



ANTIMICROBIAL MANAGEMENT OF CYSTIC FIBROSIS PULMONARY EXACERBATIONS

I. OVERVIEW: Cystic fibrosis (CF) is a genetic condition that affects multiple organ systems, most notably resulting in chronic airway infection and progressive lung disease marked by intermittent exacerbations of respiratory symptoms. As a result, people with CF (pwCF) require periodic admission to the hospital for management, including antimicrobial therapy. Over time, bacteria infecting the airways become resistant to antibiotics due to cumulative antibiotic exposure. This complicates the antibiotic management of pulmonary exacerbations.

II. PURPOSE: The purpose of this document is to provide guidance to inpatient medical providers who are caring for pwCF admitted for management of a pulmonary exacerbation requiring the use of antimicrobials (antibiotics or antifungals). Current practices are variable, and while some variability is necessary due to the complexities of each unique patient, this guideline will provide recommendations to standardize the care of these patients whenever possible, as well as streamline the process for approval of restricted antimicrobials.

III. SCOPE: This guideline includes recommendations for the antimicrobial management of non-neonatal pwCF (90 days and older) who are admitted to a pediatric inpatient general care (non-ICU) service for treatment of an acute pulmonary exacerbation. This guideline is not intended for use in patients who are post-lung transplant or who are critically ill; while aspects of this guideline could be applied to those situations, the care of these patient populations requires additional consideration beyond the scope of this guideline.

This guideline includes recommendations for antimicrobial therapy based on patient factors and available culture data. These guidelines do not address long-term antimicrobial treatment or treatment for CF exacerbations that are managed exclusively in the outpatient setting. These guidelines also do not address the other essential aspects of treatment for a pulmonary exacerbation, such as airway clearance. Pediatric Infectious Diseases (ID) or other relevant consultation may be of benefit for patients who fall outside of the scope of these guidelines.

IV. DEFINITIONS:

- **Pulmonary exacerbation:** There is a lack of consensus on the definition of a CF pulmonary exacerbation, although these events are generally characterized by an intermittent worsening of respiratory symptoms (such as increased cough, sputum production, shortness of breath), often associated with a decrease in pulmonary function, weight loss, and other systemic symptoms.
- **Restricted antimicrobials**
 - The use of some antimicrobials is restricted in all hospitalized patients, based on criteria developed by the Antimicrobial Subcommittee and approved by the Pharmacy and Therapeutics Committee
 - **Tier 1:** Tier 1 antimicrobials require prior approval from the pediatric antimicrobial stewardship program (ASP) or Pediatric ID consult team.
 - Tier 1 antimicrobials that are commonly used for the treatment of CF exacerbations include carbapenems (e.g., meropenem), new beta-lactam/beta-lactamase inhibitor combinations (e.g., ceftazidime/avibactam or meropenem/vaborbactam), linezolid, and voriconazole.
 - **Tier 2:** Tier 2 antimicrobials may be initiated without obtaining prior approval but are reviewed for appropriateness by the ASP within 24-72 hours of initiation and need to either meet certain pre-existing criteria or require approval from the pediatric antimicrobial stewardship program (ASP) or Pediatric ID consult team for continued use.
 - Tier 2 antimicrobials that are commonly used for the treatment of CF exacerbations include cefepime, ceftazidime, piperacillin/tazobactam, aztreonam, fluoroquinolones (e.g., ciprofloxacin), and vancomycin.

