Community Acquired Pneumonia

Inpatient

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Inclusion Criteria

Patients ≥ 3 months old with suspected CAP

Exclusion Criteria

Admission Criteria

Diagnostic Testing

Pneumonia is typically a clinical diagnosis.

- Laboratory testing if indicated
- Chest x-ray (2 view, upright) if not previously obtained
- Chest US **if** CXR shows either moderate to large effusion or small effusion with respiratory distress

Diagnostic Timeout

- Definition and Diagnosis
- Differential Diagnoses
- S&S by Pathogen
- Severity

Imaging showing parapneumonic effusion that is moderate or large, necrotizing pneumonia or lung abscess?

- No → High severity OR penicillin allergy?
- Yes → See algorithm for "Complicated CAP"

High severity OR penicillin allergy?

- Yes → Start Ceftriaxone if bacterial cause is likely
- No → Start Amoxicillin *or* Ampicillin** if bacterial cause is likely

Penicillin Allergy

- Use Ceftriaxone IV
- Transition to enteral clindamycin or levofloxacin. Consider graded dose amoxicillin challenge and/or Allergy referral.

Inpatient Antimicrobials

Monitor for signs of deterioration

- Worsening tachypnea or WOB
- Lethargy and altered mental status
- Hemodynamic instability (poor perfusion, tachycardia, hypotension)

Red Flags & Complications

In children, viral cause is most common

Deterioration or ill-appearing child?

- No → Mycoplasma detected by PCR?
- Yes → Consider ID consult; Consider consult to IR if effusion; ACT per clinical judgment

Mycoplasma detected by PCR?

- Yes → Add Azithromycin
- No → Adjust antibiotics to target any pathogens identified; Stop antibiotics if low suspicion for bacterial cause

ACT (ICU admission) if:

- Impending respiratory failure - need for invasive or non-invasive ventilation
- Persistent hypoxemia <90% with FiO_2 > 0.50
- BP or perfusion instability requiring pharmacologic treatment
- Altered mental status

Improvement within 72hrs on appropriate antibiotics?

- No → **Diagnostic Time-Out**
  - Consider repeat CXR; chest US if effusion/complicated PNA and potential for drainage
  - Consider uncommon causes of pneumonia (e.g., Legionella, Psittacosis, histoplasmosis)
- Yes → **Discharge when meeting criteria**
  - O_2 saturation >90% in RA for ≥8hrs
  - No signs of respiratory distress
  - Tolerating PO fluids and medications
  - Reliable follow up schedule
  - Appropriate discharge antibiotic determined and arranged if bacterial etiology likely/ confirmed

Discharge Planning

Complicated CAP on ceftriaxone.

- Transition to oral antibiotic based on diagnostics
- If Strep pneumo by PCR but not by culture (thus no MIC), use amoxicillin

Off Pathway

Individualized care

Complicated CAP - Inpatient

(Moderate or large size effusion on chest US)

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- **Consult IR for potential chest tube placement**
  - Page **EMERGENTLY** If patient clinically unstable. ACT as indicated.
  - Alternative chest tube management in discussion with IR and Pediatric Surgery whenever indicated
- **Consult ID**
- CBC diff, CRP, FARVPP and blood culture, if not already obtained
- **Start Ceftriaxone**
- Consider **adding** *Staph aureus* coverage in the following conditions:
  - Necrotizing pneumonia ***or*** critically ill ***or*** in ICU ***or*** <1 years of age ***or*** history of MRSA infection ***or*** coinfection with measles or influenza

Inpatient Antimicrobials

Suspected necrotizing pneumonia or pulmonary abscess on CXR?

Yes → **Off Pathway** Necrotizing Pneumonia or Pulmonary Abscess

No

Loculation seen on ultrasound?

No (Simple Effusion) → Simple effusion amenable to drainage?

Yes (Complicated effusion)

Simple effusion amenable to drainage?

