Executive Summary: The Management of Community-Acquired Pneumonia in Infants and Children Older Than 3 Months of Age: Clinical Practice Guidelines by the Pediatric Infectious Diseases Society and the Infectious Diseases Society of America

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Evidenced-based guidelines for management of infants and children with community-acquired pneumonia (CAP) were prepared by an expert panel comprising clinicians and investigators representing community pediatrics, public health, and the pediatric specialties of critical care, emergency medicine, hospital medicine, infectious diseases, pulmonology, and surgery. These guidelines are intended for use by primary care and subspecialty providers responsible for the management of otherwise healthy infants and children with CAP in both outpatient and inpatient settings. Site-of-care management, diagnosis, antimicrobial and adjunctive surgical therapy, and prevention are discussed. Areas that warrant future investigations are also highlighted.

EXECUTIVE SUMMARY

Guidelines for the management of community-acquired pneumonia (CAP) in adults have been demonstrated to decrease morbidity and mortality rates [1, 2]. These guidelines were created to assist the clinician in the care of a child with CAP. They do not represent the only approach to diagnosis and therapy; there is considerable variation among children in the clinical course of pediatric CAP, even with infection caused by the same pathogen. The goal of these guidelines is to decrease morbidity and mortality rates for CAP in children by presenting recommendations for clinical management that can be applied in individual cases if deemed appropriate by the treating clinician.

This document is designed to provide guidance in the care of otherwise healthy infants and children and addresses practical questions of diagnosis and management of CAP evaluated in outpatient (offices, urgent care

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clinics, emergency departments) or inpatient settings in the United States. Management of neonates and young infants through the first 3 months, immunocompromised children, children receiving home mechanical ventilation, and children with chronic conditions or underlying lung disease, such as cystic fibrosis, are beyond the scope of these guidelines and are not discussed.

Summarized below are the recommendations made in the new 2011 pediatric CAP guidelines. The panel followed a process used in the development of other Infectious Diseases Society of America (IDSA) guidelines, which included a systematic weighting of the quality of the evidence and the grade of the recommendation [3] (Table 1). A detailed description of the methods, background, and evidence summaries that support each of the recommendations can be found in the full text of the guidelines.

SITE-OF-CARE MANAGEMENT DECISIONS

I. When Does a Child or Infant With CAP Require Hospitalization?

Recommendations

1. Children and infants who have moderate to severe CAP, as defined by several factors, including respiratory distress and hypoxemia (sustained saturation of peripheral oxygen [SpO_2], <90 % at sea level) (Table 3) should be hospitalized for management, including skilled pediatric nursing care. *(strong recommendation; high-quality evidence)*
2. Infants less than 3–6 months of age with suspected bacterial CAP are likely to benefit from hospitalization. *(strong recommendation; low-quality evidence)*
3. Children and infants with suspected or documented CAP caused by a pathogen with increased virulence, such as community-associated methicillin-resistant *Staphylococcus aureus* (CA-MRSA) should be hospitalized. *(strong recommendation; low-quality evidence)*
4. Children and infants for whom there is concern about careful observation at home or who are unable to comply with therapy or unable to be followed up should be hospitalized. *(strong recommendation; low-quality evidence)*

II. When Should a Child With CAP Be Admitted to an Intensive Care Unit (ICU) or a Unit With Continuous Cardiorespiratory Monitoring?

Recommendations

5. A child should be admitted to an ICU if the child requires invasive ventilation via a nonpermanent artificial airway (eg, endotracheal tube). *(strong recommendation; high-quality evidence)*
6. A child should be admitted to an ICU or a unit with continuous cardiorespiratory monitoring capabilities if the child acutely requires use of noninvasive positive pressure ventilation (eg, continuous positive airway pressure or bilevel positive airway pressure). *(strong recommendation; very low-quality evidence)*
7. A child should be admitted to an ICU or a unit with continuous cardiorespiratory monitoring capabilities if the child has impending respiratory failure. *(strong recommendation; moderate-quality evidence)*
8. A child should be admitted to an ICU or a unit with continuous cardiorespiratory monitoring capabilities if the child has sustained tachycardia, inadequate blood pressure, or need for pharmacologic support of blood pressure or perfusion. *(strong recommendation; moderate-quality evidence)*
9. A child should be admitted to an ICU if the pulse oximetry measurement is <92% on inspired oxygen of ≥0.50. *(strong recommendation; low-quality evidence)*
10. A child should be admitted to an ICU or a unit with continuous cardiorespiratory monitoring capabilities if the child has altered mental status, whether due to hypercarbia or hypoxemia as a result of pneumonia. *(strong recommendation; low-quality evidence)*
11. Severity of illness scores should not be used as the sole criteria for ICU admission but should be used in the context of other clinical, laboratory, and radiologic findings. *(strong recommendation; low-quality evidence)*

DIAGNOSTIC TESTING FOR PEDIATRIC CAP

III. What Diagnostic Laboratory and Imaging Tests Should Be Used in a Child With Suspected CAP in an Outpatient or Inpatient Setting?

Recommendations

Microbiologic Testing

Blood Cultures: Outpatient

12. Blood cultures should not be routinely performed in nontoxic, fully immunized children with CAP managed in the outpatient setting. *(strong recommendation; moderate-quality evidence)*
13. Blood cultures should be obtained in children who fail to demonstrate clinical improvement and in those who have progressive symptoms or clinical deterioration after initiation of antibiotic therapy *(strong recommendation; moderate-quality evidence)*.

Blood Cultures: Inpatient

14. Blood cultures should be obtained in children requiring hospitalization for presumed bacterial CAP that is moderate to severe, particularly those with complicated pneumonia. *(strong recommendation; low-quality evidence)*
15. In improving patients who otherwise meet criteria for discharge, a positive blood culture with identification or

