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Pleural Effusions in the Pediatric Population

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Objectives After completing this article, readers should be able to:

1. Describe the anatomic pleural cavity.
2. Delineate the most likely causes for pediatric pleural effusions.
3. Distinguish between exudate and transudate.
4. Describe the diagnostic radiographic and laboratory examinations for pleural effusions.
5. Describe the management of parapneumonic effusion.
6. Describe other types of pleural effusions.

Introduction

Pleural effusions (liquid in the pleural space), which occur less frequently in children than in adults, can be caused by a variety of infectious and noninfectious diseases. Most of the information about pleural effusions is derived from adult studies. Causes of pleural effusions in children differ significantly from those in adults. Among adults, the most frequent cause is congestive heart failure (transudate), and bacterial pneumonia and malignancy are the most frequent causes of exudate. Pleural effusions in children most commonly are infectious (50% to 70% parapneumonic effusion); congestive heart failure is a less frequent cause (5% to 15%), and malignancy is a rare cause.

Parapneumonic effusion is defined as fluid in the pleural space in the presence of pneumonia, lung abscess, or bronchiectasis. Nontuberculous bacterial pneumonia constitutes the most frequent origin of pleural effusion in children. Establishing a specific causative agent depends on the patient's age, underlying disease, standard of laboratory culture method, and initiation of antibiotic therapy. *Staphylococcus aureus* is the single most common pathogen causing empyema (29% to 35% of cases), especially among infants younger than 2 years of age. *Streptococcus pneumoniae* is the cause in up to 25% of cases of empyema. *Haemophilus influenzae* is a less frequent pathogen but still is significant in the development of parapneumonic effusion in children up to 5 years of age. Group A streptococci have re-emerged as significant agents causing empyema in later childhood. Anaerobic pulmonary infection is uncommon, and more than 90% of affected patients manifest periodontal infections, altered consciousness, and dysphagia. The most important anaerobic bacteria are microaerophilic streptococci, *Fusobacterium nucleatum*, and *Bacteroides melaninogenicus*.

Anatomy and Physiology

The pleural space is a potential space (10 to 24 mm wide) that is defined by parietal and visceral pleura. The parietal pleura covers the inner aspect of the chest wall and the diaphragm. The visceral pleura is strongly adherent to the surface of the lungs and the interlobar fissures. A thin film of liquid separates the two surfaces. The surface of the parietal pleura contains stoma (minute apertures) that have a caudal distribution. The presence of sensory innervations (ie, pain) distinguishes the parietal from the visceral pleura. The pleural membranes are permeable to liquid, and normally a small amount (10 mL) of sterile, colorless liquid prevents contact and friction between the two pleural surfaces. Normal pleural fluid has a pH level similar to that of blood and a protein level of 1.5 g/dL (15 g/L). The pleural cavity fluid represents equilibrium between fluid formation (filtration) and removal (absorption). Liquid movement between the vascular compartment and the pleural space is controlled by the Starling principle:

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$$Q_v = K_f[(P_c - P_{is}) - (\pi_{pi} - \pi_{is})]$$

In which Q_v represents the rate of liquid movement per capillary surface area, K_f represents the capillary filtration coefficient, P_c represents the capillary hydrostatic pressure, P_{is} represents the hydrostatic pressure in interstitial space (equivalent to intrapleural pressure), π_{pi} represents plasma oncotic pressure, and π_{is} represents interstitial space oncotic pressure.

Generally, there is a net liquid absorption from the pleural space because absorption pressure is slightly greater than filtration pressure. The parietal pleura plays a vital role in clearing excess pleural fluid. This ability, which can increase up to 30 times, is crucial to prevent fluid accumulation.

Normal pleural space is free of air because of the difference between total gas pressure in the venous system and the pleural space. The partial pressures of the gases in the venous blood at sea level are: PO_2 , 40 mm Hg; PCO_2 , 40 mm Hg; PN_2 , 573 mm Hg; and PH_2O , 47 mm Hg. The sum of these is 706 mm Hg, which is 54 mm Hg (73 cm H_2O) less than atmospheric pressure. The intrapleural pressure at resting lung volume is 5 cm H_2O atmospheric pressure. Therefore, the pressure gradient is 68 cm H_2O , which favors continuing absorption of gas from the pleural space into the circulation and keeps the pleural space totally free of gas.