- Yes →
  - **Thoracostomy tube placement by IR**
  - Fibrinolytic therapy not routinely recommended
- No → Improvement in 24-48hrs on appropriate antibiotic?
  - No → (back to Simple effusion amenable to drainage?)
  - Yes → See algorithm for "CAP-Inpatient"

Improvement defined as improving fever curve, decreasing respiratory support, improving appetite, decreasing inflammatory markers

Yes (Complicated effusion) →
- **Thoracostomy tube placement by IR**
- **Start fibrinolytic therapy Q12H** with 1st dose at time of chest tube placement; 1hr dwell time (Fibrinolytic Dosing)
- Consider consult to Pediatric Surgery after discussion with IR

- Daily CXR (AP, upright if possible) or as clinically indicated
- Team placing tube to follow and manage tube care including fibrinolytics.
- Adjust antibiotics to target pathogens identified
- Consider trending CRP
- Analgesia for pain control, consider Pain Team consult

Pleural Fluid Diagnostic Testing
- Cell count with diff
- Bacterial (aerobic) culture with gram stain
- PCRs for *S. aureus, S. pyogenes, S. pneumoniae*
- Hold sample for further testing

Improvement after 72hrs of appropriate antibiotic +/- fibrinolytic therapy?

Yes →
- Consider de-escalation of antibiotics if possible
- Antibiotic route and duration for complicated CAP

Consider chest tube removal when output <0.5mL/kg/12hr ***and*** no air leak

Discharge home when meeting criteria:
- O2 saturation >90% on RA for minimum of 8hrs
- No signs of respiratory distress
- Improving CXR and clinically stable for ≥14 hrs after chest tube removal
- Tolerating PO fluids and medications
- Reliable follow up scheduled
- Appropriate discharge antibiotic determined and arranged

No →
- US or chest CT in discussion with IR and radiology
- **Pediatric Surgery** consult if not previously obtained

Complicated pleural effusion present?

- No → **Off Pathway**
- Yes → New or Persistent complicated pleural effusion?
  - New → **Fibrinolytic therapy Q12H** (3-day course) with 1hr dwell time (Fibrinolytic Dosing) → (back to Improvement after 72hrs...)
  - Persistent → Two courses of fibrinolytic therapy completed?
    - No → (back to Fibrinolytic therapy Q12H)
    - Yes → **Off Pathway** Individualized management in discussion with ID, IR and Peds Surg. Consider VATS.

Outpatient Antimicrobials

Inclusion & Exclusion Criteria

Pathway Inclusion Criteria

- Patients ≥ 3 months old with suspected CAP

Pathway Exclusion Criteria

- Suspected sepsis
- Immunodeficiency
- Suspected aspiration pneumonia
- Chronic lung disease other than asthma
- Prior/current tracheostomy
- Significant chronic condition including Sickle Cell Disease (SCD), oncologic or neuromuscular condition

Return to CAP Algorithm

Return to Complicated CAP Algorithm

Definition & Diagnosis

Is this community acquired pneumonia?

- Community acquired pneumonia (CAP) is an infection of the lung parenchyma that has been acquired outside of the hospital, in a previously healthy child
- CAP is acquired outside of the health care settings

Common presentation:

- Can start with fever, tachypnea, cough
- Can progress to hypoxemia, increased work of breathing, respiratory failure and sepsis

Signs and Symptoms based on pathogen

Diagnostic Considerations:

- Pneumonia is typically a **clinical diagnosis**, made in children with fever and historical or physical examination evidence of an infectious process with symptoms or signs of respiratory distress.

Consider a diagnostic timeout. "What else could this be?"

