Texas Children's Hospital

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 usually unidentified due to the difficulty of obtaining a direct culture of infected lung tissue. Following the introduction of pneumococcal conjugate vaccine, the burden of invasive pneumococcal disease has declined. [1] In a recent report, viral pathogens were detected in most (66%) cases of community-acquired pneumonia while bacteria (8%) and bacterial-viral co-detection (7%) were found less often. Respiratory syncytial virus (RSV) and human rhinovirus (HRV) were the most commonly detected pathogens. [2-4] *Mycoplasma pneumoniae* is more common in school-age children. RSV, adenovirus (AdV), and human metapneumovirus (HMPV) were detected most often in younger children (age <5 years). [5,6]

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. [7]

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
Tuberculosis (TB)
Pertussis
Foreign body

Diagnostic Evaluation: Pneumonia-related pathogens vary in incidence throughout the year but peak during January through April in the Southwestern United States. [7] 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 [8]

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 [8]

	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, influenza, COVID-19, and RSV-mAB (Nirsevimab) when appropriate
- 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. [9] 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 <90%, tachypnea (RR >50) and retractions
- Children 1 to 5 years: O_2 sat <90%, tachypnea (RR >40)
- Children >5 years: O_2 sat <90%, tachypnea (RR >30)

NOTE: O_2 sat ≤92% is a strong predictor of CAP. [10]

Evaluate severity of symptoms based upon the clinical parameters below.

CAP Severity Category	Description
Mild	• Mild to no use of accessory muscles, retractions, or nasal flaring • SpO2 ≥90% on room air • Non-toxic appearance
Moderate	• Moderate intercostal retractions, use of accessory muscles or nasal flaring • SpO2 <90% on room air • Need for high flow nasal cannula
Severe	• Respiratory failure requiring non-invasive positive pressure or invasive mechanical ventilation due to bacterial pneumonia • Non-invasive mechanical ventilation with FiO2 greater than 40% or escalating FiO2 requirement due to bacterial pneumonia • Signs/symptoms of inadequate perfusion

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. [11,12]

Laboratory Tests [13-16]

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. [17-19] The likelihood of a bacterial cause generally increases as WBC counts increase above 15,000/mm^3. [20]

Blood cultures are not routinely recommended in the evaluation of uncomplicated bacterial pneumonia. [21] Obtain a blood culture only if the patient requires ICU admission or is progressing to severe or complicated pneumonia. [19,22-28] 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 (e.g., Flu & RSV admission panel, respiratory viral panel, respiratory pathogen panel) 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

- If viral pneumonia is suspected, antibiotics are not recommended.
- If bacterial pathogens are suspected, the antibiotic selections below are recommended. [29-36]
  - Administer high-dose amoxicillin for 5 days for mild severity CAP to cover *S. pneumoniae*. – Strong recommendation with moderate quality evidence [29-36]
  - Administer ampicillin or amoxicillin for 5-to-7 days for moderate severity CAP to cover *S. pneumoniae*. – Strong recommendation with moderate quality evidence. [29-36]
  - Administer ceftriaxone to patients with moderate severity CAP that are clinically deteriorating. – Strong recommendation with moderate quality evidence [29-36]
  - Consider de-escalating ceftriaxone antibiotic coverage to ampicillin in patients with severe uncomplicated pneumonia that are clinically improving without a pathogen identified. – Weak recommendation, very low quality evidence [37-41]
  - Treat children with small, simple effusions with ampicillin to cover *S. pneumonia*. – Strong recommendation with low quality evidence [42-45]
  - Administer ceftriaxone for patients with severe bacterial CAP. Vancomycin may be appropriate for patients with severe complicated pneumonia (i.e. empyema, moderate-to-large effusions, necrotizing pneumonia, and/or lung abscess) or in children in which *S. aureus* is suspected. – Strong recommendation, low quality evidence [42-45]
- Manage small, simple effusions on IV antibiotics. Tube thoracostomy without fibrinolytics should be utilized as first-line therapy for moderate-to-large simple effusions. Complex effusions should be treated with tube thoracostomy with fibrinolytics as first-line therapy. If patient condition deteriorates, further intervention may be needed. Consider VATS for failed first-line treatment. – Strong recommendation, moderate quality evidence [46-53]
- Consider the Bacterial Versus Viral (BV) score in situations where clinical history and imaging are inconclusive for bacterial versus viral infection. – Weak recommendation, low quality evidence [54-61]
  Remarks: The Bacterial Versus Viral (BV) score was developed to differentiate between bacterial and viral infection. The score is calculated based upon circulating levels of tumor necrosis factor-related apoptosis-inducing ligand (TRAIL), interferon gamma-induced protein-10 (IP-10) and C-reactive protein (CRP). Established cutoffs for the test are score <35 indicates viral infection, score >65 indicates bacterial infection (including co-infection), and 35≤ score ≥65 is considered equivocal. [54-61]

