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In Brief

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Author Disclosure

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Clinical Practice: Pleural Effusion. Light RW. *N Engl J Med.* 2002;346(25):1971–1977

Chylothorax: Diagnosis and Management in Children. Soto-Martinez M, Massie J. *Paediatr Respir Rev.* 2009;10(4):199–207

Parapneumonic Effusions and Empyema. Light RW. *Proc Am Thorac Soc.* 2006;3(1):75–80

Comparative Effectiveness of Pleural Drainage Procedures for the Treatment of Complicated Pneumonia in Childhood. Shah SS, Hall M, Newland JG, et al. *J Hosp Med.* 2011;6(5):256–263

Imaging of the Pleura. Ayres J, Gleeson F. *Semin Respir Crit Care Med.* 2010;31(6):674–688

Pleural effusions are abnormal collections of fluid in the pleural space, which is a potential space between the parietal (chest cavity) pleura and the visceral (lung) pleura. Normally, the pleural space contains a small amount of fluid having a low protein concentration of 1 g/dL that is formed in the apical region of the parietal pleura and is drained through the lymphatic system. Very little fluid moves across the visceral pleura, except in the presence of pulmonary venous hypertension. Pleural effusions may be transudates caused by an imbalance of hydrostatic and oncotic pressures across intact vasculature or exudates resulting from fluid moving across leaky blood vessels into the pleural space.

Transudative pleural effusions most commonly result from heart failure, hepatic cirrhosis, nephrotic syndrome, or peritoneal dialysis. Left heart failure increases pulmonary venous pressure, which in turn forces fluid across the visceral pleura into the pleural space. Restriction to mitral flow, as with mitral stenosis, does the same, but only rarely does right heart failure or pulmonary arterial hypertension cause excessive fluid to accumulate in the pleural space.

With hepatic cirrhosis, pleural effusions develop from leakage of transudative ascitic fluid into the pleural space across minor defects in the diaphragm, usually on the right side. Similarly, a pleural effusion can accumulate during peritoneal dialysis when dialysate leaks from the abdomen.

Nephrotic syndrome is marked by a reduction in oncotic pressure from hypoalbuminemia and by increased hydrostatic pressure from compensatory hypervolumia, both of which contribute to fluid moving into the pleural space. Rarely, hypercoagulability from nephrosis may result in pulmonary embolism that can cause an exudative pleural effusion.

In contrast to transudates, pleural exudates occur primarily as a result of pleural disease. The most common childhood effusions are parapneumonic, developing in conjunction with pneumonia or lung abscess, but tuberculosis, autoimmune disease, and malignant infiltration also can cause exudative effusions.

In the neonatal period, chylothorax is the most frequent type of pleural effusion; other causes include hemothorax, congenital nephrotic syndrome, hydrops fetalis, and complications from central venous catheter placement.

Chylothorax is the accumulation of chyle in the pleural space. Chyle, the lymph derived from the intestines and liver, transports chylomicrons containing long-chain triglycerides, plasma proteins, and T lymphocytes via the thoracic duct to the central veins. The thoracic duct ascends on the right side of the vertebral column from the T12 vertebra, crossing to the left hemithorax at the T5 level. Thus, damage to the thoracic duct above T5 commonly causes a left-sided effusion; damage below this level causes a right-sided effusion. Bilateral effusions also can develop. Because chyle does not irritate the pleura, chylothorax usually is not associated with loculation or peel formation, and the high fatty acid content of chyle protects against infection.

Neonates can develop chylothorax from congenital lymphatic abnormalities that may be associated with Noonan, Turner, and Down syndromes, or from rupture of the thoracic duct with extension of the spine at birth. Acquired chylothorax in neonates and children most often follows cardiothoracic procedures. Other causes of chylothorax include rupture of the duct during violent coughing, obstruction of the superior vena cava, mediastinal inflammation, and malignant infiltration.

Diagnostic thoracocentesis is indicated for a significant pleural effusion without a known cause. If analysis reveals a transudate, additional therapy

focuses mainly on managing the cause of the transudate. Exudates, however, usually require additional microbiologic, biochemical, and cytologic evaluation to identify the cause and allow planning of appropriate treatment. Therapeutic thoracocentesis may be indicated for relief of respiratory distress.

A turbid appearance results from a high cell count or high lipid content. Fluid that has a bloody appearance and a hematocrit level greater than half of the blood hematocrit probably represents hemothorax. Fluid from chylothorax usually is milky or turbid, but it may be serous, bloody, yellowish, or greenish.

Effusions can be classified as exudates if any one of three criteria is present:

- Pleural fluid-to-serum protein ratio is 0.5 or greater,
- Pleural fluid-to-serum lactate dehydrogenase (LDH) ratio is more than 0.6, or
- Pleural fluid LDH concentration is more than 66% of the upper limit of normal for serum.

Although these criteria are extremely sensitive for the identification of exudates (99.5%), they are not as specific. Approximately 20% of transudative effusions from congestive heart failure are identified as exudates, particularly when diuretic therapy increases the concentrations of protein and LDH in pleural fluid.

Pleural fluid usually is slightly alkalotic. The pH may be reduced in parapneumonic effusions, tuberculosis, malignancies, lupus, rheumatoid arthritis, and hemothorax. Glucose typically is reduced in exudates when the pH is reduced. A low pH with increased amylase is highly suggestive of esophageal rupture, especially when there is a history of trauma. If the concentration of triglyceride in the pleural fluid is >110 mg/dL, the likelihood of a chylothorax is >99%; with a triglyceride concentration <50 mg/dL, the chance of a chylous effusion is at most 5%.