Table 1. Strength of Recommendations and Quality of Evidence

Strength of recommendation and quality of evidence	Clarity of balance between desirable and undesirable effects	Methodologic quality of supporting evidence (examples)	Implications
Strong recommendation			
High-quality evidence	Desirable effects clearly outweigh undesirable effects, or vice versa	Consistent evidence from well-performed RCTs[a] or exceptionally strong evidence from unbiased observational studies	Recommendation can apply to most patients in most circumstances; further research is unlikely to change our confidence in the estimate of effect.
Moderate-quality evidence	Desirable effects clearly outweigh undesirable effects, or vice versa	Evidence from RCTs with important limitations (inconsistent results, methodologic flaws, indirect, or imprecise) or exceptionally strong evidence from unbiased observational studies	Recommendation can apply to most patients in most circumstances; further research (if performed) is likely to have an important impact on our confidence in the estimate of effect and may change the estimate.
Low-quality evidence	Desirable effects clearly outweigh undesirable effects, or vice versa	Evidence for ≥1 critical outcome from observational studies, RCTs with serious flaws or indirect evidence	Recommendation may change when higher quality evidence becomes available; further research (if performed) is likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate.
Very low-quality evidence (rarely applicable)	Desirable effects clearly outweigh undesirable effects, or vice versa	Evidence for ≥1 critical outcome from unsystematic clinical observations or very indirect evidence	Recommendation may change when higher quality evidence becomes available; any estimate of effect for ≥1 critical outcome is very uncertain.
Weak recommendation			
High-quality evidence	Desirable effects closely balanced with undesirable effects	Consistent evidence from well-performed RCTs or exceptionally strong evidence from unbiased observational studies	The best action may differ depending on circumstances or patients or societal values; further research is unlikely to change our confidence in the estimate of effect.
Moderate-quality evidence	Desirable effects closely balanced with undesirable effects	Evidence from RCTs with important limitations (inconsistent results, methodologic flaws, indirect, or imprecise) or exceptionally strong evidence from unbiased observational studies	Alternative approaches are likely to be better for some patients under some circumstances; further research (if performed) is likely to have an important impact on our confidence in the estimate of effect and may change the estimate.
Low-quality evidence	Uncertainty in the estimates of desirable effects, harms, and burden; desirable effects, harms, and burden may be closely balanced	Evidence for ≥1 critical outcome from observational studies, from RCTs with serious flaws or indirect evidence	Other alternatives may be equally reasonable; further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate.
Very low-quality evidence	Major uncertainty in estimates of desirable effects, harms, and burden; desirable effects may or may not be balanced with undesirable effects may be closely balanced	Evidence for ≥1 critical outcome from unsystematic clinical observations or 2very indirect evidence	Other alternatives may be equally reasonable; any estimate of effect, for at ≥1 critical outcome, is very uncertain.

[a] RCTs, randomized controlled trials.

Table 2. Complications Associated With Community-Acquired Pneumonia

Pulmonary
Pleural effusion or empyema
Pneumothorax
Lung abscess
Bronchopleural fistula
Necrotizing pneumonia
Acute respiratory failure
Metastatic
Meningitis
Central nervous system abscess
Pericarditis
Endocarditis
Osteomyelitis
Septic arthritis
Systemic
Systemic inflammatory response syndrome or sepsis
Hemolytic uremic syndrome

susceptibility results pending should not routinely preclude discharge of that patient with appropriate oral or intravenous antimicrobial therapy. The patient can be discharged if close follow-up is assured. *(weak recommendation; low-quality evidence)*

Follow-up Blood Cultures

16. Repeated blood cultures in children with clear clinical improvement are not necessary to document resolution of pneumococcal bacteremia. *(weak recommendation; low-quality evidence)*

17. Repeated blood cultures to document resolution of bacteremia should be obtained in children with bacteremia caused by *S. aureus*, regardless of clinical status. *(strong recommendation; low-quality evidence)*

Table 3. Criteria for Respiratory Distress in Children With Pneumonia

Signs of Respiratory Distress
1. Tachypnea, respiratory rate, breaths/min[a]
Age 0–2 months: >60
Age 2–12 months: >50
Age 1–5 Years: >40
Age >5 Years: >20
2. Dyspnea
3. Retractions (suprasternal, intercostals, or subcostal)
4. Grunting
5. Nasal flaring
6. Apnea
7. Altered mental status
8. Pulse oximetry measurement <90% on room air

[a] Adapted from World Health Organization criteria.

Sputum Gram Stain and Culture

18. Sputum samples for culture and Gram stain should be obtained in hospitalized children who can produce sputum. *(weak recommendation; low-quality evidence)*

Urinary Antigen Detection Tests

19. Urinary antigen detection tests are not recommended for the diagnosis of pneumococcal pneumonia in children; false-positive tests are common. *(strong recommendation; high-quality evidence)*

Testing For Viral Pathogens

20. Sensitive and specific tests for the rapid diagnosis of influenza virus and other respiratory viruses should be used in the evaluation of children with CAP. A positive influenza test may decrease both the need for additional diagnostic studies and antibiotic use, while guiding appropriate use of antiviral agents in both outpatient and inpatient settings. *(strong recommendation; high-quality evidence)*

21. Antibacterial therapy is not necessary for children, either outpatients or inpatients, with a positive test for influenza virus in the absence of clinical, laboratory, or radiographic findings that suggest bacterial coinfection. *(strong recommendation; high-quality evidence)*.

22. Testing for respiratory viruses other than influenza virus can modify clinical decision making in children with suspected pneumonia, because antibacterial therapy will not routinely be required for these children in the absence of clinical, laboratory, or radiographic findings that suggest bacterial coinfection. *(weak recommendation; low-quality evidence)*

Testing for Atypical Bacteria

23. Children with signs and symptoms suspicious for *Mycoplasma pneumoniae* should be tested to help guide antibiotic selection. *(weak recommendation; moderate-quality evidence)*

24. Diagnostic testing for *Chlamydophila pneumoniae* is not recommended as reliable and readily available diagnostic tests do not currently exist. *(strong recommendation; high-quality evidence)*

Ancillary Diagnostic Testing

Complete Blood Cell Count

25. Routine measurement of the complete blood cell count is not necessary in all children with suspected CAP managed in the outpatient setting, but in those with more serious disease it may provide useful information for clinical management in the context of the clinical examination and other laboratory and imaging studies. *(weak recommendation; low-quality evidence)*

26. A complete blood cell count should be obtained for patients with severe pneumonia, to be interpreted in the context

of the clinical examination and other laboratory and imaging studies. *(weak recommendation; low-quality evidence)*

Acute-Phase Reactants

27. Acute-phase reactants, such as the erythrocyte sedimentation rate (ESR), C-reactive protein (CRP) concentration, or serum procalcitonin concentration, cannot be used as the sole determinant to distinguish between viral and bacterial causes of CAP. *(strong recommendation; high-quality evidence)*

28. Acute-phase reactants need not be routinely measured in fully immunized children with CAP who are managed as outpatients, although for more serious disease, acute-phase reactants may provide useful information for clinical management. *(strong recommendation; low-quality evidence)*

29. In patients with more serious disease, such as those requiring hospitalization or those with pneumonia-associated complications, acute-phase reactants may be used in conjunction with clinical findings to assess response to therapy. *(weak recommendation; low-quality evidence)*

Pulse Oximetry

30. Pulse oximetry should be performed in all children with pneumonia and suspected hypoxemia. The presence of hypoxemia should guide decisions regarding site of care and further diagnostic testing. *(strong recommendation; moderate-quality evidence)*