Pathophysiology of Pleural Fluid Accumulation

Fluid accumulates in the pleural cavity whenever filtration exceeds the removal mechanism and may be the result of increased filtration associated with impaired absorption or of normal filtration associated with inadequate removal. This disequilibrium may be due to disturbances in Starling forces that govern filtration and absorption, alterations in lymphatic drainage, or both. Altered Starling forces can be due to:

- Increased capillary permeability (K_f), as seen with pleuropulmonary infection, systemic lupus erythematosus, circulating toxin, or tumors.
- Increased capillary hydrostatic pressure (P_c), as in congestive heart failure or pericarditis.
- Decreased hydrostatic or interstitial space pressure (P_{is}), as in postthoracentesis or trapped lung.
- Decreased plasma oncotic pressure (π_{pi}), as in the hypoalbuminemic state, nephrosis, and hepatic cirrhosis.
- Increased oncotic pressure of interstitial space (π_{is}), as in pulmonary infarction.

Table 1. Common Causes of Pleural Effusions in the Pediatric Population

Cause	Incidence
Pneumonia (parapneumonic effusion)	50% to 70%
Renal disease	9%
Trauma	7%
Viral disease	7%
Malignancy	5% to 10%
Congenital heart disease	5% to 11%
Others (liver failure, sickle cell anemia, meningitis)	3%

Pleural fluid accumulates if lymphatic channels cannot provide adequate drainage, as in fibrosis of the parietal pleura (eg, tuberculosis), mediastinal lymphadenopathy, or obstruction of the thoracic duct or hypoplastic lymphatic channels (eg, pulmonary lymphangiectasis).

In children, parapneumonic effusion due to subpleural infectious pneumonia is the most common cause of pleural effusion (Table 1). There are three stages associated with parapneumonic effusion that may overlap:

- *Exudative stage (stage of uncomplicated effusion)*. Airway and parenchymal infection may follow aspiration of the microorganism into subpleural alveoli, which causes migration and adherence of polymorphonuclear neutrophils (PMNs) to the adjacent endothelium. Oxygen metabolites and products of activated PMNs cause endothelial injury of subpleural and pleural vessels and increase capillary permeability. The leaking protein-rich fluid increases interstitial pressure, resulting in a gradient that drives fluid from the interstitium into the pleural space. The parapneumonic fluid initially tends to be a small volume of sterile, PMN-predominant exudate. The pleural chemistry is normal.
- *Fibropurulent stage (second or bacterial invasive stage)*. If the pneumonia remains untreated, endothelial injury becomes more pronounced, and pleural fluid formation increases. Bacteria continue to multiply and invade the pleural space. This stage is characterized by increased numbers of PMNs and a decrease in the glucose level (increased glycolysis by PMNs and bacterial metabolism). Because the end products of glucose metabolism are carbon dioxide and lactic acid, their accumulation in the pleural space leads to a decrease in pH. The lactic dehydrogenase (LDH) level increases, often to more than 1,000 U/L, due to lysis of PMNs

(complicated effusion) and increased levels of interleukin-8, a major chemotactic factor of PMNs. In this stage, the pleural fluid is clottable because blood procoagulants may move in the space and fibrinolytic activity may be lost due to mesothelial injury. This process increases deposition of fibrin layers on pleural surfaces. Fibroblasts move into the pleural space and begin to secrete collagen. Both fibrin and collagen compartmentalize the pleural fluid into loculations by bridging the two pleural surfaces. Without therapy, the third stage ensues.

- *Stage of organization (third stage of empyema)*. Empyema fluid is a thick, purulent coagulum whose specific character is due to the coagulability of pleural fluid, the abundance of cellular debris (bacteria and PMNs), increased fibrin, and collagen deposition. The resultant inelastic pleural “peel” impairs pleural fluid drainage and inhibits lung expansion. Untreated empyema may drain through the chest wall (empyema necessitatis) or into the lung (bronchopleural fistula). The incidence of sterile empyema has increased because of effective antibiotic therapy prior to thoracentesis.

Functional Pathology

The degree of dysfunction due to pleural effusion depends on the rapidity of its development, quantity of pleural fluid, nature of the underlying disorder, and status of cardiopulmonary reserve. The usual result of pleural effusion is limited lung inflation and a resultant decrease in vital capacity. Pleurisy (pain on inspiration with subsequent shallow breaths) may evolve early in the course of pleural effusion. The decreased tidal volume is associated with an increased dead space/tidal volume ratio that can lead to hypoxemia and hypercapnea. Pleural fluid also may distort the chest wall, causing it to bulge outward and displace the ipsilateral hemidiaphragm downward. Rarely, a large pleural effusion may produce mediastinal shift, decreased venous return, and compromised cardiac output.

