VASP Community-Acquired Pneumonia – Inpatient Management

This guidance document is meant to provide general recommendations and does not supersede clinical decision making.

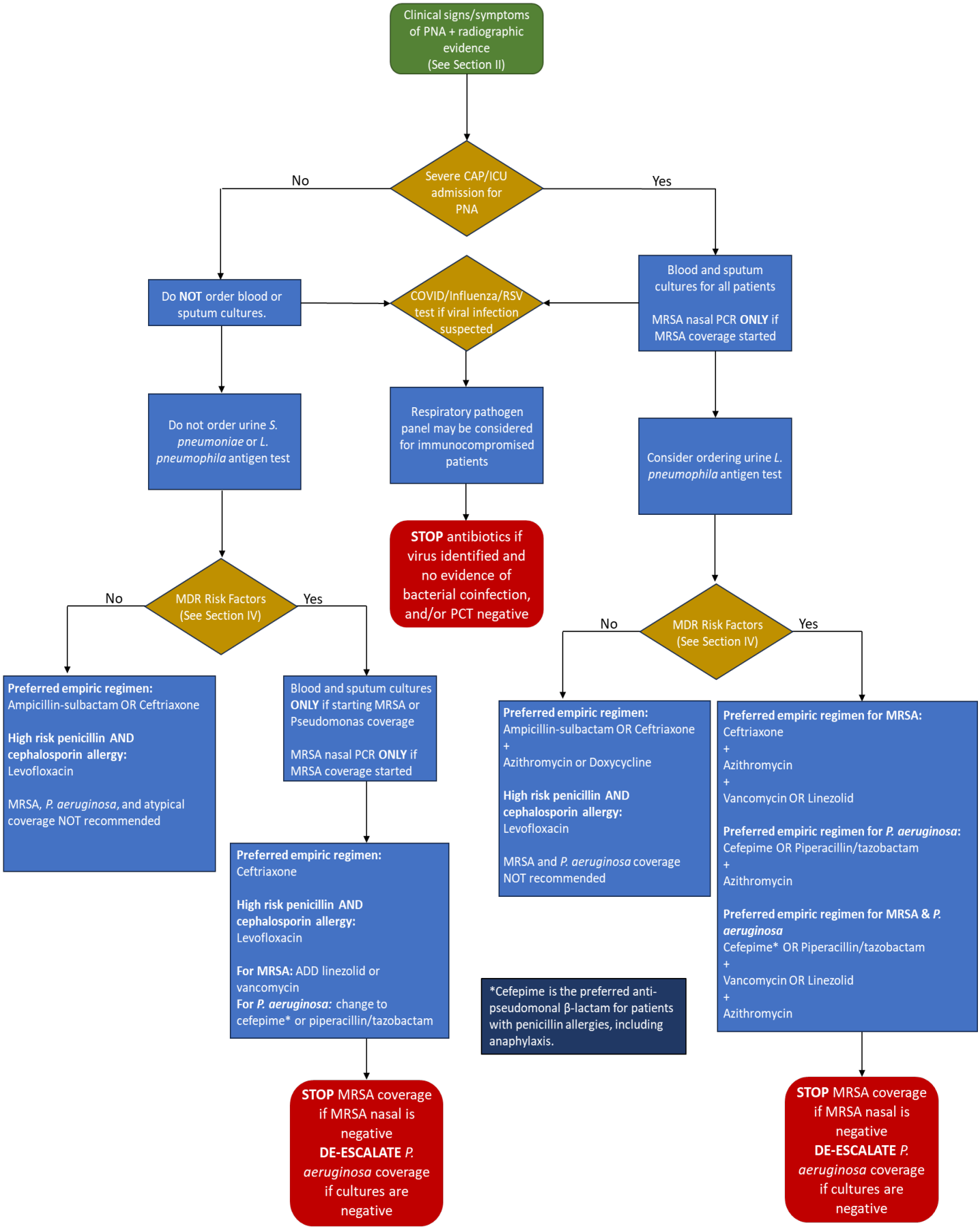
Inclusion: patients presenting to the hospital with pneumonia or who develop pneumonia within 48 hours of hospital admission.

Use the links in the table of contents below to navigate to individual sections within the document.

Table of Contents

Date last updated: 12/06/23
Date approved: 12/06/23

I. Algorithm Overview



Date last updated: 12/06/23
Date approved: 12/06/23

II. Diagnosis

a. Clinical symptoms: cough, purulent sputum, shortness of breath, pleuritic chest pain, dyspnea, hypoxia ± supplemental O2 requirement **PLUS**
b. Radiographic (CXR or CT) infiltrates not explained by other conditions (e.g. pulmonary edema, atelectasis)
c. Non-specific findings: leukocytosis, fever, elevated ESR or CRP

III. Laboratory Tests

a. Blood cultures and sputum cultures for severe CAP (Table 1) or patients started on empiric MRSA or *P. aeruginosa* coverage.

