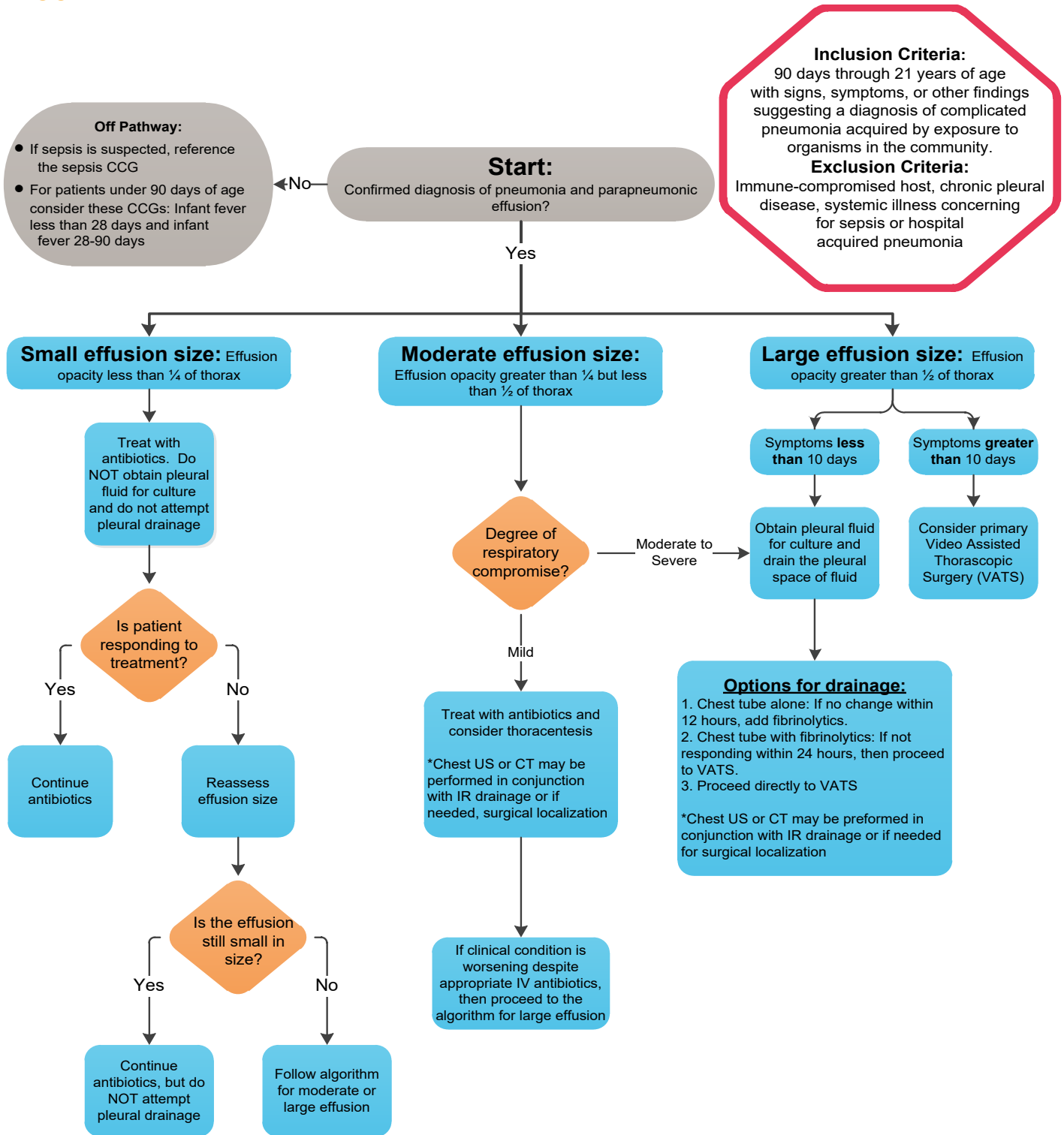


COMPLICATED COMMUNITY ACQUIRED PNEUMONIA (CAP)

ALGORITHM



Adapted from Bradley et al. Clinical Infectious Disease. 2011.

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TARGET POPULATION

Inclusion Criteria

- 90 days through 21 years of age
- Patients with signs, symptoms, or other findings suggesting a diagnosis of complicated pneumonia acquired by exposure to organisms in the community.