Clinical Manifestations

Respiratory symptoms in the presence of fluid in the pleural space are common in children. When the underlying cause is pneumonia, the predominant symptoms are cough, fever, chills, and dyspnea. If the effusion is not associated with pneumonia, the child may be asymptomatic until the effusion becomes sufficiently large to cause dyspnea or orthopnea. Children who have neurologic impairments are more likely to aspirate secretions or gastric content and develop anaerobic infections, which cause a more insidious onset of pneumonia and effusion.



Figure 1. Posteroanterior chest radiograph showing accumulation of pleural effusion in the right hemithorax.

Older children may complain of a sharp pleuritic pain with inspiration or cough, which is due to stretching of the parietal pleura. As the effusion increases and separates the pleural membranes, pleuritic pain becomes a dull ache and disappears. Specific signs indicating pleural effusion are much more difficult to elicit in the infant or the young child. Dullness to percussion and decreased breath sounds over the affected area almost always are present, but they can be difficult to perceive if the effusion is small. In infants, breath sounds from one lung often are transmitted throughout the chest, making unilateral findings difficult to appreciate. A pleural rub, due to roughened pleural surfaces, can be present in the early phase, but it disappears as fluid accumulates. Decreased vocal fremitus and fullness of the intercostal spaces can be detected. Expectoration of purulent sputum may herald the onset of bronchopleural fistula and ensuing pyopneumothorax. Findings of chest wall abscess and costal chondritis indicate extension of the process (ie, empyema necessitatis). Decreased heart tones and pericardial rub indicate extension to the pericardium.

Imaging of the Pleural Space

Chest radiography in the posteroanterior position is the primary tool for diagnosing pleural effusion (Fig. 1). Obliteration of the costophrenic sinus is the earliest diagnostic sign of the effusion (in adults, at least 200 mL of fluid must be present). Because the posteroanterior view may be inadequate, a lateral decubitus film may provide information about the quality and the quantity (as little as 50 mL) of the effusion, allowing evaluation of the underlying parenchyma. Thin and mobile fluid “layers

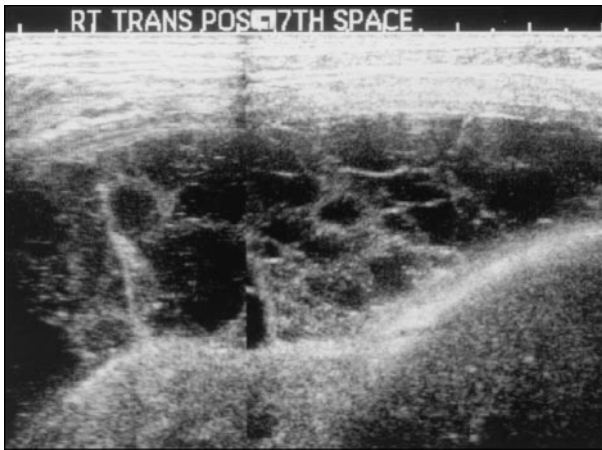


Figure 2. Ultrasonography of the pleura showing organized pleural fluid with multiple septae.

out” on the dependent side. A decubitus film demonstrating more than 10 mm of fluid between the inside of the chest wall and the lung indicates an effusion of sufficient volume for thoracentesis. Failure of liquid to shift in the decubitus view indicates loculation.

Ultrasonography can differentiate pleural thickening from effusion, detect the amount of fluid, and allow distinction between nonaerated lung and pleural fluid (Fig. 2). It helps to identify the best site for thoracentesis or insertion of a thoracostomy tube, detects loculations, and can determine the quality of the effusion. Multiple echogenic foci on ultrasonography indicate exudate or empyema. Differentiation of solid mass from echogenic pleural fluid is apparent by variation of the latter with breaths.

Computed tomography (CT) is extremely helpful in evaluating the pleura and underlying parenchyma (Fig. 3). Pleural thickening, a mass, or a foreign body is readily apparent. It is also useful for assessing the location and volume of fluid and lung parenchyma (pneumonia, bronchiectasis, abscess, or pneumatocele, especially in the chest that has opacified hemithorax). Magnetic resonance imaging has no advantage over CT in evaluating pleural disorders.

