Published in final edited form as:

Pediatr Infect Dis J. 2007 May ; 26(5): 445–446.

Management of Parapneumonic Empyema

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Keywords

parapneumonic empyema; VATS; fibrinolytics; chest tube

Parapneumonic empyema, or pus in the pleural space, was once a rare complication of bacterial pneumonia in children.¹ It has become increasingly common in the United States (US) and Europe.^{2–6} At our institution alone (Primary Children’s Medical Center in Salt Lake City, UT) we have cared for over 500 children with parapneumonic empyema in the last decade. The rate of parapneumonic empyema in Utah increased dramatically from 1/100,000 children in 1993 to 14/100,000 children in 2003.^{2,7,8}

PATHOPHYSIOLOGY

The classification and characteristics of parapneumonic empyema are shown in Table 1. Empyema is associated with significant short-term morbidity and mortality. Among 74 cases of culture-confirmed pneumococcal empyema, 51% of children required intensive care, 38% had concomitant bacteremia, 5.5% developed hemolytic uremic syndrome, and 5% died.⁸

MICROBIOLOGY

Bacteria associated with empyema in children in the US include *Streptococcus pneumoniae*, *Staphylococcus aureus* and *S. pyogenes*. *S. pneumoniae* is the most common cause of empyema and accounts for much of the increase in the burden of empyema in the United Kingdom and parts of the US. Community-acquired methicillin-resistant *S. aureus* has recently emerged as an important cause of empyema in some parts of the US.^{9–10} Empyema secondary to *S. pyogenes* is an important complication of varicella infection.²

CLINICAL MANIFESTATION AND DIAGNOSTIC EVALUATION

The majority of children with empyema present with clinical manifestations of bacterial pneumonia: fever, cough, dyspnea, lethargy, pleuritic chest pain, splinting and referred pain to the abdomen. Physical findings may include decreased breath sounds and chest wall excursion, crackles and friction rub on inspiration, and dullness on percussion.

Erect and decubitus chest radiographs are the first step in diagnosis of a parapneumonic effusion. Small, free-flowing effusions are less likely to be complicated. Chest ultrasound is useful in detecting fibrous strands or septations, and can localize fluid collections and guide interventional procedures.¹¹ Computed tomography of the chest with contrast is useful in defining lung consolidation, abscess, necrosis and pleural space anatomy for interventional procedures.

Typical laboratory findings include peripheral blood leukocytosis with a left shift and thrombocytosis; platelet counts may exceed 1 million/ μ L during the recovery phase of the illness. The erythrocyte sedimentation rate and C-reactive protein are usually markedly elevated at presentation. C-reactive protein values decrease more rapidly than the erythrocyte

sedimentation rate and may be a useful indicator of adequate drainage and appropriate antibiotic selection.

Evaluation of pleural fluid (PF) is imperative. Typical findings include an elevated PF white blood cell count ($>1000/\text{mm}^3$) with a neutrophil predominance. PF protein and lactate dehydrogenase are elevated relative to serum levels with ratio of PF to serum levels of >1 . PF glucose levels are low ($<40 \text{ mg/dL}$) with ratio of PF to serum levels of <1 . PF pH levels <7.20 are associated with a need for drainage. Evidence-based guidelines for the evaluation of risk of complications based on PF analysis and clinical findings have been developed for adults but have not been fully evaluated in children.¹²

Children with empyema often have negative blood or PF cultures because of prior antibiotic therapy. For culture-negative empyema, acute and convalescent serology including ASO and anti-DNase B for *S. pyogenes* and a pneumococcal antibody panel for *S. pneumoniae* may be useful. Recent studies using new pneumococcal antigen detection and polymerase chain reaction suggest that these modalities may become important for identifying the causative organism.¹³

TREATMENT OPTIONS

The optimal treatment of pediatric empyema remains controversial. Medical options include appropriate antimicrobials along with chest tube drainage (CTD) with or without fibrinolysis. Surgical options include videoscopic-assisted thoracoscopy surgery (VATS) or open drainage (thoracotomy and decortication). Management options based on stage of empyema are shown in Table 1. The choice of antibiotics depends on the epidemiology and antibiotic resistance patterns of complicated bacterial pneumonia in each locale. The duration of therapy (intravenous followed by oral) is 2 to 6 weeks depending on the extent of infection, clinical and laboratory response—3 to 4 weeks will be adequate in most cases.

CTD has long been successfully used in the management of parapneumonic empyema. Fibrinolytic agents in addition to CTD have been used with conflicting results. A large, double blind trial in adults did not show benefit for streptokinase, but this may not be generalizable to children or newer fibrinolytic agents such as tissue plasminogen activator (tPA).¹⁴ Large randomized trials of empyema treatment in children are not available. In a series of 58 children with empyema who had tPA instilled into chest tubes placed under fluoroscopic or ultrasound guidance, 54 (93%) recovered without additional surgical drainage.¹⁵ A randomized trial in the UK that compared CTD and fibrinolytics with primary VATS in 60 children with empyema found no differences in total hospital stay, failure rates or radiologic outcomes at 6 months. However, hospital costs in the VATS arm were 25% higher.

VATS has been advocated in the management of empyema at any stage in children. VATS allows visual inspection of the lung and pleura, optimal placement of chest tubes and immediate fibrinolysis and decortication if needed. In an uncontrolled cases series, VATS use was associated with few complications and short hospital stays (approximately 7 days).¹⁶ In recent years the need for open thoracotomy with pleural peel decortication has become less frequent. At Primary Children's Medical Center in Salt Lake City, UT, the rate of surgical intervention for pediatric empyema decreased from 77% in 1993-1999 to 20% (all accomplished with VATS) during 2000-2004 after introduction of a protocol using initial CTD combined with tPA.¹⁷

Adjunct care of the child with empyema includes careful monitoring of nutritional status, as many children will be unable to eat for several days and may experience significant weight loss. Calorie counts and enteral feedings or parenteral nutrition supplementation should be considered early in the course of treatment. Attention to adequate analgesia is also paramount.

While optimal management will be uncertain until larger randomized trials are conducted, we favor initial CTD with fibrinolysis. However, children whose PF has a high white blood cell count ($>15,000$), low glucose, poor output drainage by chest tube, the presence of bacteria on Gram stain or culture and peripheral blood bandemia may benefit from early VATS.¹⁷ Long-term follow-up of children with empyema indicates that outcomes are excellent following current treatment approaches and that most children will recover fully.

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Classification, Characteristics and Management of Parapneumonic Empyema¹⁸

TABLE 1

Stage/Name	Characteristics of Pleural Fluid	pH	Glucose	LDH	Gram Stain	Culture	Management
Stage 1/exudative stage	Free-flowing serous effusion with neutrophils	>7.20	>60 mg/dL	>3 times the upper limit of normal	Negative, often sterile		Antibiotics significant
Stage 2/fibronopurulent stage	Uncomplicated	<7.20	<60 mg/dL	>3 times the upper limit of normal	Positive		Antibiotics
	Invasion by organism, neutrophil predominance, and fibrinous strands	Complicated	<7.00	<60 mg/dL	>3 times the upper limit of normal	Positive	Chest tube, drainage, consider fibrinolysis (tPA)
	Complicated	—			Positive		Antibiotics
Stage 3/organizing stage	Frank pus or loculated effusion						Chest tube, drainage, consider fibrinolysis or VATS
	Fibrinous peel, lung entrapment				Negative, often sterile		Antibiotics, VATS, decortication of pleural peel if VATS unsuccessful