Pleural Effusion
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Pleural effusion is the manifestation of an underlying disease process. The most common cause of pleural effusion in developed countries is congestive heart failure. Pulmonary embolism should be considered in patients with pulmonary effusions of uncertain etiology. Therapeutic thoracentesis is indicated in the emergency department for relief of acute respiratory or cardiovascular distress. Diagnostic thoracentesis should be performed in the emergency department to diagnose immediately life-threatening conditions in toxic-appearing patients.

EPIDEMIOLOGY
Because pleural effusions are harbingers of underlying disease, their precise incidence is difficult to determine. The incidence in the United States is estimated to be at least 1.5 million cases annually.1 In industrialized countries worldwide, the incidence approaches 320 cases per 100,000 people—with heart failure, bacterial pneumonia, cirrhosis, malignancy, and pulmonary embolism representing the most common causes. The morbidity and mortality associated with pleural effusion are directly related to cause, stage of disease at the time of diagnosis, and biochemical findings in the pleural fluid. Because pleural effusions are manifestations of underlying diseases, age, sex, race, and socioeconomic status reflect the variation in incidence of the causative disease state or disorder.

PATHOPHYSIOLOGY
Under normal physiologic conditions, the parietal and visceral pleurae are in close apposition, with only a small potential space between them. This potential space contains a small amount of pleural fluid (1 mL) to minimize friction from continuous movement of the appositional lining. The accumulation of pleural fluid (whether osmotic or hydrostatic in nature) can usually be explained by either increased pleural fluid formation or decreased pleural fluid absorption, or both.

Pleural effusions caused by an increase in pleural fluid formation can be further subdivided into elevation in hydrostatic pressure (e.g., congestive heart failure), decreased colloid osmotic pressure (e.g., cirrhosis, nephrotic syndrome), increased capillary permeability (e.g., infection, neoplasm), passage of fluid through openings in the diaphragm (e.g., ascites), or reduction of pleural space pressure (e.g., atelectasis). An effusion caused by decreased pleural fluid absorption can be qualified further as either lymphatic obstruction or elevation of systemic venous pressure resulting in impaired lymphatic drainage (e.g., superior vena cava syndrome).

The presence of fluid in the normally negative pressure environment of the pleural space has a number of consequences for respiratory physiology. Pleural effusions produce a restrictive ventilatory defect and also decrease total lung capacity, functional residual capacity, and forced vital capacity. They may cause ventilation-perfusion mismatches and, when large enough, compromise cardiac output.2

The classic work of Light et al.3 in 1972 demonstrated that 99% of pleural effusions could be classified into these two general categories, transudative and exudative (Box 52.1). A basic difference is that transudates generally reflect a systemic process whereas exudates usually signify underlying local pleuropulmonary disease.3

PRESENTING SIGNS AND SYMPTOMS
In many cases, pleural effusions are asymptomatic when discovered. Physical findings of pleural effusion are unlikely to be manifested until an effusion exceeds 300 mL. Dyspnea, the most common symptom associated with pleural effusion, is related more to distortion of the diaphragm and chest wall during respiration than to hypoxemia. Less commonly, symptoms of pleural effusions consist of a mild, nonproductive cough and chest pain. Pleuritic chest pain indicates inflammation of the parietal pleura because the visceral pleura is not innervated. In many patients, drainage of pleural fluid alleviates the symptoms despite limited improvement in gas exchange. Findings on lung examination such as decreased breath sounds, dullness to percussion, pleural friction rub, egophony, and reduced tactile fremitus have all been described.1,2 Auscultation alone can miss up to 600 mL of fluid in the lung.4,6
Box 52.1 Light Criteria for Classification of Pleural Effusions

In 1972, Light et al. developed the currently accepted benchmark for classifying pleural fluid, as follows:

- Pleural fluid protein-to-serum protein ratio > 0.5:1
- Pleural fluid lactate dehydrogenase (LDH)-to-serum LDH ratio > 0.6:1
- Pleural fluid LDH greater than two thirds the upper limit of normal for serum LDH (a cutoff value of 200 IU/L was used previously)

Pleural fluid is classified as an exudate if it meets any of the aforementioned criteria. Conversely, if all three characteristics are absent, the fluid is classified as a transudate. These researchers achieved a diagnostic sensitivity of 99% and specificity of 98% for classification of an exudate.