Examination of Pleural Fluid

Evaluation of liquid by thoracentesis may confirm the clinical and radiological diagnosis of effusion. In adults, thoracentesis should be performed in every patient who has a moderate-to-large effusion, but not every child requires the procedure. Small parapneumonic effusions associated with minimal blunting of the costophrenic angle should not receive thoracentesis. Thoracentesis or

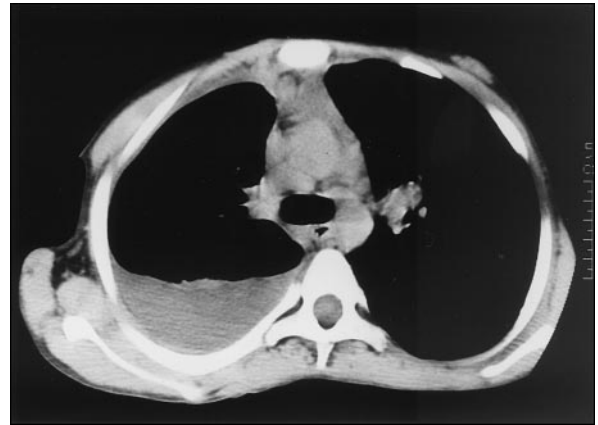


Figure 3. Chest computed tomography showing accumulation of dependent pleural fluid in the right hemithorax.

chest tube drainage is recommended in children who have persistent fever, toxicity, specific organisms (eg, *S aureus* or pneumococcus), respiratory compromise, a mediastinal shift, pleuritic pain, underlying disease, respiratory difficulty, or a defined pleural meniscus line above the diaphragm at about 25% of the lung field or higher that appears to shift freely on lateral decubitus films. Chest tube drainage is appropriate when the fluid examination after thoracentesis demonstrates a pH less than 7.2, a glucose level less than 40 mg/dL (2.2 mmol/L), and an LDH level more than 1,000 U/mL.

There is no absolute contraindication for thoracentesis in children, although minimal fluid, a bleeding diathesis, the use of anticoagulants, and mechanical ventilation are considered relative contraindications.

The gross appearance of the liquid may provide a clue to the cause of the effusion. Pale yellow liquid suggests a transudate; milky white opalescent liquid implies the presence of chyle. Bloody fluid suggests vascular erosion from malignancy, trauma, or lung infection. A purulent specimen indicates bacterial infection of the pleura. Chocolate brown fluid suggests amebiasis. Anaerobic pleural infection has a characteristic putrid odor. Blood in the effusion due to thoracentesis tends to vary in intensity during the procedure. Platelets may be present in fluid from traumatic thoracentesis. Hemothorax is present if the hematocrit of the pleural fluid is more than 50% of the peripheral blood hematocrit.

The number and type of white blood cells (WBCs) in the pleural fluid assist in determining the cause of the effusion. Lymphocytes, macrophages, and monocytes predominate in the transudate. Lymphocytes also are seen commonly in lymphoma, tuberculosis, chronic rheumatoid arthritis, chylothorax, and yellow nail syn-

Table 2. Chemical Separation of Transudate and Exudate*

Type of Effusion	Pleural Liquid Concentration		Pleural/Serum Concentration Ratio		pH level
	Protein	LDH	Protein	LDH	
Transudate	<3 g/dL	<2/3	<0.5	<0.6	>7.45
Exudate	≥3 g/dL	>2/3	≥0.5	≥0.6	<7.3

* Pleural lactate dehydrogenase (LDH) levels should be less than two times the upper level of serum LDH.

drome. The concentration of WBCs in parapneumonic effusion (empyema), acute pancreatitis, and lupus pleuritis usually is greater than 10,000 U/L, with PMNs predominating.

Eosinophils that comprise greater than 10% of the fluid usually result from pleural injury, recent hemothorax or pneumothorax, pulmonary infarction, or parasitic or fungal infection.

