**Purpose:**
This guideline is intended to help guide antimicrobial therapy for patients admitted to pediatric service lines following the results of Gram Stain, Organism Identification (with or without Verigene™ molecular resistance results) and Antimicrobial Susceptibilities. Deviation from the recommendations in this guideline may be required for patients with concomitant infections, history of resistant pathogens, or with antimicrobial allergies or intolerance.

The recommendations in this guideline reflect susceptibility patterns found at Michigan Medicine and C. S. Mott Children’s Hospital.

**How to use this guideline:**
For patients with ONLY Gram stain results, refer to the left column (labeled GRAM STAIN) for treatment recommendations.

For patients with organism identification results, refer to the middle column (labeled ORGANISM IDENTIFICATION) for treatment recommendations.

For patients with antimicrobial susceptibility results, refer to the right column (labeled SUSCEPTIBILITIES) for treatment recommendations.

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<th><strong>GRAM STAIN</strong></th>
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| *Gram-positive cocci in clusters: Vancomycin* | *S. aureus and mecA negative:*
Endocarditis or CNS infection: **Nafcillin**
Other infections: **Cefazolin**

*S. aureus and mecA positive or mecA not performed: Vancomycin* | *S. aureus or S. lugdunensis sensitive to methicillin:*
Non-CNS/endocarditis: **Cefazolin**
CNS infection or endocarditis: **Nafcillin**
Life-threatening PCN allergy: **Vancomycin**

*S. lugdunensis: Vancomycin* | *S. aureus or S. lugdunensis intermediate or resistant to methicillin: Vancomycin*

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**Antimicrobial Subcommittee Approval**: 12/2018

**Originated**: 12/2018

**P&T Approval**: 03/2019

**Last Revised**: 09/2019

**Revision History**: 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 profession 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 change from time to time. 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 and independent source.

If obtained from a source other than med.umich.edu/asp, please visit the webpage for the most up-to-date document.
**GRAM STAIN**

**ORGANISM IDENTIFICATION**

**All Candida species:**
Neonatal: **Consult ID**
Infant – Adult: **Micafungin**

See **Candidemia Guideline**. Therapy should not be de-escalated until guideline criteria are met.

ID consult is strongly recommended.

If concern for urinary, ocular, endocarditis, or CNS infection, alternative therapy may be needed.
Consult with ID

**Cryptococcus spp.**:
Liposomal amphotericin B (Ambisome™)
+ Fluycytosine

Consult ID

**Histoplasma**:
Liposomal amphotericin B (Ambisome™)

Consult ID

**SUSCEPTIBILITIES**

*C. albicans, C. parapsilosis, C. tropicalis, C. dublinensis, and C. lusitaniae*:
Consider de-escalation to Fluconazole for clinically stable patients with clearance of blood cultures and fluconazole susceptibility

Otherwise: **Micafungin**

See **Candidemia Guideline**. Therapy should not be de-escalated until guideline criteria are met, in conjunction with ID consult recommendations

**C. glabrata** with fluconazole MIC <8 (SDD):
Consider de-escalation to Fluconazole for clinically stable patients with clearance of blood cultures

Otherwise: **Micafungin**

**Cryptococcus spp.**:
Fluconazole may be appropriate for step down therapy when criteria is met in conjunction with ID consult recommendations

**Histoplasma**:
Step down therapy may be appropriate when clinically stable in conjunction with ID consult recommendations

**Yeast**:
Neonatal (<44 weeks PMA): **Consult ID**
Infant (>44 weeks PMA) – Adult: **Micafungin**

Consult ID

If suspicion for *Cryptococcus* or *Histoplasmosis* (fungemia in setting of pneumonia or meningitis in immunocompromised patient), call Infectious Diseases consult service for immediate antifungal recommendations
**ORGANISM IDENTIFICATION**

- **S. aureus and meca negative:**
  - Endocarditis or CNS infection: **Nafcillin**
  - Other infections: **Cefazolin**

- **S. aureus and meca positive or meca not performed:**
  - **Vancomycin**

- **S. lugdunensis:**
  - **Vancomycin**

  **Consult ID**

Consider discontinuing adjunctive gram-negative therapy between 48-72 hours if cultures are negative for gram-negative pathogens, except for patients with intra-abdominal infections.

- Single positive culture for Coagulase-negative Staphylococcus or **S. epidermidis** in suspected infection of prosthetic material, neutropenia, premature neonates, or in hemodynamically unstable patients:
  - **S. epidermidis and meca negative:**
    - **Cefazolin**

  **S. epidermidis and meca positive or coagulate negative**

  **Staphylococcus:**
  - **Vancomycin**

For patients who do not meet the above criteria, a single positive culture for coagulate-negative Staphylococcus or **S. epidermidis may represent contamination, assess for possible source of infection and hold antibiotics if clinically stable.**

**SUSCEPTIBILITIES**

- **S. aureus or S. lugdunensis sensitive to methicillin:**
  - Non-CNS/endocarditis: **Cefazolin**
  - CNS infection or endocarditis: **Nafcillin**
  - Life-threatening PCN allergy: **Vancomycin**