Exclusion Criteria

- Immune-compromised host
- Chronic pleural disease
- Systemic illness concerning for sepsis or hospital acquired pneumonia

BACKGROUND | DEFINITIONS

- **Community Acquired Pneumonia:** Infection of airways and lung tissue caused by a multitude of organisms, including a viral and bacterial etiology, which was acquired outside of the hospital.
- **Pleural effusion:** Excess fluid between the visceral and parietal pleurae that cover the lungs.
- **Complicated Pneumonia:** Pneumonia with significant effusion, empyema, severe or impending respiratory failure, and/or signs and symptoms of sepsis or shock.
- **Parapneumonic effusion:** A type of pleural effusion that arises as a result of a pneumonia, lung abscess, or bronchiectasis. Parapneumonic effusions evolve through three stages:
 - **Exudative:** sterile, free-flowing fluid, 2-5 days after the onset of the effusion.
 - **Fibro-purulent:** deposition of fibrin over the visceral and parietal pleurae, fluid becomes loculated or septated, 5-10 days after the onset of the effusion.
 - **Organized:** A thick and stiff pleural peel or rind develops and is attached to both visceral and parietal pleurae, 10-14 days after the onset of the effusion.
- **Empyema:** A parapneumonic effusion with purulent material (pleural fluid leukocytosis and/or presence of bacteria) caused by the infection spreading from the lung tissue into the pleural space.

CLINICAL MANAGEMENT

Prevention

- Hand hygiene
- [“Isolation and Standard Precautions”](#) policy (Infection Prevention & Control Manual)
- Influenza and pneumococcal vaccination protocols. Please refer to the [“CDC immunization schedules”](#)

Clinical Assessment

- Symptoms of parapneumonic effusions are similar to that of pneumonia without effusion, can develop over several days, and may develop after appropriate antibiotic treatment. Hospitalized children with empyema, compared to those with pneumonia without empyema, are more likely to have dyspnea, chest pain, and a longer duration of fever before admission^[1].
- Assessment elements should include:
 - Immunization history
 - TB exposure including exposure to anyone with a chronic cough
 - History of foreign body aspiration risk
 - Travel history
 - Consider exposure to unusual pathogens including tularemia (ticks/rabbits), plague (squirrels/prairie dogs/dead animals), and fusobacterium (history of sore throat)
 - Other ill contacts including family members or day care/school exposures
- Physical examination findings of parapneumonic effusion are similar to that of pneumonia and may include increased work of breathing, focal decreased breath sounds, crackles, and dullness to percussion^[2].

Table 1. World Health Organization Age-Specific Criteria for Tachypnea

Age	Approximate normal respiratory rates (breaths/min)	Tachypnea threshold (breaths/min)
2 to 12 months	25 to 40	50
1 to 5 years	20 to 30	40
5 years or older	15 to 25	30

Monitoring

- Vital sign frequency should be ordered per provider’s discretion
- Pain assessment/reassessment per the [“Pain Assessment & Management”](#) policy

Fluids, Electrolytes, Nutrition

Diet:

- NPO until determined if patient will need drainage procedure
- Assess fluid status, appropriately administer IVF for dehydration or if remaining NPO
- If respiratory status allows for PO intake, regular diet as tolerated. Continue to assess fluid balance and safety to continue feeds with changes in respiratory status.

DIAGNOSTIC TESTS | STUDIES

Initial Radiologic Studies

Definitive diagnostic imaging should not be delayed as early treatment of parapneumonic effusion/empyema is associated with decreased morbidity, hospital costs, and length of stay

- AP or PA and lateral chest radiographs (CXR)^[3]
 - Should be performed as the initial study in hospitalized patients with suspected pneumonia to:
 - Establish diagnosis of pneumonia
 - Confirm the presence or absence of pleural fluid
 - Evaluate for foreign body
 - Promote judicious use of antibiotics
 - Direct appropriate therapy
 - Determine approx. size of effusion

Note: The size of the effusion is an important factor that determines management
 - Repeat single view AP or PA CXR should be obtained for:
 - Clinical deterioration or instability
 - Lack of clinical improvement
 - To assess effectiveness of drainage
 - **Follow-up CXR should be one frontal view, preferably upright with the exception of problem solving tube drainage and trying to determine where the tube is directed.**
- A decubitus view is not necessary, but can be considered if useful for problem solving such as if there is a subpulmonic effusion.
- Consider a Chest ultrasound (US)^[3]