Transudate Versus Exudate

Pleural fluid was classified into transudate and exudate according to criteria developed and tested in adults; no studies have confirmed these results in children. The classification can be valuable because certain diseases produce transudate almost exclusively (eg, congestive heart failure); others produce exudate (eg, pleural infection). However, the parameters of classification are not as reliable in differentiating between transudate and exudate in children. Generally, transudate occurs when the mechanical forces of the hydrostatic and oncotic pressures favor liquid filtration in excess of absorption and do not involve the pleural surface directly. In contrast, exudate results either from inflammatory disease that affects the pleural surface or from impaired lymphatic drainage.

Exudate has at least one of the following features (Table 2):

- Pleural fluid/serum protein ratio of 0.5 or greater
- Pleural liquid LDH greater than the upper limit of the normal serum level or pleural liquid/serum LDH ratio greater than 0.6
- Pleural liquid protein concentration more than 3 g/dL (30 g/L)

Pleural fluid pH is considered the most accurate test for determining if a parapneumonic effusion is an empyema, exudate, or transudate. A pH less than 7.3 occurs in the presence of increased carbon dioxide production (eg, infection, acid leak into the pleural space [esophageal rupture], or decrease in normal hydrogen transport from the pleural space in pleuritis). A pH of greater than 7.45

or greater than the blood pH generally is consistent with a transudate.

A pleural fluid glucose level less than 50% of blood values or less than 40 mg/dL (2.2 mmol/L) may be seen in empyema, tuberculosis, lupus pleuritis, rheumatoid arthritis, malignancy, and esophageal rupture. Pleuritis due to collagen vascular disease can be evaluated by specific tests, such as antinuclear antibody or rheumatoid factor.

Pleural Biopsy

Biopsy is indicated for patients in whom the inflammatory pleural effusion is unexplained. This technique has a limited role in pediatrics, but can be of great importance in ruling out tuberculosis or malignancy. The major complications are pneumothorax and bleeding.

Management of Parapneumonic Effusion and Empyema

Conservative Therapy

Most pediatric patients who have uncomplicated parapneumonic effusion respond well to appropriate antibiotic therapy and do not require tube thoracostomy. The treatment of empyema (complicated parapneumonic effusion) in children begins with conservative therapy. The initial treatment is administration of antibiotics directed at the underlying infection and drainage of infected fluid by thoracentesis or by closed thoracostomy tube. Antibiotics should be selected (Table 3) to cover the most common pathogens for pneumonia for the child's age group. Until the condition is diagnosed, broad-spectrum antibiotics are warranted due to the high morbidity and mortality associated with empyema. Intravenous antibiotics should be continued until the child is afebrile for at least 7 to 10 days, has been weaned from supplemental oxygen, and no longer appears ill. Oral antibiotics subsequently are administered for 1 to 3 weeks.

Prompt drainage of the empyema prevents the development of loculation and fibrous peel. Further, at the second stage of disease, tube drainage becomes less ef-

fective. Whether all empyemas require drainage remains controversial; no data in children clearly establish criteria. Generally, immediate closed-tube thoracostomy should be considered strongly with the following:

- Pleural fluid pH is less than 7.2 or more than 0.05 units below the arterial pH
- Pleural fluid glucose is less than 40 mg/dL (2.2 mmol/L)
- Pleural fluid LDH is greater than 1,000 U/L
- Presence of frank pus
- Positive Gram stain
- Sepsis due to *S aureus* or *H influenzae*

When the chest tube drainage reaches less than 30 to 50 mL/d and the patient's constitutional symptoms improve, the chest tube may be removed. Treatment of loculated parapneumonic effusion (especially stage 2 and 3) or for children who remain febrile, distressed, and anorexic after several days of intravenous antibiotic therapy varies considerably. Failure of tube thoracostomy to drain is related to the loculation and the viscosity of the pleural fluid.

Another effective therapy is introduction of streptokinase (SK) or urokinase (UK) into the empyema cavity, which has been shown to lyse adhesions, enhance drainage, and resolve the symptoms. SK is a bacteria-derived protein that indirectly activates the fibrinolytic system. Problems associated with this regimen include allergic reactions and antibody neutralization of the SK. UK is a direct plasminogen activator. Unlike SK, there is a one-to-one relationship of plasmin production for each molecule of UK, making more efficient use of pre-existing plasminogen. UK is not antigenic. Studies have documented complete resolution of fluid collection with persistent loculated fluid following instillation of UK into the chest tube. No complication occurred in either series. Basic indications for UK in pleural effusion include:

- Poor drainage despite an appropriately positioned chest tube

Table 3. Common Organism Causing Parapneumonic Effusion in Children and Corresponding Empiric Antibiotic Therapy

