A sample of pleural fluid must be obtained at thoracentesis to confirm the diagnosis.

Bronchoscopy and esophagogastrosocopy are necessary for establishing a diagnosis. The bronchial stump needs to be examined for leaks, healing, and formation and size of bronchial fistula. The esophagus should be examined for intraoperative transmural injury during pneumonectomy.

A bronchogram is necessary by contrast study is using Omnipaque bronchography and sinogram to assess the bronchial stump. Contrast thin liquid barium is helpful in assessing for esophageal–pleural fistula.

### CLINICS CARE POINTS

- Bronchopleural fistula and empyema complicating pneumonectomy.
- Esophageal injury in the mediastinum during pulmonary resection and complicating post-pneumonectomy empyema from esophago-pleural fistula.
- Pathogenesis of sepsis in the postpneumonectomy space due to infecting bacteria.
- Factors predisposing to the formation of bronchopleural fistula.
- Clinical presentation of postpneumonectomy empyema.
- Management of postpneumonectomy empyema.
- Drainage procedures in the management of postpneumonectomy empyema.

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