Evidence Lacking/Inconclusive

- Consider the use of ceftriaxone in unvaccinated (two-month vaccines including Haemophilus influenzae type B [Hib]) children or children with confirmed penicillin allergies with mild or moderate CAP. – Consensus recommendation.

Evidence Against

- Use of antibiotics with viral pneumonia. [29-45]
- Do **not** routinely use macrolides. Macrolides (e.g., 5 days of azithromycin) should only be considered if an atypical pathogen is suspected in infants ≤3 months (e.g., *Chlamydia trachomatis*) and children ≥6 years (e.g., *Mycoplasma pneumoniae*). 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). – Strong recommendation, low quality evidence [36,62,63]
  Remarks: The use of macrolides as an anti-inflammatory agent for previously healthy patients or patients with asthma is discouraged.
- Do not utilize procalcitonin levels to determine whether to initiate antibiotic therapy. [65-80] – Strong recommendation, low quality evidence

- MRSA nasal PCR protocols are not recommended at this time to reduce the usage of vancomycin in children with suspected community acquired pneumonia. [81-90] – Strong recommendation, low quality evidence
  Remarks: At this time, there are low rates of MRSA in the community. The ordering process for vancomycin provides an automatic stop order at 48 hours when warranted by culture results. With a current turnaround time of 24 hours for the MRSA nasal PCR lab, implementation of this test may not substantially lower the time on anti-MRSA antibiotics for our population. This recommendation should be revisited with the availability of new evidence or a change in laboratory turnaround time.

*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. [12]

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
- Appropriate support system (e.g., PCP, caregivers)