Age	Predominant Pathogens	Therapy
0 to 6 mon	Gram-negative rods* <i>Staphylococcus aureus</i> <i>Streptococcus</i> [†]	Nafcillin, gentamicin, and ampicillin
7 to 12 mon	<i>Haemophilus influenzae</i> [#] Pneumococcus <i>Streptococcus</i> [†]	Nafcillin and cefuroxime
13 to 24 mon	<i>H influenzae</i> [#] Pneumococcus <i>S aureus</i>	Cefuroxime and clindamycin
2 to 5 y	<i>H influenzae</i> [#] Pneumococcus <i>S aureus</i> <i>Streptococcus</i> [†] Anaerobes	Cefuroxime and clindamycin or imipenem
6 to 12 y	Pneumococcus <i>S aureus</i> <i>Streptococcus</i> [†] Anaerobes	Cefuroxime and clindamycin or imipenem
13 to 18 y	Pneumococcus <i>S aureus</i> Anaerobes	Nafcillin or cefuroxime plus clindamycin

* *Pseudomonas*, *Escherichia coli*, *Proteus*, *Klebsiella*
[†] Species other than *S pneumoniae*
[#] Prior to universal immunization

- Multiple loculi, as depicted by septation on ultrasonography or CT
- Presumed multi loculi, as indicated by initial drainage of a volume far less than expected by imaging studies

Relative contraindications for UK use include active bleeding, surgery in the past few days, and pregnancy. The dosage varies from 20,000 to 100,000 U into the chest tube mixed with normal saline solution (20 to 100 mL); the optimal dosage has not been determined. Following instillation of UK, the chest tube is capped for 1 to 2 hours, and the patient is encouraged to shift positions to distribute the solution. Instillation of UK may be repeated two to three times in 2 to 3 days.

Because the management of empyema, especially in the second and the third stages, remains controversial, some advocate the use of early surgical intervention, such as video-assisted thoracoscopy (VATS), with pleural debridement or thoracotomy and decortication with the removal of the thick pleural peel. This approach should be based on the disease stage, causative pathogen, response to initial treatment, and degree of lung trapping.

In the late fibropurulent and organizing phases, prolonged pleural drainage is inadequate. If the patient still has respiratory difficulty, daily fever, and persistent leukocytosis following antibiotic therapy, early lung decortication or VATS should be considered. When the empyema reaches the organizing stage, there is little excuse not to undertake the procedure.

VATS or early lung decortication should be considered in selected children who have parapneumonic effusion or empyema whose clinical course does not improve, severe lung trapping, or empyema caused by infectious bacteria other than *S aureus*. Ultrasonography or chest CT showing multiple loculi or an extensive pleural peel and lung trapping suggest the need for early decortication. Complete re-expansion of the lung following decortication can alter the natural history of the disease substantially in symptomatic children. Generally, surgery should not be performed in children for any reason other than persistent pleural sepsis because clinical improvement, pulmonary function, and radiographic abnormalities eventually resolve in the pediatric population.

Prognosis

Children who have uncomplicated parapneumonic effusion respond well to conservative management with no apparent residual lung damage. Viral and mycoplasmal pleural disease generally resolve spontaneously. Patients who have empyema have more prolonged and complicated hospital courses. Virtually no deaths should occur with prompt therapy. Case fatality rates of 3% to 6% have been reported in some recent series, with the highest rate occurring among infants younger than 1 year of age. In contrast to adults, infants and children have a remarkable ability to resolve pleural thickening with no effect on subsequent lung growth and lung function.

Other Types of Effusion

Chylothorax

Chylothorax is characterized by pleural fluid that has a turbid or milky white appearance due to high lipid content. The fluid may be clear in neonates or if a patient is fasting. Chyle lipid consists of triglycerides that enter the pleural space as chyle, most commonly from disruption of the thoracic duct at some point along its course in the chest. Chyle also contains lymphocytes (T lymphocytes) as a major cellular component. The electrolyte content of chyle is similar to plasma, and the protein concentration is usually greater than 3 g/dL (30 g/L) (Table 4). The causes of chylothorax can be traumatic and nontraumatic. Surgical procedures and trauma from accidents account for most traumatic cases of chylothorax; medi-

Table 4. Physical and Chemical Characteristics of Chyle

- Sterile
- Ingested lipophilic dyes stain in the effusion
- Lymphocytic predominance
- Sudan stain; fat globules
- Total fat content exceeds that of plasma (eg, up to 660 mg/dL)
- Protein content is 50% or same as that of plasma (usually ≥ 3.0 g/dL [30 g/L])
- Glucose, urea nitrogen, and electrolyte concentrations similar to those in plasma

astinal tumors, especially lymphoma and infection, cause nontraumatic chylothorax. Other rare causes of chylothorax are lymphatic abnormalities with lymphangiectasis and lymphangiomyomatosis.