- **Consider other alternate clinical problem and diagnosis when:**
  - Afebrile
  - Wheezing, especially if risk factors for asthma, bronchiolitis or foreign body aspiration
  - Risk factors or suspicion for anatomical abnormality, aspiration, chronic respiratory symptoms, drug/chemical exposure, vasculitic/rheumatologic process, blood clotting disorder, cardiac condition, metabolic acidosis, malignancy

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Admission Criteria

- **Admit uncomplicated CAP to Infectious Diseases, or to Hospital Pediatrics as needed during times with high census.**

- **Admit complicated CAP i.e. with moderate or large size effusion, to Infectious Diseases (if no PICU criteria met).**

- **Admission criteria:**
  - **Patient Factors Indications**
    - Age ≤6 months with suspected bacterial pneumonia
    - Failure of outpatient treatment
    - Concern for clinical deterioration with outpatient treatment
    - Inability to tolerate oral antibiotics
    - Adequate follow up cannot be ensured

  - **Respiratory Indications**
    - Oxygen saturation <90% on room air
    - Signs of respiratory distress or toxic appearance
    - Evidence of advanced disease (e.g. hemoptysis, cavitary lesion)
    - Pneumonia suspected to be due to drug-resistant pathogen (MRSA)
    - Complicated CAP (pleural effusion, necrotizing pneumonia, lung abscess)

  - **Other Indications**
    - Bacteremia
    - Dehydration or not tolerating PO
    - Altered mental status
    - Isolation indicated that cannot be performed outside of the hospital setting

- **PICU admission criteria:**
  - HFNC, NIPPV or mechanical ventilation
  - Persistent tachycardia after 3 IVF boluses
  - Signs of poor perfusion
  - Hypotension not resolved with IVF boluses

Return to CAP Algorithm

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Differential Diagnoses

- Foreign body
- Asthma
- Bronchiolitis
- Cystic Fibrosis
- Primary Ciliary Dyskinesia
- Primary Immunodeficiency
- Post-infectious Bronchiolitis Obliterans
- Chronic Aspiration
- Tuberculosis
- Malformation
- Neoplasm
- Lymphadenopathy
- Histoplasmosis
- Hypersensitivity pneumonitis
- E-cigarette or Vaping Associated Lung Injury (E-VALI)
- Congestive cardiac failure
- Systemic vasculitis
- Pulmonary infarction
- Lemierre syndrome (septic thrombophlebitis of the internal jugular vein)

(Drummond et al. 2022, Principles and practice of pediatric infectious diseases / editor, Sarah S. Long 2023)

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S&S by Pathogen

Pathogen	Epidemiology	Clinical	CXR
Bacterial In order of prevalence: • Strep. pneumoniae • Staph. aureus including MRSA • Strep. pyogenes (group A Streptococcus) • Haemophilus influenzae type b (if unimmunized)	Prevalence: 2 – 50%, with higher rate in hospitalized children with more severe illness Usual age: any	Fever, chills, ill appearance Focal, crackles or decreased breath sounds, bronchial breath sounds, egophony. (Absence of wheezing)	Alveolar infiltrate; lobar or segmental consolidation, complications incl. pleural effusion
Viral or viral/bacterial co-infection • Respiratory syncytial virus (RSV) • Rhinovirus (RV) • Human metapneumovirus (hMPV) • Adenovirus • Influenza • Enterovirus D68 • Parainfluenza virus	Prevalence: 73% Age < 2 years: > 80% Age > 2 years: 49 %	Non-toxic, preceding congestion/rhinorrhea Diffuse crackles, wheezing	Interstitial infiltrate, patchy atelectasis, peribronchial thickening, hyperinflation
Atypical • Mycoplasma pneumoniae • Chlamydia pneumoniae	Prevalence: 3 – 23 % Usual age: ≥5 years	Malaise, sore throat, low-grade fever, headache, cough developing over 3-5 days Rash and mucositis.	Variable; bilateral diffuse infiltrates or focal (perihilar/peribronchial or lobar/segmental) abnormalities

Fever, cough and tachypnea can be seen with any etiology of pneumonia.