Box 52.2 Signs and Symptoms of Effusion

Dyspnea
Cough (dry, nonproductive)
Chest pain (pleuritic or nonpleuritic)
Chest wall discomfort
Decreased breath sounds
Dullness to percussion
Egophony, tactile fremitus
Pleural friction rub
Disease-specific signs and symptoms may include:
- Orthopnea
- Paroxysmal nocturnal dyspnea
- Fever
- Night sweats

*A detailed past medical history may uncover the cause of the effusion.

The emergency physician should assess for the cause of the effusion. If a patient complains of fever, weight loss, and a progressively worsening cough with associated dyspnea, an oncologic or infectious cause is likely. Constant chest wall pain may reflect chest wall invasion by bronchogenic carcinoma or malignant mesothelioma. Pleuritic chest pain suggests either pulmonary embolism or an inflammatory pleural process. An effusion can mimic the classic symptoms of acute coronary syndrome, such as chest pain, dyspnea, and shoulder pain (Box 52.2).

Differential Diagnosis and Medical Decision Making

A pleural effusion is frequently identified during evaluation of the underlying chief complaint of the patient. Because the etiology of pleural effusion is myriad, a thorough history and physical examination may narrow the differential diagnosis substantially. Box 52.3 lists the common causes of pleural effusion. Frequently, effusion is identified on physical examination or with basic chest radiography, but additional imaging modalities, including radiography, ultrasonography, and computed tomography (CT), may identify the cause and provide additional insight about the effusion.

Box 52.3 Causes of Pleural Effusions

**Transudates**
- Atelectasis (early)
- Congestive heart failure
- Cirrhosis
- Glomerulonephritis
- Hypoalbuminemia
- Myxedema
- Nephrotic syndrome
- Peritoneal dialysis
- Pulmonary embolism
- Superior vena cava syndrome

**Exudates**
- **Infectious**
  - Bacterial infection
  - Bronchiectasis
  - Fungal infection
  - Lung abscess
  - Parasitic infection
  - Traumatic hemothorax
  - Tuberculosis
  - Viral illness

- **Malignancies**
  - Lymphoma
  - Mesothelioma
  - Primary lung cancer
  - Pulmonary metastasis

- **Connective Tissue Disease**
  - Rheumatoid arthritis
  - Systemic lupus erythematosus

- **Abdominal/Gastrointestinal**
  - Esophageal rupture
  - Pancreatic disorders
  - Subphrenic abscess

- **Other**
  - Atelectasis (chronic)
  - Chylothorax
  - Drug reactions (amiodarone)
  - Postpartum state
  - Pulmonary infarction or embolism
  - Uremia

FACTS AND FORMULAS

\[ \frac{SI}{SV} = \frac{B6A} \]

Auscultation alone can miss effusions of up to 600 mL. Effusions of approximately 400 mL are routinely visible on upright chest radiographs.

Bedside ultrasonography is effective for visualizing and characterizing effusions. Ultrasound-guided thoracentesis should be performed when available.
DIAGNOSTIC CONSIDERATIONS

RADIOGRAPHY
Erect posteroanterior and lateral chest radiographs are still the most important initial tools in the diagnosis of a pleural effusion. On upright and lateral decubitus films, loss of the costophrenic angle is seen. With increasing size of the pleural effusion, the hemidiaphragm is obscured (Fig. 52.1), and a mass effect with shift of the mediastinum away from the affected side is noted. If a film is taken with the patient supine, one may see only a nonspecific haze over the affected hemithorax because the fluid layers posteriorly. To confirm that the fluid is free flowing, lateral decubitus films with the affected side down are often obtained. With very large effusions, the affected side may remain opacified, thus rendering the decubitus film unhelpful. In adults the minimum amount of fluid required for identification of effusion on an upright film is approximately 400 mL, whereas lateral decubitus films (with the affected side down) may detect as little as 50 mL of fluid. A lateral decubitus film with the affected side up may facilitate evaluation of the underlying lung for atelectasis, a mass, or infiltrates along the lateral portion of the lung.6

Mediastinal shift contralateral to the effusion (observed with effusions > 1000 mL) with concomitant displacement of the trachea is an important clue to obstruction of a lobar bronchus by an endobronchial lesion, possibly because of malignancy or, less commonly, obstruction by a foreign body.

