TEXAS CHILDREN'S HOSPITAL
EVIDENCE-BASED OUTCOMES CENTER
Community-Acquired Pneumonia (CAP)
Evidence-Based Guideline

Definition: The presence of signs and symptoms of pneumonia in a previously healthy child, due to an infection of the pulmonary parenchyma that has been acquired outside of the hospital.

Etiology: The exact etiology of pneumonia is often unidentified due to the difficulty of obtaining a direct culture of infected lung tissue. Following the introduction of pneumococcal vaccine, the burden of invasive pneumococcal disease has declined. [(1)] Currently, mixed etiologies account for 30 to 50% of the children with community-acquired pneumonia. [(2-4)] *Mycoplasma pneumoniae* and *Chlamydia pneumoniae* are more common in school-age children. Viruses are most often identified in children <5 years of age, with respiratory syncytial virus (RSV) being the most common viral etiology in children <3 years of age. [(5-7)] In the Southwestern United States, data confirm the importance of *Streptococcus pneumoniae* and atypical pathogens *(M. pneumoniae, C. pneumoniae),* and the frequent occurrence of mixed infections in children with community-acquired pneumonia. [(8)] In children with parapneumonic effusion at Texas Children's Hospital, *Staphylococcus aureus* has become the most common organism actually isolated. [(9)]

Inclusion Criteria
- Age ≥60 days to 17 years
- Healthy without underlying conditions

Exclusion Criteria
- Aspiration
- Recent hospitalization (<7 days before the onset of illness)

Differential Diagnosis

Viral bronchiolitis	Pertussis
Tuberculosis (TB)	Foreign body

Diagnostic Evaluation: Pneumonia-related pathogens vary in incidence throughout the year but peak during January through April in the Southwestern United States. [(8)] Pathogens currently circulating in the local community should be considered in the diagnostic evaluation. Children with community-acquired pneumonia have a risk of progressing to septic shock.

Table 1. Vital Sign Changes of Sepsis [(10)]

Age	Heart Rate	Resp Rate	Systolic BP	Temp (°C)
0d - 1m	>205	>60	<60	<36 or >38
>1m - 3m	>205	>60	<70	<36 or >38
>3m - 1y	>190	>60	<70	<36 or >38.5
>1y - 2y	>190	>40	<70 + (age in yr x 2)	<36 or >38.5
>2y - 4y	>140	>40	<70 + (age in yr x 2)	<36 or >38.5
>4y - 6y	>140	>34	<70 + (age in yr x 2)	<36 or >38.5
>6y - 10y	>140	>30	<70 + (age in yr x 2)	<36 or >38.5
>10y - 13y	>100	>30	<90	<36 or >38.5
>13y	>100	>20	<90	<36 or >38.5

Table 2. Signs and Symptoms of Shock [(10)]

	Sign and/or Symptom
Peripheral Pulses	Decreased or weak Bounding
Capillary refill	≥ 3 sec Flash (< 1 sec)
Skin	Mottled, cool Flushed, ruddy, erythroderma (other than face) Petechiae below the nipple, any purpura
Mental status	Decreased, irritability, confusion inappropriate crying or drowsiness, poor interaction with parents, lethargy, diminished arousability, obtunded

History: Assess for
- Age of child
- Immunization status, especially *S. pneumoniae,* pertussis, and influenza
- Exposure to tuberculosis (TB)

Physical Examination

The severity assessment of pneumonia is based on overall clinical appearance and behavior, including a child's alertness, respiratory effort, and ability to take oral fluids. A small percentage of children <5 years of age may present with abdominal pain or with fever and no signs of respiratory illness. [(11)] Although wheezing is more common in children with asthma, it can be a manifestation of viral or Mycoplasma pneumonia.

A complete physical examination should be performed. A combination of clinical findings, including vital signs and pulse oximetry, is most predictive in determining CAP:
- Infants <12 months: Nasal flaring, O_2 sat <96%, tachypnea (RR >50) and retractions
- Children 1 to 5 years: O_2 sat <96%, tachypnea (RR >40)
- Children >5 years: O_2 sat <96%, tachypnea (RR >30)

NOTE: O_2 sat ≤92% is a strong predictor of CAP. [(12)]

Evaluate the severity of symptoms using the Clinical Respiratory Score (CRS).

Clinical Respiratory Score (CRS)			
Assess	**Score 0**	**Score 1**	**Score 2**
Respiratory Rate	<2 mos: <50 2-12 mos: <40 1-5 yrs: <30 >5 yrs: <20	<2 mos: 50-60 2-12 mos: 40-50 >1-5 yrs: 30-40 >5 yrs: 20-30	<2 mos: >60 2-12 mos: >50 >1-5 yrs: >40 >5 yrs: >30
Auscultation	Good air movement, scattered expiratory wheezing, loose rales/crackles	Depressed air movement, inspiratory and expiratory wheezes or rales/crackles	Diminished or absent breath sounds, severe wheezing, or rales/crackles, or marked prolonged expiration
Use of Accessory Muscles	Mild to no use of accessory muscles, mild to no retractions, no nasal flaring on inspiration	Moderate intercostal retractions, mild to moderate use of accessory muscles, nasal flaring	Severe intercostal and substernal retractions, nasal flaring
Mental Status	Normal to mildly irritable	Irritable, agitated, restless.	Lethargic
Room Air SpO_2	>95%	90-95%	<90%
Color	Normal	Pale to normal	Cyanotic, dusky

(Add score from all rows to calculate total CRS score)

Consider the presence of parapneumonic effusion or empyema in children with pneumonia who present severely ill. Signs of pleural effusion include dyspnea, dry cough, and pain over the chest wall, exaggerated by deep breathing or coughing. Auscultatory findings may include a friction rub (leathery, rough inspiratory and expiratory breath sounds). Breath sounds may also be diminished or absent over the affected areas. [13,14]

Laboratory Tests [15-18]

Empiric antibiotic therapy should not be delayed while awaiting diagnostic test results. Laboratory tests and chest x-rays should be ordered based on clinical findings.

Routine measurement of CBC is not necessary in all children with suspected CAP; however, CBC can be helpful in deciding whether to use antibiotics or not. A CBC should be obtained in children with severe disease. [19-22] The likelihood of a bacterial cause generally increases as WBC counts increase above 15,000/mm^3. [21,23]

Blood cultures are not routinely recommended in the evaluation of uncomplicated bacterial pneumonia. [24] Obtain a blood culture only if the patient requires ICU admission or is progressing to severe or complicated pneumonia. [22,25-32]

Pending results should not delay discharge if child is being treated with appropriate antibiotics and discharge criteria has been met (see p. 3, “Discharge Criteria”).