V. GUIDELINE:

Initial antimicrobial selection

- A critically ill pwCF (severe sepsis or severe respiratory failure) falls outside the scope of this guideline, but the antimicrobial regimen should, *at a minimum*, include coverage for all bacterial species grown from respiratory culture within the last year, as well as empiric coverage for *Staphylococcus aureus*, *Pseudomonas aeruginosa*, and *Burkholderia cepacia* complex.
 - Pediatric Pulmonology and Pediatric Infectious Diseases should be consulted to further discuss the appropriate treatment for critically ill patients
- Otherwise, the choice of antimicrobials should be based on consideration of the following:
 - Typical airway pathogens for age
 - In young children with CF, the primary airway pathogens are oral commensal bacteria and *S. aureus*; most children will not require anti-pseudomonal antibiotics if they have not had a respiratory culture grow *P. aeruginosa* within the past 2 years.
 - Recent respiratory culture data (coverage for bacterial species grown from respiratory cultures within the past 1 year, or past 2 years for *P. aeruginosa*)
 - An anti-pseudomonal antibiotic is not necessary for initial therapy unless patients have had:
 - Respiratory culture positive for *P. aeruginosa* in the past 2 years
 - Respiratory culture positive for non-aeruginosa *Pseudomonas* species (*Pseudomonas putida*, *Pseudomonas fluorescens*, etc.) in the past 1 year
 - Culture results from a patient's sibling should not be used to guide routine treatment, but may be considered in the setting of critical illness
 - See "[Incorporating *P. aeruginosa* susceptibility data into treatment decisions](#)" below for more details on use of susceptibility data for *P. aeruginosa*
 - Recent outpatient antimicrobial use
 - Previous antibiotic regimens that have resulted in clinical improvement
 - If a patient typically receives a non-preferred agent for *P. aeruginosa* (such as meropenem) based on lack of improvement with preferred agents in the past, a repeat trial of a preferred agent should be considered after 1 year
 - Patient allergies and adverse effects
 - For patients with penicillin or cephalosporin allergy, refer to [β-lactam Allergy Evaluation and Empiric Therapy Guidance](#) for alternative β-lactam treatment options; consultation to the β-lactam Allergy Evaluation Service (BLAES) may also be appropriate
 - If there is a history of other complications or adverse effects (e.g., hearing loss due to aminoglycoside use), alternatives to that antibiotic(s) should be considered
- **Incorporating *P. aeruginosa* susceptibility data into treatment decisions:**
 - Treatment with antibiotics based on susceptibility testing results for *P. aeruginosa* does not consistently correlate with clinical outcomes in pwCF
 - Changes to an antimicrobial regimen should not be made based on new susceptibility testing results for *P. aeruginosa* if the patient is doing well on the current regimen
 - If there has been no improvement with the initially selected antimicrobial regimen, consider changes based on results of susceptibility testing for *P. aeruginosa*

Initial Antibiotic Recommendations by Organism

- Oral microbes only (including *Moraxella*, *H. influenzae*):
 - **PREFERRED:** Ampicillin/sulbactam
 - **FOR BETA-LACTAM ALLERGY**
 - For low/medium-risk¹ penicillin allergy: cefuroxime, cefdinir or ceftriaxone
- *Pseudomonas aeruginosa*