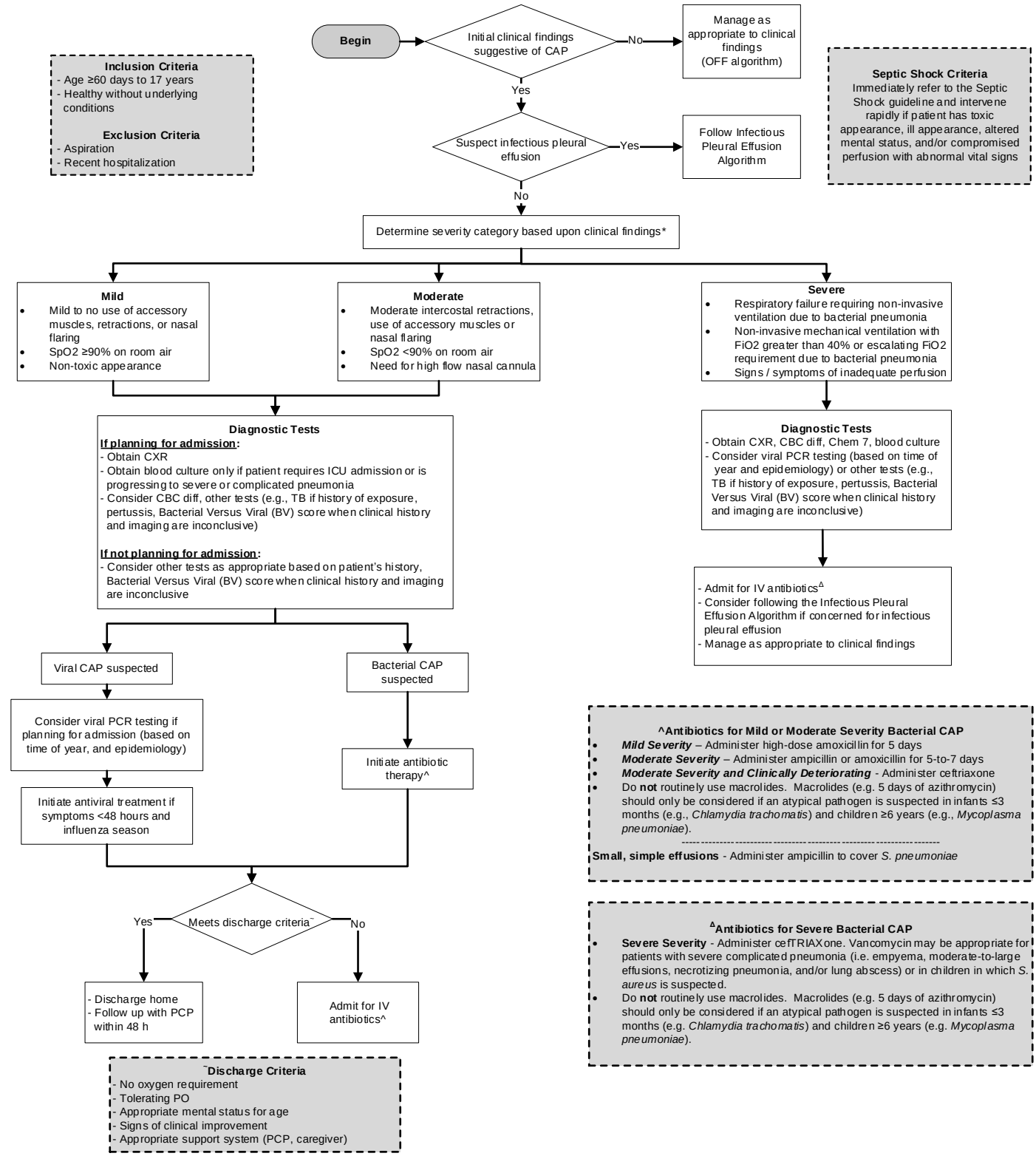
Consults/Referrals:
- Consultation with an ID specialist should be considered when allergies or prior antibiotic non-responsiveness confound the choice of therapy.
- Consultation with pulmonary, surgery, ID, and/or IR is appropriate when uncertain about management of an effusion or persistent pneumonia.