In the newborn period, the causative factors of chylothorax are less precise. The basis of a noniatrogenic defect probably involves a malformation of the mediastinal and pulmonary lymphatics, with the remainder of the lymphatic system being normal. In this period, chyle effusion occurs more commonly on the right side.

In the neonatal period or in life-threatening situations, immediate and repeated thoracentesis is required. In the absence of a life-threatening situation, initial treatment for neonatal and most causes of traumatic or traumatic surgical chylothorax include:

- Complete drainage of chyle by single thoracentesis
- Use of medium-chain triglycerides (MCTs) as the major source of dietary fat
- Replacement of nutrient losses

The use of an MCT diet coupled with avoidance of long-chain fatty acids reduces lymph flow because MCT is absorbed directly into the portal system and contributes little to chylomicron formation. Generally, chylous effusion ceases by the end of the second week of treatment. A trial of fasting and parenteral hyperalimentation is indicated for patients in whom chyle reaccumulates rapidly. Conservative treatment should be continued for 4 to 5 weeks to allow closure of lymphatic channel fistulae. Rarely, a chylothorax is due to lymphangiomyomatosis and does not respond to dietary manipulation.

Surgical procedures should be considered if chylothorax persists despite multiple aspirations or chest tube drainage. Such procedures include pleurodesis or ligation of the thoracic duct via thoracotomy or VATS. Overtly prolonged drainage of the chylothorax should be

avoided to prevent a patient from becoming malnourished and immunosuppressed. Pleural drainage and diet therapy resolve most cases of idiopathic chylothorax, especially if the chylothorax was induced by unrecognized minor trauma. Importantly, prolonged chest tube placement presents a negligible risk for pleural space infection because of the bacteriostatic properties of the chyle.

Pleural Effusion in Acquired Immunodeficiency Syndrome

Human immunodeficiency virus (HIV)-infected individuals are susceptible to a variety of pleural space diseases due to effusions, infections, and neoplastic disease. Pleural effusions, especially parapneumonic effusion or empyemas, are the most important cause of pleural fluid accumulation in HIV-positive patients (up to 30%). Up to 20% of the pleural effusions are transudates, more commonly due to hypoalbuminemia, 10% are due to tuberculous effusion, and 2% to 5% are related to malignancies, tuberculous pleural effusion is an isolated finding.

The pleural fluid is generally turbid or serosanguineous and exudative, with a mean WBC count of $4 \times 10^3/\text{mL}$ ($4 \times 10^9/\text{L}$). In about two thirds of the cases, lymphocytes predominate. Recent data suggest that elevated levels of gamma-interferon in the pleural effusion distinguish tuberculous from nontuberculous effusion. Gamma-interferon may be a better parameter than adenosine deaminase for diagnosing HIV-related tuberculous pleurisy. The diagnostic yield of a pleural fluid smear is lower (15%) than pleural biopsies (50% to 75%). Treatment is generally successful.

P. carinii is a common cause of pneumonia in HIV, but it is a rare cause of pleural effusion.

Typically aggressive nonHodgkin lymphoma B-cell tumors frequently are associated with bilateral pleural effusion in HIV patients. Often effusions are exudative and exhibit elevated white and red blood cell counts. The glucose concentration in pleural fluid is low in 40% of patients who have effusion. Unlike the poor diagnostic yield of pleural fluid cytology in nonHIV patients who have lymphoma, pleural fluid cytology and pleural biopsies are diagnostic in 75% and 100%, respectively, of HIV-infected individuals.

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Tuberculous Pleural Effusion

Pleural effusion is an early complication of primary tuberculosis.