Subpulmonic effusions are an uncommon manifestation of pleural effusions seen when fluid accumulates between the lower lung lobe and diaphragm. The fluid collection may mimic an elevated hemidiaphragm in upright imaging (Fig. 52.2). Upward of 400 mL of fluid can collect in the subpulmonic region before the posterior costophrenic sinus is filled. Evidence of an elevated hemidiaphragm with steep lateral peaks, obscured pulmonary vessels below the level of the diaphragm on a lateral projection, or a flat appearance of the posterior aspect of the hemidiaphragm on a lateral projection is suggestive of a subpulmonic effusion.6

ULTRASONOGRAPHY
Ultrasoundography is effective for visualizing an effusion and determining whether the fluid is free flowing or loculated (Fig. 52.3).7-9 In a prospective study, Piccoli et al.8 compared ultrasonography, physical examination, and radiography in patients with suspected effusions. Findings on physical examination and radiography were in agreement 76% of the time, with a kappa value of 0.52. When compared with chest ultrasonography, physical examination showed a sensitivity of 69% and a specificity of 77%. Ultrasonography may help distinguish a large solid chest mass from an effusion and can be used to guide thoracentesis. Ramnath et al.10 suggested early use of ultrasonography to identify complicated effusions (loculations or organization) because patients whose effusions were
SECTION V THORACIC AND RESPIRATORY DISORDERS

RED FLAGS

Failure to establish a working differential diagnosis or identify the underlying cause
Failure to initiate prompt source management for an underlying infectious cause
Failure to identify and manage tension physiology caused by large effusions on an emergency basis

BOX 52.4 Fluid Analysis of Pleural Effusions

<table>
<thead>
<tr>
<th>Exudates</th>
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</thead>
<tbody>
<tr>
<td>Protein content &gt; 3 g/dL</td>
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<tr>
<td>High lactate dehydrogenase (LDH) content</td>
</tr>
<tr>
<td>Pleural fluid-to-serum LDH ratio &gt; 0.6:1</td>
</tr>
<tr>
<td>Pleural fluid-to-serum protein ratio &gt; 0.5:1</td>
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</tbody>
</table>

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<tr>
<th>Differential Clues</th>
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<tbody>
<tr>
<td>Gross blood in pleural fluid suggests tumor, trauma, or infarction.</td>
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<tr>
<td>Pleural fluid amylase elevation is associated with pancreatic disease, esophageal rupture, or malignancy.</td>
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<tr>
<td>Pleural fluid pH is normally higher than 7.30; a pH lower than 7.2 suggests an infectious process such as empyema.</td>
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<tr>
<td>Consider pulmonary emboli as the cause of loculated pleural effusions, particularly if the pleural fluid predominantly contains lymphocytes.</td>
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</tbody>
</table>

Fig. 52.4 A pleural effusion (arrow) seen on chest computed tomography.

PLEURAL FLUID ANALYSIS

Ideally, evaluation of a pleural effusion should begin with diagnostic thoracentesis and proceed to classification of the pleural fluid as either a transudate or an exudate. The currently accepted benchmark for classifying pleural fluid, developed by Light et al., is shown in Box 52.1. A number of later studies used modifications of the Light criteria but had poorer diagnostic accuracy.

Normal pleural fluid pH has been estimated to be approximately 7.64. A pH below 7.30 suggests the presence of an inflammatory or infiltrative process, such as parapneumonic effusion, empyema, malignancy, connective tissue disease, tuberculosis, or esophageal rupture. According to the current American College of Chest Physicians consensus statement on the treatment of parapneumonic effusions, pH is the preferred pleural fluid chemistry test for classifying the category of a parapneumonic effusion for subsequent management (Box 52.4). Additional testing considerations for pleural fluid include cholesterol, glucose, amylase, and adenosine deaminase.

TREATMENT

Acute medical management of pleural effusions is based on both therapeutic and diagnostic considerations. In the emergency department (ED), therapeutic thoracentesis is indicated for relief of acute respiratory or cardiovascular distress. Diagnostic thoracentesis should be used in the ED to diagnose immediately life-threatening conditions in toxic-appearing patients. Circumstances outside these situations should not necessitate emergency thoracentesis, but appropriate monitoring and further medical management are essential. Table 52.1 summarizes findings dictating the appropriateness of intervention.