Chest Radiography

Initial Chest Radiographs: Outpatient

31. Routine chest radiographs are not necessary for the confirmation of suspected CAP in patients well enough to be treated in the outpatient setting (after evaluation in the office, clinic, or emergency department setting). *(strong recommendation; high-quality evidence)*

32. Chest radiographs, posteroanterior and lateral, should be obtained in patients with suspected or documented hypoxemia or significant respiratory distress (Table 3) and in those with failed initial antibiotic therapy to verify the presence or absence of complications of pneumonia, including parapneumonic effusions, necrotizing pneumonia, and pneumothorax. *(strong recommendation; moderate-quality evidence)*

Initial Chest Radiographs: Inpatient

33. Chest radiographs (posteroanterior and lateral) should be obtained in all patients hospitalized for management of CAP to document the presence, size, and character of parenchymal infiltrates and identify complications of pneumonia that may lead to interventions beyond antimicrobial agents and supportive medical therapy. *(strong recommendation; moderate-quality evidence)*

Table 4. Criteria for CAP Severity of Illness in Children with Community-Acquired Pneumonia

Criteria
Major criteria
Invasive mechanical ventilation
Fluid refractory shock
Acute need for NIPPV
hypoxemia requiring FiO_2 greater than inspired concentration or flow feasible in general care area
Minor criteria
Respiratory rate higher than WHO classification for age
Apnea
Increased work of breathing (eg, retractions, dyspnea, nasal flaring, grunting)
PaO_2/FiO_2 ratio <250
Multilobar infiltrates
PEWS score >6
Altered mental status
Hypotension
Presence of effusion
Comorbid conditions (eg, HgbSS, immunosuppression, immunodeficiency)
Unexplained metabolic acidosis

Modified from Infectious Diseases Society of America/American Thoracic Society consensus guidelines on the management of community-acquired pneumonia in adults [27, table 4]. Clinician should consider care in an intensive care unit or a unit with continuous cardiorespiratory monitoring for the child having ≥1 major or ≥2 minor criteria.

Abbreviations: FiO_2, fraction of inspired oxygen; HgbSS, Hemoglobin SS disease; NIPPV, noninvasive positive pressure ventilation; PaO_2, arterial oxygen pressure; PEWS, Pediatric Early Warning Score [70].

Follow-up Chest Radiograph

34. Repeated chest radiographs are not routinely required in children who recover uneventfully from an episode of CAP. *(strong recommendation; moderate-quality evidence)*

35. Repeated chest radiographs should be obtained in children who fail to demonstrate clinical improvement and in those who have progressive symptoms or clinical deterioration within 48–72 hours after initiation of antibiotic therapy. *(strong recommendation; moderate-quality evidence)*

36. Routine daily chest radiography is not recommended in children with pneumonia complicated by parapneumonic effusion after chest tube placement or after video-assisted thoracoscopic surgery (VATS), if they remain clinically stable. *(strong recommendation; low-quality evidence)*

37. Follow-up chest radiographs should be obtained in patients with complicated pneumonia with worsening respiratory distress or clinical instability, or in those with persistent fever that is not responding to therapy over 48-72 hours. *(strong recommendation; low-quality evidence)*

38. Repeated chest radiographs 4–6 weeks after the diagnosis of CAP should be obtained in patients with recurrent pneumonia involving the same lobe and in patients with lobar collapse at initial chest radiography with suspicion of an anatomic anomaly, chest mass, or foreign body aspiration. *(strong recommendation; moderate-quality evidence)*

IV. What Additional Diagnostic Tests Should Be Used in a Child With Severe or Life-Threatening CAP?

Recommendations

39. The clinician should obtain tracheal aspirates for Gram stain and culture, as well as clinically and epidemiologically guided testing for viral pathogens, including influenza virus, at the time of initial endotracheal tube placement in children requiring mechanical ventilation. *(strong recommendation; low-quality evidence)*

40. Bronchoscopic or blind protected specimen brush sampling, bronchoalveolar lavage (BAL), percutaneous lung aspiration, or open lung biopsy should be reserved for the immunocompetent child with severe CAP if initial diagnostic tests are not positive. *(weak recommendation; low-quality evidence)*

ANTI-INFECTIVE TREATMENT

V. Which Anti-Infective Therapy Should Be Provided to a Child With Suspected CAP in Both Outpatient and Inpatient Settings?

Recommendations

Outpatients

41. Antimicrobial therapy is not routinely required for preschool-aged children with CAP, because viral pathogens are responsible for the great majority of clinical disease. *(strong recommendation; high-quality evidence)*

42. Amoxicillin should be used as first-line therapy for previously healthy, appropriately immunized infants and preschool children with mild to moderate CAP suspected to be of bacterial origin. Amoxicillin provides appropriate coverage for *Streptococcus pneumoniae,* the most prominent invasive bacterial pathogen. Table 5 lists preferred agents and alternative agents for children allergic to amoxicillin *(strong recommendation; moderate-quality evidence)*

43. Amoxicillin should be used as first-line therapy for previously healthy appropriately immunized school-aged children and adolescents with mild to moderate CAP for *S. pneumoniae*, the most prominent invasive bacterial pathogen. Atypical bacterial pathogens (eg, *M. pneumoniae*), and less common lower respiratory tract bacterial pathogens, as discussed in the Evidence Summary, should also be considered in management decisions. *(strong recommendation; moderate-quality evidence)*

44. Macrolide antibiotics should be prescribed for treatment of children (primarily school-aged children and adolescents) evaluated in an outpatient setting with findings compatible with CAP caused by atypical pathogens. Laboratory testing for *M. pneumoniae* should be performed if available in a clinically relevant time frame. Table 5 lists preferred and alternative agents for atypical pathogens. *(weak recommendation; moderate-quality evidence)*

45. Influenza antiviral therapy (Table 6) should be administered as soon as possible to children with moderate to severe CAP consistent with influenza virus infection during widespread local circulation of influenza viruses, particularly for those with clinically worsening disease documented at the time of an outpatient visit. Because early antiviral treatment has been shown to provide maximal benefit, treatment should not be delayed until confirmation of positive influenza test results. Negative results of influenza diagnostic tests do not conclusively exclude influenza disease. Treatment after 48 hours of symptomatic infection may still provide clinical benefit to those with more severe disease. *(strong recommendation; moderate-quality evidence)*

Inpatients

46. Ampicillin or penicillin G should be administered to the fully immunized infant or school-aged child admitted to a hospital ward with CAP when local epidemiologic data document lack of substantial high-level penicillin resistance for invasive *S. pneumoniae.* Other antimicrobial agents for empiric therapy are provided in Table 7. *(strong recommendation; moderate-quality evidence)*