Samples of pleural fluid should be anticoagulated to ensure accurate cell counts. Bacterial infections (occasionally tuberculosis) are associated with predominantly neutrophilic effusions. Lymphocytosis is seen with chylothorax, autoimmune diseases, tuberculosis, and malignancy. Malignant cells that may be seen on microscopy include nephroblastoma, Wilms' tumor, hepatoblastoma, malignant germ cell tumor, and rhabdomyosarcoma. Lung involvement with neuroblastoma is rare. Non-Hodgkin's lymphoma can present with a mediastinal mass, pleural effusion, and respiratory distress. Cytology of pleural fluid may help establish the diagnosis in critically ill children and allow initiation of appropriate chemotherapy.

The growth of bacteria, tubercle bacilli, or fungi from pleural fluid confirms infection. The isolation of aerobic and anaerobic organisms is improved by adding pleural fluid to blood culture containers at the bedside. In areas of high endemicity, pleural adenosine deaminase has a high positive predictive value for tuberculosis. The most common organisms isolated from parapneumonic effusions in children are *Streptococcus pneumoniae*, *Staphylococcus aureus*, and group A *Streptococcus*.

Although parapneumonic effusions may begin as sterile exudates, they can progress to an infected fibrinopurulent stage with adhesions and loculations that may then organize with formation of a pleural peel, preventing expansion of the underlying lung. When the infected effusion is thick, viscid, and purulent, it is termed an empyema, which raises the morbidity and mortality of pneumonia. Drainage of effusions becomes more difficult with development of loculation, and progression to loculation can occur when drainage is delayed by as little as 12 to 24 hours.

Parapneumonic effusions <10 to 20 mm in depth have a good prognosis and do not require drainage. Effusions >10 to 20 mm in depth should be sampled for analysis. Outcomes are poorer if the pH is <7.20, the glucose concentration is <60 mg/dL (3.3 mmol/L), the fluid is purulent, bacteria are cultured from the fluid, or the effusion occupies more than half of the hemithorax. These findings define a "complicated" parapneumonic effusion and indicate the need for drainage.

Imaging can identify parapneumonic effusions and associated conditions such as lung abscess. On plain chest radiography, the collection of a significant amount of pleural fluid causes blunting of the costophrenic angle on an upright posterior-anterior image, followed by the characteristic meniscus, eventually progressing to opacification of the hemithorax and displacement of the mediastinum. Freely flowing pleural effusions form dependent fluid layers that move when the patient assumes the lateral decubitus position, in contrast to pleural thickening that does not change with position.

Ultrasonography is very sensitive for detecting small effusions, septations, and pleural thickening and can guide thoracocentesis. The procedure is portable and does not require sedation, but it is operator-dependent and is not effective in detecting abscesses beyond normal lung tissue or loculated effusions in the mediastinal area or in the fissures.

Computed tomographic (CT) scan is an excellent modality for imaging effusions, inaccessible loculations, atelectasis, and lung abscesses, and for guiding thoracocentesis, particularly because this imaging demarcates effusions from underlying pneumonia. The limitations of computed tomographic imaging include radiation exposure, expense, and the potential need for sedation.

The usual initial intervention for complicated pleural effusions is tube

thoracostomy with underwater drainage. Smaller tubes (8–12 French) probably are as effective as larger tubes and can be positioned under imaging guidance. Successful tube thoracostomy along with adequate antibiotic coverage should result in clinical and radiologic improvement within 24 hours. Instillation of fibrinolytic agents such as tissue thromboplastin activator into the pleural space may help resolve an empyema, but the exact role of fibrinolysis remains to be defined. When effusions persist after tube thoracostomy, especially with pleural loculations, thoracoscopic surgery can visualize the pleura, break down adhesions, and drain an empyema. Open thoracotomy and debridement may be necessary in the presence of thick pleural peel with trapped lung or with extensive debris. The role of thoracoscopic surgery as a primary treatment for complicated parapneumonic effusions has not been defined.

Prevention is preferable to treatment. Although the introduction of vaccine dramatically reduced the incidence of empyema from *Haemophilus influenzae* type B pneumonia, the 7-valent conjugated pneumococcal vaccine has been associated with an increased incidence of empyema in children despite decreases in pneumonia. It is hoped that the new 13-valent pneumococcal vaccine, which addresses serotypes associated with empyema, will reduce the incidence of empyema in children.

Comments: When Dr Muzumdar previously wrote about pleural fluid, I commented that, rightly, pediatricians are not quick on the draw with invasive procedures for children but sometimes our hesitancy can be counterproductive. Early drainage of a pleural effusion can be therapeutic in its own right, but particularly with rising rates of resistant pneumococcal and community-associated methicillin-resistant staphylococcal infections, thoracentesis can also provide material for culture to guide antibiotic use.

In his *In Brief*, Dr Muzumdar remarks that the role of fibrinolytic agents in the treatment of pleural disease remains to be defined. A study from the United Kingdom published in the *New England Journal of Medicine* (2011;365:518–526) provides evidence that, at least in adults, the combination of intrapleural tissue plasminogen activator and deoxyribonuclease improves fluid drainage, reduces the likelihood of surgery, and shortens the course of hospitalization, which neither agent on its own was able to do. One can hope that we will see confirmation in children.

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Editor, In Brief

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