APPROACH TO UNILATERAL PLEURAL EFFUSION

Thoracentesis should be performed for new and unexplained pleural effusions when sufficient fluid is present to allow a safe procedure. Conventional wisdom holds that if a 10-mm layer of fluid is visible on a radiograph, sufficient fluid is present for thoracentesis to be successful. Treatment of the underlying disorder is generally all that is required for effusions caused by renal, cardiac, or rheumatologic diseases.
THORACENTESIS: THE IDEAL APPROACH

Thoracentesis is an elective procedure requiring informed consent. Sterile technique and procedural experience lower the incidence of complications.

Drainage of a pleural effusion is indicated for the following reasons:

- Diagnostic fluid or cellular analysis
- Therapeutic relief of symptomatic dyspnea
- Evaluation of complicated parapneumonic effusions or empyema

POSITIONING

Ideally for thoracentesis, the patient should sit on the edge of the bed, lean forward slightly, and rest on an adjustable table. If the patient cannot sit up because of hemodynamic status, mental status, or the presence of tubes and indwelling lines, thoracentesis can be performed with the patient supine. In this case, the patient should turn onto the side with the effusion and move to position the back at the edge of the bed.

PROCEDURAL APPROACH

Diagnostic thoracentesis is used to determine the cause of a pleural effusion, and therapeutic thoracentesis is performed to relieve symptoms of respiratory distress. Therapeutic thoracentesis may be repeated if indicated, but more definitive therapy such as sclerosis is usually needed to treat recurrent symptomatic pleural effusions. If more than 1.0 to 1.5 L of fluid is removed at one time, reexpansion pulmonary edema (RPE) and postthoracentesis shock should be anticipated in the postprocedural period. Supplemental oxygen should be provided because postthoracentesis decreases in arterial oxygenation have been reported. The magnitude and duration of this decline roughly correlate with the amount of fluid removed. If removal of a large volume of fluid is anticipated, concurrent fluid resuscitation should be considered to blunt postthoracentesis shock. Depending on the causative process, reaccumulation of pleural fluid may occur.

After appropriate positioning, the patient is prepared in standard sterile fashion. The effusion can be identified along

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### Table 52.1 Management of Patients with Parapneumonic Effusions

<table>
<thead>
<tr>
<th>PLEURAL ANATOMY</th>
<th>PLEURAL FLUID MICROBIOLOGY</th>
<th>PLEURAL FLUID CHEMICAL ANALYSIS</th>
<th>PERFORM DRAINAGE?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimal effusion: &lt;10 mm on lateral decubitus radiograph No loculations</td>
<td>Unknown culture and Gram stain results</td>
<td>Unknown pH</td>
<td>No</td>
</tr>
<tr>
<td>Small to moderate effusion: &gt;10 mm but &lt;½ the hemithorax on lateral decubitus radiograph No loculations</td>
<td>Negative culture and Gram stain results</td>
<td>pH &gt; 7.20</td>
<td>No</td>
</tr>
<tr>
<td>Large effusion: &gt;½ the hemithorax or associated loculations or pleural thickening</td>
<td>Positive culture or Gram stain results</td>
<td>pH &lt; 7.20</td>
<td>Yes</td>
</tr>
<tr>
<td>Other</td>
<td>Purulent</td>
<td>pH &lt; 7.0</td>
<td>Yes</td>
</tr>
</tbody>
</table>
the posterior infrascapular line by either clinical examination (auscultation and percussion) or bedside ultrasonography. Ultrasonography is recommended because it identifies not only the level of effusion but also the subdiaphragmatic organs that should be avoided and the depth of the fluid pocket. As the angiocatheter is advanced, the neurovascular bundles located on the inferior aspect of the ribs should be avoided. Aspiration of fluid can continue until enough fluid is obtained for diagnostic purposes or therapeutic relief.

Needle thoracentesis is adequate for both diagnostic evaluation and therapeutic management of most parapneumonic pleural effusions. When the effusion has progressed to the fibrinopurulent or organizational stage, needle thoracentesis is often inadequate. Thoracoscopy offers the advantages of visual evaluation of the pleura, direct tissue sampling, and therapeutic intervention such as dissecting loculations and pleurodesis. Appropriate consultation for medical thoracoscopy and video-assisted thoracoscopy is indicated in these circumstances.

