pleural effusions typically reaccumulate, the majority of patients will require a pleurodesis.

See also: Interstitial Lung Disease: Lymphangioleiomyomatosis. Pleural Effusions: Overview; Pleural Fluid Analysis, Thoracentesis, Biopsy and Chest Tube.

Further Reading


Hemothorax

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Abstract

Hemothorax is a collection of bloody fluid in the pleural space with a hematocrit at least 50% of the peripheral blood. Hemothorax is most commonly caused by trauma and rarely due to malignancy or pulmonary embolism. Hemothoraces are commonly encountered in clinical practice and may need to be drained depending on their size and effect on gas exchange. Diagnosis hinges on the clinical setting and confirmation by pleural fluid analysis. Apposition of the parietal and visceral pleura by drainage may arrest intrapleural bleeding via tamponade. Thoracoscopy and thoracotomy may be required if drainage alone is unsuccessful. The pathogenesis of large hemothoraces can involve progressive organization and fibrosis leading to lung restriction, arguing for the removal of this fibrotic encasement. Intrapleural thrombolytic therapy is an alternative approach to address organizing hemothoraces.

The pleural space is a potential compartment that separates the lung from the ribcage, the diaphragm, and mediastinum. It is lined by the parietal and visceral pleura and normally contains a thin layer of fluid measuring approximately 5–15 ml. A hemothorax is typically a bloody exudative effusion. Laennec first described spontaneous hemothorax in 1819. A pleural fluid hematocrit representing greater than 50% of the peripheral hematocrit defines the presence of a hemothorax. Blood-tinged pleural fluids containing lesser amounts are termed hemorrhagic effusions.
Etiology

The most common cause of hemothorax is trauma. Malignancies including malignant mesothelioma and pulmonary embolism cause hemothoraces less commonly. Rare causes include bleeding diatheses, catamenial hemopneumothorax, aortic dissection, post-cardiac injury syndrome (PCIS), benign asbestos pleural effusion (BAPE), and uremia. Trauma may be penetrating or nonpenetrating. A fractured rib may lacerate the pulmonary parenchyma and lacerate vessels from the pulmonary or bronchial circulation. Laceration of the subclavian vessels during central line placement or of the intercostal vessels during thoracentesis may be iatrogenic causes of hemothorax. Lung and breast cancer along with lymphoma constitute the most common causes of a malignant effusion and may be associated with hemothorax. Pulmonary embolism must be considered in any effusion, including hemothorax, where the cause is unclear. Hemothorax present for more than 1 year is unlikely to be malignant. It may be due to recurrent embolism or a rare cause of hemothorax.

Pathology

The pathologic hallmark of hemothorax is the presence of blood in the pleural space. Blood that enters the pleural space may be diluted by pleural fluid that is already present or results due to exudative pleuritis, which can decrease the pleural fluid hematocrit. Over the course of days, such collections may clot, organize, and ultimately remodel with scar formation.

Clinical Features

Clinical presentation may be due to the presence of an effusion, blood loss into the pleural space, or reflect the etiology of the hemothorax. Symptoms due to effusion are detailed in Pleural Effusions: Overview. Patients may be asymptomatic, but most present with chest pain, cough, or shortness of breath. The quality of pain may be pleuritic. Pain may be referred to the ipsilateral shoulder if the diaphragmatic pleura on the same side is involved. Cough is usually nonproductive and attributable to reflex stimulation of receptors in the atelectatic lung segments. Shortness of breath depends on the volume of effusion and the presence of underlying lung or cardiovascular disease. Fever may occur due to embolism, malignancy, infection of a hemothorax, or underlying pneumonia. PCIS occurs with recent cardiac surgery and presents with fever, dyspnea, and chest pain. Catamenial hemothorax is usually right sided and occurs during menses. Patients with a bleeding diathesis may bleed from other sites.

A history of trauma or a thoracic procedure is of diagnostic importance, as is that of underlying malignancy. In particular, malignant mesothelioma should be considered with a history of remote, more than 20 years previous, asbestos exposure. In the first two decades after exposure, the most common entity attributable to asbestos is BAPE. Patients with pulmonary embolism may present with pleuritic pain and dyspnea that is out of proportion to the volume of the effusion. Blood loss may be associated with dizziness and fatigue. Pneumonias are a rare cause of hemothorax. Hemothorax is rarely associated with inhalational anthrax, tuberculosis, tularemia, plague, and other pneumonias, especially if associated with dissemination and in an immunocompromised host.

On examination, the patient may be tachycardic or tachypneic, depending on the volume of the hemothorax. Extensive blood loss may cause orthostasis and shock. Hemolysis of the lost blood may cause jaundice. The trachea may be shifted to the contralateral side in the presence of a large hemothorax. Breath sounds and vocal resonance will be diminished on auscultation. Patients with trauma may have a flail chest. Patients with malignancy may have cachexia, clubbing, or lymphadenopathy. PCIS may be associated with a pleuropericardial rub if the effusion is small.