Consider molecular diagnostic tests (Flu & RSV admission panel), respiratory viral DFA, or rhinovirus PCR based on time of year and epidemiology. For more detailed information, see the Weekly Viral Epidemiology Snapshot.

Consider nasopharyngeal swab for pertussis PCR when typical symptoms are present.

PPD should be placed with history of exposure to TB including personal or family travel to TB prevalent areas.

Critical Points of Evidence*

Evidence Supports

- Administer high-dose amoxicillin for 7 days for mild severity CAP to cover *S. pneumoniae*. [22,29,30,33--54] – Strong recommendation, moderate quality evidence
  Remarks: The recommended duration of antibiotic therapy was primarily guided by the 2016 IDSA guideline on the management of hospital-acquired and ventilator-associated pneumonia in adults. This guideline recommends 7 days of antimicrobial therapy for hospital-acquired and ventilator-associated pneumonia, based on studies demonstrating equivalence between shorter and longer courses of therapy in patients with ventilator-associated pneumonia (moderate quality evidence).
- Administer ampicillin for 7 days for moderate severity CAP to cover *S. pneumoniae*. [22,29-30,33-54] – Strong recommendation, moderate quality evidence
  Remarks: The recommended duration of antibiotic therapy was primarily guided by the 2016 IDSA guideline on the management of hospital-acquired and ventilator-associated pneumonia in adults. This guideline recommends 7 days of antimicrobial therapy for hospital-acquired and ventilator-associated pneumonia, based on studies demonstrating equivalence between shorter and longer courses of therapy in patients with ventilator-associated pneumonia (moderate quality evidence).
- Treat children with small, simple effusions with ampicillin to cover *S. pneumoniae*. [22,29,30,43,45,51,52,54-56] – Strong recommendation, low quality evidence
- Administer cefTRIAXone and vancomycin for severe bacterial CAP to cover *S. pneumoniae* and *S. aureus*. [22,29,30,43,45,51,52,54-56] – Strong recommendation, low quality evidence
- Treat ill-appearing children or those with clinical deterioration with cefTRIAXone and vancomycin. [22,29,30,43,45,51,52,54-56] – Strong recommendation, low quality evidence
- Consider chest thoracostomy tube drainage with or without fibrinolytics or VATS as treatment options for complicated pleural effusion. [22,29,57-81] – Strong recommendation, moderate quality evidence

Evidence Against

- Do not routinely use macrolides. Consider adding a macrolide (e.g., 5 days of azithromycin) only if an atypical pathogen is suspected in infants ≤3 months (e.g., *Chlamydia trachomatis*) and children ≥6 years (e.g., *Mycoplasma pneumoniae*). [22,29,30,33-54] Atypical pneumonia is unlikely for the following: consolidated lobar pneumonia, necrotizing pneumonia, cavitary pneumonia, large empyema, unilateral pneumonia, infant ≤3 months without a known exposure, or child is not school-aged. Consider atypical pneumonia for the following scenarios: antibiotic failure; diffuse, bilateral, interstitial infiltrate on X-ray (if obtained); maternal history of recent Chlamydia infection (for infants ≤3 months). [2,22,30,63,82-84] – Weak recommendation, low quality evidence
- Do not utilize procalcitonin levels to determine whether to initiate antibiotic therapy. [22,29,30,51,53,85-92] – Strong recommendation, low quality evidence

*NOTE: The references cited represent the entire body of evidence reviewed to make each recommendation.

Condition-Specific Elements of Clinical Management

General:
The clinical picture of children with community-acquired pneumonia (CAP) is highly variable making the determination of etiology difficult. The child's age and severity of illness are important factors to consider in diagnosing and managing this disease. (14)

Admission Criteria
- Unable to tolerate oral fluids and medications; severely dehydrated
- Moderate or severe respiratory distress
- Failed outpatient antibiotic treatment
- Altered mental status
- Oxygen saturation consistently <90%
- Unsafe to send home/poor follow-up

Discharge Criteria
- No oxygen requirement
- Tolerating PO
- Appropriate mental status for age
- Signs of clinical improvement and decreasing fever for at least 12 hours
- Appropriate support system (e.g., PCP, caregivers)

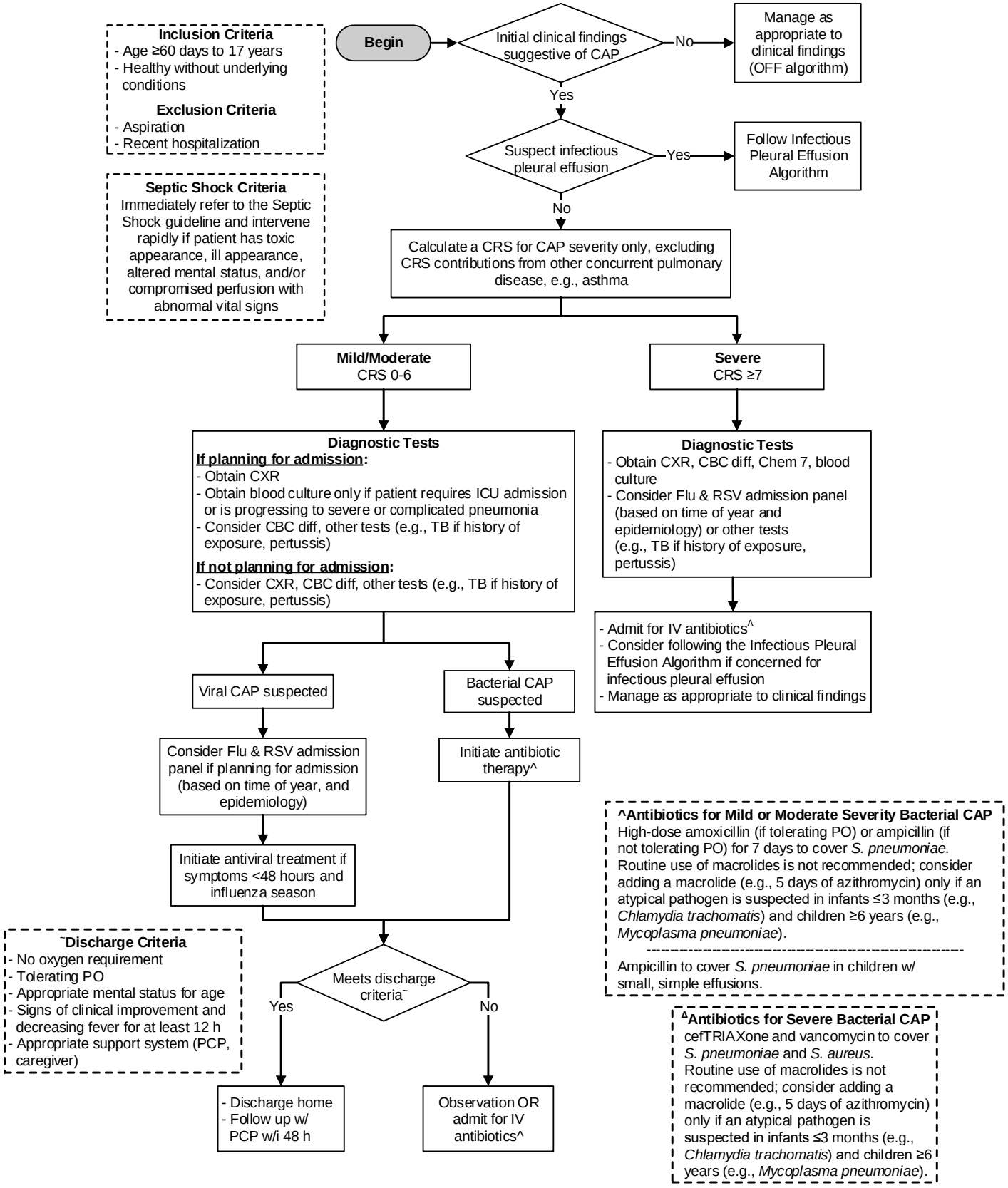
Consults/Referrals:
- Consultation with an ID specialist should be considered when allergies or prior antibiotic non-responsiveness confound the choice of therapy.
- Consultation with pulmonary, surgery, ID, and/or IR is appropriate when uncertain about management of an effusion or persistent pneumonia.