### CONTRAINDICATIONS

Procedural contraindications to pleurocentesis or thoracoscopy are listed in Box 52.5. Absolute contraindications include coagulopathy, known adhesions, and a history of pleurodesis. If the patient is symptomatic and coagulopathic, correction of coagulopathy and ultrasonographic guidance are recommended to minimize bleeding risks. Pleurodesis, or the chest cavity that causes the pleurae to adhere to each other and prevents or reduces further accumulation of pleural fluid. Thoracentesis should be avoided in patients at increased risk for adverse reactions as a result of unstable angina or arrhythmia or known medical noncompliance, including lack of established outpatient care. Relative contraindications include mechanical ventilation because of an increased risk for lung collapse and difficulty with positioning. In intubated patients, use of ultrasonography or CT for thoracentesis or postponing the procedure is recommended if the indication is not urgent. Patients with known bullous lung disease are at increased risk for postprocedural pneumothorax. Placement of the thoracentesis needle through a concurrent chest wall infection should be avoided because the pleural space may become seeded. A postprocedure radiograph should always be obtained to assess for pneumothorax.

### DOCUMENTATION

Identify the size and location of the effusion.
Consider the cause and duration of the effusion.
Discuss the appropriate intervention and associated risks.
Assess respiratory function before and after any intervention.
Document repeated physical examination and vital signs during the postprocedural period.
Ensure appropriate outpatient follow-up or inpatient evaluation.

### BOX 52.5 Contraindications to Thoracentesis

**Absolute Contraindications**
- Adhesions, pleurodesis
- Coagulopathy
- Dysrhythmia
- Known medical noncompliance or lack of established outpatient care

**Relative Contraindications**
- Bullous disease
- Concurrent chest wall infection
- Mechanical ventilation

### COMPLICATIONS

Adverse outcomes associated with pleural effusions can be characterized as iatrogenic or pathologic. Thoracentesis can predispose patients to pneumothorax, acute RPE, shock, subsequent fluid reaccumulation, bleeding, infection, and solid organ injury. If untreated, the parapneumonic effusion can progress to fibrinopurulent empyema, which frequently requires surgical intervention.

If the patient complains of increasing respiratory distress within the first hour after thoracentesis, RPE or pneumothorax may be occurring, and an emergency chest radiograph should be obtained. RPE is a syndrome associated with hypotension and hypoxemia. It is thought to be a result of combined alveolar-capillary membrane disruption initiated by distention, reperfusion-mediated injury, and increased pulmonary flow. Risk factors include previous atelectasis and rapid reexpansion of the lung parenchyma. Typically, a patient with significant RPE becomes symptomatic within 15 minutes to 2 hours after rapid reexpansion of the lung. Treatment is based on adequate oxygenation and circulation, generally with positive end-expiratory pressure. Concern about the potential for RPE after thoracentesis is important because mortality in patients with this condition is consistently 15% to 20% despite mechanical ventilation.

### FOLLOW-UP, NEXT STEPS IN CARE, AND PATIENT EDUCATION

In many cases, small pleural effusions are identified during evaluation of the patient’s chief complaint. Although not all effusions require immediate drainage, when thoracentesis is performed, stable patients with a clear etiology and well-established care plan may be discharged after an appropriate observation period of 3 to 6 hours. Patients with large-volume evacuation or exudative effusions or those who require further evaluation and stabilization should be admitted to the hospital.

Close outpatient follow-up and management are required for all patients evaluated for pleural effusion, regardless of whether they underwent thoracentesis, to further address the underlying cause and monitor the effusion.
PATIENT TEACHING TIPS

Pleural effusions represent an underlying disease process that must be addressed. Possible complications of pleural effusions include pneumothorax, respiratory failure secondary to massive fluid reaccumulation, septicemia, bronchopleural fistula, and pleural thickening. Follow-up is recommended for all patients undergoing thoracentesis. Some experts recommend serial chest radiographs to ensure clearing. Some perform computed tomography after plain radiographs show clearing.

TIPS AND TRICKS

Establish bedside ultrasonography as part of assessment for pleural effusions. Consider pulmonary embolism with an uncertain pleural effusion etiology. Ultrasound-guided thoracentesis enhances visualization and minimizes complications. Complicated pleural effusions may require surgical intervention. “Two-test” and “three-test” rules for pleural fluid analysis exist but are not as specific as the Light criteria.

SUGGESTED READINGS


REFERENCES

References can be found on Expert Consult @ www.expertconsult.com.
REFERENCES