47. Empiric therapy with a third-generation parenteral cephalosporin (ceftriaxone or cefotaxime) should be prescribed for hospitalized infants and children who are not fully immunized, in regions where local epidemiology of invasive pneumococcal strains documents high-level penicillin resistance, or for infants and children with life-threatening infection, including those with empyema (Table 7). Non–β-lactam agents, such as vancomycin, have not been shown to be more effective than third-generation cephalosporins in the treatment of pneumococcal pneumonia for the degree of resistance noted currently in North America. *(weak recommendation; moderate-quality evidence)*

48. Empiric combination therapy with a macrolide (oral or parenteral), in addition to a β-lactam antibiotic, should be prescribed for the hospitalized child for whom *M. pneumoniae* and *C. pneumoniae* are significant considerations; diagnostic testing should be performed if available in a clinically relevant time frame (Table 7). *(weak recommendation; moderate-quality evidence)*

49. Vancomycin or clindamycin (based on local susceptibility data) should be provided in addition to β-lactam therapy if

Table 5. Selection of Antimicrobial Therapy for Specific Pathogens

Pathogen	Parenteral therapy	Oral therapy (step-down therapy or mild infection)
Streptococcus pneumoniae with MICs for penicillin ≤2.0 μg/mL	Preferred: ampicillin (150–200 mg/kg/day every 6 hours) or penicillin (200 000–250 000 U/kg/day every 4–6 h); Alternatives: ceftriaxone (50–100 mg/kg/day every 12–24 hours) (preferred for parenteral outpatient therapy) or cefotaxime (150 mg/kg/day every 8 hours); may also be effective: clindamycin (40 mg/kg/day every 6–8 hours) or vancomycin (40–60 mg/kg/day every 6–8 hours)	Preferred: amoxicillin (90 mg/kg/day in 2 doses or 45 mg/kg/day in 3 doses); Alternatives: second- or third-generation cephalosporin (cefpodoxime, cefuroxime, cefprozil); oral levofloxacin, if susceptible (16–20 mg/kg/day in 2 doses for children 6 months to 5 years old and 8–10 mg/kg/day once daily for children 5 to 16 years old; maximum daily dose, 750 mg) or oral linezolid (30 mg/kg/day in 3 doses for children <12 years old and 20 mg/kg/day in 2 doses for children ≥12 years old)
S. pneumoniae resistant to penicillin, with MICs ≥4.0 μg/mL	Preferred: ceftriaxone (100 mg/kg/day every 12–24 hours); Alternatives: ampicillin (300–400 mg/kg/day every 6 hours), levofloxacin (16–20 mg/kg/day every 12 hours for children 6 months to 5 years old and 8–10 mg/kg/day once daily for children 5–16 years old; maximum daily dose, 750 mg), or linezolid (30 mg/kg/day every 8 hours for children <12 years old and 20 mg/kg/day every 12 hours for children ≥12 years old); may also be effective: clindamycin[a] (40 mg/kg/day every 6–8 hours) or vancomycin (40–60 mg/kg/day every 6–8 hours)	Preferred: oral levofloxacin (16–20 mg/kg/day in 2 doses for children 6 months to 5 years and 8–10 mg/kg/day once daily for children 5–16 years, maximum daily dose, 750 mg), if susceptible, or oral linezolid (30 mg/kg/day in 3 doses for children <12 years and 20 mg/kg/day in 2 doses for children ≥12 years); Alternative: oral clindamycin[a] (30–40 mg/kg/day in 3 doses)
Group A *Streptococcus*	Preferred: intravenous penicillin (100 000–250 000 U/kg/day every 4–6 hours) or ampicillin (200 mg/kg/day every 6 hours); Alternatives: ceftriaxone (50–100 mg/kg/day every 12–24 hours) or cefotaxime (150 mg/kg/day every 8 hours); may also be effective: clindamycin, if susceptible (40 mg/kg/day every 6–8 hours) or vancomycin[b] (40–60 mg/kg/day every 6–8 hours)	Preferred: amoxicillin (50–75 mg/kg/day in 2 doses), or penicillin V (50–75 mg/kg/day in 3 or 4 doses); Alternative: oral clindamycin[a] (40 mg/kg/day in 3 doses)
Stapyhylococcus aureus, methicillin susceptible (combination therapy not well studied)	Preferred: cefazolin (150 mg/kg/day every 8 hours) or semisynthetic penicillin, eg oxacillin (150–200 mg/kg/day every 6–8 hours); Alternatives: clindamycin[a] (40 mg/kg/day every 6–8 hours) or >vancomycin (40–60 mg/kg/day every 6–8 hours)	Preferred: oral cephalexin (75–100 mg/kg/day in 3 or 4 doses); Alternative: oral clindamycin[a] (30–40 mg/kg/day in 3 or 4 doses)
S. aureus, methicillin resistant, susceptible to clindamycin (combination therapy not well-studied)	Preferred: vancomycin (40–60 mg/kg/day every 6–8 hours or dosing to achieve an AUC/MIC ratio of >400) or clindamycin (40 mg/kg/day every 6–8 hours); Alternatives: linezolid (30 mg/kg/day every 8 hours for children <12 years old and 20 mg/kg/day every 12 hours for children ≥12 years old)	Preferred: oral clindamycin (30–40 mg/kg/day in 3 or 4 doses); Alternatives: oral linezolid (30 mg/kg/day in 3 doses for children <12 years and 20 mg/kg/day in 2 doses for children ≥12 years)
S. aureus, methicillin resistant, resistant to clindamycin (combination therapy not well studied)	Preferred: vancomycin (40–60 mg/kg/day every 6-8 hours or dosing to achieve an AUC/MIC ratio of >400); Alternatives: linezolid (30 mg/kg/day every 8 hours for children <12 years old and 20 mg/kg/day every 12 hours for children ≥12 years old)	Preferred: oral linezolid (30 mg/kg/day in 3 doses for children <12 years and 20 mg/kg/day in 2 doses for children ≥12 years old); Alternatives: none; entire treatment course with parenteral therapy may be required

Table 5. (*Continued*)