Follow-Up Care:
- Children diagnosed with CAP who are not hospitalized should follow up with their PCP within 24 to 48 hours regardless of initiating antibiotic therapy.
- Follow-up care is recommended for all children hospitalized with CAP.
- For the child who is not following the expected clinical course, consider complications, viral etiology, TB, an alternative diagnosis, or ineffective antibiotic treatment due to lack of antibiotic coverage or resistance patterns.

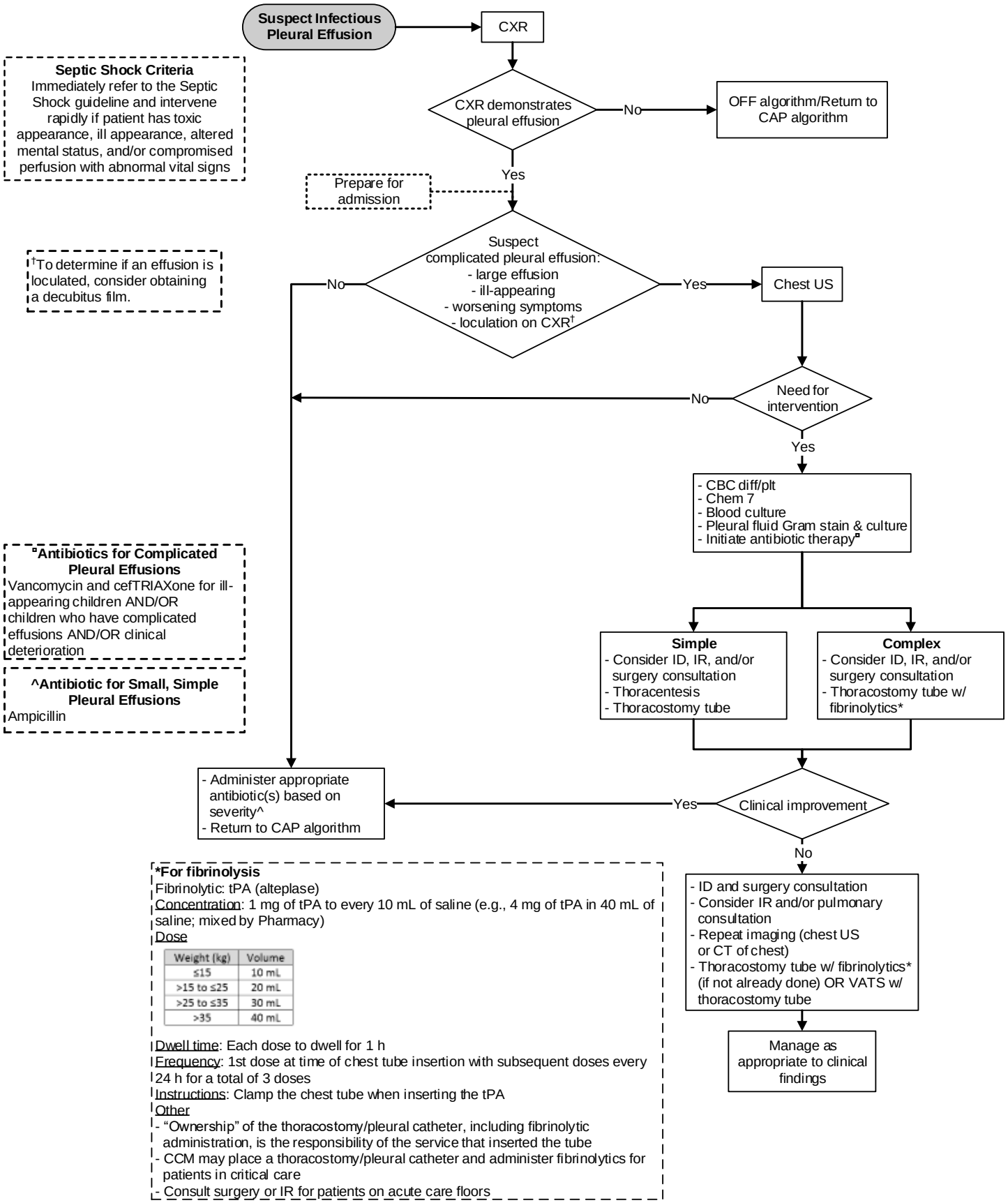
Measures
Process
- Percentage of patients on protocol
- Length of stay (inpatient, ICU)
- # of patients receiving vancomycin

Outcome
- Time to initiation of O_2 wean
- Time to O_2 wean completion
- Mortality rate
- Failure to respond to antibiotic treatment
  - Unplanned readmission within 48 hours and type of antibiotic
  - Unplanned clinic revisit within 48 hours and type of antibiotic
- Need for surgery following fibrinolytic therapy and thoracostomy tube
- Direct variable costs

TCH Evidence-Based Outcomes Center
Clinical Algorithm for Community-Acquired Pneumonia (CAP)



TCH Evidence-Based Outcomes Center
Clinical Algorithm for Infectious Pleural Effusions