- There are few data to support the practice of using two antibiotics with anti-pseudomonal activity; however, this is standard practice currently supported by the CF Foundation
- **PREFERRED:** Cefepime PLUS tobramycin or a fluoroquinolone (ciprofloxacin or levofloxacin)
 - Ceftazidime or piperacillin/tazobactam are preferred alternatives to cefepime based on individual patient factors
 - Broader-spectrum agents such as carbapenems should be considered only if the above agents have been ineffective previously, or cannot be used due to allergy or adverse effects
- **FOR BETA-LACTAM ALLERGY**
 - For low/medium-risk¹ cephalosporin allergy: Piperacillin/tazobactam
 - For high-risk² penicillin or cephalosporin allergy or contraindication³: Aztreonam
 - Consultation to the β -lactam Allergy Evaluation Service (BLAES) may also be appropriate
- Non-aeruginosa *Pseudomonas* species (e.g., *P. fluorescens*, others)
 - Double coverage of *Pseudomonas* species other than *P. aeruginosa* is not indicated
 - **PREFERRED:** Cefepime
 - Ceftazidime or piperacillin/tazobactam are preferred alternatives to cefepime based on individual patient factors
 - Broader-spectrum agents such as carbapenems should be considered only if the above agents have been ineffective previously, or cannot be used due to allergy or adverse effects
 - **FOR BETA-LACTAM ALLERGY**
 - For low/medium-risk¹ cephalosporin allergy: Piperacillin/tazobactam
 - For high-risk² penicillin or cephalosporin allergy or contraindication³: Aztreonam
 - Consultation to the β -lactam Allergy Evaluation Service (BLAES) may also be appropriate
- *Staphylococcus aureus*
 - Double coverage of *S. aureus* is not indicated
 - **Methicillin susceptible (MSSA)**
 - **PREFERRED:** Cefazolin
 - If other agents with activity against MSSA (such as cefuroxime, ceftriaxone, cefepime, ampicillin-sulbactam, piperacillin/tazobactam) are being used for treatment of other organisms, additional antibiotics are not needed for MSSA
 - Other options include oral trimethoprim/sulfamethoxazole (TMP-SMX), doxycycline, clindamycin
 - The above antibiotics are highly bioavailable and there is no benefit when given IV, if a patient can tolerate the oral form
 - Avoid vancomycin whenever possible
 - **Methicillin resistant (MRSA)**
 - **PREFERRED:** Oral TMP-SMX, doxycycline, clindamycin
 - For hospitalized patients, it is reasonable to first try one of the above highly bioavailable oral options, but if a patient has failed these options, vancomycin is the preferred IV agent
- Other gram-negative rods (GNR)
 - Susceptibility results should be considered when selecting antibiotics for GNR other than *P. aeruginosa*
 - Use of two agents (double coverage) for GNR other than *P. aeruginosa* is not indicated
 - **Achromobacter species**
 - **PREFERRED:** Piperacillin/tazobactam or ceftazidime; alternatives include cefepime (only if susceptible), oral TMP-SMX or minocycline

- ***Acinetobacter* species**
 - **PREFERRED:** Ampicillin/sulbactam or cefepime; alternatives include oral TMP-SMX or minocycline
- ***Burkholderia* species**
 - **PREFERRED:** Ceftazidime; alternatives include TMP-SMX or minocycline
- ***Stenotrophomonas maltophilia* complex**
 - **PREFERRED:** TMP-SMX; alternatives include ceftazidime, levofloxacin, or minocycline
- Non-tuberculous mycobacteria (NTM)
 - If there is concern that NTM is contributing to current symptoms and/or lung function decline, consult Pediatric ID or refer to Pulmonary-ID combined clinic
 - In conjunction with Pediatric ID consult team, consider treatment for NTM pulmonary disease if there is recurrent growth of NTM from respiratory culture, lung imaging consistent with NTM disease, and no clinical improvement despite treatment with antibiotics directed at other bacteria from airway cultures, and optimization of all other therapies (airway clearance, nutrition, etc.)
 - Many drug-drug interactions exist with antimicrobials used for NTM in pwCF (e.g., rifampin, macrolides, fluoroquinolones, linezolid, SSRIs, azole antifungals). Careful evaluation of drug interactions must occur when making treatment plans for NTM. Consult with CF PharmD for evaluation for potential dose reduction of CFTR modulators when treating NTM pulmonary disease (see monitoring section below).
- Aspergillus species
 - *Aspergillus* may contribute to pulmonary symptoms in multiple ways.
 - If concern for Allergic Bronchopulmonary Aspergillosis (ABPA), follow existing CF Foundation treatment guidelines.
 - If invasive *Aspergillus* is suspected, in conjunction with Pediatric ID consult team, consider treatment if there is recurrent growth of *Aspergillus* from respiratory culture, lung imaging consistent with *Aspergillus* disease, and no clinical improvement despite treatment with antibiotics and optimization of all other therapies (airway clearance, nutrition, etc.). Refer to [Guidelines for Treatment of Invasive Aspergillus](#).
 - Consult with CF PharmD for evaluation for potential dose reduction of CFTR modulators when treating *Aspergillus* (see monitoring section below).
- Other molds (e.g., *Exophiala*, *Scedosporium/Lomentospora*, *Penicillium*, others)
 - Consult Pediatric ID to discuss potential treatment