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

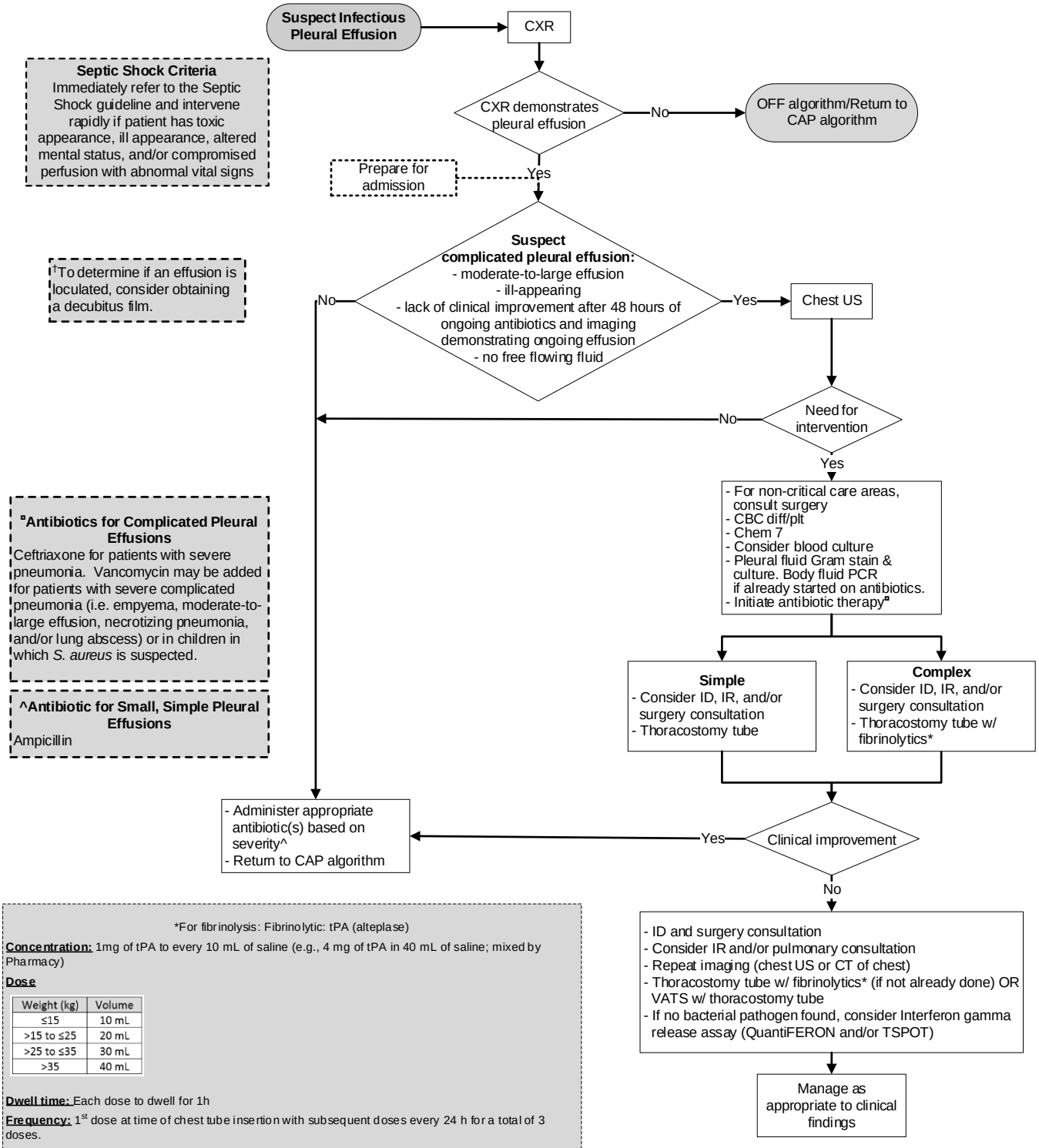
Outcome
- Time to initiation of O_2 wean
- Time to O_2 wean completion
- Mortality rate
- Failure to respond to antibiotic treatment
  - Unplanned readmission within 48 hours and type of antibiotic
  - Unplanned clinic revisit within 48 hours and type of antibiotic
- Need for surgery following fibrinolytic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

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



Clinical standards are developed for 80% of the patient population with a particular disease. Each practitioner must use his/her clinical judgment in the management of any specific patient.

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



*For fibrinolysis: Fibrinolytic: tPA (alteplase)

Concentration: 1mg of tPA to every 10 mL of saline (e.g., 4 mg of tPA in 40 mL of saline; mixed by Pharmacy)

Dose

Weight (kg)	Volume
≤15	10 mL
>15 to ≤25	20 mL
>25 to ≤35	30 mL
>35	40 mL

Dwell time: Each dose to dwell for 1h

Frequency: 1st dose at time of chest tube insertion with subsequent doses every 24 h for a total of 3 doses.

Instructions: Clamp the chest tube when inserting the tPA

Other
- "Ownership" of the thoracostomy/pleural catheter, including fibrinolytic administration, is the responsibility of the service that inserted the tube
- CCM may place a thoracostomy/pleural catheter and administer fibrinolytics for patients in critical care
- Consult surgery or IR for patients on acute care floors