On chest X-ray, hemothorax, if not loculated, will obliterate the posterior and lateral costophrenic angles with approximately 200 and 500 ml collection of fluid, respectively. Larger effusions may shift the mediastinum to the contralateral side. If the mediastinum does not shift, then one should suspect fixation due to carcinoma or atelectasis of the underlying lung. Smaller amounts of fluid may be detected on a lateral decubitus radiograph. Chest trauma may be associated with a fractured rib, pneumothorax, pneumomediastinum, pulmonary contusion, or subcutaneous emphysema. Hemothorax from pulmonary embolism is usually small and seen on the initial radiograph. Hemothorax associated with malignancy may occur with radiographic evidence of a mass, adenopathy, bronchial obstruction, or atelectasis. Patients with hemothorax and malignant mesothelioma may exhibit pleural thickening or the radiographic suggestion of lung encasement in association with hemothorax.

A computed tomography (CT) scan of the chest will delineate the previously mentioned radiographic features in three dimensions and at a higher resolution. Contrast will enhance hemothoraces in a CT scan. Magnetic resonance imaging may likewise indicate the presence of blood. Ultrasound of the thorax can be used to localize, quantitate, and show loculation of a hemothorax. Laboratory evaluation may reveal the presence of anemia, suggestion of a bleeding diathesis.
on coagulation profile, or other findings referable to the specific underlying cause of the hemothorax.

Pathogenesis

Traumatic hemothorax is associated with vascular disruption. Hemothorax in malignancy may be due to tumor invasion into blood vessels and increased vascular permeability. Hemorrhage in embolism is due to ischemia of the visceral pleura that is likewise associated with increased vascular permeability and red cell diapedesis. PCIS is an immunological response to trauma or infarction of the myopericardium. Catamenial hemothorax occurs from ectopically situated endometrial tissue in the pleural space that ‘hemorrhages’ during menses. Hemothoraces that are sizeable and persist in the pleural space can organize. In this process, the intrathoracic blood clots. The coagulum forms a transitional neomatrix that is invaded by inflammatory cells and fibroblasts in a process that recapitulates wound healing. Ultimately, formation of mature scar tissue can occur, leading to clinical sequelae attributable to restriction of the underlying lung (Figure 1).

Animal Models

Diverse models of pleural effusion have been used to determine the volume of pleural fluid that is amenable to detection by various radiological techniques. A swine model of penetrating trauma has evaluated the efficacy of different aspiration systems for evacuating a hemothorax.

Management and Current Therapy

Diagnosis of a hemothorax is usually established by thoracentesis. Ultrasound or CT guidance may be obtained for thoracentesis, especially if the fluid is loculated. Because hemothorax is exudative, the lactate dehydrogenase and protein content is elevated in pleural fluid. A reddish tint by itself has no diagnostic significance, but at counts of 100,000 red cells per milliliter the fluid is frankly hemorrhagic. Pleural fluid, which is bloody but then clears, is due to a traumatic thoracentesis. Fluid from a traumatic tap will clot immediately and will have a clear supernatant. The supernatant will be reddish in a hemothorax if there has been time for hemolysis to occur. Bloody pleural aspirates should be submitted for hematocrit estimation. Pleural fluid hematocrit < 1% is a non-specific finding. Hematocrit between 1 and 25% of the hematocrit of peripheral blood is consistent with trauma, embolism, or malignancy. Pleural fluid hematocrit is at least 50% of the peripheral blood in a hemothorax. A hemorrhagic effusion in the absence of trauma should heighten the suspicion for malignancy. However, a pleural fluid hematocrit > 50% of the peripheral hematocrit is unusual in malignancies. Hematocrit similar to peripheral blood is consistent with trauma.

Treatment of a hemothorax depends largely on its etiology (Figure 2). Patients with a large hemothorax, especially after trauma, may be unstable and require resuscitation. It is not mandatory that a hemothorax be evacuated because blood is usually reabsorbed from the pleural space. However, tube thoracostomy is indicated if intrathoracic bleeding is 1.5 liter per day; 100–200 ml h⁻¹ for 12 h; necessitates blood transfusion or causes hemodynamic instability. Chest tube drainage helps quantitation of the bleeding and allows the parietal and visceral layers of the pleura to approximate and tamponade the bleeding site. Tamponade by approximation of the lung with the chest wall following pleural drainage of blood may be useful, especially with bleeding from the bronchial or intercostal vessels under systemic pressure. The hematocrit is monitored serially and blood transfused depending on the severity of blood loss and the accompanying hemodynamic status. Blood from the pleural space in nonpenetrating trauma may be autotransfused. Stable hemothoraces may be monitored or aspirated depending on the clinical scenario and may need tube placement only when there is nonresolution or suspicion of pleural infection. In approximately 10% of trauma patients, there will be increasing opacification of the hemithorax at 48 h. CT scan will help to resolve whether the opacification is due to parenchymal contusion, clotted blood in the pleural space, or fibrothorax. Thoracoscopic or thoracotomy may be needed to control bleeding in an acute setting. In a subacute setting, thoracoscopy is performed when there is 500 ml of clotted blood or opacification of one-third of the hemithorax or fibrin encasement. Angiographic embolization of both the bronchial and the intercostal circulation has been achieved in certain centers, especially in patients who are not surgical candidates. Thoracotomy is undertaken if there is bronchial disruption, failure of thoracoscopy to contain the bleeder, bleeders are located near the central portions of the lung or in the