References

1. Whitney, C. G., Farley, M. M., Hadler, J., Harrison, L. H., Bennett, N. M., Lynfield, R., et al. (2003). Decline in invasive pneumococcal disease after the introduction of protein-polysaccharide conjugate vaccine. *New England Journal of Medicine, 348*(18), 1737-1746.
2. Korppi, M., Don, M., Valent, F., & Canciani, M. (2008). The value of clinical features in differentiating between viral, pneumococcal and atypical bacterial pneumonia in children. *Acta Paediatrica, 97*(7), 943-947.
3. Heiskanen-Kosma, T., Korppi, M., & Leinonen, M. (2003). Serologically indicated pneumococcal pneumonia in children: A population-based study in primary care settings. *APMIS, 111*(10), 945-950.
4. Juvén, T., Mertsola, J., Waris, M., Leinonen, M., Meurman, O., Roivainen, M., et al. (2000). Etiology of community-acquired pneumonia in 254 hospitalized children. *Pediatric Infectious Disease Journal, 19*(4), 293-296.
5. Williams, J. V., Harris, P. A., Tollefson, S. J., Halburnt-Rush, L. L., Pingsterhaus, J. M., Edwards, K. M., et al. (2004). Human metapneumovirus and lower respiratory tract disease in otherwise healthy infants and children. *New England Journal of Medicine, 350*(5), 443-450.
6. Laundy, M., Ajayi-Obe, E., Hawrami, K., Aitken, C., Breuer, J., & Booy, R. (2003). Influenza A community-acquired pneumonia in East London infants and young children. *Pediatric Infectious Disease Journal, 22*(10), s223-s227.
7. Murphy, T. F., Henderson, F. W., Clyde, W. A., Collier, A. M., & Denny, F. W. (1981). Pneumonia: An eleven-year study in a pediatric practice. *American Journal of Epidemiology, 113*(1), 12-21.
8. Michelow, I. C., Olsen, K., Lozano, J., Rollins, N. K., Duffy, L. B., Ziegler, T., et al. (2004). Epidemiology and clinical characteristics of community-acquired pneumonia in hospitalized children. *Pediatrics, 113*(4), 701-707.
9. Schultz, K. D., Fan, L. L., Pinsky, J., Ochoa, L., Smith, E. O. B., Kaplan, S. L., et al. (2004). The changing face of pleural empyemas in children: Epidemiology and management. *Pediatrics, 113*(6), 1735-1740.
10. American Heart Association & American Academy of Pediatrics. (2016). Pediatric Advanced Life Support: Provider Manual. Dallas, TX: American Heart Association.
11. Seidel, H. M., Ball, J. W., Dains, J. E., & Benedict, G. W. (1999). Mosby's Guide to Physical Examination (5th ed.). St. Louis: Mosby.
12. Neuman, M. I., Monuteaux, M. C., Scully, K. J., & Bachur, R. G. (2011). Prediction of pneumonia in a pediatric emergency department. *Pediatrics, 128*(2), 246-253.
13. Balfour-Lynn, I. M., Abrahamson, E., Cohen, G., Hartley, J., King, S., Parikh, D., et al. (2005). BTS guidelines for the management of pleural infection in children. *Thorax, 60*(Suppl 1), i1-i21.
14. Behrman, R. E., Kleigman, R. M., & Jenson, H. B. (2004). Nelson Textbook of Pediatrics (17th ed.). Philadelphia: Saunders.
15. Elemraid, M. A., Rushton, S. P., Thomas, M. F., Spencer, D. A., Gennery, A. R., & Clark, J. E. (2014). Utility of inflammatory markers in predicting the aetiology of pneumonia in children. *Diagnostic Microbiology and Infectious Disease, 79*(4), 458-462.
16. Hatipoglu, N., Somer, A., Badur, S., Unuvar, E., Akcay-Ciblak, M., Yekeler, E., et al. (2011). Viral etiology in hospitalized children with acute lower respiratory tract infection. *Turkish Journal of Pediatrics, 53*(5), 508-516.
17. Karadeg-Oncel, E., Ozsurekci, Y., Kara, A., Karahan, S., Cengiz. A. B., & Ceyhan, M. (2013). The value of mean platelet volume in the determination of community acquired pneumonia in children. *Italian Journal of Pediatrics, 39*, 16.
18. Williams, D. J., Hall, M., Auger, K. A., Tieder, J. S., Jerardi, K. E., Queen, M. A., et al. (2015). Association of white blood cell count and C-reactive protein with outcomes in children hospitalized for community-acquired pneumonia. *Pediatric Infectious Disease Journal, 34*(7), 792-793.
19. Korppi, M. (2004). Non-specific host response markers in the differentiation between pneumococcal and viral pneumonia: What is the most accurate combination? *Pediatrics International, 46*(5), 545-550.
20. Toikka, P., Irjala, K., Juvén, T., Virkki, R., Mertsola, J., Leinonen, M., et al. (2000). Serum procalcitonin, C-reactive protein and interleukin-6 for distinguishing bacterial and viral pneumonia in children. *Pediatric Infectious Disease Journal, 19*(7), 598-602.
21. Bachur, R., Perry, H., & Harper, M. B. (1999). Occult pneumonias: Empiric chest radiographs in febrile children with leukocytosis. *Annals of Emergency Medicine, 33*(2), 166-173.
22. Bradley, J. S., Byington, C. L., Shah, S. S., Alverson, B., Carter, E. R., Harrison, C., et al. (2011). 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. *Clinical Infectious Diseases, 5*3(7), e25-e76.
23. Shuttleworth, D. B., & Charney, E. (1971). Leukocyte count in childhood pneumonia. *American Journal of Diseases of Children, 122*(5), 393-396.
24. Hickey, R. W., Bowman, M. J., & Smith, G. A. (1996). Utility of blood cultures in pediatric patients found to have pneumonia in the emergency department. Annals of Emergency Medicine, 27(6), 721-725.
25. Lai, E. M., Nathan, A. M., de Bruyne, J. A., & Chan, L. L. (2015). Should all children admitted with community acquired pneumonia have blood cultures taken? *Indian Journal of Pediatrics, 82*(5), 439-444.
26. McCulloh, R. J., Koster, M. P., Yin, D. E., Milner, T. L., Ralston, S. L., Hill, V. L., et al. (2015). Evaluating the use of blood cultures in the management of children hospitalized for community-acquired pneumonia. *PLOS ONE, 10*(2), e0117462.
27. Neuman, M. I., Hall, M., Lipsett, S. C., Hersh, A. L., Williams, D. J., Gerber, J. S., et al. (2017). Utility of blood culture among children hospitalized with community-acquired pneumonia. *Pediatrics, 140*(3), pii: e20171013.