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. 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.
8. American Heart Association & American Academy of Pediatrics. (2016). Pediatric Advanced Life Support: Provider Manual. Dallas, TX: American Heart Association.
9. Seidel, H. M., Ball, J. W., Dains, J. E., & Benedict, G. W. (1999). Mosby's Guide to Physical Examination (5th ed.). St. Louis: Mosby.
10. 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.
11. 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.
12. Behrman, R. E., Kleigman, R. M., & Jenson, H. B. (2004). Nelson Textbook of Pediatrics (17th ed.). Philadelphia: Saunders.
13. 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.
14. 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.
15. 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.
16. 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.
17. 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.
18. 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.
19. 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.
20. Shuttleworth, D. B., & Charney, E. (1971). Leukocyte count in childhood pneumonia. *American Journal of Diseases of Children, 122*(5), 393-396.
21. 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.
22. 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, 8*2(5), 439-444.
23. 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.
24. 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.
25. 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.
26. Children's Hospital of Philadelphia. (2012, Revised 2016). Evaluation and treatment of child with community-acquired pneumonia.
27. 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.
28. Texas Children's Hospital. (2017). Internal data.
29. Barratt, S., Bielicki, J., Dunn, D., Faust, S., Finn, A., Harper, L., et al. (2021). Amoxicillin duration and dose for community-acquired pneumonia in children: the CAP-IT factorial non-inferiority RCT. Health Technology Assessment, 25(60), 1 – 72.
30. 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.
31. Li, Q., Zhou, Q., Florez, I., Mathew, J., Shang, L., Shang, G., et. al. (2022). Short-course vs. long-course antibiotic therapy for children with nonsevere community-acquired pneumonia: A systematic review and meta-analysis. JAMA Pediatrics, 176(12), 1199-1207.
32. Marques, I., Calvi, I., Cruz, S., Sanchez, L., Baroni, I., Oommen, C., Padrao, E., & Mari, P. (2022). Shorter versus longer duration of amoxicillin-based treatment for pediatric patients with community-acquired pneumonia: A systematic review and meta-analysis. European Journal of Pediatrics, 181, 3795-3804.
33. McCallum, G., Fong, S., Grimwood, K., Nathan, A., Byrnes, C., et al. (2021). Extended versus standard antibiotic course duration in children <5 years of age hospitalized with community-acquired pneumonia in high-risk settings: Four-week outcomes of a multicenter, double-blinded, parallel, superiority randomized controlled trial. Pediatric Infectious Disease, 41, 549-555.
34. Pernica, J., Harman, S., Kam, A., Carciumaru, R., Vanniyasingam, T., et al. (2021). Short-course antimicrobial therapy for pediatric community-acquired pneumonia: The SAFER randomized clinical trial. JAMA Pediatrics, 175(5), 475-482.
35. Williams, D., Creech, B., Walter, E., Martin, J., Gerber, J., et al. (2022). Short- vs standard-course outpatient antibiotic therapy for community-acquired pneumonia in children: The SCOUT-CAP randomized controlled trial. JAMA Pediatrics, 176(3), 253-261.
36. Metlay, J., Waterer, G., Long, A., Anzueto, A., Brozek, J., et al. (2019). Diagnosis and treatment of adults with community-acquired pneumonia: An official clinical practice guideline of the American Thoracic Society and Infectious Disease Society of America. American Journal of Respiratory and Critical Care Medicine, 200(7), e45-e67.
37. Blot, M., Pivot, D., Bourredjem, A., Salmon-Rousseau, A., Curraize, C., Croisier, D., et al. (2017). Effectiveness of and obstacles to antibiotic streamlining to amoxicillin monotherapy in bacteremic pneumococcal pneumonia. International Journal of Antimicrobial Agents, 50, 359-364.
38. Khan, R., & Aziz, Z. (2017). Antibiotic de-escalation in patients with pneumonia in the intensive care unit: A systematic review and meta-analysis. The International Journal of Clinical Practice, 72, e13245.
39. Ohji, G., Doi, A., Yamamoto, S., & Iwata, K. (2016). Is de-escalation of antimicrobials effective? A systematic review and meta-analysis. International Journal of Infectious Diseases, 49, 71-79.
40. Song, J., & Lee, J. (2023). The impact of antimicrobial de-escalation therapy in culture-negative pneumonia: A systematic review and meta-analysis. Korean J Intern Med, 38, 704-713.
41. You, A., Fukunaga, B., Hanlon, A., Lozano, A., & Goo, R. (2018). The effects of vancomycin use and de-escalation in patients hospitalized with pneumonia. Hawai'I Journal of Medicine & Public Health, 77(10), 261-267.
42. 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.
43. Lodha, R., Kabra, S. K., & Pandey, R. M. (2013). Antibiotics for community-acquired pneumonia in children. *Cochrane Database of Systematic Reviews* (6), CD004874.
44. 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.
45. 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.
46. Derderian, S. C., Meier, M., Partrick, D., Demasellis, G., Reiter, P., Annam, A., & Bruny, J. (2020). Pediatric empyema – Has the pendulum swung too far? Journal of Pediatric Surgery, 55, 2356-2361.
47. Fernandez Elviro, C., Longcroft-Harris, B., Allin, E., Leache, L., Woo, K., Bone, J., et al. (2023). Conservative and surgical modalities in the management of pediatric parapneumonic effusion and empyema: A living systematic review and network meta-analysis. Chest, 164(5), 1125-1138.
48. Knebel, R., Fraga, J., Amantea, S., Isolan, P. (2018). Videothorascopic surgery before and after chest tube drainage for children with complicated parapneumonic effusion. J Pediatr, 94(2), 140-145.

