Parapneumonic Effusions/Empyema

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Injury/Disease Demographics

- A parapneumonic effusion is a pleural fluid collection that accompanies a pneumonia; it occurs in 20%-57% of hospitalized patients with bacteria pneumonia, but is not limited to bacterial pathogens, as viral, fungal, and atypical microorganisms can cause parapneumonic effusions.
- Parapneumonic effusions in patients with pneumonia are associated with increased length of hospital stay, interventions, costs, and patient mortality.
- An empyema is defined by the presence of purulence in the pleural space and includes the presence of microorganisms on Gram's stain. An empyema can result from 1) a complicated undrained parapneumonic effusion, 2) lung abscesses which drain into the pleural space, 3) instrumentation of the pleural space, and 4) contamination from chest tube insertion. An empyema can also originate from sources below the diaphragm or from the mediastinum.
- Complicated parapneumonic pleural effusions and empyemas can result in a *trapped lung* from a thickened pleural peel that limits full lung expansion; this can cause respiratory compromise.

Clinical Presentation

- Patients with an empyema often report dyspnea, cough, pleuritic chest pain, and manifest signs and symptoms of systemic infection, such as fever and chills, tachycardia, and tachypnea.
- Symptoms can be acute or can present insidiously over days or even weeks.
- Physical examination will demonstrate decreased breath sounds of the affected side, diminished lung excursion on auscultation with inspiration, and dullness to chest percussion.

Evaluation

- A patient with pneumonia who develops a small pleural effusion is likely to have a parapneumonic effusion; an empyema should be suspected in patients with a history of acute respiratory illness and an associated complicated pleural effusion.
- Other causes of a pleural effusion should be ruled out, including malignant pleural effusions and those due to congestive heart failure. The clinical context in which a patient presents with a pleural effusion is important to distinguish between non-infectious etiologies and parapneumonic effusions/empyemas.
- Parapneumonic effusions can be classified as uncomplicated or complicated. Uncomplicated parapneumonic effusions are not purulent and have a negative gram stain of the pleural fluid. Complicated parapneumonic effusions have loculations or are actually empyemas with positive gram stain or fluid culture.
- Empyemas have been described to progress through 3 disease stages: Exudative (acute phase) → Fibrinopurulent (transitional phase) → Organizing (chronic phase).

    - In the exudative phase, the pleural membrane deposits fibrin over the pleural surface but does not yet prevent lung re-expansion.
    - Thickened, gelatinous fibrin deposits are present in the fibrinopurulent phase, and the pleural fluid is turbid or frankly purulent, and loculations are present.
    - In the organizing phase of an empyema, the pus in the pleural space is thick, and both the visceral and parietal pleural are encased within a thickened, collagenous peel. The lung is encased by this fibrotic peel on its surface and is unable to re-expand.
- Identifying the potential cause for development of an empyema is important in treatment. Although the majority of empyemas result from pneumonia, other causes of empyemas such as esophageal perforation, endocarditis with septic lung emboli, and endobronchial tumor obstruction should not be overlooked.

Diagnostics

- Biochemical analysis of pleural fluid (i.e. obtained from thoracentesis) is useful to guide treatment:
    - Parapneumonic effusions with low pH (<7.2); low glucose (< 60mg/dL); high LDH (>1000 U/L) should be more aggressively treated with drainage as they are likely to develop into empyemas
- Gram positive aerobic organisms account for the most frequent organisms identified in community acquired pleural infections with Streptococcal species (e.g. S. milleri) accounting for the majority. Anaerobic bacteria (e.g. Fusobacterium, Bacteroides) also account for nearly 20% of bacterial isolates in community acquired pleural infections.
- Nearly 50% of hospital acquired pleural infection are bacterial isolates and consist of Staph aureus; MRSA may account for nearly 2/3 of these cases. Gram negative organisms, such as E. coli, Enterobacter spp, and Pseudomonas spp are commonly isolated in the remainder of hospital acquired empyemas
- Negative bacterial cultures using standard culture techniques have been reported to occur in up to 40% of cases of pleural infections. This can be due to early antibiotic therapy with clearance of organisms from the pleural space, sampling error from missing the loculated effusion by thoracentesis, or the presence of anaerobic organisms which can be more difficult to culture.
    - Despite the negative culture data, complicated parapneumonic effusions usually require surgical intervention (i.e. VATS) to adequately clear the pleural space of the loculated fluid collections.