Return to CAP Algorithm

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CAP Severity, Red Flags & Complications

	Mild Severity	Moderate Severity	High Severity
Symptoms & Signs	• No hypoxemia • Minimally increased WOB	• Hypoxemia (spO2 <90%), • Moderately increased work of breathing (grunting, retracting, tachypnea)	• Severely increased work of breathing or apnea • Impending respiratory failure • BP or perfusion instability requiring pharmacologic treatment • Altered mental status • Signs of sepsis
Response to Therapy	• Stable in RA	• Stable O_2 sat >90% with <50% FiO2	• Failure to maintain O_2 sat ≥ 90% with FiO2 of ≥ 50% • Require positive pressure ventilation

Red Flags

- Rapid progression of respiratory distress
- Altered mental status
- Incomplete pneumococcal and Hib vaccination increases the risk for ampicillin-resistant infection. Given low resistance rates at NCH, vaccination status does not typically impact initial antibiotic choice but should be considered in patients not responding to therapy.
- Adolescent with fever, odynophagia/pharyngitis, neck pain/swelling/tenderness; can have cough/SOB, headache, cavitating pneumonia; concern for Lemierre syndrome (septic thrombophlebitis of the internal jugular vein). Consider CT neck with IV contrast

(Carius et al 2022, Galbraith et al. 2022)

Complications

Pulmonary:

- Acute respiratory failure
- Pleural effusion /empyema
- Pneumothorax
- Lung abscess
- Bronchopleural fistula
- Necrotizing pneumonia
- Pneumatocele

Metastatic:

- Meningitis
- CNS abscess
- Pericarditis
- Endocarditis
- Osteomyelitis
- Septic arthritis

Systemic:

- Systemic inflammatory response syndrome or sepsis
- Hemolytic uremic syndrome associated with *S. pneumoniae* infection

(Bradley et al. 2011)

Return to CAP Algorithm

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Inpatient Laboratory Testing

- **Viral testing**
  - Rapid Influenza test - if in season
  - Rapid RSV - if in season
  - Rapid COVID
  - FARVPP - if viral cause of illness is suspected and test result will guide treatment

- **Mycoplasma pneumoniae throat PCR**
  - if **atypical pneumonia suspected**

- CBC with diff, CRP and blood culture with IV placement in the **ED**
- Procalcitonin and ESR is not recommended unless evaluating for bacteremia/sepsis

- **Nasal *S. aureus* PCR**
  - Consider if severe or complicated pneumonia

- **Blood Culture, if:**
  - Requiring hospitalization for CAP that is moderate to severe
  - < 6 months with fever
  - Not fully immunized or immunocompromised
  - Complicated CAP (effusion, empyema or necrotizing pneumonia on chest radiograph)
  - Central line
  - Admitted to the ICU
  - Complex/chronic medical conditions

Adapted, with some modifications, from Children's Mercy Kansas City (CMKC), Evidence Based Practice Clinical Practice Guide, Community Acquired Pneumonia, Date Finalized/Revised: 10/2018; 03/2020. https://www.childrensmercy.org/contentassets/d53d2a2d180c430e88a0cf04590b3025/community-acquired-pneumonia-synopsis.pdf

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Size & Classification of Parapneumonic Effusions

Small Effusion: Fluid occupying <10 mm on lateral decubitus radiograph or opacifying less than one-fourth of the hemithorax

Moderate Effusion: >10 mm rim of fluid but opacifies less than half of the hemithorax

Large Effusion: Opacifies more than half of the hemithorax

Stage of Effusion	Fluid Appearance	Fluid Characteristics	Ultrasound appearance
Simple	Clear	Typically, no organisms seen on gram stain or culture; normal pH and glucose	No loculations or septations seen
Complicated	Clear or cloudy	Gram stain or culture MAY be positive; decreased pH and glucose, increased LDH	Loculations present
Empyema	Frank pus	Gram stain or culture MAY be positive; decreased pH and glucose, increased LDH	Loculations present

Ref: Bradley JS, Byington CL, Shah SS, Alverson B, Carter ER, Harrison C, et al. Infectious Diseases Society and the Infectious Diseases Society of America. Clin Infect Dis. 2011;53(7):e25-76.