49. Pacilli, M. & Nataraja, R. (2019). Management of paediatric empyema by video-assisted thoracoscopic surgery (VATS) versus chest drain with fibrinolysis: Systematic review and meta-analysis. Paediatric Respiratory Reviews, 30, 42-48.
50. Rodriguez, M., Perez, J., Rueda, F., Pascual, F., Torres, S., & Esteban, R. (2022). Fibrinolysis versus thoracoscopy: Comparison of results in empyema management in the child. Ann Thorac Med, 17, 145-150.
51. Shen, K., Bribriesco, A., Crabtree, T., Denlinger, C., Eby, J., et al. (2017). The American Association for Thoracic Surgery consensus guidelines for the management of empyema. Journal of Thoracic and Cardiovascular Surgery, 153(6), e129-e146.
52. Scarci, M., Abah, U., Solli, P., Page, A., Waller, D. et al. (2015). EACTS expert consensus statement for surgical management of pleural empyema. European Journal of Cardiothoracic Surgery, 48(5), 642-653.
53. Bell, A., Baker, C., & Duret, A. (2023). Is chest drain insertion and fibrinolysis therapy equivalent to video-assisted thoracoscopic surgery to treat children with parapneumonic effusions? Archives of Disease in Childhood, 108(11), 940-942.
54. Mor, M., Paz, M., Amir, L., Levy, I., Scheuerman, O., et al. (2023). Bacterial vs viral etiology of fever: A prospective study of a host score for supporting etiologic accuracy of emergency department physicians. PLoS ONE, 18(1), e0281018.
55. Oved, K., Cohen, A., Boico, O., Navon, R., Friedman, T., et al. (2015). A novel host-proteome signature for distinguishing between acute bacterial and viral infections. PLoS ONE, 10(3), e0120012.
56. Papan, C., Argentiero, A., Porwoll, M., Hakim, U., Farinelli, E., et al. (2022a). A host signature based on TRAIL, IP-10, and CRP for reducing antibiotic overuse in children by differentiating bacterial from viral infections: A prospective, multicentre, cohort study. Clinical Microbiology and Infection, 28, 723-730.
57. Papan, C., Argentiero, A., Adams, O., Porwoll, M., Hakim, U., et al. (2022b). Association of viral load with TRAIL, IP-10, CRP biomarker signature and disease severity in children with respiratory tract infection or fever without a source: A prospective multicenter, cohort study. Journal of Medical Virology, e28113.
58. Papan, C., Sidorov, S., Greiter, B., Buhler, N., Berger, C., et al. (2023). Combinatorial host-response biomarker signature (BV score) and its subanalytes TRAIL, IP-10, and C-reactive protein in children with *Mycoplasma pneumonia* community acquired pneumonia. The Journal of Infectious Diseases, doi: 10.1093/infdis/jiad573.
59. Srugo, I., Klein, A., Stein, M., Golan-Shany, O., Kerem, N. et al. (2017). Validation of a novel assay to distinguish bacterial and viral infections. Pediatrics, 140(4), e20163453.
60. Stein, M., Shapira, M., Bamberger, E., Christyakov, I., Dumov, D., et al. (2022). BV score differentiates viral from bacterial-viral co-infection in adenovirus PCR positive children. Frontiers in Pediatrics, 10, 990750.
61. van Houten, C., de Groot, J., Klein, A., Srugo, I., Christyakov, I., et al. (2017). A host protein based assay to differentiate between bacterial and viral infections in preschool children (OPPORTUNITY): A double, blind, multicentre validation study. Lancet Infectious Disease, 17, 431-440.
62. Ambroggio, L., Test, M., Metlay, J., Graf, T., Blosky, M., et al. (2016). Beta-lactam versus beta-lactam/macrolide therapy in pediatric outpatient pneumonia. Pediatric Pulmonology, 51(5), 541-548.
63. Williams, D., Edwards, K., & Grijalva, C. (2017). Effectiveness of B-lactam monotherapy vs macrolide combination therapy for children hospitalized with pneumonia. JAMA Pediatrics, 171(2), 1184-1191.
64. 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.
65. 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.
66. Dugenon, D., Levy, C., Chalumeau, M., Biscardi, S., Dommergues, M., Dubos, F., Levieux, K., et al. (2021). Diagnostic accuracy of routinely available biomarkers to predict bacteremia in children with community-acquired pneumonia: A secondary analysis of the GPIP/ACTIV Pneumonia Study in France, 2009-2018. Front Pediatr, 9, 684628.
67. 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.
68. Farida, H., Triasih, R., Lokida, D., Mardian, Y., Salim, G., et al. (2023). Epidemiologic, clinical, and serum markers may improve discrimination between bacterial and viral etiologies of childhood pneumonia. Front Med (Lausanne), 10, 1140100.