Imaging

- Most patients with clinical symptoms suggestive of an empyema should undergo a chest radiograph as the initial study. The chest film can demonstrate opacification of the pleural space from a pleural effusion and can often indicate that the pleural effusion is complex.
- Contrast computed tomography (CT) of the chest remains the imaging modality of choice for a patient with a complicated parapneumonic effusion or an empyema. The CT can

identify pleural loculations, a thickened peel to suggest a trapped lung, associated parenchymal lung abnormalities, and other anatomic features useful to treatment considerations and approaches.

- Ultrasound can be used to evaluate the pleural space and demonstrate a pleural effusion. Complex pleural effusions suggestive of an empyema frequently demonstrate echogenicity within the pleural fluid and pleural loculations indicating a complex effusion. Ultrasound imaging is very useful to guide drainage of the pleural space (e.g. thoracentesis and tube thoracostomy) but should not replace the valuable information obtained by CT.

Role of Conservative Management and Associated Considerations

- Patients with a suspected empyema should be started on empiric antibiotics after the cavity has been drained and cultures sent. Antibiotics should be started prior to source control and cultures if the patient is in septic shock or there will be an extensive delay to source control.
- The antibiotic regimen depends on the clinical status of the patient and usually can be tailored depending on culture data. When culture data is not available, it is appropriate to initiate broad spectrum antibiotics until such information becomes available.
- Guidelines for sepsis management should be followed.
- Complicated parapneumonic effusions require drainage, which often is the initial step in management. The approach to drainage depends upon the clinical circumstance. Tube thoracostomy can be placed at the bedside and should ideally be positioned in the dependent position. Percutaneous guided thoracostomy tube drainage is useful when loculations are present; however, frequently the diameter of percutaneous tubes that are inserted are of smaller caliber and do not adequately drain the effusions.
    - Radiographic resolution after drainage should be confirmed. If there is inadequate fluid resolution, undrained loculations, or poor clinical improvement, additional interventions should be considered.
- Intrapleural fibrinolytic therapy (tissue plasminogen activator/DNAse) administered through the chest tube can be considered in situations where there remains pleural loculations and inadequate pleural fluid drainage.
    - This approach generally should be reserved for patients where surgical intervention is not feasible. Typically these are patients whose acute pathophysiological condition would not tolerate single lung ventilation for the operative procedure.

Indications for Operative Intervention

- Operation is indicated for:
    - inadequate drainage of complicated parapneumonic effusions.
    - empyema with the presence of loculations.
    - patients who have associated inadequate lung expansion on imaging and poor clinical function.

Pre-operative Preparation/Impact of Associated Injuries

- Physiological assessment should be performed to determine if single lung ventilation of the non-operative lung can be tolerated.
    - Isolated lung ventilation can be achieved through a double lumen endotracheal tube or placement of a bronchial blocker
    - Flexible bronchoscopy is useful to evaluate the tracheobronchial airways prior to the operative procedure to clear secretions; this optimizes single lung mechanical ventilation

Operative Techniques

- Video-assisted thoracoscopic surgery (VATS)
    - VATS is usually successful in treating parapneumonic effusion. Complicated parapneumonic effusions and frequently early stage empyemas can be treated by the VATS approach
- Thoracotomy
    - This approach is usually required for patients with empyemas in the fibrinopurulent and chronic stage, particularly when there is evidence that the lung cannot expand because it is encased by thickened, fibrotic pleural peel