- Can be used to confirm the presence of a pleural fluid collection in unclear cases
 - The clinical utility of US is to localize the effusion and determine the presence of septation. The presence or absence of septation does not reliably predict successful catheter drainage.
- Can be used to guide the thoracentesis or drain placement
- Chest computed tomography with contrast (CT)^[3]
 - Should not be performed routinely
 - Should be reserved for the occasional case where there is concern for parenchymal disease or for guidance where US provides inadequate visualization
 - If clinically indicated should be performed with IV contrast unless there is a contraindication to contrast (i.e. impaired renal function or history of severe contrast reaction)

Initial Laboratory Studies

Recommended:

- Obtain baseline C-reactive protein (CRP) as a marker of inflammation
 - CRP may be used to help monitor response in patients who are not typically improving with initial therapy or those who present with systemic illness concerning for sepsis
- Blood Cultures
 - Blood cultures should be obtained in hospitalized children with complicated pneumonia; the yield of identifying bacteremia is higher than in uncomplicated pneumonia; 2 recent studies report positive blood cultures in 10% and 18% of patients^[4, 5].

Consider:

- Viral Studies
 - Viral testing including the CHCO respiratory pathogen panel (RPP) or influenza-specific PCR is indicated if results would change management. Providers should stratify their testing based on clinical concern for the respective viruses/atypical bacteria detected by these tests. If an RPP is chosen (see atypical bacteria testing below), the influenza-specific PCR is not recommended (as influenza A and B are detected on the panel).
 - The RPP is a PCR-based test that can detect multiple viruses including influenza A (and its 2009 H1 and H3 subtypes) and influenza B. Other viruses include adenovirus, human metapneumovirus, parainfluenza viruses 1-4, RSV, coronaviruses, and rhinovirus/enterovirus. It also detects *Mycoplasma pneumoniae*, *Chlamydophila pneumoniae*, and *Bordetella pertussis*.
 - There is also an influenza A and B only PCR. If concerned only about influenza, order the influenza A and B PCR, not the RPP.
- Testing for atypical bacteria
 - The RPP can detect *Mycoplasma pneumoniae* and *Chlamydophila pneumoniae*. *Bordetella pertussis* is also detected but results must be confirmed before results are finalized.
 - If testing for these pathogens would change management (i.e. patient with negative result and would stop atypical coverage or patient with positive result and would add atypical coverage), the RPP should be sent.
 - Children with a negative test should not be treated for atypical bacteria.
 - The clinical benefit of azithromycin in treatment of *Mycoplasma pneumoniae* is unclear. Not all children with a positive test need to be treated. For example, a provider may elect not to treat because data for benefit is unclear (particularly late in course), risks of antimicrobials may outweigh benefit, or *Mycoplasma* PCR may be positive for extended periods and may not reflect disease

- Sputum sample
 - Consider obtaining a sputum Gram stain and culture on high quality specimens when managing children capable of producing an adequate sample (typically 8yrs or older)
 - A high quality sputum is usually defined by the presence of less than 10 squamous epithelial cells and greater than 25 WBCs per low power field [6, 7]
- Tuberculin Skin Testing (TST)/Quantiferon Testing
 - Testing should be conducted in children with a history of exposure to tuberculosis, chronic cough, personal or family travel in areas where tuberculosis is prevalent.
 - Reference the RedBook for guidance on which test, TST or IGRA (Quantiferon), should be performed based on age and BCG-immunization status.
 - If Quantiferon is performed it is important to strictly follow the collection and processing instructions included in the kit to prevent indeterminate results.
 - TB isolation precautions and notification of epidemiology is required if TB is strongly suspected or confirmed. See [TB information](#)
- Pleural fluid
 - Pleural fluid may be obtained for both diagnostic and/or therapeutic indications. In a patient without respiratory distress but in whom an analysis of the pleural fluid would be diagnostically useful, a thoracentesis can be performed by interventional radiology without leaving in an indwelling chest tube.
 - Gram stain and bacterial culture of pleural fluid should be performed whenever a pleural fluid specimen is obtained.
 - Analysis of the pleural fluid white blood cell (WBC) count, with cell differential analysis, is recommended primarily to help differentiate bacterial from mycobacterial etiologies and from malignancy.
 - Analysis of pleural fluid parameters, such as pH and levels of glucose, protein, and lactate dehydrogenase, rarely change patient management and are not recommended.
 - Inflammatory markers
 - Complete blood cell count (CBC) with differential, erythrocyte sedimentation rate (ESR) and procalcitonin (PCT) should be obtained as inflammatory markers.

Other:

- It is recommended that when historical, physical, radiologic, or laboratory findings are inconsistent, additional studies be considered to evaluate for alternative or coincident conditions, such as foreign body aspiration, oncologic process, or immunodeficiency.