69. Fernandes, C., Arriaga, M., Costa, M. C., Costa, M. C., Costa, M. C., Vinhaes, C., Silveira-Mattos, P., Fukutani, K., & Andrade, B. (2018). Host inflammatory biomarkers of disease severity in pediatric community acquired pneumonia: A systematic review and meta-analysis. Open Forum Infectious Disease, 6(12), ofz520.
70. Florin, T., Ambroggio, L., Brokamp, C., Zhang, Y., Rattan, M., Crotty, E., Belsky, M., Krueger, S., Epperson, T., et al. (2020). Biomarkers and disease severity in children with community-acquired pneumonia. Pediatrics, 145(6), e20193728.
71. 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.
72. 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.
73. Kamat, I. S., Ramachandran, V., Eswaran, H., Guffey, D., & Musher, D. M. (2020). Procalcitonin to distinguish viral from bacterial pneumonia: A systematic review and meta-analysis. Clin Infect Dis, 70(3), 538-542.
74. 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.
75. Ratageri, V., Panigatti, P., Mukherjee, A., Das, R., Goyal, J. P., et al. (2022). Role of procalcitonin in diagnosis of community acquired pneumonia in children. BMC Pediatrics, 22(1), 217.
76. Schultz, P., Wirz, Y., Sager, R., Christ-Crain, M., Stolz, D., Tamm, M., et al. Procalcitonin to initiate or discontinue antibiotics in acute respiratory tract infections. Cochrane Database of Systematic Reviews, Issue 10. Art. No.: CD007498.
77. Seckman, M., Johnson, J., Zhu, Y., Sartori, L., Grijalva, C., Stassun, J., Arnold, D., et al. (2022). Association between procalcitonin and antibiotics in children with community-acquired pneumonia. Hospital Pediatrics, 12(4), 384-391.
78. 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.
79. Wrotek, A., Robakiewicz, J., Pawlik, K., Rudzinski, P., Pilarska, I., Jaron, A., Imielowska, A., et al. (2022). The etiology of community-acquired pneumonia with serum inflammatory markers in children. J Clin Med, 11(19)
80. 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.
81. Baby, N., Faust, A., Smith, T., Sheperd, L., Knoll, L., & Goodman, E. (2017). Nasal methicillin-resistant staphyhlococcus aureaus (MRSA) PCR testing reduces the duration of MRSA-Targeted therapy in patients with suspected MRSA pneumonia. Antibmicrobial Agents and Chemotherapy, 61(4), e02432-16.
82. Dadzie, P., Dietrich, T., & Ashurst, J. (2019). Impact of a pharmacist-driven methicillin-resistant staphylococcus aureus polymerase chain reaction nasal swab protocol on the de-escalation of empiric vancomycin in patients with pneumonia in a rural healthcare setting. Cureus, 11(12), e6378.
83. Dangerfield, B., Chung, A., Webb, B., & Sevelle, M. (2017). Predictive value of methicillin-resistant *Staphylococcus aureus* (MRSA) nasal swab PCR assay for MRSA pneumonia. Antimicrobial Agents and Chemotherapy, 58(2), 859-864.
84. Dunaway, S., Orwig, K., Arbogast, Z., Myers, Z., Sizemore, J., & Giancola, S. (2018). Evaluation of a pharmacy-driven methicillin-resistant staphylococcus aureus surveillance protocol in pneumonia. International Journal of Clinical Pharmacy, 40, 526-532.
85. Meng, L., Pourali, S., Hitchcock, M., Ha, D., Mui, E., Alegria, W., Fox, E., et al. (2021). Discontinuation patterns and cost avoidance of a pharmacist-driven methicillin-resistant staphylococcus aureus nasal polymerase chain reaction testing protocol for de-escalation of empiric vancomycin for suspected pneumonia. Open Forum Infectious Diseases, 8(4), doi: 10.1093/ofid/ofab099.
86. Parente, D., Cunha, C., Mylonakis, E., & Timbrook, T. (2018). The clinical utility of methicillin-resistant staphylococcus aureus (MRSA) nasal screening to rule out MRSA pneumonia: A diagnostic meta-analysis with antimicrobial stewardship implications. *Clinical Infectious Disease, 67*(1), 1 – 7.
87. Pham, S., Sturm, A., Jacoby, J., Egwuatu, N., & Dumkow, L. (2021). Impact of a pharmacist driven MRSA nasal PCR protocol on pneumonia therapy. *Hospital Pharmacy, 56*(4), 221-227.
88. Renzoni, A., Peksa, G., & DeMott, J. (2021). Emergency department methicillin-resistant Staphylococcus aureus nare screen effect on pneumonia treatment duration. *American Journal of Emergency Medicine, 44*, 68-71.
89. Sindelar, M., Zepeski, A., Lawler, B., Johnston, S., & Faine, B. (2022). MRSA nasal swab PCR to de-escalate antibiotics in the emergency department. *American Journal of Emergency Medicine, 55*, 133-137.
90. Troyer, B., Shingle, A., & Scherrer, N. (2022). Duration of gram-negative antibiotic therapy in patients with pneumonia prior to and after the implementation of MRSA nasal swabs, an antimicrobial stewardship tool. *Journal of Antimicrobial Chemotherapy, 77*, 2557-2560.