Table 1: Severe CAP Criteria[ǂ]

Major Criteria (≥1 criterion)	Minor Criteria (≥3 criterion)
Septic shock with use of vasopressors Respiratory failure requiring mechanical ventilation	Respiratory rate ≥30 breaths/min Pa_{O2}/FI_{O2} ratio ≤250 Multilobar infiltrates Confusion/disorientation Uremia (BUN ≥20 mg/dL) Leukopenia (WBC <4,000 cells/µL) Thrombocytopenia (platelet count <100,000/µL) Hypothermia (temperature < 36℃) Hypotension requiring aggressive fluid resuscitation

[ǂ]CURB-65 and Pneumonia Severity Index are common scoring systems to determine treatment location (e.g., ICU vs. floor).

b. Prioritize ordering of the COVID/Influenza/RSV test for patients who have upper respiratory tract infection symptoms or when there is clinical suspicion for viral pneumonia.
    i. Patients who are immunocompromised may have the Respiratory Pathogen Panel (RPP) ordered instead if results are likely to effect management.
c. Urine *S. pneumoniae* antigen testing is not necessary as all CAP regimens cover this organism.
d. Urine *L. pneumophila* antigen testing recommended for patients with severe CAP or with risk factors for this organism (e.g. recent travel, known outbreak)
    i. Only detects serogroup 1 that causes ~70% of infections.
    ii. Consider adding this test on patients without empiric atypical coverage who are not clinically improving.
    iii. Sent to reference lab and takes several days to result.
e. MRSA nasal PCR may be used when empiric MRSA coverage is started (e.g. vancomycin or linezolid)
    i. Administration of vancomycin or linezolid before collecting nasal swab will NOT impact results of nasal PCR.
    ii. If test is negative, MRSA active agents should be discontinued.
    iii. If test is positive, use clinical judgement for continuation of MRSA active agents. A positive test has low positive predictive value for a MRSA infection and should not be interpreted as a definitive reason to continue MRSA coverage.

iv. Patients in the ICU routinely receive mupirocin nasal decolonization upon admission to the unit and should not have a MRSA nasal PCR ordered after decolonization has started.

f. Procalcitonin (PCT) may help to guide duration of antibiotic therapy (Appendix 1), especially to STOP antibiotics in patients with an identified viral etiology or non-infectious condition. It may also help to decrease the overall duration of therapy for bacterial pneumonia.
   i. Clinical judgement should be used when interpreting procalcitonin results.
   ii. NOT intended for deciding whether to start antimicrobial therapy.
   iii. AVOID use in patients with the following:
      1. Elevated serum creatinine due to AKI or CKD
      2. Major trauma within the previous 7 days
      3. Surgical procedures within the previous 7 days
      4. Cardiopulmonary arrest within the previous 7 days

IV. Multi-Drug Resistant Organism Risk Factors

a. MRSA and *P. aeruginosa* are rare causes of community-acquired pneumonia (<5% of cases) and are unlikely in non-severe infections.
b. Presence of any single finding below would place patient at an increased risk.
b. MRSA
   i. Respiratory tract culture or nasal PCR positive in previous 12 months.
   ii. Cavitary or necrotizing pneumonia
   iii. Post-influenza pneumonia
c. *P. aeruginosa*
   i. Respiratory tract culture positive in previous 12 months.
   ii. Bronchiectasis or structural lung disease
d. Both MRSA AND *P. aeruginosa*
   i. Hospitalization AND IV antibiotics in previous 90 days
   ii. Immunocompromising conditions
      1. Solid organ transplant in previous 12 months
      2. Solid organ transplant AND treated for rejection in previous 6 months
      3. Hematopoietic stem cell transplant in previous 12 months
      4. Chronic GVHD
      5. HIV with CD4 <200
      6. Neutropenia with ANC <1000
      7. Autoimmune disorders on biologic agents (e.g. TNFα inhibitors, rituximab, etc.)
      8. Long-term corticosteroids (prednisone equivalent ≥ 20mg/day for at least 2 weeks)

V. Antimicrobial Dosing

a. Reference available on the VASP website at the following link.