28. Tam, P.-Y. I., Bernstein, E., Ma, X., & Ferrieri, P. (2015). Blood culture in evaluation of pediatric community-acquired pneumonia: A systematic review and meta-analysis. *Hospital Pediatrics, 5*(6), 324-326.
29. Children's Hospital of Philadelphia. (2012, Revised 2016). Evaluation and treatment of child with community-acquired pneumonia.
30. Seattle Children's Hospital. (2012, Revised 2016). Community-acquired pneumonia.
31. American Academy of Pediatrics Section on Emergency Medicine on Quality Transformation. (2017). Clinical algorithm for emergency department evaluation and management of pediatric community acquired pneumonia. Retrieved from http://pedemmorsels.com/wp-content/uploads/2017/02/AAP-Pneumonia-Algorithm-Final-Feb-17.pdf.
32. Texas Children's Hospital. (2017). Internal data.
33. Ambroggio, L., Taylor, J. A., Tabb, L. P., Newschaffer, C. J., Evans, A. A., & Shah, S. S. (2012). Comparative effectiveness of empiric beta-lactam monotherapy and beta-lactam-macrolide combination therapy in children hospitalized with community-acquired pneumonia. *Journal of Pediatrics, 161*(6), 1097-1103.
34. Atkinson, M., Lakhanpaul, M., Smyth, A., Vyas, H., Weston, V., Sithole, J., et al. (2007). Comparison of oral amoxicillin and intravenous benzyl penicillin for community acquired pneumonia in children (PIVOT trial): A multicentre pragmatic randomised controlled equivalence trial. *Thorax, 62*(12), 1102-1106.
35. Cardoso, M. R., Nascimento-Carvalho, C. M., Ferrero, F., Berezin, E. N., Ruvinksy, R., Camargos, P. A., et al. (2008). Penicillin-resistant pneumococcus and risk of treatment failure in pneumonia. *Archives of Disease in Childhood, 93*(3), 221- 225.
36. Dinur-Schejter, Y., Cohen-Cymberknoh, M., Tenenbaum, A., Brooks, R., Averbuch, D., Kharasch, S., & Kerem, E. (2013). Antibiotic treatment of children with community-acquired pneumonia: Comparison of penicillin or ampicillin versus cefuroxime. *Pediatric Pulmonology, 48*(1), 52-58.
37. Fu, L. Y., Ruthazer, R., Wilson, I., Patel, A., Fox, L. M., Tuan, T. A., et al. (2006). Brief hospitalization and pulse oximetry for predicting amoxicillin treatment failure in children with severe pneumonia. *Pediatrics, 118*(6), e1822-e1830.
38. Greenberg, D., Givon-Lavi, N., Sadaka, Y., Ben-Shimol, S., Bar-Ziv, J., & Dagan, R. (2014). Short-course antibiotic treatment for community-acquired alveolar pneumonia in ambulatory children: A double-blind, randomized, placebo-controlled trial. *Pediatric Infectious Disease Journal, 33*(2), 136-142.
39. Haider, B. A., Lassi, Z. S., & Bhutta, Z. A. (2008). Short-course versus long-course antibiotic therapy for non-severe community-acquired pneumonia in children aged 2 months to 59 months. *Cochrane Database of Systematic Reviews*, Issue 2. Art. No.: CD005976.
40. Hazir, T., Fox, L. M., Nisar, Y. B., Fox, M. P., Ashraf, Y. P., MacLeod, W., et al. (2008). Ambulatory short-course high-dose oral amoxicillin for treatment of severe pneumonia in children: A randomised equivalency trial. *The Lancet, 371*(9606), 49-55.
41. Kabra, S. K., Lodha, R., & Pandey, R. M. (2010). Antibiotics for community-acquired pneumonia in children. *Cochrane Database of Systematic Reviews*, Issue 3. Art. No.: CD004874.
42. Kaplan, S. L., Mason, E. O., Jr., Barson, W., Tan, T. Q., Schutze, G. E., Bradley, J. S., et al. (2001). Outcome of invasive infections outside the central nervous system caused by Streptococcus pneumoniae isolates nonsusceptible to ceftriaxone in children treated with beta-lactam antibiotics. *Pediatric Infectious Disease Journal, 20*(4), 392-396.
43. Lassi, Z. S., Das, J. K., Haider, S. W., Salam, R. A., Qazi, S. A., & Bhutta, Z. A. (2014). Systematic review on antibiotic therapy for pneumonia in children between 2 and 59 months of age. *Archives of Disease in Childhood, 99*(7), 687-693.
44. Leyenaar, J. K., Shieh, M. S., Lagu, T., Pekow, P. S., & Lindenauer, P. K. (2014). Comparative effectiveness of ceftriaxone in combination with a macrolide compared with ceftriaxone alone for pediatric patients hospitalized with community-acquired pneumonia. *Pediatric Infectious Disease Journal, 33*(4), 387-392.
45. Lodha, R., Kabra, S. K., & Pandey, R. M. (2013). Antibiotics for community-acquired pneumonia in children. *Cochrane Database of Systematic Reviews* (6), CD004874.
46. Queen, M. A., Myers, A. L., Hall, M., Shah, S. S., Williams, D. J., Auger, K. A., et.al. (2014). Comparative effectiveness of empiric antibiotics for community-acquired pneumonia. *Pediatrics, 133*(1), e23-29.
47. Shah, S. S., Test, M., Sheffler-Collins, S., Weiss, A. K., & Hall, M. (2012). Macrolide therapy and outcomes in a multicenter cohort of children hospitalized with Mycoplasma pneumoniae pneumonia. *Journal of Hospital Medicine, 7*(4), 311-317.
48. Thomson, J., Ambroggio, L., Murtagh Kurowski, E., Statile, A., Graham, C., Courter, J. D., et.al. (2015). Hospital outcomes associated with guideline-recommended antibiotic therapy for pediatric pneumonia. *Journal of Hospital Medicine, 10*(1), 13-18.
49. Williams, D. J., Hall, M., Shah, S. S., Parikh, K., Tyler, A., Neuman, M. I., et.al. (2013). Narrow vs broad-spectrum antimicrobial therapy for children hospitalized with pneumonia. *Pediatrics, 132*(5), e1141-1148.
50. Williams, D. J., Edwards, K. M., Self, W. H., Zhu, Y., Arnold, S. R., McCullers, J. A., et al. (2017). Effectiveness of β-lactam monotherapy vs macrolide combination therapy for children hospitalized with pneumonia. *JAMA Pediatrics*, epub ahead of print.
51. British Thoracic Society. (2011). The management of community acquired pneumonia in children.