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.

Community-Acquired Pneumonia Content Expert Team

Aderonke Adekunle-Ojo, MD, Emergency Medicine
Danny Castro, MD, Critical Care
Andrea Cruz, MD, Emergency Medicine
Khoulood Fakhoury, MD, Pulmonary
Catherine Foster, MD, Infection Control
Suzanne Iniguez, RT, Respiratory Care
Huay-ying Lo, MD, Pediatric Hospital Medicine
Matthew Musick, MD, Critical Care
Deb Palazzi, MD, Infectious Disease
Amir Pezeshkmehr, MD, Interventional Radiology
Ricardo Quinonez, MD, Pediatric Hospital Medicine
Brittany Rodriguez, PharmD, Pharmacy
Yan Shi, MD, Pediatric Surgery
Grant Stimes, PharmD, Pharmacy
Margaret Taylor, MD, Infection Control
Sanjeev Vasudevan, MD, Pediatric Surgery
EBOC Team

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 2022; Seattle Children's Hospital 2012, Revised 2023; Cincinnati Children's Hospital 2012; American Thoracic Society and Infectious Disease Society of America 2019; European Association for Cardio Thoracic Surgery (EACTS) 2015; The American Association for Thoracic Surgery 2017
3. Literature Review of Relevant Evidence
   - Searched: PubMed, Cochrane, AHRQ, CINAHL, Trip, BestBETs, AAP, BMJ Clinical Evidence, Google Scholar

4. Critically Analyze the Evidence
   - 14 meta-analyses, 8 randomized controlled trials, and 37 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 should 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.

Permission of Use

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
June 2024	Guideline Update
Dec 2024	Alteplase Dosing Revised on Pleural Effusion Algorithm