VI. Treatment Recommendations

Non-Severe/Non-ICU CAP Without Resistant Pathogen Risk Factors		
Empiric Therapy	**Comments**	**Duration of Therapy**

Preferred:
Ampicillin-sulbactam 3g IV q6h OR
Ceftriaxone 2g IV daily
 	
High Risk Penicillin AND Cephalosporin Allergy:
Levofloxacin 750mg PO (or IV) daily
 	
MRSA or *P. aeruginosa* Coverage:
• Do **NOT** start empirically.
• If identified in culture, may start targeted therapy if not clinically improving.
 	
If cultures are positive, target antibiotics to the recovered pathogen.
	Atypical Coverage
	• Not routinely recommended for non-severe CAP
	• If RPP is positive for *M. pneumoniae* or *C. pneumoniae*, doxycycline 100mg PO BID is preferred.
	• If RPP is negative and atypical coverage was already started, it should be discontinued.
	• If high suspicion for *Legionella* or positive urine antigen, azithromycin 500mg PO daily is preferred.
	
	Anaerobic Coverage
	• Do **NOT** start anaerobic coverage for aspiration pneumonia.
	• Anaerobic coverage should be considered if empyema or lung abscess detected.
	  ○ Ampicillin-sulbactam OR
	  ○ Add metronidazole 500mg PO (or IV) BID
	
	Transition to Oral Antibiotics
	• Should occur as soon as patient able to tolerate PO medications.
	  ○ Ideal transition for non-severe CAP is within 24-hours of IV antibiotics.
	  ○ If patient has concurrent bacteremia, transition after at least 3 days of IV antibiotics.
	• Recommended PO options:
	  ○ Amoxicillin 1g PO TID
	  ○ Amoxicillin/clavulanate 875/125mg PO BID
	  ○ Cefuroxime 500mg PO BID (for penicillin-allergic patients)
		Clinical Stability Criteria (no more than 1 criteria not met)*
		• HR <100 bpm
		• RR <24 breaths/min
		• SBP > 90 mmHg
		• O_2 sat >90%
		• Normal mental status
		*Based on patient baseline status
		
		If ALL clinical stability criteria are met on day 3, antibiotics should be **discontinued**.
		
		If at least 4 of the 5 clinical stability criteria are met on day 5, antibiotics should be **discontinued**.
		
		If patients have a delayed response to treatment, antibiotics should be **discontinued** 48 hours after 4 of the 5 clinical stability criteria are met.
		
		Exceptions to Short Durations
		• MRSA or non-fermenting GNR (e.g. *P. aeruginosa*): **7 days**
		• Streptococcal bacteremia: **7-14 days**
		• Legionella: **7-10 days**
		• GNR bacteremia: **7 days**
		• MRSA bacteremia: **14+ days**
		• Empyema or lung abscess: **variable**

Date last updated: 12/06/23
Date approved: 12/06/23

Severe/ICU CAP Without Resistant Pathogen Risk Factors		
Empiric Therapy	**Comments**	**Duration of Therapy**

Preferred:
Ampicillin-sulbactam 3g IV q6h OR
Ceftriaxone 2g IV daily
+
Azithromycin 500mg IV (or PO) daily OR
Doxycycline 100mg IV (or PO) q12h
 	
High Risk Penicillin AND Cephalosporin Allergy:
Levofloxacin 750mg IV (or PO) daily
 	
MRSA or *P. aeruginosa* Coverage:
• Do **NOT** start empirically.
• If identified in culture, start targeted therapy.
 	
If cultures are positive, target antibiotics to the recovered pathogen.
 	
Addition of steroids per ICU protocol
	Atypical Coverage
	• If RPP and Legionella urine antigen (if collected) negative, atypical coverage should be **discontinued**.
	• If RPP is positive for *M. pneumoniae* or *C. pneumoniae*, doxycycline 100mg PO BID is preferred.
	• If high suspicion for *Legionella* or positive urine antigen, azithromycin or levofloxacin are preferred over doxycycline.
	
	Anaerobic Coverage
	• Do **NOT** start metronidazole or clindamycin for aspiration pneumonia.
	• Anaerobic coverage should be considered if empyema or lung abscess detected.
	  ○ Ampicillin-sulbactam OR
	  ○ Add metronidazole 500mg PO (or IV) BID
	
	Transition to Oral Antibiotics
	• Should occur as soon as patient is afebrile and hemodynamically stable with clinical improvement x 48 hours.
	• Recommended PO options:
	  ○ Amoxicillin/clavulanate 875/125mg PO BID
	  ○ Cefuroxime 500mg PO BID (for penicillin-allergic patients)
	  ○ Levofloxacin (if high-risk penicillin or cephalosporin allergy)
		Clinical Stability Criteria (no more than 1 criteria not met)*
		• HR <100 bpm
		• RR <24 breaths/min
		• SBP > 90 mmHg
		• O_2 sat >90%
		• Normal mental status
		*Based on patient baseline status
		
		Antibiotics should be **discontinued** in most patients on day 5 of antibiotic therapy.
		