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**Figure 1** Pathogenesis of fibrothorax.
mediastinum, or failure of tube thoracotomy to adequately drain the pleural space and re-expand the lung. Thoracoscopy obviates the need for thoracotomy in 60% of patients. Adequate drainage of large hemothoraces is essential to prevent development of a fibrothorax. Thrombolytic therapy has been used to clear large organizing hemothoraces but should not be used in the setting of known or recent intrapleural hemorrhage or in the presence of other contraindications to the use of thrombolytic therapy, as described in the American Heart Association’s Advanced Cardiac Life Support guidelines. Mortality and length of stay in the intensive care unit and ventilator time increase with delayed evacuation of hemothorax and formation of fibrothorax or empyema.

In selected circumstances, caveats apply. In patients with hemothorax and malignancy, radiation to the hemithorax usually is contraindicated and chemotherapy is usually not very effective. Hemothorax associated with embolism is not a contraindication for anticoagulation. The hemothorax usually resolves spontaneously but can persist beyond 10 days when associated with pulmonary infarction. Recurrence of effusion in an embolism usually suggests re-embolization, an alternative diagnosis, or hemorrhage due to anticoagulation. If the hemothorax increases in size and the hematocrit is more than 50% that of the peripheral blood, then bleeding is likely due to anticoagulation. Anticoagulation should then be discontinued and chest tube drainage instituted.

An infected hemothorax is treated by drainage and antibiotics. Catamenial hemothorax is treated with hormonal manipulation. PCIS is usually self-limited and may be treated with aspirin or nonsteroidal

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**Figure 2**  Treatment of hemothorax.
anti-inflammatory drugs. If the effusion is large and causes dyspnea, then it must be evacuated. Steroids may be added to limit inflammation and preclude graft occlusion.

See also: Mesothelioma, Malignant. Pleural Effusions: Overview; Pleural Fluid, Transudate and Exudate; Pleural Fluid Analysis, Thoracentesis, Biopsy, and Chest Tube; Malignant Pleural Effusions; Postsurgical Effusions; Pleural Fibrosis. Pulmonary Thromboembolism: Pulmonary Emboli and Pulmonary Infarcts.

Further Reading


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Abstract

The pleural cavity consists of a double-layered membrane lining the inside of the thoracic cavity (parietal pleura) and the outside of the lung surface (visceral pleura). Each pleural membrane consists of a layer of mesothelial cells lined with a brush border of microvilli, and several noncellular layers. The structure of the mesothelial cell and the noncellular layers are variable according to the underlying tissue and the amount of movement of the chest wall. Absorption of pleural fluid occurs via the parietal pleura through direct communications (stomata) between the pleural space and a complex underlying lymphatic network. These allow passage of large molecules, including cells, between the pleural space and the systemic circulation via the parietal lymphatics. A constant layer of pleural fluid is maintained between the visceral and parietal pleura, allowing smooth lung movement and elasticity within the thoracic cage. Fluid may accumulate within the pleural space in pathologic states via a variety of mechanisms which either increase production of pleural fluid or decrease its absorption, or both. Air may enter the pleural space (pneumothorax) from the lung via rupture of blebs through the visceral pleura; or from outside the chest cavity when the pleural space is penetrated accidentally or iatrogenically. The mesothelial cell is multipotent and is the predominant cell type in the pleural cavity. In the normal state, there are few leukocytes in the pleural cavity, but inflammatory cells can be recruited efficiently during pleural inflammation or infection. Cancer cells can invade the pleura and often lead to increased vascular permeability and accumulation of malignant effusions.

Anatomy, Histology, and Structure

Introduction

The pleura is an intriguing tissue with significant interspecies variation: its precise structure and function is not fully understood. In humans the pleural cavities are separated by the mediastinum. Many other species, such as the mouse, do not have a complete mediastinal separation such that fluid and air can freely move between the left and right pleural cavities. Some large animals such as the bison (American buffalo) are also known to have a single pleural cavity.

On the other hand, the elephant does not have a pleural cavity. While the fetal elephant has a normal pleural space, in late gestation a sheet of dense connective tissue replaces the parietal pleura and the two pleural membranes are separated by loose connective tissue that allows sliding of the lung over the chest wall. Such variations in the pleural structure in different species have not been explained.

This article describes the anatomy and function of the pleural cavity in humans.