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Necrotizing Pneumonia or Pulmonary Abscess

Fibrinolytic Dosing

Lexicomp®

Alteplase (Nationwide Children's Hospital Formulary)

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Necrotizing Pneumonia or Pulmonary Abscess

Necrotizing Pneumonia or Pulmonary Abscess

- Consider CT chest with contrast for confirmation
- Drainage **NOT** routinely recommended, **except** if abscess is peripheral and not communicating with airway, in which case drainage and catheter placement +/- fibrinolytic therapy should be considered. Percutaneous aspiration may be undertaken if failure to respond to empiric therapy and identification of pathogen needed.
- IV antibiotics per “Complicated CAP” algorithm
- Individualized care per clinical judgment

(Andronikou et al. 2017, Islam et al. 2012, St Peter et al 2009)

Return to Complicated CAP Algorithm

Route & Duration of Antibiotics for Complicated CAP

Route

- Continue IV antibiotics until afebrile for 48-72 hours, then switch to PO regimen

Duration

- Duration of antibiotics depends on clinical response and adequacy of fluid drainage
- Ranges from 7 days after fluid drainage (if performed) or 7 days after afebrile, to 2-3 weeks for more complicated disease.

Return to Complicated CAP Algorithm

Pneumonia Inpatient Antimicrobials

Antimicrobial	Indication	Dosing	Duration* Since start of effective therapy	Comment
Amoxicillin	First Line Therapy in uncomplicated CAP	90 mg/kg/day, PO, **divided** Q8 to Q12H Max: 4 g/day	5-7 days	
Ampicillin	First Line Therapy in uncomplicated CAP and PO route inappropriate	200 mg/kg/day, IV, **divided** Q6H Max: 2000 mg/dose	5-7 days	
Ceftriaxone	High severity or complicated CAP	75 mg/kg/day, IV, daily, Max: 2g/day	5-7 days	
Clindamycin	**Preferred** oral treatment for confirmed **penicillin allergy**	30 to 40 mg/kg/day, PO or IV, **divided** Q8H Max: 1.8g/day	5-7 days	
Levofloxacin	Oral treatment **alternative** for **penicillin allergy** when Clindamycin has failed	**Greater than 6 months and less than 5 years**: 8-10 mg/kg/dose, PO, Q12H (max 750 mg/day) **Greater than or equal to 5 years**: 8-10 mg/kg/dose, PO, QDAY (max 750 mg/day)	5-7 days 5-7 days	
Vancomycin	Concern for *S. aureus* OR ill-appearing child	Follow dosing and monitoring in NCH Vancomycin Dosing Guidelines		Target an AUC/MIC ratio of 400- 600 mg•hour/L
Azithromycin	*Mycoplasma* or *Chlamydia pneumoniae*	10mg/kg/dose once on Day1 (max dose: 500mg), followed by 5mg/kg/dose daily on days 2 to 5 (max dose: 250mg)	5 days	
Oseltamivir	Positive influenza testing in high-risk/hospitalized patient or < 48 hours of onset of symptoms	3 to 8 months: 3 mg/kg/dose, PO, twice daily 9mo-11mo: 3.5 mg/kg/dose, twice daily 1-12y: ≤15 kg: PO, 30 mg, twice daily >15 to 23 kg: PO, 45 mg, twice daily >23 to 40 kg: 60 mg, PO, twice daily >40 kg: 75 mg, PO, twice daily ≥13y: 75mg, PO, twice daily	5 days	
Peramivir IV	If indicated and patient cannot tolerate or absorb Oseltamivir	Contact ID for approval		

***Duration** applies to Uncomplicated CAP. For Complicates CAP see **Route and Duration of Antibiotics for Complicated CAP**

Oral cephalosporins are NOT recommended for treatment of pneumonia

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Penicillin (PCN) Allergy

PCN Allergy – Medium or High Risk

- Immediate (minutes to < 24 hrs) IgE-mediated reaction, angioedema, anaphylaxis or severe delayed reactions
  - Do not give PCN without Allergy & Immunology input