		If patients have a delayed response to treatment, antibiotics should be **discontinued** 48 hours after 4 of the 5 clinical stability criteria are met.
		
		Exceptions to Short Duration
		• MRSA or non-fermenting GNR (e.g. *P. aeruginosa*): **7 days**
		• Streptococcal bacteremia: **7-14 days**
		• Legionella: **7-10 days**
		• GNR bacteremia: **7 days**
		• MRSA bacteremia: **14+ days**
		• Empyema or lung abscess: **varies**

Date last updated: 12/06/23
Date approved: 12/06/23

Non-Severe/Non-ICU CAP With Resistant Pathogen Risk Factors*		
Empiric Therapy	**Comments**	**Duration of Therapy**

Preferred:
Ceftriaxone 2g IV daily
 	
High Risk Cephalosporin Allergy:
Levofloxacin 750mg PO (or IV) daily
 	
MRSA or *P. aeruginosa* Coverage:
• Obtain blood and respiratory cultures before starting antibiotics.
• If necrotizing/cavitary pneumonia or lung transplant, ADD MRSA coverage.
• If bronchiectasis/structural lung disease, lung transplant, neutropenic, or high-dose steroids, change preferred treatment to pseudomonal ß-lactam.
 	
MRSA Options:
• Vancomycin, pharmacy consult
• Linezolid 600mg PO (or IV) BID
 	
P. aeruginosa Options†:
• Cefepime 2g IV q8h
• Piperacillin/tazobactam 3.375g IV q8h
 	
*If MRSA or *P. aeruginosa* are not recovered on culture, change to routine CAP coverage.
 	
If cultures are positive, target antibiotics to the recovered pathogen.
	Atypical Coverage
	• Not routinely recommended for non-severe CAP
	• If *M. pneumoniae* or *C. pneumoniae* identified, doxycycline 100mg PO BID is preferred.
	• If RPP is negative and atypical coverage was already started, it should be discontinued.
	• If high suspicion for *Legionella* or positive urine antigen, azithromycin 500mg PO daily is preferred.
	
	Anaerobic Coverage
	• Do **NOT** start anaerobic coverage for aspiration pneumonia.
	• Anaerobic coverage should be considered if empyema or lung abscess detected.
	  ○ Piperacillin/tazobactam OR
	  ○ Add metronidazole 500mg PO (or IV) BID
	
	Transition to Oral Antibiotics
	• Should occur as soon as patient able to tolerate PO medications and is clinically improving.
	  ○ If patient has concurrent bacteremia, transition after at least 3 days of IV antibiotics.
	• Recommended PO options:
	  ○ Amoxicillin/clavulanate 875/125mg PO BID
	  ○ Cefuroxime 500mg PO BID (if penicillin allergy)
	  ○ Levofloxacin (if *P. aeruginosa* risk factors or positive culture)
	  ○ Linezolid (if MRSA positive sputum/BAL)
		Clinical Stability Criteria (no more than 1 criteria not met)*
		• HR <100 bpm
		• RR <24 breaths/min
		• SBP > 90 mmHg
		• O_2 sat >90%
		• Normal mental status
		*Based on patient baseline status
		
		Antibiotics should be **discontinued** in most patients on day 5 of antibiotic therapy.
		
		If patients have a delayed response to treatment, antibiotics should be **discontinued** 48 hours after 4 of the 5 clinical stability criteria are met.
		
		Exceptions to Short Duration
		• MRSA or non-fermenting GNR (e.g. *P. aeruginosa*): **7 days**
		• Streptococcal bacteremia: **7-14 days**
		• Legionella: **7-10 days**
		• GNR bacteremia: **7 days**
		• MRSA bacteremia: **14+ days**
		• Empyema or lung abscess: **varies**

*If concern for opportunistic infection, mycobacteria, or fungal pneumonia consider ID consult

†Cefepime is the preferred anti-pseudomonal β-lactam for patients with penicillin allergies, including anaphylaxis.