Approval for restricted antimicrobials:

- If a tier 1 restricted antimicrobial (see Table 1) is indicated based on the above guideline or other patient factors, the Pediatric Antimicrobial Stewardship team (pager 36149) should be contacted (prior to 5pm on the day of planned admissions) and approval noted in admission documentation, in the following manner:
 - Direct admit from clinic or home: pediatric CF clinical pharmacy specialist will call Pediatric Antimicrobial Stewardship team
 - When pediatric CF clinical pharmacy specialist is out, admitting provider will call Pediatric Antimicrobial Stewardship team
 - Admit from ED: Admitting pulmonology fellow or attending will call Pediatric Antimicrobial Stewardship team
 - Notation in admission documentation should state information such as, "Tier 1 restricted antimicrobial reviewed and approved by [name of Pediatric Antimicrobial Stewardship team member] on [date/time]."
- If a tier 2 restricted antimicrobial is indicated based on the above guideline or other patient factors, the

primary team does NOT need prior approval, but should ensure they meet [criteria for continued use](#) or have another justification for its use

Oral Antibiotics

- For highly bioavailable antibiotics (see Table 1), the oral route should be utilized if the patient is able to tolerate enteral medications

Home antibiotics (including inhaled antibiotics):

- Home azithromycin should be continued unless there are concerns about side effects such as QT prolongation with other medications being used (such as fluoroquinolones)
- Home inhaled antibiotics are generally continued
- Of note, currently inhaled tobramycin and colistimethate are on hospital formulary whereas inhaled aztreonam is not

Re-evaluation of antimicrobials based on new culture results

- If a new bacterial species grows in culture after admission, the initially selected antibiotic regimen may be continued without changes if the patient is improving (with the exception of *P. aeruginosa* and *B. cepacia*, which should always be treated if isolated from culture)
 - o Refer to Eradication of Initial *P. aeruginosa* Clinical Care Guidelines
- If the patient is not improving on the initial antibiotic regimen, it is reasonable to change antibiotics to cover the new bacterial species
- Narrowing antibiotics based on lack of growth may be appropriate in some circumstances and should be considered on a case-by-case basis
- Antibiotics should not be adjusted based solely on new susceptibility results for *P. aeruginosa* (see [“Incorporating *P. aeruginosa* susceptibility data into treatment decisions”](#) above), unless the patient is not improving on the current antibiotic regimen

Re-evaluation of antimicrobials after 5-7 days of therapy

- If patients remain admitted, re-evaluate at approximately day 5-7 of antimicrobial therapy, which may include review of clinical status, respiratory support, and repeat PFTs
 - o If patient is not improving:
 - Reassess other contributing factors (such as airway clearance, co-morbidities)
 - Consider further evaluation (such as bronchoscopy or chest CT), if appropriate
 - Consider Pediatric ID consult to discuss changes to antimicrobial regimen

Pediatric ID Consultation

- Consider Pediatric ID consultation in the following scenarios:
 - o Difficulty choosing an empiric regimen due to multi-drug resistant organisms and/or multiple allergies/intolerances
 - o Growth of an unfamiliar organism, or one of unclear significance (including NTM, molds)
 - o Discussion of new antibiotic regimen after failure to improve on the chosen empiric regimen after 5-7 days

Duration of antimicrobials

- Antimicrobials should be continued for a 14-day course in most cases (recent evidence from the STOP2 trial suggests that 21 days of therapy for exacerbation is not superior to 14 days). If all or almost all 14 days are completed in the hospital, additional antibiotics at home are not indicated.