PCN Allergy – Low Risk

- Previous allergy reaction was delayed (>24 hrs) with isolated and non-progressive symptoms (maculopapular rash or GI symptoms)
  - Trial PCN in the ED or inpatient setting and monitor for 1 hr
    - If no reaction, remove PCN allergy from chart and continue therapy
    - If hives, respiratory distress or anaphylaxis, treat as clinically indicated and consult Allergy & Immunology

No PCN allergy

- PCN avoidance based on family history alone ***or***
- Has tolerated PCN since concerning incident without reaction
  - Remove PCN allergy from chart

Powell et a. 2023; Maureen Eagan Bauer et al. 2021

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Return to Inpatient Antimicrobials

Pneumonia Discharge Antimicrobials

Antimicrobial	Indication (Pathogen)	Dosing	Duration Since start of effective therapy
Amoxicillin	**Uncomplicated CAP**: First Line Therapy. **Complicated CAP on ceftriaxone**: Transition to oral antibiotic based on diagnostics. If S. pneumoniae by PCR but not by culture (thus no MIC), use amoxicillin	90 mg/kg/day, PO, **divided** Q8 to Q12H Max: 4 g/day	5-7 days
Clindamycin	**Preferred** treatment for **penicillin allergy**	30 to 40 mg/kg/day, PO, **divided** Q8H Max: 1.8g/day	5-7 days
Levofloxacin	Treatment **alternative** for **penicillin allergy** (when Clindamycin has failed	> 6 months and <5 years 8-10 mg/kg/dose po q 12 hours with maximum dose of 750 mg/day > 5 y: 8-10 mg/kg/dose, PO, QDay Max: 750 mg, PO, daily	5-7 days
		>16y: Use weight-based dosing to account for smaller sized patients over 16 years of age, PO, daily	5-7 days
Azithromycin	*Mycoplasma or Chlamydia pneumoniae*	10mg/kg/dose once on Day1 (max dose: 500mg), followed by 5mg/kg/dose once on days 2 to 5 (max dose: 250mg)	3 days
			5 days
Oseltamivir	Positive influenza testing in high-risk/hospitalized patient or < 48 hours of onset of symptoms	3 to 8 months: 3 mg/kg/dose, PO, BID	5 days
		9mo-11mo: 3.5 mg/kg/dose, BID	5 days
		1-12y: ≤15 kg: PO, 30 mg BID >15 to 23 kg: PO, 45 mg, BID >23 to 40 kg: 60 mg, PO, BID >40 kg: 75 mg, PO, BID	5 days
		≥13y: 75mg, PO, BID	5 days

Complicated CAP on ceftriaxone: Transition to oral antibiotic based on diagnostics. If *S. pneumoniae* by PCR but not by culture (thus no MIC), use amoxicillin

Oral cephalosporins are NOT recommended for treatment of pneumonia

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Metrics

Pathway Goals

- To facilitate efficient and evidence-based management of CAP in hospitalized patients
- To decrease use of unnecessary testing and ineffective treatments

Quality Measures

Process Measures:
- ED and IP Order set use
- Time to administration of antibiotic
- Time to chest tube placement

Outcome Measures:
- Decrease routine ordering of blood cultures, inflammatory markers and chest PT in uncomplicated CAP
- Decrease duration of antibiotic treatment for uncomplicated PNA
- Decrease IP LOS

Balance Measures
- ED return rate and readmission rate

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Origination Date: *June, 2023*

Next Revision Date: *June 2026*

Clinical Pathway Development

This clinical pathway was developed using the process described in the NCH Clinical Pathway Development Manual v6.

Clinical Pathways at Nationwide Children's Hospital (NCH) are standards which provide general guidance to clinicians. Patient choice and clinician judgment remain central to the selection of diagnostic tests and therapy. The ordering provider is ultimately responsible for care decisions. Nationwide Children's clinical pathways are reviewed periodically for consistency with new evidence; however, new developments may not be represented.

For more information about our pathways and program please contact:
ClinicalPathways@NationwideChildrens.org

Return to CAP Algorithm

Return to Complicated CAP Algorithm