Date last updated: 12/06/23
Date approved: 12/06/23

Severe/ICU CAP With Resistant Pathogen Risk Factors*		
Empiric Therapy	**Comments**	**Duration of Therapy**

MRSA Risk Factors Only:
Ceftriaxone 2g IV daily
+
Azithromycin 500mg IV (or PO) daily
+
Vancomycin, pharmacy consult OR
Linezolid 600mg IV (or PO) q12h
 	
P. aeruginosa Risk Factors Only‡:
Piperacillin/tazobactam 3.375g IV q8h OR
Cefepime 2g IV q8h
+
Azithromycin 500mg IV (or PO) daily
 	
Both MRSA and *P. aeruginosa* Risk Factors‡:
Piperacillin/tazobactam 3.375g IV q8h OR
Cefepime 2g IV q8h
+
Vancomycin, pharmacy consult OR
Linezolid 600mg IV (or PO) q12h
+
Azithromycin 500mg IV (or PO) daily
 	
*If MRSA or *P. aeruginosa* are not recovered on culture, change to routine CAP coverage.
 	
If cultures are positive, target antibiotics to the recovered pathogen.
 	
Addition of steroids per ICU protocol
	Atypical Coverage
	• If RPP and Legionella urine antigen (if collected) negative, atypical coverage should be **discontinued**.
	• If RPP is positive for *M. pneumoniae* or *C. pneumoniae*, doxycycline 100mg PO BID is preferred.
	• If high suspicion for *Legionella* or positive urine antigen, azithromycin or levofloxacin are preferred over doxycycline.
	
	Anaerobic Coverage
	• Do **NOT** start anaerobic coverage for aspiration pneumonia.
	• Anaerobic coverage should be considered if empyema or lung abscess detected.
	  ○ Piperacillin/tazobactam OR
	  ○ Add metronidazole 500mg IV (or PO) BID
	
	Transition to Oral Antibiotics
	• Should occur as soon as patient is afebrile and hemodynamically stable with clinical improvement x 48 hours.
	• Recommended PO options:
	  ○ Amoxicillin/clavulanate 875/125mg PO BID
	  ○ Cefuroxime 500mg PO BID (if penicillin allergy)
	  ○ Levofloxacin (if *P. aeruginosa* risk factors or positive culture)
	  ○ Linezolid (if MRSA positive sputum/BAL)
		Clinical Stability Criteria (no more than 1 criteria not met)*
		• HR <100 bpm
		• RR <24 breaths/min
		• SBP > 90 mmHg
		• O_2 sat >90%
		• Normal mental status
		*Based on patient baseline status
		
		Antibiotics should be **discontinued** in most patients on day 5 of antibiotic therapy.
		
		If patients have a delayed response to treatment, antibiotics should be **discontinued** 48 hours after 4 of the 5 clinical stability criteria are met.
		
		Exceptions to Short Duration
		• MRSA or non-fermenting GNR (e.g. *P. aeruginosa*): **7 days**
		• Streptococcal bacteremia: **7-14 days**
		• GNR bacteremia: **7 days**
		• MRSA bacteremia: **14+ days**
		• Empyema or lung abscess: **varies**

*If concern for opportunistic infection, mycobacteria, or fungal pneumonia consider ID consult.

‡Cefepime is the preferred anti-pseudomonal β-lactam for patients with penicillin allergies, including anaphylaxis.