52. World Health Organization. (2014). Classification and treatment of childhood pneumonia at health facilities.
53. Infectious Diseases Society of America. (2016). Management of adults with hospital-acquired and ventilator-associated pneumonia.
54. Cincinnati Children's Hospital. (2012). Community-acquired pneumonia - Anti-infective selection from IDSA & BTS guidelines.
55. Asghar, R., Banajeh, S., Egas, J., Hibberd, P., Iqbal, I., Katep- Bwalya, M., et al. (2008). Chloramphenicol versus ampicillin plus gentamicin for community acquired very severe pneumonia among children aged 2-59 months in low resource settings: Multicentre randomised controlled trial (SPEAR study). *BMJ, 336*(7635), 80-84.
56. Lee, K.-Y., Lee, H.-S., Jhong, J.-H., Lee, M.-H., Lee, H.-S., Burgner, D., et al. (2006). Role of prednisolone treatment in severe mycoplasma pneumoniae pneumonia in children. *Pediatric Pulmonology, 41*(3), 263-268.
57. Avansino, J. R., Goldman, B., Sawin, R. S., & Flum, D. R. (2005). Primary operative versus nonoperative therapy for pediatric empyema: A meta-analysis. *Pediatrics, 115*(6), 1652-1659.
58. Aydoğan, M., Aydoğan, A., Özcan, A., Tugay, M., Gokalp, A. S., & Arısoy, E. S. (2008). Intrapleural streptokinase treatment in children with empyema. *European Journal of Pediatrics, 167*(7), 739-744.
59. Aziz, A., Healey, J. M., Qureshi, F., Kane, T. D., Kurland, G., Green, M., et al. (2008). Comparative analysis of chest tube thoracostomy and video-assisted thoracoscopic surgery in empyema and parapneumonic effusion associated with pneumonia in children. *Surgical Infections, 9*(3), 317-323.
60. Carter, E., Waldhausen, J., Zhang, W., Hoffman, L., & Redding, G. (2010). Management of children with empyema: Pleural drainage is not always necessary. *Pediatric Pulmonology, 45*(5), 475-480.
61. Cohen, E., Weinstein, M., & Fisman, D. N. (2008). Cost-effectiveness of competing strategies for the treatment of pediatric empyema. *Pediatrics, 121*(5), e1250-e1257.
62. Gates, R. L., Caniano, D. A., Hayes, J. R., & Arca, M. J. (2004). Does VATS provide optimal treatment of empyema in children? A systematic review. *Journal of Pediatric Surgery, 39*(3), 381-386.
63. Guo, W.-l., Wang, J., Zhu, L.-y., & Hao, C.-l. (2015). Differentiation between mycoplasma and viral community-acquired pneumonia in children with lobe or multi foci infiltration: A retrospective case study. *BMJ Open, 5*(1), e006766.
64. Hilliard, T. N., Henderson, A. J., & Langton Hewer, S. C. (2003). Management of parapneumonic effusion and empyema. *Archives of Disease in Childhood, 88*(10), 915-917.
65. Kobr, J., Pizingerova, K., Sasek, L., Fremuth, J., Siala, K., & Racek, J. (2010). Treatment of encapsulated pleural effusions in children: A prospective trial. *Pediatrics International, 52*(3), 453-458.
66. Kurt, B. A., Winterhalter, K. M., Connors, R. H., Betz, B. W., & Winters, J. W. (2006). Therapy of parapneumonic effusions in children: Video-assisted thoracoscopic surgery versus conventional thoracostomy drainage. *Pediatrics, 118*(3), 547-553.
67. Li, S.-T. T., & Gates, R. L. (2008). Primary operative management for pediatric empyema: Decreases in hospital length of stay and charges in a national sample. *Archives of Pediatrics & Adolescent Medicine, 162*(1), 44-48.
68. Livingston, M. H., Colozza, S., Vogt, K. N., Merritt, N., & Butter, A. (2016). Making the transition from video-assisted thoracoscopic surgery to chest tube with fibrinolytics for empyema in children: Any change in outcomes? *Canadian Journal of Surgery, 59*(3), 167-171.
69. Redden, M. D., Chin, T. Y., & van Driel, M. L. (2017). Surgical versus non-surgical management for pleural empyema. *Cochrane Database of Systematic Reviews*, 3, CD010651.
70. Schneider, C. R., Gauderer, M. W., Blackhurst, D., Chandler, J. C., & Abrams, R. S. (2010). Video-assisted thorascopic surgery as a primary intervention in pediatric parapneumonic effusion and empyema. *The American Surgeon, 76*(9), 957-961.
71. Shah, S. S., DiCristina, C. M., Bell, L. M., Ten Have, T., & Metlay, J. P. (2008). Primary early thoracoscopy and reduction in length of hospital stay and additional procedures among children with complicated pneumonia: Results of a multicenter retrospective cohort study. *Archives of Pediatrics & Adolescent Medicine, 162*(7), 675-681.
72. Shah, S. S., Ten Have, T. R., & Metlay, J. P. (2010). Costs of treating children with complicated pneumonia: A comparison of primary video-assisted thoracoscopic surgery and chest tube placement. *Pediatric Pulmonology, 45*(1), 71-77.
73. Shah, S. S., Hall, M., Newland, J. G., Brogan, T. V., Farris, R. W. D., Williams, D. J., et al. (2011). Comparative effectiveness of pleural drainage procedures for the treatment of complicated pneumonia in childhood. *Journal of Hospital Medicine, 6*(5), 256-263.
74. Singh, M., Mathew, J. L., Chandra, S., Katariya, S., & Kumar, L. (2004). Randomized controlled trial of intrapleural streptokinase in empyema thoracis in children. *Acta Paediatrica, 93*(11), 1443-1445.
75. St. Peter, S. D., Tsao, K., Harrison, C., Jackson, M. A., Spilde, T. L., Keckler, S. J., et al. (2009). Thoracoscopic decortication vs tube thoracostomy with fibrinolysis for empyema in children: A prospective, randomized trial. *Journal of Pediatric Surgery, 44*(1), 106-111.
76. Thomson, A. H., Hull, J., Kumar, M. R., & Balfour Lyn, I. M. (2002). Randomised trial of intrapleural urokinase in the treatment of childhood empyema. *Thorax, 57*(4), 343-347.
77. van Loo, A., van Loo, E., Selvadurai, H., Cooper, P., Van Asperen, P., & Fitzgerald, D. A. (2014). Intrapleural urokinase versus surgical management of childhood empyema. *Journal of Paediatrics and Child Health, 50*(10), 823-826.
78. Wang, J. N., Yao, C. T., Yeh, C. N., Liu, C. C., Wu, M. H., Chuang, H. Y., et al. (2006). Once-daily vs. twice-daily intrapleural urokinase treatment of complicated parapneumonic effusion in paediatric patients: A randomised, prospective study. *International Journal of Clinical Practice, 60*(10), 1225-1230.
79. Wells, R. G., & Havens, P. L. (2003). Intrapleural fibrinolysis for parapneumonic effusion and empyema in children. *Radiology, 228*(2), 370-378.
80. Zampoli, M., Kappos, A., Verwey, C., Mamathuba, R., & Zar, H. J. (2015). Impact of fibrinolytics on the outcome of empyema in South African children. *South African Medical Journal, 105*(7), 549-553.
81. European Association for Cardio-Thoracic Surgery. (2015). Expert consensus statement for surgical management of pleural empyema.
82. Defilippi, A., Silvestri, M., Tacchella, A., Giacchino, R., Melioli, G., Di Marco, E., et al. (2008). Epidemiology and clinical features of Mycoplasma pneumoniae infection in children. *Respiratory Medicine, 102*(12), 1762-1768.
83. Huong, P. L. T., Thi, N. T., Nguyet, N. T. T., Van, T. K., Hang, D. T., Huong, V. T. T., et al. (2007). First report on clinical features of Mycoplasma pneumoniae infections in Vietnamese children. *Japan Journal of Infectious Diseases, 60*(6), 370-373.
84. Ma, Y.-J., Wang, S.-M., Cho, Y.-H., Shen, C.-F., Liu, C.-C., Chi, H., et al. (2015). Clinical and epidemiological characteristics in children with community-acquired mycosplasma pneumonia in Taiwan: A nationwide surveillance. *Journal of Microbiology, Immunology and Infection, 48*(6), 632-638.
85. Agnello, L., Bellia, C., Di Gangi, M., Lo Sasso, B., Calvaruso, L., Bivona, G., et al. (2016). Utility of serum procalcitonin and C-reactive protein in severity assessment of community-acquired pneumonia in children. *Clinical Biochemistry, 49*(1-2), 47-50.
86. Baer, G., Baumann, P., Buettcher, M., Heininger, U., Berthet, G., Schafer, J., et al. (2013). Procalcitonin guidance to reduce antibiotic treatment of lower respiratory tract infection in children and adolescents (ProPAED): A randomized controlled trial. *PLOS ONE, 8*(8), e68419.
87. Esposito, S., Tagliabue, C., Picciolli, I., Semino, M., Sabatini, C., Consolo, S., et al. (2011). Procalcitonin measurements for guiding antibiotic treatment in pediatric pneumonia. *Respiratory Medicine, 105*(12), 1939-1945.
88. Fonseca, T., Gendrel, D., Ruuskanen, O., & Nascimento-Carvalho, C. (2015). Pleural effusion increases serum procalcitonin values in children with community-acquired pneumonia. *Pediatric Infectious Disease Journal, 34*(8), 914-915.
89. Fonseca, T., Vasconcellos, A., Gendrel, D., Ruuskanen, O., & Nascimento-Carvalho, C. (2017). Recovery from childhood community-acquired pneumonia in a developing country: Prognostic value of serum procalcitonin. *Clinicia Chimica Acta,* epub ahead of print.
90. Lee, J., Hwang, S., Shim, J., Jung, H., Park, M., Woo, H. Y., et al. (2010). Clinical significance of serum procalcitonin in patients with community-acquired lobar pneumonia. *Korean Journal of Medicine, 30*(4), 406-413.
91. Stockman, C., Ampofo, K., Killpack, J., Williams, D., Edwards, K., Grijalva, C. G., et al. (2018). Procalcitonin accurately identifies hospitalized children with low risk of bacterial community-acquired pneumonia. *Journal of the Pediatric Infectious Diseases Society, 7*(1), 46-53.
92. Zhu, F., Jiang, Z., Li, W., Wei, H., & Su, G. (2015). Clinical significance of serum procalcitonin level monitoring on early diagnosis of severe pneumonia on children. *European Review for Medical and Pharmacological Sciences, 19*(22), 4300-4303.