Antimicrobial dosing and monitoring

Table 1. Antimicrobials for Pulmonary Exacerbations in Cystic Fibrosis Patients

Antimicrobial Agent	Dose	Comments:
Amikacin	Refer to Aminoglycoside - Empiric Dosing and Monitoring guideline	
Ampicillin/sulbactam	50 mg/kg/DOSE of ampicillin IV q6h (max: 2000 mg of ampicillin/dose)	
Aztreonam	50 mg/kg/DOSE IV q8h (max: 2000 mg/dose)	<ul style="list-style-type: none"> If targeting current or past growth of <i>P. aeruginosa</i>, use extended infusion over 4 hours
Cefazolin	50 mg/kg/DOSE IV q8h (max: 2000 mg/dose)	
Cefepime	50 mg/kg/DOSE IV q8h (max: 2000 mg/dose)	<ul style="list-style-type: none"> If targeting current or past growth of <i>P. aeruginosa</i>, use extended infusion over 4 hours
Ceftazidime	50 mg/kg/DOSE IV q8h (max dose: 2000 mg)	<ul style="list-style-type: none"> If targeting current or past growth of <i>P. aeruginosa</i>, use extended infusion over 4 hours Ceftazidime does not cover gram + organisms (e.g., MSSA, <i>Streptococcus</i> species)
Ceftazidime/avibactam	50 mg/kg/DOSE of ceftazidime IV q8h (max: 2000 mg of ceftazidime)	<ul style="list-style-type: none"> If targeting current or past growth of <i>P. aeruginosa</i>, use extended infusion over 4 hours Ceftazidime does not cover gram + organisms (e.g., MSSA, <i>Streptococcus</i> species) Requires ID approval prior to first dose (pager 36149)
Ciprofloxacin	20 mg/kg/DOSE PO q12h (max: 1000 mg/dose)	<ul style="list-style-type: none"> Highly bioavailable, oral therapy preferred
Clindamycin	13 mg/kg/DOSE PO q8h (max: 450 mg/dose)	<ul style="list-style-type: none"> Highly bioavailable, oral therapy preferred
Doxycycline	2 mg/kg/DOSE PO q12h (max: 100 mg/dose)	<ul style="list-style-type: none"> Highly bioavailable, oral therapy preferred Can be used for short courses in children younger than 8 years
Imipenem	25 mg/kg/DOSE IV q6h (max: 1000 mg/dose)	<ul style="list-style-type: none"> If targeting current or past growth of <i>P. aeruginosa</i>, use extended infusion over 4 hours Requires ID approval prior to first dose (pager 36149)
Levofloxacin	<u>Younger than 5 years:</u> 10 mg/kg/DOSE PO q12h (max: 375 mg/dose)	<ul style="list-style-type: none"> Highly bioavailable, oral therapy preferred

Antimicrobial Agent	Dose	Comments:
	5 years and older: 10 mg/kg/DOSE PO daily (max: 750 mg/dose)	
Linezolid	Younger than 12 years: 10 mg/kg/DOSE PO/IV q8h (max: 600 mg/dose) 12 years and older: 10 mg/kg/DOSE PO/IV q12h (max: 600 mg/dose)	<ul style="list-style-type: none"> Highly bioavailable, oral therapy preferred Requires ID approval prior to first dose (pager 36149)
Meropenem	40 mg/kg/DOSE IV q8h (max: 2000 mg/dose)	<ul style="list-style-type: none"> If targeting current or past growth of <i>P. aeruginosa</i>, use extended infusion over 4 hours Requires ID approval prior to first dose (pager 36149)
Piperacillin/tazobactam	100 mg/kg/DOSE of piperacillin IV q6h (max: 4000 mg of piperacillin/dose)	<ul style="list-style-type: none"> If targeting current or past growth of <i>P. aeruginosa</i>, use extended infusion over 4 hours
Sulfamethoxazole/trimethoprim	6 mg/kg/DOSE of trimethoprim PO q12h (max: 320 mg of trimethoprim/dose)	<ul style="list-style-type: none"> Highly bioavailable, oral therapy preferred
Tobramycin	Refer to Aminoglycoside - Empiric Dosing and Monitoring guideline	
Vancomycin	Refer to Vancomycin - Empiric Dosing and Monitoring	
Voriconazole	Younger than 16 years: 9 mg/kg/DOSE PO q12h 16 years and older: 6 mg/kg/DOSE PO q12h x2 doses, then 4 mg/kg/DOSE PO q12h	<ul style="list-style-type: none"> Highly bioavailable, oral therapy preferred Requires ID approval prior to first dose (pager 36149)