TREATMENT

The patient's degree of respiratory compromise is an important factor that determines the management of parapneumonic effusions. See the complicated community acquired pneumonia algorithm.

Pleural Drainage Procedures

- Children with pleural empyema have excellent outcomes with virtually no long-term sequelae, regardless of the treatment approach during the acute phase of illness^[8]
- Therefore, drainage procedures should be considered in patients with respiratory compromise; management without drainage is an option in those without significant respiratory distress
- Data are limited regarding optimal drainage procedure and procedure type is often based on institutional expertise; options include thoracentesis, chest tube placement +/- fibrinolytics, VATS (video assisted thoracoscopic surgery), or thoracotomy

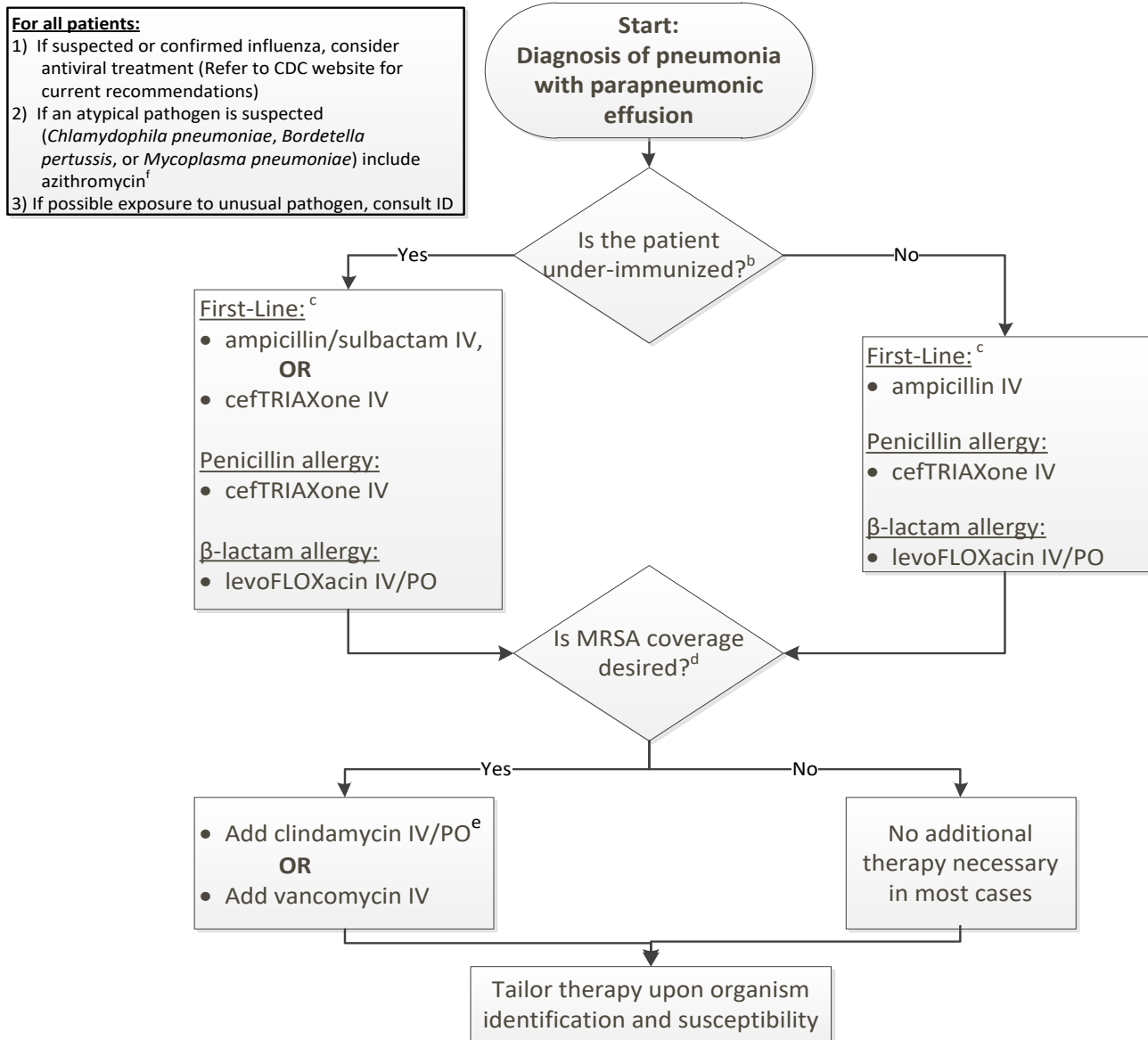
- A systematic review of randomized controlled trials comparing VATS to chest tube with fibrinolytics found no significant difference in hospital length of stay (excluding one study that used fibrinolytics only as rescue therapy)^[9]. A large multicenter retrospective study found that length of stay was similar between different drainage strategies; chest tube placement alone was least expensive; and compared to VATS, chest tube +/- fibrinolytics was associated with a higher rate of additional drainage procedures^[10].
- Chest tube may be placed by general surgery or interventional radiology
- Consider fibrinolytics with chest tube placement: tissue plasminogen activator x 3 total doses (every 24 hours): dwell time one hour^[11]. To be administered by the primary team according to the [“Alteplase: Chest Tube Instillation policy”](#).