Date last updated: 12/06/23

Date approved: 12/06/23

VII. References

1. Aujesky D, Stone RA, Obrosky DS, et al. Using randomized controlled trial data, the agreement between retrospectively and prospectively collected data comprising the pneumonia severity index was substantial. *J Clin Epidemiol*. 2005 Apr;58(4):357-63. doi: 10.1016/j.jclinepi.2004.08.011. PMID: 15862721.
2. Baby N, Faust AC, Smith T, et al. Nasal Methicillin-Resistant Staphylococcus aureus (MRSA) PCR Testing Reduces the Duration of MRSA-Targeted Therapy in Patients with Suspected MRSA Pneumonia. *Antimicrob Agents Chemother*. 2017 Mar 24;61(4):e02432-16. doi: 10.1128/AAC.02432-16. PMID: 28137813; PMCID: PMC5365699.
3. Castro-Guardiola A, Viejo-Rodríguez AL, Soler-Simon S, et al. Efficacy and safety of oral and early-switch therapy for community-acquired pneumonia: a randomized controlled trial. *Am J Med*. 2001 Oct 1;111(5):367-74. doi: 10.1016/s0002-9343(01)00868-3. PMID: 11583639.
4. Ciarkowski CE, Timbrook TT, Kukhareva PV, et al. A Pathway for Community-Acquired Pneumonia With Rapid Conversion to Oral Therapy Improves Health Care Value. *Open Forum Infect Dis*. 2020 Oct 19;7(11):ofaa497. doi: 10.1093/ofid/ofaa497. PMID: 33269294; PMCID: PMC7686657.
5. Deshpande A, Klompas M, Guo N, et al. Intravenous to Oral Antibiotic Switch Therapy Among Patients Hospitalized With Community-Acquired Pneumonia. *Clin Infect Dis*. 2023 Jul 26;77(2):174-185. doi: 10.1093/cid/ciad196. PMID: 37011018.
6. Dinh A, Ropers J, Duran C, et al. Discontinuing β-lactam treatment after 3 days for patients with community-acquired pneumonia in non-critical care wards (PTC): a double-blind, randomised, placebo-controlled, non-inferiority trial. *Lancet*. 2021 Mar 27;397(10280):1195-1203. doi: 10.1016/S0140-6736(21)00313-5. Erratum in: Lancet. 2021 Jun 5;397(10290):2150. PMID: 33773631.
7. Figueiredo-Mello C, Naucler P, Negra MD, Levin AS. Ceftriaxone versus ceftriaxone plus a macrolide for community-acquired pneumonia in hospitalized patients with HIV/AIDS: a randomized controlled trial. *Clin Microbiol Infect*. 2018 Feb;24(2):146-151. doi: 10.1016/j.cmi.2017.06.013. Epub 2017 Jun 23. PMID: 28648859.
8. Garin N, Genné D, Carballo S, et al. β-Lactam monotherapy vs β-lactam-macrolide combination treatment in moderately severe community-acquired pneumonia: a randomized noninferiority trial. *JAMA Intern Med*. 2014 Dec;174(12):1894-901. doi: 10.1001/jamainternmed.2014.4887. PMID: 25286173.
9. Gupta V, Yu KC, Schranz J, Gelone SP. A Multicenter Evaluation of the US Prevalence and Regional Variation in Macrolide-Resistant *S. pneumoniae* in Ambulatory and Hospitalized Adult Patients in the United States. *Open Forum Infect Dis*. 2021 Feb 4;8(7):ofab063. doi: 10.1093/ofid/ofab063. PMID: 34250183; PMCID: PMC8266646.
10. Guz D, Bracha M, Steinberg Y, et al. Ceftriaxone versus ampicillin for the treatment of community-acquired pneumonia. A propensity matched cohort study. *Clin Microbiol Infect*. 2023 Jan;29(1):70-76. doi: 10.1016/j.cmi.2022.07.022. Epub 2022 Aug 5. PMID: 35934196.
11. Jain S, Self WH, Wunderink RG, Fakhran S, et al. Community-Acquired Pneumonia Requiring Hospitalization among U.S. Adults. *N Engl J Med*. 2015 Jul 30;373(5):415-27. doi: 10.1056/NEJMoa1500245. Epub 2015 Jul 14. PMID: 26172429; PMCID: PMC4728150.
12. Kato H, Hagihara M, Asai N, et al. Meta-analysis of fluoroquinolones versus macrolides for treatment of legionella pneumonia. *J Infect Chemother*. 2021 Mar;27(3):424-433. doi: 10.1016/j.jiac.2020.10.002. Epub 2020 Oct 23. PMID: 33268272.