Monitoring Parameters for Select Antimicrobials

- Aminoglycosides:
 - o For patients on once-daily aminoglycosides, order a 3-hour and 10-hour serum level after the 2nd dose; refer to [Aminoglycoside - Empiric Dosing and Monitoring guideline](#) for goal serum level
 - o For patients on q8h dosing, obtain a 3-hour peak serum level and a trough 1-hour level around the 3rd or 4th dose
 - o For patients on q12h dosing, obtain a 3-hour peak serum level and a trough 1-hour level around the 3rd dose
 - o Monitor renal panel at least twice per week
 - o Monitor CBC with differential weekly
 - o Vestibular testing (at least annually) for patients >10 years, or with frequent tobramycin use
- Beta-lactam antibiotics (e.g., penicillins, cephalosporins, aztreonam, carbapenems):
 - o Monitor CBC with differential weekly
 - o Monitor renal panel at least weekly
 - o For *ampicillin/sulbactam*, *piperacillin/tazobactam*, *aztreonam*, *ceftriaxone*, *imipenem*, or *meropenem*, monitor liver function tests and bilirubin at baseline and if therapy continues beyond 14 days

- Fluoroquinolones:
 - Can prolong QT; avoid use with other QT-prolonging medications (e.g., erythromycin, voriconazole, fluconazole)
 - Consider baseline EKG if patient is receiving multiple medications known to prolong the QT interval

- Linezolid:
 - Monitor CBC with differential weekly
 - Monitor liver function tests and bilirubin weekly
 - Can cause serotonin syndrome; avoid use with SSRIs (e.g., citalopram, sertraline, paroxetine) when possible

- Trimethoprim/sulfamethoxazole:
 - Monitor CBC with differential weekly
 - Monitor renal panel at least weekly
 - Monitor liver function tests and bilirubin weekly

- Vancomycin:
 - Target AUC=400-600 mcg*hr/mL
 - Order a 3-hour random serum level and a trough 1-hour level before the next dose when the patient reaches steady state (5th dose on q6h, 4th dose on q8h)
 - Monitor renal panel at least twice weekly
 - Monitor CBC with differential weekly

- Voriconazole:
 - Monitor CBC with differential weekly
 - Monitor renal panel at least weekly
 - Monitor liver function tests weekly
 - Monitor voriconazole trough level 5-7 days after initiating therapy; goal trough: 1-5; refer to [Therapeutic Drug Monitoring of Antifungal Agents](#)
 - Assess for visual hallucinations (e.g., floaters)
 - Can prolong QT; avoid use with other QT-prolonging medications (e.g., fluoroquinolones, erythromycin, clarithromycin)
 - Consider baseline EKG if patient is receiving multiple medications known to prolong the QT interval
 - Concomitant use of voriconazole with ivacaftor (Kalydeco[®]) will result in significant increases in serum ivacaftor concentrations. If used concomitantly, ivacaftor use should be decreased to 2 times per week
 - Concomitant use of voriconazole with tezacaftor/ivacaftor (Symdeko[®]) will result in significant increases in serum tezacaftor and ivacaftor concentrations. If used concomitantly, tezacaftor/ivacaftor use should be decreased to 2 times per week and the evening dose of ivacaftor should be discontinued
 - Concomitant use of voriconazole with elexacaftor/tezacaftor/ivacaftor (Trikafta[®]) will result in significant increases in serum elexacaftor, tezacaftor, and ivacaftor concentrations. If used concomitantly, elexacaftor/tezacaftor/ivacaftor use should be decreased to 2 times per week and the evening dose of ivacaftor should be discontinued
 - Concomitant use of voriconazole with lumacaftor/ivacaftor (Orkambi[®]) will result in significant decreases in serum voriconazole concentrations. Concomitant use should be avoided as voriconazole is unlikely to be effective. If possible, consider holding lumacaftor/ivacaftor during the course of voriconazole

- **Footnotes:**

¹Low-risk allergies include: pruritus without rash, remote (>10 years) unknown reaction, patient denies allergy but is on record, mild rash with no other symptoms (mild rash: non-urticarial rash that resolves without medical intervention). Medium-risk allergies include: urticaria/hives with no other symptoms, severe rash with no other symptoms (severe rash: requires medical intervention [corticosteroids, anti-histamines] and/or ER visit or hospitalization).