Intraoperative Considerations

- The objective of surgical intervention is to disrupt all pleural loculations, drain all the pleural fluid, and allow the lung to fully expand. When this is approached thoracoscopically, placement of the initial port site should be guided by the CT scan. Commonly, placement of the initial port site anteriorly along the pre-axillary line at the level of the infra-mammary crease is appropriate. At this level, the incision can be extended posteriorly should conversion to a thoracotomy be required. Once entry into the pleural cavity is achieved, careful dissection with instruments placed alongside the thoracoscopic video camera through this incision allows visualization of the pleural space inferiorly and posteriorly to insert second thoracoscopic port site. The thoracoscope can then be placed through this second incision to obtain better perspective of the pleural space.
- Any pleural peel should be removed from the lung surface, including along the lobar fissures to allow lung expansion (decortication). Often this can be facilitated by asking the anesthetist to manually apply controlled positive pressure to the gently expand the lung which helps delineate the lung surface from the pleural peel to be decorticated.
- Pleural peel inhibiting the diaphragm mobility should be lysed and removed.
- Repeat samples of the pleural peel and pleural cavity fluid obtained intraoperatively should routinely be re-sent for culture, even if previous pleural fluid samples have been identified. It is not uncommon for an empyema to be due to polymicrobial organisms.

- Extensive drainage of the hemithorax should be accomplished by strategically placing chest tubes under visualization. Usually, at minimum 2 chest tubes are inserted and often 3 chest are placed to adequately drain the pleural cavity.
    - Chest tubes are occasionally required for air leak management caused by parenchymal lung tears associated with decortication
    - Chest tubes may serve as empyema tube drains which are slowly backed out of the pleural space over time
- Patients who are unable to be managed thoracoscopically should be considered for thoracotomy, either using a muscle-sparing technique or the more formal posterolateral thoracotomy.
- Ipsilateral lung re-inflation should be confirmed prior to terminating any surgical procedure.

Postoperative Management

- Attention to bronchopulmonary hygiene following VATS or thoracotomy is crucial for successful post-operative outcomes.
- Adequate pain control to allow good pulmonary effort to avoid lung atelectasis and for secretion management often requires acute pain management with an epidural catheter, particularly for patients who have undergone thoracotomy.
- Intravenous antibiotics should be tailored to available culture results. Contemporary practice has been to shorten the necessary antibiotic duration; however, there remains paucity of evidence based studies comparing the efficacy of different antibiotic durations. Antibiotics should be continued until clinical improvement is achieved.
- The nutritional status of the patient post-operatively should be closely monitored and optimized to promote overall recovery.

Complications

- Most complications associated with empyemas occur in the chronic organizing phase of the disease process. These cases usually result from inadequate treatment of an empyema and usually occur after a necrotizing pneumonia or pulmonary abscess. These complications include the following:

    - Chest wall contraction associated with restrictive pulmonary function
    - Bronchopleural fistula
    - Empyema necessitans
        - Empyema necessitans is a now rare complication of pleural space infections and occurs when the infected fluid dissects spontaneously into the chest wall from the pleural space.
    - Abscess of the mediastinum or subphrenic compartments
- Other complications associated with complicated parapneumonic effusions or empyemas result from other organ system derangements caused by the underlying sepsis

Considerations for Special Populations

Post-pneumonectomy/lobectomy empyema

- Most often this condition is associated with a pneumonectomy but can occur after partial lung resections.
    - It most commonly occurs because of a bronchopleural fistula
    - Initial management of the post-lung resection/post-pneumonectomy empyema is chest tube drainage and antibiotic coverage.
    - The empyema can occur early after pneumonectomy or during a later time period; it is associated with high mortality.
    - Traditionally, management included open pleural drainage, serial wound cavity debridement and packing, followed by bronchopleural fistula closure, and then eventually chest closure with installation of antibiotic solution

Trapped lung

- In some circumstances, the lung is unable to be decorticated and cannot fully expand and a residual pleural space remains. When this occurs, the pleural space should be drained with chest tube that serves as an *empyema tube.*
    - Once the chest tube no longer tidals with respiration and there is no longer evidence of any air leak, the chest tube is shortened by cutting it and slowly advanced out of the chest cavity over a period of several days to weeks.
- When a large residual space remains or if the patient's underlying condition does not allow total lung decortication to be tolerated or to be appropriate (i.e. loculated empyema in a patient with metastatic cancer) then an open pleural drainage procedure creating a pleurocutaneous flap (Eloesser-type flap) should be considered.

Suggested Readings

- Scarci M, Abah U, Solli P, et al. EACTS expert consensus statement for surgical management of pleural empyema. Eur J Cardiothoracic Surg 2015; 48: 642-53.
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