Appendix A

We did not critically evaluate the evidence for infants <60 days. In an effort to provide guidance for these children, Infectious Disease has provided the antibiotic recommendations below.

- Infants <60 days with mild severity bacterial CAP (outpatient) should be treated with high-dose amoxicillin to cover *S. pneumoniae*.
- Neonates <28 days with moderate severity bacterial CAP should initially be treated with ampicillin and gentamicin.
- Infants ≥28 days to 60 days with moderate severity bacterial CAP should be treated with ampicillin ± macrolide to cover *S. pneumoniae* and atypical pathogens.
- Infants <60 days with severe bacterial CAP should be treated with cefTRIAXone and vancomycin to cover *S. pneumoniae* and *S. aureus*.
- Do not routinely use macrolides. Consider adding a macrolide (e.g., 5 days of azithromycin) only if an atypical pathogen is suspected in infants ≤3 months (e.g., *Chlamydia trachomatis*). [22,29,30,33-54] Atypical pneumonia is unlikely for the following: consolidated lobar pneumonia, necrotizing pneumonia, cavitary pneumonia, large empyema, unilateral pneumonia, infant ≤3 months without a known exposure, or child is not school-aged. Consider atypical pneumonia for the following scenarios: antibiotic failure; diffuse, bilateral, interstitial infiltrate on X-ray (if obtained); maternal history of recent Chlamydia infection (for infants ≤3 months). [2,22,30,63,82-84]

Appendix B

Pneumonia Without Effusion/Empyema Pathway

	Acute Care Floor Target Length of Stay: 2.5 Days	PCU	PICU
Admission Criteria	ANY of the following: ☐ Oxygen therapy ☐ Frequent suctioning or respiratory treatments (no more frequently than every 2 hours; if every 2 hours, then can continue for at most 12 hours) ☐ Respiratory distress ☐ Need for IV antibiotics (failed outpatient oral therapy) ☐ IV fluids for inadequate oral intake	ANY of the following: ☐ CPAP or BiPAP initiation ☐ High flow oxygen that does not meet acute care criteria ☐ Moderate-severe respiratory distress ☐ Respiratory distress requiring extended frequent observation, respiratory treatments, or suctioning every 1 hour for more than 4 hours or every 2 hours for more than 12 hours ☐ Moderate-severe dehydration	ANY of the following: ☐ Impending respiratory failure ☐ Impending intubation ☐ Severe dehydration
Goals for Transfer to Lower Level of Care		☐ Decreased respiratory support (oxygen and suctioning) to meet acute care floor criteria • Off CPAP or BiPAP	☐ Decreased respiratory support to meet PCU or acute care floor criteria • Extubated
Discharge Criteria	ALL of the following: ☐ O_2 sat ≥90% without supplemental O_2 ☐ Improved work of breathing ☐ Fever curve stable or trending down (need not be afebrile) ☐ Maintaining hydration status without supplemental IV fluids ☐ Age-appropriate or baseline mental status for age		
Discharge Preparation	ALL of the following: ☐ Appropriate medication regimen prescribed and patient's ability to obtain medication confirmed ☐ Evaluate support system (caregiver, PCP, funding, etc.) and address identified needs ☐ Pending consults completed ☐ Prepare patient/caregiver for transition to self-care (transportation arrangements confirmed, care management needs met, PCP confirmed) ☐ Patient/caregiver education		