Pathogen	Parenteral therapy	Oral therapy (step-down therapy or mild infection)
Haemophilus influenza, typeable (A-F) or nontypeable	Preferred: intravenous ampicillin (150-200 mg/kg/day every 6 hours) if β-lactamase negative, ceftriaxone (50–100 mg/kg/day every 12-24 hours) if β-lactamase producing, or cefotaxime (150 mg/kg/day every 8 hours); Alternatives: intravenous ciprofloxacin (30 mg/kg/day every 12 hours) or intravenous levofloxacin (16-20 mg/kg/day every 12 hours for children 6 months to 5 years old and 8-10 mg/kg/day once daily for children 5 to 16 years old; maximum daily dose, 750 mg)	Preferred: amoxicillin (75-100 mg/kg/day in 3 doses) if β-lactamase negative) or amoxicillin clavulanate (amoxicillin component, 45 mg/kg/day in 3 doses or 90 mg/kg/day in 2 doses) if β-lactamase producing; Alternatives: cefdinir, cefixime, cefpodoxime, or ceftibuten
Mycoplasma pneumoniae	Preferred: intravenous azithromycin (10 mg/kg on days 1 and 2 of therapy; transition to oral therapy if possible); Alternatives: intravenous erythromycin lactobionate (20 mg/kg/day every 6 hours) or levofloxacin (16-20 mg/kg/day every 12 hours; maximum daily dose, 750 mg)	Preferred: azithromycin (10 mg/kg on day 1, followed by 5 mg/kg/day once daily on days 2–5); Alternatives: clarithromycin (15 mg/kg/day in 2 doses) or oral erythromycin (40 mg/kg/day in 4 doses); for children >7 years old, doxycycline (2–4 mg/kg/day in 2 doses; for adolescents with skeletal maturity, levofloxacin (500 mg once daily) or moxifloxacin (400 mg once daily)
Chlamydia trachomatis or *Chlamydophila pneumoniae*	Preferred: intravenous azithromycin (10 mg/kg on days 1 and 2 of therapy; transition to oral therapy if possible); Alternatives: intravenous erythromycin lactobionate (20 mg/kg/day every 6 hours) or levofloxacin (16-20 mg/kg/day in 2 doses for children 6 months to 5 years old and 8-10 mg/kg/day once daily for children 5 to 16 years old; maximum daily dose, 750 mg)	Preferred: azithromycin (10 mg/kg on day 1, followed by 5 mg/kg/day once daily days 2–5); Alternatives: clarithromycin (15 mg/kg/day in 2 doses) or oral erythromycin (40 mg/kg/day in 4 doses); for children >7 years old, doxycycline (2-4 mg/kg/day in 2 doses); for adolescents with skeletal maturity, levofloxacin (500 mg once daily) or moxifloxacin (400 mg once daily)

Doses for oral therapy should not exceed adult doses.

Abbreviations: AUC, area under the time vs. serum concentration curve; MIC, minimum inhibitory concentration.

[a] Clindamycin resistance appears to be increasing in certain geographic areas among *S. pneumoniae* and *S. aureus* infections.

[b] For β-lactam–allergic children.

clinical, laboratory, or imaging characteristics are consistent with infection caused by *S. aureus* (Table 7). *(strong recommendation; low-quality evidence)*

VI. How Can Resistance to Antimicrobials Be Minimized?

Recommendations

50. Antibiotic exposure selects for antibiotic resistance; therefore, limiting exposure to any antibiotic, whenever possible, is preferred. *(strong recommendation; moderate-quality evidence)*

51. Limiting the spectrum of activity of antimicrobials to that specifically required to treat the identified pathogen is preferred. *(strong recommendation; low-quality evidence)*

52. Using the proper dosage of antimicrobial to be able to achieve a minimal effective concentration at the site of infection is important to decrease the development of resistance. *(strong recommendation; low-quality evidence)*

53. Treatment for the shortest effective duration will minimize exposure of both pathogens and normal microbiota to antimicrobials and minimize the selection for resistance. *(strong recommendation; low-quality evidence)*

VII. What Is the Appropriate Duration of Antimicrobial Therapy for CAP?

Recommendations

54. Treatment courses of 10 days have been best studied, although shorter courses may be just as effective, particularly for more mild disease managed on an outpatient basis. *(strong recommendation; moderate-quality evidence)*

55. Infections caused by certain pathogens, notably CA-MRSA, may require longer treatment than those caused by *S. pneumoniae*. *(strong recommendation; moderate-quality evidence)*

Table 6. Influenza Antiviral Therapy

		Dosing recommendations			
		Treatment		Prophylaxis[a]	
Drug	Formulation	Children	Adults	Children	Adults
Oseltamivir (Tamiflu)	75-mg capsule; 60 mg/5 mL Suspension	≥24 months old: ~4 mg/kg/day in 2 doses, for a 5-day treatment course	150 mg/day in 2 doses for 5 days	≤15 kg: 30 mg/day; >15 to 23 kg: 45 mg/day; >23 to 40 kg: 60 mg/day; >40 kg: 75 mg/day (once daily in each group)	75 mg/day once daily
		≤15 kg: 60 mg/day; >15 to 23 kg: 90 mg/day; >23 to 40 kg: 120 mg/day; >40 kg: 150 mg/day (divided into 2 doses for each group)			
		9–23 months old: 7 mg/kg/day in 2 doses; 0–8 months old: 6 mg/kg/day in 2 doses; premature infants: 2 mg/kg/day in 2 doses		9–23 months old: 3.5 mg/kg once daily; 3–8 months old: 3 mg/kg once daily; not routinely recommended for infants <3 months old owing to limited data in this age group	
Zanamivir (Relenza)	5 mg per inhalation, using a Diskhaler	≥7 years old: 2 inhalations (10 mg total per dose), twice daily for 5 days	2 inhalations (10 mg total per dose), twice daily for 5 days	≥5 years old: 2 inhalations (10 mg total per dose), once daily for 10 days	2 inhalations (10 mg total per dose), once daily for 10 days
Amantadine (Symmetrel)[b]	100-mg tablet; 50 mg/5 mL suspension	1–9 years old: 5–8 mg/kg/day as single daily dose or in 2 doses, not to exceed 150 mg/day; 9–12 years old: 200 mg/day in 2 doses (not studied as single daily dose)	200 mg/day, as single daily dose or in 2 doses	1–9 years old: same as treatment dose; 9–12 years old: same as treatment dose	Same as treatment dose
Rimantadine (Flumadine)[b]	100-mg tablet; 50 mg/5 mL suspension	Not FDA approved for treatment in children, but published data exist on safety and efficacy in children; suspension: 1–9 years old: 6.6 mg/kg/day (maximum 150 mg/kg/day) in 2 doses; ≥10 years old: 200 mg/day, as single daily dose or in 2 doses	200 mg/day, either as a single daily dose, or divided into 2 doses	FDA approved for prophylaxis down to 12 months of age. 1–9 years old: 5 mg/kg/day once daily, not to exceed 150 mg; ≥10 years old: 200 mg/day as single daily dose or in 2 doses	200 mg/day, as single daily dose or in 2 doses

NOTE. Check Centers for Disease Control and Prevention Website (http://www.flu.gov/) for current susceptibility data.

[a] In children for whom prophylaxis is indicated, antiviral drugs should be continued for the duration of known influenza activity in the community because of the potential for repeated and unknown exposures or until immunity can be achieved after immunization.