²High-risk allergies include: respiratory symptoms (chest tightness, bronchospasm, wheezing, cough), angioedema (swelling, throat tightness), cardiovascular symptoms (hypotension, dizzy/lightheadedness, syncope/passing out, arrhythmia), anaphylaxis. If a patient has a high-risk allergy to penicillins, cephalosporins, or carbapenems, the only beta-lactam antibiotic that can be safely used without Allergy consult is aztreonam (if the allergy is to ceftazidime or aztreonam, aztreonam should be avoided as well).

³Previous reactions that are contraindications to further beta-lactam use (except aztreonam, which can be used unless the reaction was to ceftazidime or aztreonam) unless approved by Allergy: organ damage (kidney, liver), drug-induced immune-mediated anemia/thrombocytopenia/leukopenia, rash with mucosal lesions (Stevens Johnson Syndrome/Toxic Epidermal Necrosis), rash with pustules (acute generalized exanthematous pustulosis), rash with eosinophils and organ injury (DRESS – drug rash eosinophilia and systemic symptoms), rash with joint pain, fever, and myalgia (Serum Sickness).

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- **Key References:**

- 2019 Cystic Fibrosis Foundation Patient Registry
- Flume PA, Mogayzel PJ Jr, Robinson KA, et al. Cystic fibrosis pulmonary guidelines: treatment of pulmonary exacerbations. *Am J Respir Crit Care Med* 2009; 180:802.
- Somayaji R, Parkins MD, Shah E, et al. Antimicrobial susceptibility testing (AST) and associated clinical outcomes in individuals with cystic fibrosis: A systematic review. *J Cyst Fibros* 2019; 18:236.
- Norris AH, Shrestha NK, Allison GM, Keller SC, Bhavan KP, Zurlo JJ, Hersh AL, Gorski LA, Bosso JA, Rathore MH, Arrieta A, Petrak RM, Shah A, Brown RB, Knight SL, Umscheid CA. 2018 Infectious Diseases Society of America Clinical Practice Guideline for the Management of Outpatient Parenteral Antimicrobial Therapy. *Clin Infect Dis*. 2019 Jan 1;68(1):e1-e35. doi: 10.1093/cid/ciy745. PMID: 30423035.
- Jordan CL, Noah TL, Henry MM. Therapeutic challenges posed by critical drug-drug interactions in cystic fibrosis. *Pediatr Pulmonol* 2016;51:S61-S70.
- Goss CH, Heltshe SL, West NE, Skalland M, Sanders DB, Jain R, Barto TL, Fogarty B, Marshall BC, VanDevanter DR, Flume PA; STOP2 Investigators. A Randomized Trial of Antimicrobial Duration for Cystic Fibrosis Pulmonary Exacerbation Treatment. *Am J Respir Crit Care Med*. 2021 Sep 1. doi: 10.1164/rccm.202102-0461OC. PMID: 34469706.

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The recommendations in this guide are meant to serve as treatment guidelines for use at Michigan Medicine facilities. If you are an individual experiencing a medical emergency, call 911 immediately. These guidelines should not replace a provider's professional medical advice based on clinical judgment, or be used in lieu of an Infectious Diseases consultation when necessary. As a result of ongoing research, practice guidelines may from time to time change. The authors of these guidelines have made all attempts to ensure the accuracy based on current information, however, due to ongoing research, users of these guidelines are strongly encouraged to confirm the information contained within them through an independent source.

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