Appendix B (Continued)

Pneumonia Without Effusion/Empyema Pathway

Recommendations for Inpatient Care			
	Acute Care Floor **Target Length of Stay: 2.5 Days**	**PCU**	**PICU**
Assessment & Testing	• Bloodwork not routinely indicated • Repeat chest x-ray not routinely indicated	• Bloodwork not routinely indicated • Repeat chest x-ray not routinely indicated	• Mini-BAL if indicated
Consults	• Child Life consult if needed for coping techniques, procedural teaching, psychosocial support • Social Work consult if needed; Case Manager consult if home care needs identified; Financial Counselor consult if patient unfunded • For complicated pneumonia, take patient off pathway and consider Surgery, IR, ID, and/or Pulmonary consult(s)		
O_2	• Pulse oximetry per oxygen weaning protocol • Wean oxygen per oxygen weaning protocol to maintain O_2 sat ≥90%	Per PCU orders	Per PICU orders
Medications	• Antibiotics per CAP Guidelines: Use oral antibiotics unless indication for IV therapy • Pain medication per protocol • IV fluids if indicated • Additional medications as indicated	• Antibiotics per CAP Guidelines: Transition to oral antibiotics when signs of clinical improvement • Pain medication per protocol • IV fluids if indicated Additional medications as indicated	• Antibiotics per CAP Guidelines: Transition to oral antibiotics when signs of clinical improvement • Pain medication per protocol • IV fluids if indicated Additional medications as indicated
Other	Other orders: vital signs, ins/outs, age appropriate diet, activity as tolerated, isolation precautions if needed		

Clinical Standards Preparation

This clinical standard was prepared by the Evidence-Based Outcomes Center (EBOC) team in collaboration with content experts at Texas Children's Hospital. Development of this clinical standard supports the TCH Quality and Patient Safety Program initiative to promote clinical standards and outcomes that build a culture of quality and safety within the organization.

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No relevant financial or intellectual conflicts to report.

Development Process

This clinical standard was developed using the process outlined in the EBOC Manual. The literature appraisal documents the following steps:

1. Review Preparation
   - PICO questions established
   - Evidence search confirmed with content experts

2. Review of Existing External Guidelines
   - Infectious Diseases Society of America and American Thoracic Society 2016; Pediatric Infectious Diseases Society and Infectious Diseases Society of America (IDSA) 2011; British Thoracic Society (BTS) 2011; World Health Organization 2014; European Association for Cardio-Thoracic Surgery 2015; Children's Hospital of Philadelphia 2012, Revised 2016; Seattle Children's Hospital 2012, Revised 2016; Cincinnati Children's Hospital 2012
3. Literature Review of Relevant Evidence
   - Searched: PubMed, Cochrane, AHRQ, CINAHL, Trip, BestBETs, AAP, BMJ Clinical Evidence, Google Scholar

4. Critically Analyze the Evidence
   - 7 meta-analyses, 12 randomized controlled trials, and 33 nonrandomized studies

5. Summarize the Evidence
   - Materials used in the development of the clinical standard, literature appraisal, and any order sets are maintained in a Community-Acquired Pneumonia evidence-based review manual within EBOC.

Evaluating the Quality of the Evidence

Published clinical guidelines were evaluated for this review using the **AGREE II** criteria. The summary of these guidelines are included in the literature appraisal. AGREE II criteria evaluate Guideline Scope and Purpose, Stakeholder Involvement, Rigor of Development, Clarity and Presentation, Applicability, and Editorial Independence using a 4-point Likert scale. The higher the score, the more comprehensive the guideline.

This clinical standard specifically summarizes the evidence *in support of* or *against* specific interventions and identifies where evidence is *lacking/inconclusive*. The following categories describe how research findings provide support for treatment interventions.
"Evidence Supports" provides evidence to support an intervention
"Evidence Against" provides evidence against an intervention.
"Evidence Lacking/Inconclusive" indicates there is insufficient evidence to support or refute an intervention and no conclusion can be drawn *from the evidence.*

The **GRADE** criteria were utilized to evaluate the body of evidence used to make practice recommendations. The table below defines how the quality of the evidence is rated and how a strong versus weak recommendation is established. The literature appraisal reflects the critical points of evidence.

Recommendation	
STRONG	Desirable effects clearly outweigh undesirable effects or vice versa
WEAK	Desirable effects closely balanced with undesirable effects
Quality	**Type of Evidence**
High	Consistent evidence from well-performed RCTs or exceptionally strong evidence from unbiased observational studies
Moderate	Evidence from RCTs with important limitations (e.g., inconsistent results, methodological flaws, indirect evidence, or imprecise results) or unusually strong evidence from unbiased observational studies
Low	Evidence for at least 1 critical outcome from observational studies, RCTs with serious flaws or indirect evidence
Very Low	Evidence for at least 1 critical outcome from unsystematic clinical observations or very indirect evidence

Recommendations

Practice recommendations were directed by the existing evidence and consensus amongst the content experts. Patient and family preferences were included when possible. The Content Expert Team and EBOC team remain aware of the controversies in the diagnosis and management of community-acquired pneumonia in children. When evidence is lacking, options in care are provided in the clinical standard and the accompanying order sets (if applicable).

Approval Process

Clinical standards are reviewed and approved by hospital committees as deemed appropriate for its intended use. Clinical standards are reviewed as necessary within EBOC at Texas Children's Hospital. Content Expert Teams are involved with every review and update.

Disclaimer

Practice recommendations are based upon the evidence available at the time the clinical standard was developed. Clinical standards (guidelines, summaries, or pathways) do not set out the standard of care and are not intended to be used to dictate a course of care. Each physician/practitioner must use his or her independent judgment in the management of any specific patient and is responsible, in consultation with the patient and/or the patient's family, to make the ultimate judgment regarding care.

Version History

Date	Comments
Oct 2008	Originally completed
Jan 2013	Updated
Aug 2018	Updated
Jan 2019	Revised the 'Vital Sign Changes of Sepsis' table
Sept 2021	Revised Signs and Symptoms of Shock Table