[b] Amantadine and rimantadine should be used for treatment and prophylaxis only in winter seasons during which a majority of influenza A virus strains isolated are adamantine susceptible; the adamantanes should not be used for primary therapy because of the rapid emergence of resistance. However, for patients requiring adamantane therapy, a treatment course of ~7 days is suggested, or until 24–48 hours after the disappearance of signs and symptoms.

VIII. How Should the Clinician Follow the Child With CAP for the Expected Response to Therapy?

Recommendation

56. Children on adequate therapy should demonstrate clinical and laboratory signs of improvement within 48–72 hours. For children whose condition deteriorates after admission and initiation of antimicrobial therapy or who show no improvement within 48–72 hours, further investigation should be performed. *(strong recommendation; moderate-quality evidence)*

ADJUNCTIVE SURGICAL AND NON–ANTI-INFECTIVE THERAPY FOR PEDIATRIC CAP

IX. How Should a Parapneumonic Effusion Be Identified?

Recommendation

57. History and physical examination may be suggestive of parapneumonic effusion in children suspected of having CAP, but chest radiography should be used to confirm the presence of pleural fluid. If the chest radiograph is not conclusive, then

Table 7. Empiric Therapy for Pediatric Community-Acquired Pneumonia (CAP)

Site of care	Empiric therapy		
	Presumed bacterial pneumonia	Presumed atypical pneumonia	Presumed influenza pneumonia[a]
Outpatient			
<5 years old (preschool)	Amoxicillin, oral (90 mg/kg/day in 2 doses[b]); alternative: oral amoxicillin clavulanate (amoxicillin component, 90 mg/kg/day in 2 doses[b])	Azithromycin oral (10 mg/kg on day 1, followed by 5 mg/kg/day once daily on days 2–5); alternatives: oral clarithromycin (15 mg/kg/day in 2 doses for 7-14 days) or oral erythromycin (40 mg/kg/day in 4 doses)	Oseltamivir
≥5 years old	Oral amoxicillin (90 mg/kg/day in 2 doses[b] to a maximum of 4 g/day[c]); for children with presumed bacterial CAP who do not have clinical, laboratory, or radiographic evidence that distinguishes bacterial CAP from atypical CAP, a macrolide can be added to a β-lactam antibiotic for empiric therapy; alternative: oral amoxicillin clavulanate (amoxicillin component, 90 mg/kg/day in 2 doses[b] to a maximum dose of 4000 mg/day, eg, one 2000-mg tablet twice daily[b])	Oral azithromycin (10 mg/kg on day 1, followed by 5 mg/kg/day once daily on days 2–5 to a maximum of 500 mg on day 1, followed by 250 mg on days 2–5); alternatives: oral clarithromycin (15 mg/kg/day in 2 doses to a maximum of 1 g/day); erythromycin, doxycycline for children >7 years old	Oseltamivir or zanamivir (for children 7 years and older); alternatives: peramivir, oseltamivir and zanamivir (all intravenous) are under clinical investigation in children; intravenous zanamivir available for compassionate use
Inpatient (all ages)[d]			
Fully immunized with conjugate vaccines for *Haemophilus influenzae* type b and *Streptococcus pneumoniae*; local penicillin resistance in invasive strains of pneumococcus is minimal	Ampicillin or penicillin G; alternatives: ceftriaxone or cefotaxime; addition of vancomycin or clindamycin for suspected CA-MRSA	Azithromycin (in addition to β-lactam, if diagnosis of atypical pneumonia is in doubt); alternatives: clarithromycin or erythromycin; doxycycline for children >7 years old; levofloxacin for children who have reached growth maturity, or who cannot tolerate macrolides	Oseltamivir or zanamivir (for children ≥7 years old; alternatives: peramivir, oseltamivir and zanamivir (all intravenous) are under clinical investigation in children; intravenous zanamivir available for compassionate use
Not fully immunized for *H, influenzae* type b and *S. pneumoniae*; local penicillin resistance in invasive strains of pneumococcus is significant	Ceftriaxone or cefotaxime; addition of vancomycin or clindamycin for suspected CA-MRSA; alternative: levofloxacin; addition of vancomycin or clindamycin for suspected CA-MRSA	Azithromycin (in addition to β-lactam, if diagnosis in doubt); alternatives: clarithromycin or erythromycin; doxycycline for children >7 years old; levofloxacin for children who have reached growth maturity or who cannot tolerate macrolides	As above

For children with drug allergy to recommended therapy, see Evidence Summary for Section V. Anti-Infective Therapy. For children with a history of possible, nonserious allergic reactions to amoxicillin, treatment is not well defined and should be individualized. Options include a trial of amoxicillin under medical observation; a trial of an oral cephalosporin that has substantial activity against *S. pneumoniae*, such as cefpodoxime, cefprozil, or cefuroxime, provided under medical supervision; treatment with levofloxacin; treatment with linezolid; treatment with clindamycin (if susceptible); or treatment with a macrolide (if susceptible). For children with bacteremic pneumococcal pneumonia, particular caution should be exercised in selecting alternatives to amoxicillin, given the potential for secondary sites of infection, including meningitis.

Abbreviation: CA-MRSA, community-associated methicillin-resistant *Staphylococcus aureus*.

[a] See Table 6 for dosages.

[b] See text for discussion of dosage recommendations based on local susceptibility data. Twice daily dosing of amoxicillin or amoxicillin clavulanate may be effective for pneumococci that are susceptible to penicillin.

[c] Not evaluated prospectively for safety.

[d] See Table 5 for dosages.

further imaging with chest ultrasound or computed tomography (CT) is recommended. *(strong recommendation; high-quality evidence)*

X. What Factors Are Important in Determining Whether Drainage of the Parapneumonic Effusion Is Required?

Recommendations

58. The size of the effusion is an important factor that determines management (Table 8, Figure 1). *(strong recommendation; moderate-quality evidence)*

59. The child's degree of respiratory compromise is an important factor that determines management of parapneumonic effusions (Table 8, Figure 1) *(strong recommendation; moderate-quality evidence)*

XI. What Laboratory Testing Should Be Performed on Pleural Fluid?

Recommendation

60. Gram stain and bacterial culture of pleural fluid should be performed whenever a pleural fluid specimen is obtained. *(strong recommendation; high-quality evidence)*

Table 8. Factors Associated with Outcomes and Indication for Drainage of Parapneumonic Effusions

Size of effusion	Bacteriology	Risk of poor outcome	Tube drainage with or without fibrinolysis *or* VATS[a]
Small: <10 mm on lateral decubitus radiograph *or* opacifies less than one-fourth of hemithorax	Bacterial culture and Gram stain results unknown or negative	Low	No; sampling of pleural fluid is not routinely required
Moderate: >10-mm rim of fluid but opacifies less than half of the hemithorax	Bacterial culture and/or Gram stain results negative *or* positive (empyema)	Low to moderate	No if the patient has no respiratory compromise and the pleural fluid is not consistent with empyema (sampling of pleural fluid by simple thoracentesis may help determine presence or absence of empyema and need for a drainage procedure, and sampling with a drainage catheter may provide both diagnostic and therapeutic benefit); Yes, if the patient has respiratory compromise or if pleural fluid is consistent with empyema if the patient has respiratory compromise or if pleural fluid is consistent with empyema
Large: opacifies more than half of the hemithorax	Bacterial culture and/or Gram stain results positive (empyema)	High	Yes in most cases

[a] VATS, video-assisted thoracoscopic surgery.