Date last updated: 12/06/23
Date approved: 12/06/23

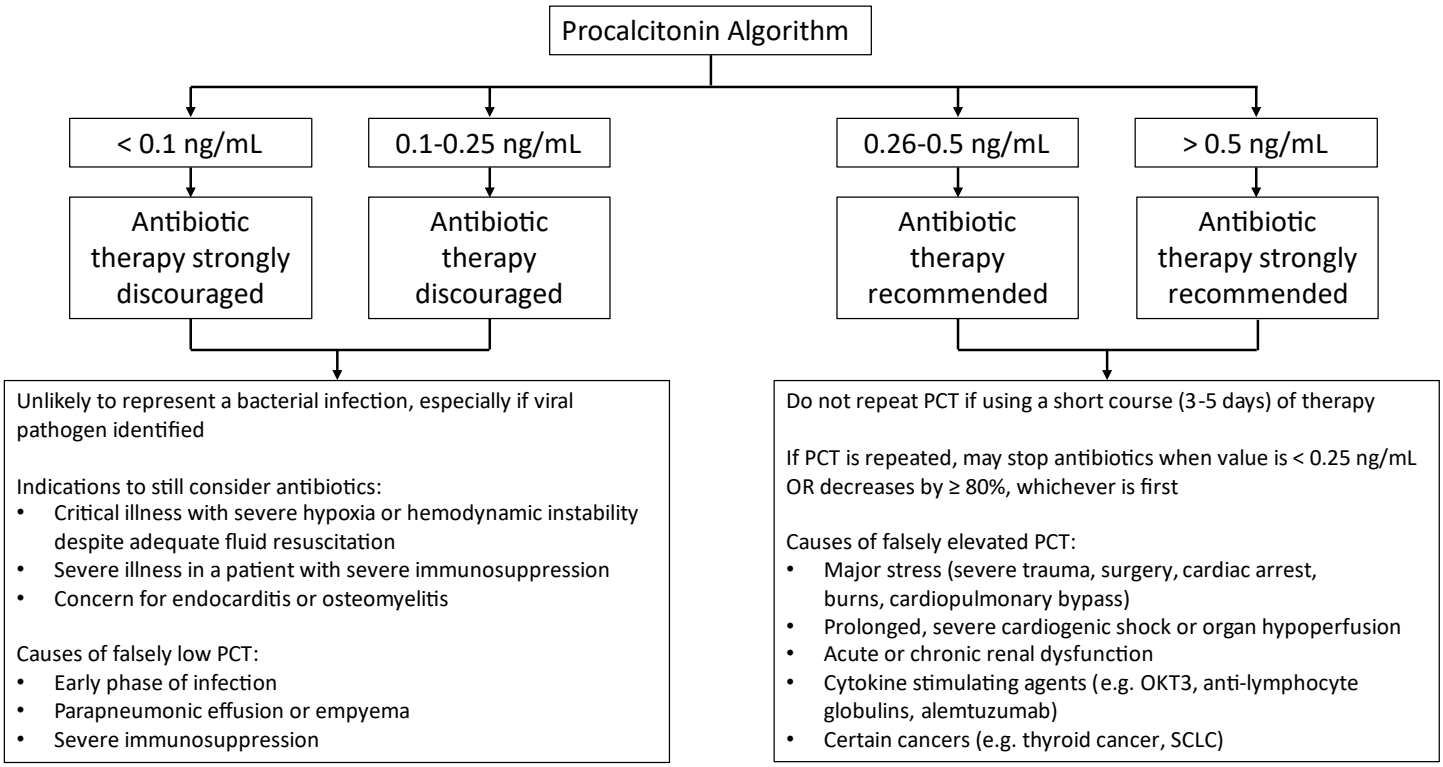
13. Klompas M, McKenna C, Ochoa A, et al. Ultra-Short-Course Antibiotics for Suspected Pneumonia With Preserved Oxygenation. *Clin Infect Dis*. 2023 Feb 8;76(3):e1217-e1223. doi: 10.1093/cid/ciac616. PMID: 35883250; PMCID: PMC10498383.
14. Lui G, To HKW, Lee N, et al. Adherence to Treatment Guideline Improves Patient Outcomes in a Prospective Cohort of Adults Hospitalized for Community-Acquired Pneumonia. *Open Forum Infect Dis*. 2020 Apr 24;7(5):ofaa146. doi: 10.1093/ofid/ofaa146. PMID: 32467825; PMCID: PMC7243378.
15. Marin-Corral J, Pascual-Guardia S, Amati F, et al. Aspiration Risk Factors, Microbiology, and Empiric Antibiotics for Patients Hospitalized With Community-Acquired Pneumonia. *Chest*. 2021 Jan;159(1):58-72. doi: 10.1016/j.chest.2020.06.079. Epub 2020 Jul 17. PMID: 32687909.
16. Mergenhagen KA, Starr KE, Wattengel BA, et al. Determining the Utility of Methicillin-Resistant Staphylococcus aureus Nares Screening in Antimicrobial Stewardship. *Clin Infect Dis*. 2020 Aug 22;71(5):1142-1148. doi: 10.1093/cid/ciz974. PMID: 31573026.
17. Metlay JP, Waterer GW, Long AC, et al. Diagnosis and Treatment of Adults with Community-acquired Pneumonia. An Official Clinical Practice Guideline of the American Thoracic Society and Infectious Diseases Society of America. Am J Respir Crit Care Med. 2019 Oct 1;200(7):e45-e67. doi: 10.1164/rccm.201908-1581ST. PMID: 31573350; PMCID: PMC6812437.
18. Moradi T, Bennett N, Shemanski S, et al. Use of Procalcitonin and a Respiratory Polymerase Chain Reaction Panel to Reduce Antibiotic Use via an Electronic Medical Record Alert. *Clin Infect Dis*. 2020 Oct 23;71(7):1684-1689. doi: 10.1093/cid/ciz1042. PMID: 31637442; PMCID: PMC7108168.
19. Musher DM, Abers MS, Bartlett JG. Evolving Understanding of the Causes of Pneumonia in Adults, With Special Attention to the Role of Pneumococcus. *Clin Infect Dis*. 2017 Oct 30;65(10):1736-1744. doi: 10.1093/cid/cix549. PMID: 29028977; PMCID: PMC7108120.
20. Postma DF, van Werkhoven CH, van Elden LJ, et al. Antibiotic treatment strategies for community-acquired pneumonia in adults. *N Engl J Med*. 2015 Apr 2;372(14):1312-23. doi: 10.1056/NEJMoa1406330. PMID: 25830421.
21. Raz-Pasteur A, Shasha D, Paul M. Fluoroquinolones or macrolides alone versus combined with β-lactams for adults with community-acquired pneumonia: Systematic review and meta-analysis. *Int J Antimicrob Agents*. 2015 Sep;46(3):242-8. doi: 10.1016/j.ijantimicag.2015.04.010. Epub 2015 Jun 3. PMID: 26092096.
22. Restrepo MI, Babu BL, Reyes LF, et al. Burden and risk factors for *Pseudomonas aeruginosa* community-acquired pneumonia: a multinational point prevalence study of hospitalised patients. *Eur Respir J.* 2018 Aug 9;52(2):1701190. doi: 10.1183/13993003.01190-2017. PMID: 29976651.
23. Schuetz P, Christ-Crain M, Thomann R, et al. Effect of procalcitonin-based guidelines vs standard guidelines on antibiotic use in lower respiratory tract infections: the ProHOSP randomized controlled trial. *JAMA*. 2009 Sep 9;302(10):1059-66. doi: 10.1001/jama.2009.1297. PMID: 19738090.
24. Schweitzer VA, van Heijl I, Boersma WG, et al. Narrow-spectrum antibiotics for community-acquired pneumonia in Dutch adults (CAP-PACT): a cross-sectional, stepped-wedge, cluster-randomised, non-inferiority, antimicrobial stewardship intervention trial. *Lancet Infect Dis*. 2022 Feb;22(2):274-283. doi: 10.1016/S1473-3099(21)00255-3. Epub 2021 Oct 7. PMID: 34627499.
25. Self WH, Wunderink RG, Williams DJ, et al. Staphylococcus aureus Community-acquired Pneumonia: Prevalence, Clinical Characteristics, and Outcomes. *Clin Infect Dis*. 2016 Aug 1;63(3):300-9. doi: 10.1093/cid/ciw300. Epub 2016 May 8. PMID: 27161775; PMCID: PMC4946021.