Therapeutics

Antibiotic Therapy (See [Figure 1](#) and [Table 2](#))

- The most common bacterial pathogen in complicated CAP is *Streptococcus pneumoniae* followed by *Streptococcus pyogenes*^[12]. *Staphylococcus aureus* (both MSSA and MRSA) have also been implicated in complicated CAP and consideration can be given to other CAP organisms (*Haemophilus influenzae*, *Moraxella catarhalis*, *Mycoplasma pneumoniae*).
- Empiric coverage for *Staphylococcus aureus* infection in children hospitalized with influenza-associated complicated pneumonia should be considered^[13].
- Several weeks of antibiotic therapy is typically used for treatment of complicated pneumonia; however, there is a lack of data to support a definitive length of treatment. Length of therapy should be determined by the clinical course and response to therapy.
- Intravenous (IV) antibiotic(s) are recommended as initial therapy to optimize antimicrobial concentrations in the lung tissue and pleural fluid.
- Oral antibiotic(s) may be used following marked response to initial IV therapy (improving inflammatory markers, stable respiratory status, patient able to tolerate orals) to complete a course. In a recent study evaluating IV or PO treatment of complicated pneumonia in the outpatient setting, there were no differences in complications related to infection in patients treated with IV or PO antibiotics^[12]. Please refer to the [Community Acquired Pneumonia \(CAP\), Uncomplicated Pathway](#) for recommended agents and doses.
- Antibiotics should be tailored upon identification and susceptibility of isolated pathogens. If vancomycin, clindamycin, or broader antibiotics that cover gram negatives and anaerobes are used for empiric therapy, consider discontinuation if cultures do not support continued use, as the most common pathogens (*Streptococcus pneumoniae* and *Streptococcus pyogenes*) are commonly susceptible to ampicillin.
- Consider consultation with an Infectious Diseases specialist if there is lack of improvement despite adequate drainage or unusual etiologies on the differential.

Figure 1. Complicated CAP Empiric^a Antibiotic Treatment Algorithm



^a This algorithm contains only *empiric* therapy recommendations. Therapy should be tailored upon identification and susceptibility of isolated pathogens.

^b Assess whether the child is fully and appropriately immunized for age against *H. influenzae* type B and consider the risk for invasive *H. influenzae* B disease based on the vaccine coverage in your community (herd protection).

^c See Table 2 for dosing recommendations and other implications of therapy.

^d Consider addition of *S. aureus* coverage in patients with septic shock, with toxin mediated disease (see RedBook for Toxic Shock) and in those who are influenza positive. Those with toxin mediated disease may benefit from the addition of clindamycin for toxin inhibition.

^e In 2015, 18% of our MSSA and 27% of our MRSA were resistant to clindamycin.

^f Alternatives to azithromycin for treatment of atypical pathogens include clarithromycin, erythromycin, or if patient is older than 7 years: doxycycline. If using levoFLOxacin, atypical pathogen coverage is adequate without the addition of azithromycin.