61. Antigen testing or nucleic acid amplification through polymerase chain reaction (PCR) increase the detection of pathogens in pleural fluid and may be useful for management. *(strong recommendation; moderate-quality evidence)*

62. Analysis of pleural fluid parameters, such as pH and levels of glucose, protein, and lactate dehydrogenase, rarely change patient management and are not recommended. *(weak recommendation; very low-quality evidence)*

63. Analysis of the pleural fluid white blood cell (WBC) count, with cell differential analysis, is recommended primarily to help differentiate bacterial from mycobacterial etiologies and from malignancy. *(weak recommendation; moderate-quality evidence)*

XII. What Are the Drainage Options for Parapneumonic Effusions?

Recommendations

64. Small, uncomplicated parapneumonic effusions should not routinely be drained and can be treated with antibiotic therapy alone. *(strong recommendation; moderate-quality evidence)*

65. Moderate parapneumonic effusions associated with respiratory distress, large parapneumonic effusions, or documented purulent effusions should be drained. *(strong recommendation; moderate-quality evidence)*

66. Both chest thoracostomy tube drainage with the addition of fibrinolytic agents and VATS have been demonstrated to be effective methods of treatment. The choice of drainage procedure depends on local expertise. Both of these methods are associated with decreased morbidity compared with chest tube drainage alone. However, in patients with moderate-to-large effusions that are free flowing (no loculations), placement of a chest tube without fibrinolytic agents is a reasonable first option. *(strong recommendation; high-quality evidence)*

XIII. When Should VATS or Open Decortication Be Considered in Patients Who Have Had Chest Tube Drainage, With or Without Fibrinolytic Therapy?

Recommendation

67. VATS should be performed when there is persistence of moderate-large effusions and ongoing respiratory compromise despite ~2–3 days of management with a chest tube and completion of fibrinolytic therapy. Open chest débridement with decortication represents another option for management of these children but is associated with higher morbidity rates. *(strong recommendation; low-quality evidence)*

XIV. When Should a Chest Tube Be Removed Either After Primary Drainage or VATS?

68. A chest tube can be removed in the absence of an intrathoracic air leak and when pleural fluid drainage is <1 mL/kg/24 h, usually calculated over the last 12 hours. *(strong recommendation; very low-quality evidence)*

XV. What Antibiotic Therapy and Duration Is Indicated for the Treatment of Parapneumonic Effusion/Empyema?

Recommendations

69. When the blood or pleural fluid bacterial culture identifies a pathogenic isolate, antibiotic susceptibility should be used to determine the antibiotic regimen. *(strong recommendation; high-quality evidence)*

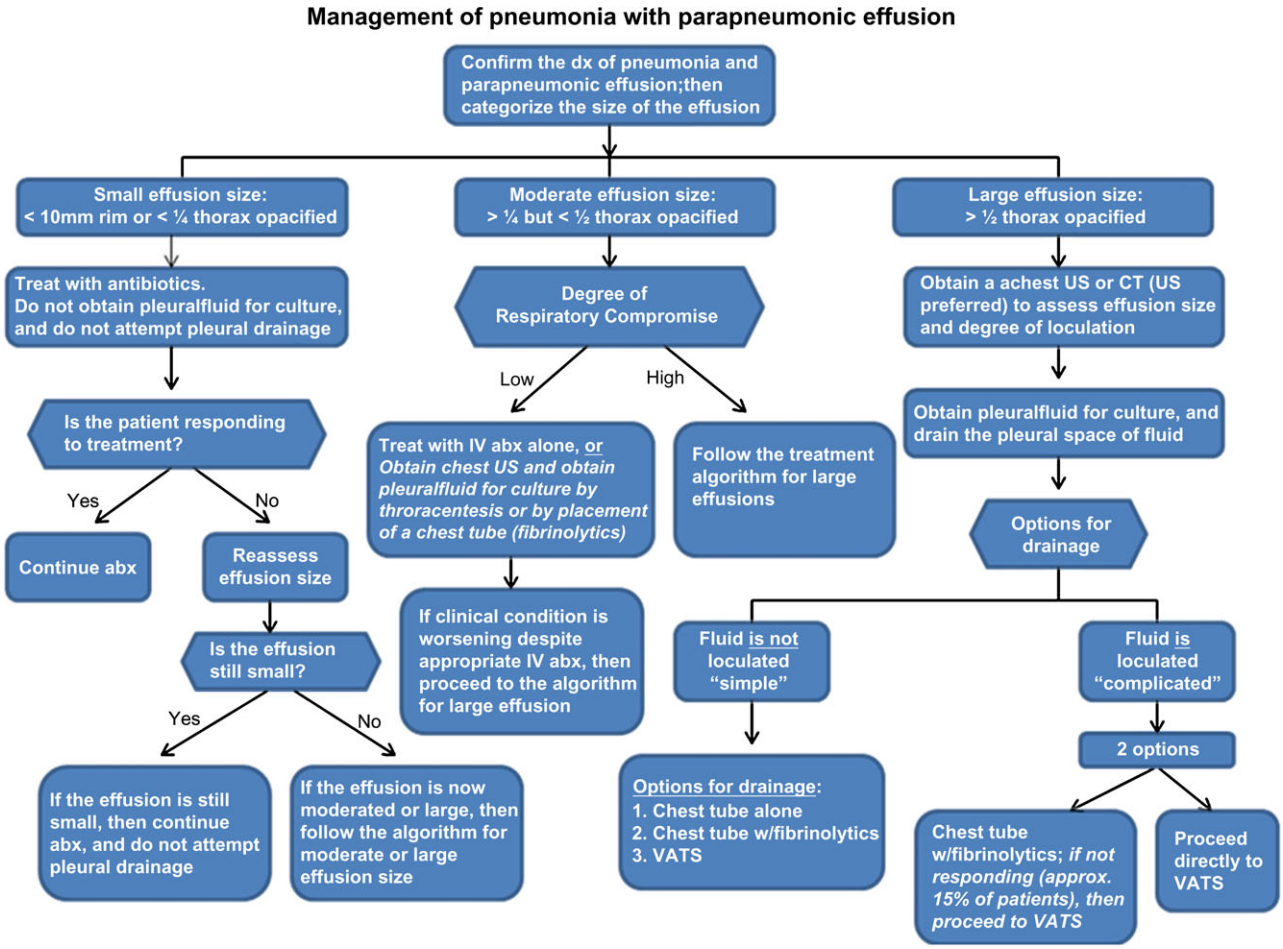

Figure 1. Management of pneumonia with parapneumonic effusion; abx, antibiotics; CT, computed tomography; dx, diagnosis; IV, intravenous; US, ultrasound; VATS, video-assisted thoracoscopic surgery.