Date last updated: 12/06/23
Date approved: 12/06/23

26. Shorr AF, Khashab MM, Xiang JX, et al. Levofloxacin 750-mg for 5 days for the treatment of hospitalized Fine Risk Class III/IV community-acquired pneumonia patients. *Respir Med*. 2006 Dec;100(12):2129-36. doi: 10.1016/j.rmed.2006.03.019. Epub 2006 May 26. PMID: 16730170.
27. Sligl WI, Asadi L, Eurich DT, et al. Macrolides and mortality in critically ill patients with community-acquired pneumonia: a systematic review and meta-analysis. *Crit Care Med*. 2014 Feb;42(2):420-32. doi: 10.1097/CCM.0b013e3182a66b9b. PMID: 24158175.
28. Uranga A, España PP, Bilbao A, et al. Duration of Antibiotic Treatment in Community-Acquired Pneumonia: A Multicenter Randomized Clinical Trial. *JAMA Intern Med*. 2016 Sep 1;176(9):1257-65. doi: 10.1001/jamainternmed.2016.3633. PMID: 27455166.
29. Vaughn VM, Gandhi TN, Hofer TP, et al. A Statewide Collaborative Quality Initiative to Improve Antibiotic Duration and Outcomes in Patients Hospitalized With Uncomplicated Community-Acquired Pneumonia. *Clin Infect Dis*. 2022 Aug 31;75(3):460-467. doi: 10.1093/cid/ciab950. PMID: 34791085; PMCID: PMC9427146.

Date last updated: 12/06/23
Date approved: 12/06/23

Appendix: Procalcitonin Algorithm



Modified from: Albrich WC, Dusemund F, Bucher B, et al. Effectiveness and safety of procalcitonin-guided antibiotic therapy in lower respiratory tract infections in "real life": an international, multicenter poststudy survey (ProREAL). *Arch Intern Med*. 2012 May 14;172(9):715-22. doi: 10.1001/archinternmed.2012.770.

Date last updated: 12/06/23
Date approved: 12/06/23