Table 2. Complicated CAP Empiric Antimicrobials – Dosing and Implications of Therapy

Antibiotic	Recommended Dose	Implications of Therapy
Ampicillin (IV)	200mg/kg/day divided q6h (max: 8,000mg/day)	<ul style="list-style-type: none"> Does not cover MSSA, MRSA, or <i>M. catarrhalis</i>. In 2015, ~43% of <i>H. influenzae</i> were resistant.
Ampicillin/Sulbactam (IV)	200mg/kg/day divided q6h (max: 8,000mg/day)	<ul style="list-style-type: none"> Does not cover MRSA.
Azithromycin (IV or PO)	10mg/kg/day 1 st day (max: 500mg/day), followed by 5mg/kg/day (max: 250mg/day) days 2-5	<ul style="list-style-type: none"> ONLY indicated for coverage of atypical pneumonias as 40% of CHCO <i>S. pneumoniae</i> isolates are predicted to be resistant. If an RVP is ordered and <i>Mycoplasma pneumoniae</i>, <i>Chlamydophila pneumoniae</i>, or <i>Bordetella pertussis</i> are not detected, it is strongly encouraged to discontinue azithromycin therapy.
CefTRIAXone (IV)	50mg/kg/day q24h (max: 2,000mg/day)	<ul style="list-style-type: none"> Can be used for penicillin-allergic patients. If a PO transition is warranted, it is recommended that either amoxicillin or amoxicillin-clavulanate be prescribed given the unfavorable pharmacokinetic profile of oral cephalosporins in the treatment of <i>Streptococcus pneumoniae</i>.
Clindamycin (IV or PO)	30-40mg/kg/day divided TID (max PO: 1,800mg/day, max IV: 2,700mg/day)	<ul style="list-style-type: none"> In 2015, ~10% of our <i>S. pneumoniae</i> were resistant. In 2015, 18% of our MSSA and 27% of our MRSA were resistant. Highly bioavailable, consider transitioning to oral therapy if patient can tolerate.
LevoFLOXacin (IV or PO)	<ul style="list-style-type: none"> Age 6 months to less than 5 years: 20mg/kg/day divided q12h (max: 750mg/day) Age 5 years and older: 10 mg/kg/day q24h (max: 750mg/day) 	<ul style="list-style-type: none"> Can be used in patients with severe β-lactam allergies. LevoFLOXacin adequately covers both <i>Mycoplasma pneumoniae</i> and <i>Chlamydophila pneumoniae</i>. Additional atypical coverage with azithromycin is not necessary. Highly bioavailable, consider transitioning to oral therapy if patient can tolerate. A recently published study suggests that guideline-recommended dosing of levoFLOXacin results in suboptimal exposure for adequate coverage against <i>Streptococcus pneumoniae</i>. If not improving, higher dosing is available for children 14 years and younger^[14] (Consult ID)
Vancomycin (IV)	Dosing variable for age, renal function, and past requirements. Please contact pharmacy for appropriate dose.	<ul style="list-style-type: none"> Therapeutic drug monitoring: goal trough = 15-20 mcg/mL.

ADMISSION | DISCHARGE CRITERIA

Admission

- Critical care
 - Respiratory failure or impending respiratory failure (hypercapnea, acidosis, supplemental O₂, altered mental status, ventilation [invasive, noninvasive, or HHFNC meeting ICU criteria]) with need for increased support, , or acutely compromised ability to handle secretions or maintain airway
 - Sustained tachycardia, sustained hypotension, or need for pharmacologic support of blood pressure or perfusion
 - Consult either pulmonary or surgery services for continuation of care outside of ICU setting
- Inpatient setting-Admit to either pulmonary, surgery, or hospital medicine services
 - Cannot take oral antibiotics
 - Dehydration requiring IV fluids
 - O₂ requirement
 - Concern or risk for progressive or complicated pneumonia
 - Underlying co-morbidity
 - Baseline NIV

Discharge

- Oxygen requirements (see [Table 3](#))
- Stable and improving O₂ requirement and improving clinical status, patients may be discharged home on O₂ after 24 hours or more of observation and treatment. Reliable follow up and social situation
- Respiratory rate approaching normal as expected for age
- Normal work of breathing
- Able to maintain adequate oral intake
- Baseline mental status
- Medications:
 - Able to take oral medications
 - Able to obtain prescription to complete course
 - Most children hospitalized with complicated pneumonia can be discharged on oral antibiotics; treatment failure is uncommon and the effectiveness of oral antibiotics is comparable to outpatient parenteral antibiotic therapy^[12].

Follow-up

- Establish primary care physician (PCP) follow up within 2 to 3 days.
- Do not need routine recurrent CXRs, CXR 3 months after may be beneficial for healing benefit is looking for unusual sequelae, such as trapped air
- When to worry – Return for fever, increased cough, or difficulty breathing

Table 3. Maximum oxygen liter flow for discharge

Age of patient:	Maximum liter flow for discharge:
Less than 24 months and stable	½ liter per minute or less
Older than 24 months and stable	1 liter per minute or less

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- Antimicrobial Stewardship Committee – August 19, 2016
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