70. In the case of culture-negative parapneumonic effusions, antibiotic selection should be based on the treatment recommendations for patients hospitalized with CAP (see Evidence Summary for Recommendations 46–49). *(strong recommendation; moderate-quality evidence)*

71. The duration of antibiotic treatment depends on the adequacy of drainage and on the clinical response demonstrated for each patient. In most children, antibiotic treatment for 2–4 weeks is adequate. *(strong recommendation; low-quality evidence)*

MANAGEMENT OF THE CHILD NOT RESPONDING TO TREATMENT

XVI. What Is the Appropriate Management of a Child Who Is Not Responding to Treatment for CAP?

Recommendation

72. Children who are not responding to initial therapy after 48–72 hours should be managed by one or more of the following:

a. Clinical and laboratory assessment of the current severity of illness and anticipated progression in order to determine whether higher levels of care or support are required. *(strong recommendation; low-quality evidence)*

b. Imaging evaluation to assess the extent and progression of the pneumonic or parapneumonic process. *(weak recommendation; low-quality evidence)*

c. Further investigation to identify whether the original pathogen persists, the original pathogen has developed resistance to the agent used, or there is a new secondary infecting agent. *(weak recommendation; low-quality evidence)*

73. A BAL specimen should be obtained for Gram stain and culture for the mechanically ventilated child. *(strong recommendation; moderate-quality evidence)*

74. A percutaneous lung aspirate should be obtained for Gram stain and culture in the persistently and seriously ill child for whom previous investigations have not yielded a microbiologic diagnosis. *(weak recommendation; low-quality evidence)*

75. An open lung biopsy for Gram stain and culture should be obtained in the persistently and critically ill, mechanically ventilated child in whom previous investigations have not yielded a microbiologic diagnosis. *(weak recommendation; low-quality evidence)*

XVII. How Should Nonresponders With Pulmonary Abscess or Necrotizing Pneumonia Be Managed?

Recommendation

76. A pulmonary abscess or necrotizing pneumonia identified in a nonresponding patient can be initially treated with intravenous antibiotics. Well-defined peripheral abscesses without connection to the bronchial tree may be drained under imaging-guided procedures either by aspiration or with a drainage catheter that remains in place, but most abscesses will drain through the bronchial tree and heal without surgical or invasive intervention. *(weak recommendation; very low-quality evidence)*

DISCHARGE CRITERIA

XVIII. When Can a Hospitalized Child With CAP Be Safely Discharged?

Recommendations

77. Patients are eligible for discharge when they have documented overall clinical improvement, including level of activity, appetite, and decreased fever for at least 12–24 hours. *(strong recommendation; very low-quality evidence)*

78. Patients are eligible for discharge when they demonstrate consistent pulse oximetry measurements >90% in room air for at least 12–24 hours. *(strong recommendation; moderate-quality evidence)*

79. Patients are eligible for discharge only if they demonstrate stable and/or baseline mental status. *(strong recommendation; very low-quality evidence)*

80. Patients are not eligible for discharge if they have substantially increased work of breathing or sustained tachypnea or tachycardia *(strong recommendation; high-quality evidence)*

81. Patients should have documentation that they can tolerate their home anti-infective regimen, whether oral or intravenous, and home oxygen regimen, if applicable, before hospital discharge. *(strong recommendation; low-quality evidence)*

82. For infants or young children requiring outpatient oral antibiotic therapy, clinicians should demonstrate that parents are able to administer and children are able to comply adequately with taking those antibiotics before discharge. *(weak recommendation; very low-quality evidence)*

83. For children who have had a chest tube and meet the requirements listed above, hospital discharge is appropriate after the chest tube has been removed for 12–24 hours, either if there is no clinical evidence of deterioration since removal or if a chest radiograph, obtained for clinical concerns, shows no significant reaccumulation of a parapneumonic effusion or pneumothorax. *(strong recommendation; very low-quality evidence)*

84. In infants and children with barriers to care, including concern about careful observation at home, inability to comply with therapy, or lack of availability for follow-up, these issues should be identified and addressed before discharge. *(weak recommendation; very low-quality evidence)*

XIX. When Is Parenteral Outpatient Therapy Indicated, In Contrast to Oral Step-Down Therapy?

Recommendations

85. Outpatient parenteral antibiotic therapy should be offered to families of children no longer requiring skilled nursing care in an acute care facility but with a demonstrated need for ongoing parenteral therapy. *(weak recommendation; moderate-quality evidence)*

86. Outpatient parenteral antibiotic therapy should be offered through a skilled pediatric home nursing program or through daily intramuscular injections at an appropriate pediatric outpatient facility. *(weak recommendation; low-quality evidence)*

87. Conversion to oral outpatient step-down therapy when possible, is preferred to parenteral outpatient therapy. *(strong recommendation; low-quality evidence)*

PREVENTION

XX. Can Pediatric CAP Be Prevented?

Recommendations

88. Children should be immunized with vaccines for bacterial pathogens, including *S. pneumoniae*, *Haemophilus influenzae* type b, and pertussis to prevent CAP. *(strong recommendation; high-quality evidence)*

89. All infants ≥6 months of age and all children and adolescents should be immunized annually with vaccines for influenza virus to prevent CAP. *(strong recommendation; high-quality evidence)*

90. Parents and caretakers of infants <6 months of age, including pregnant adolescents, should be immunized with vaccines for influenza virus and pertussis to protect the infants from exposure. *(strong recommendation; weak-quality evidence)*

91. Pneumococcal CAP after influenza virus infection is decreased by immunization against influenza virus. *(strong recommendation; weak-quality evidence)*

92. High-risk infants should be provided immune prophylaxis with respiratory syncytial virus (RSV)–specific monoclonal antibody to decrease the risk of severe pneumonia and hospitalization caused by RSV. *(strong recommendation; high-quality evidence)*

Notes

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