antibiotics alone, and we recommend tube thoracostomy (LOE B).
4. Class I: Obtain pleural fluid culture specimens during aspiration or drainage procedures, not from previously inserted tubes or drains (LOE B). Inoculate freshly drained pleural fluid into aerobic and anaerobic blood culture vials in addition to sterile containers for gram stain and culture (LOE B).

General laboratory studies. Although pleural fluid analysis remains the single most important predictor of clinical outcomes, certain general laboratory data have been associated with an increased likelihood of progression to a pleural space infection in patients admitted for community-acquired pneumonia (see the section "Clinical Presentation") and should be investigated: hypoalbuminemia (<30 g/dL), hyponatremia (<130 mmol/L), and elevated C-reactive protein (>100 mg/L).[12] Blood cultures are positive in a minority of patients with pleural-space infection.[3]

Thoracentesis: Technique and sample processing. There is in general no possibility to predict based on imaging alone whether a parapneumonic effusion will have a complicated clinical course and therefore diagnostic thoracentesis is indicated in all suspected parapneumonic effusion when the pleural fluid thickness is >1 cm on CXR and >2 cm on CT.[37,38] Loculated and large pleural effusions, however, are likely to be associated with a complicated clinical course irrespective of pleural fluid analysis.[39,40] In addition, several studies have demonstrated that pleural fluid analysis may substantially differ from one locule to another, limiting the value of pleural fluid analysis in this instance.[8,41,42]

Diagnostic thoracentesis should be performed with US guidance to reduce the risk of pneumothorax.[16-18] A frankly purulent appearance obviates the need for pleural pH analysis. The pleural fluid pH (see the section "Pleural fluid analysis and biomarkers") should be measured with an arterial blood gas analyzer within 1 hour of sampling.[43-45] Residual lidocaine, heparin (decrease), or air in the syringe (increase) may affect the pH results in a clinically meaningful way.[43]

Pleural fluid analysis and biomarkers. In general, purulence of the pleural fluid or a positive Gram's stain or culture from the pleural fluid establishes the diagnosis of empyema and should prompt tube thoracostomy drainage,[38,46,47] although exceptions may occur.[48] In the absence of these factors, a large meta-analysis suggests that pleural pH <7.2 is the next most useful predictor of a complicated clinical course in the absence of adequate chest tube drainage.[49] If pleural pH is not measured, a pleural fluid glucose value <40 mg/dL should prompt chest tube drainage.[38,49] Likewise, a pleural fluid LDH value >1000 IU/L is also predictive of the need for tube thoracostomy.[38,49] An additional rare situation is that of pleural space infections caused by urease-splitting organisms such as Proteus species, which may result in a spuriously elevated pleural pH.[50]

Pleural fluid culture. Culture specimens should be obtained in all cases of acute bacterial empyema. Because 44% of cultures from previously placed catheters or tubing are inaccurate,[51] it is recommended that culture specimens are acquired during aspiration or drainage procedures. When combined with standard laboratory culture, inoculation of BACTEC culture bottles (Becton, Dickinson, and Company, Franklin Lakes, NJ), by properly trained individuals, improves culture yields.[52,53] Swabs should not be used for culture. If only a small amount of fluid is available, then fluid should be inoculated only into the standard specimen culture container. Pleural fluid analysis for cell count and chemistries should always accompany pleural fluid cultures.

ACUTE PLEURAL EMPYEMA: ANTIBIOTIC TREATMENT

Recommendations

1. Appropriate empiric antibiotic therapy for acute pleural empyema incorporates an understanding of (1) the patient's clinical history, (2) local antimicrobial resistance patterns, (3) institutional antibiotic stewardship, and (4) pharmacologic characteristics of the antibiotics. Recommendations include:
   a. Class IIa: For community-acquired empyema: a parenteral second- or third-generation cephalosporin (eg, ceftriaxone) with metronidazole or parenteral aminopenicillin with β-lactamase inhibitor (eg, ampicillin/sulbactam) (LOE C).
   b. Class IIa: For hospital-acquired or postprocedural empyema: include antibiotics active against methicillin-resistant *Staphylococcus aureus* and *Pseudomonas aeruginosa* (eg, vancomycin, cefepime, and metronidazole or vancomycin and piperacillin/tazobactam [dosed for activity against *P aeruginosa*]) (LOE C).
   c. Class I: Avoid aminoglycosides in the management of empyema (LOE B).
   d. Class IIa: There is no role for intrapleural administration of antibiotics (LOE C).
2. Class I: If possible, choose antibiotic therapy based on culture results (LOE C).
   a. Class IIa: Consider continuing anaerobic coverage empirically when the anaerobic cultures are negative (LOE C).
3. Class IIb: The duration of antibiotic therapy for acute bacterial empyema is influenced by the organism, adequacy of source control, and clinical response (LOE C).

Reasoning. Choice of empiric antimicrobials should be guided by clinical history, local antimicrobial resistance