The effusion is usually unilateral; when it is bilateral, it often is associated with miliary disease or hematogenous dissemination. Pulmonary tuberculosis typically causes fibrinous or dry pleurisy and generally occurs when the infection extends from a subpleural focus. Considerable effusion may result from a specific allergic reaction of the pleural membranes. The onset of effusion is within 6 months of the primary infection and is coincident with the development of cell-mediated immunity. A patient who has pleural effusion and a positive Mantoux tuberculin test reaction should be considered to have tuberculous pleural effusion until proven otherwise.

The fluid withdrawn is usually an exudate that has a protein level greater than 4 g/dL (40 g/L), decreased glucose concentration ($<40 \text{ mg/dL}$ [2.2 mmol/L]), and often elevated LDH levels. The WBC count varies from 2 to $10 \times 10^3/\text{mL}$ (2 to $10 \times 10^9/\text{L}$), and lymphocytes predominate. Culture is positive in only 50% of cases because tubercle bacilli are usually present in small numbers, and allergic reaction to tuberculin often

Children who have uncomplicated parapneumonic effusion respond well to conservative management with no apparent residual lung damage.

nancy (lymphoma or Kaposi sarcoma). *Pneumocystis carinii* infection is not a common cause.

Bacterial pneumonia is the most common cause of parapneumonic effusion in HIV, with *S pneumoniae*, *S aureus*, *H influenzae*, and *P aeruginosa* being the major organisms recovered. The rate of bacterial pneumonia increases as the CD4 cell count decreases. Patients may have frequent bacteremia and commonly develop empyema. Cultures of pleural fluid and blood are likely to be positive, and patients have a longer period of fever than those who are not HIV-positive. HIV-positive patients more frequently require tube thoracostomy. Therapy is similar to that for immunocompetent hosts. Prompt sampling of the fluid is essential for diagnosis and treatment. For patients in whom tube thoracostomy does not provide drainage, intrapleural instillation of UK or even surgery must be considered.

Approximately 50% of HIV-infected patients who have tuberculous infection exhibit pulmonary infiltrate or hilar/mediastinal lymphadenopathy; in 25% of pa-

is the causative factor for the effusion. Tuberculous pleural effusion usually is reabsorbed completely with minimal sequelae. Treatment is the same as for primary pulmonary tuberculosis, with steroids added to promote fluid resorption.

Suggested Reading

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Please note that the deadline for submission of your answer sheets for the quizzes in the issues of 2002 has been extended to January 31, 2003.

PIR Quiz

Quiz also available online at www.pedsinreview.org.

5. A previously healthy 7-year-old boy has had a cough, chest pain, and fever for 4 days. Two days ago, he was diagnosed with bronchitis at an urgent care center and has been taking clarithromycin twice daily. Your examination reveals dullness to percussion, diminished breath sounds, and decreased vocal fremitus over the entire right hemithorax. A lateral decubitus radiograph confirms free-flowing fluid in the pleural space. Of the following, the *most* likely cause is:
- A. Chylothorax.
 - B. Congestive heart failure.
 - C. Hemothorax.
 - D. Lymphoma.
 - E. Parapneumonic effusion.
6. Thoracentesis yields 300 mL of cloudy yellowish fluid that has a pH of 7.25, glucose concentration of 35 mg/dL (1.94 mmol/L), protein of 3.5 g/dL (35 g/L), and lactate dehydrogenase of 1,100 U/L. Gram stain reveals clumps of neutrophils, but no organisms. These findings are *most* consistent with:
- A. Chylothorax.
 - B. Congestive heart failure.
 - C. Hemothorax.
 - D. Lymphoma.
 - E. Parapneumonic effusion.
7. The fluid accumulation in this case is *best* explained by:
- A. Decreased interstitial space hydrostatic pressure.
 - B. Decreased plasma oncotic pressure.
 - C. Increased capillary hydrostatic pressure.
 - D. Increased capillary permeability.
 - E. Obstruction of the thoracic duct.
8. The most appropriate *initial* treatment in this case is to combine parenteral cefuroxime and clindamycin with:
- A. Closed-tube thoracostomy.
 - B. Intrapleural urokinase.
 - C. No other treatment.
 - D. Repeat thoracentesis as necessary.
 - E. Video-assisted thoracoscopy and pleural debridement.
9. Milky white pleural fluid obtained by thoracentesis *best* suggests:
- A. Amebic infection.
 - B. Congestive heart failure.
 - C. Disruption of the thoracic duct.
 - D. Empyema.
 - E. Hypoalbuminemia.

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