- **S. aureus or S. lugdunensis intermediate or resistant to methicillin:**
  - **Vancomycin**

- **Coagulase-negative Staphylococcus or S. epidermidis sensitive to methicillin:**
  - Non-CNS/endocarditis: **Cefazolin**
  - CNS infection or endocarditis: **Nafcillin**
  - Life-threatening PCN allergy: **Vancomycin**

- **Coagulase-negative Staphylococcus or S. epidermidis intermediate or resistant to methicillin:**
  - **Vancomycin**
**GRAM STAIN**

Gram-positive cocci in chains or pairs:
- **Vancomycin**

**ORGANISM IDENTIFICATION**

**E. faecalis and vanA/vanB Negative:**
- Ampicillin
  (consider **piperacillin-tazobactam** as alternative for intra-abdominal infections)
- Life-threatening PCN allergy: **Vancomycin**

**E. faecalis and vanA/vanB positive:**
- Ampicillin
  (consider **piperacillin-tazobactam** as alternative for intra-abdominal infections)
- Life-threatening PCN allergy: **Linezolid** or **Daptomycin** for BMT patients with ANC <1,000

**E. faecium and vanA/vanB negative:**
- **Vancomycin**

**E. faecium and vanA/vanB positive:**
- **Linezolid** or **Daptomycin** for BMT patients with ANC <1,000

**E. casseliflavus, E. gallinarium:**
- **Linezolid** or **Daptomycin** for BMT patients with ANC <1,000

**Other Enterococcus species:**
- **Vancomycin**

**S. pneumoniae, S. anginosus or Streptococcus species:**
- Non-CNS/endocarditis: **Ceftriaxone***
- CNS infection or endocarditis: **Ceftriaxone*** + **Vancomycin**
- Febrile neutropenia: **Vancomycin** + anti-Pseudomonal beta-lactam

**S.agalactiae or S. pyogenes:**
- **Penicillin** or **Ampicillin**
  - Mild PCN allergy: **Cefazolin** (if no CNS infection)
  - Life-threatening PCN allergy: **Vancomycin**

**SUSCEPTIBILITIES**

**Penicillin-based antibiotics should be first line therapy for all Enterococcus species if sensitive:**
- **Ampicillin**
  (consider **ampicillin-sulbactam** or **piperacillin-tazobactam** for intra-abdominal infections)

- Life-threatening PCN allergy or ampicillin-resistant **Enterococcus**:
  - **Vancomycin**

- **Patients with vancomycin allergy or ampicillin-resistant Enterococcus:**
  - **Linezolid** or **Daptomycin** for BMT patients with ANC <1,000

- **Patients with suspected endocarditis will likely require combination therapy and ID consult is strongly recommended**

**Penicillin-based antibiotics should be first line therapy for all Streptococcus species infections, if sensitive:**
- **Penicillin** or **Ampicillin**
  - Mild PCN allergy: **Cefazolin** (if no CNS infection)
  - Mild PCN allergy CNS infection: **Ceftriaxone***
  - Life-threatening PCN allergy: **Vancomycin**

- **Febrile neutropenic patients should be continued on anti-Pseudomonal beta-lactam**

* neonates should receive **cefotaxime** in the place of ceftriaxone
**GRAM STAIN**

- **Gram-negative bacilli:** Cefepime
  (add metronidazole for intra-abdominal infections)

  *Evaluate if patient has history of resistance to cefepime with prior year and modify therapy accordingly

**ORGANISM IDENTIFICATION**

*E. coli, Klebsiella, or Proteus:*

- No CTX-M, KPC, IMP, VIM, NDM, OXA detected:
  - Ceftriaxone (cefotaxime for neonates)

  *CTX-M positive:*
  - Meropenem

  *KPC positive:*
  - Meropenem-vaborbactam

  *IMP, VIM, or NDM positive:*
  - Ceftazidime-avibactam + Aztreonam + Polymyxin B*

  *OXA positive:*
  - Ceftazidime-avibactam

  *substitute Tobramycin for Polymyxin B when treating Proteus

*Enterobacter, Serratia, Morganella, or Citrobacter:*

- No CTX-M, KPC, IMP, VIM, NDM, OXA detected:
  - Cefepime

  *CTX-M positive:*
  - Meropenem

  *KPC positive:*
  - Meropenem-vaborbactam + Polymyxin B*

  *IMP, VIM, or NDM positive:*
  - Ceftazidime-avibactam + Aztreonam + Polymyxin B*

  *OXA positive:*
  - Ceftazidime-avibactam

  *substitute Tobramycin for Polymyxin B when treating Morganella or Serratia

**SUSCEPTIBILITIES**

Narrow antibiotic selection based on susceptibility results, clinical status, concomitant infections:

- **ID consult is strongly encouraged for patients with infections from organisms with CTX-M, KPC, IMP, VIM, NDM, or OXA resistance genes**

- **Enterobacter, Serratia and Citrobacter freundii** frequently have an inducible beta-lactamase resistance gene (*AmpC*), which can confer resistance to penicillin, ampicillin, ampicillin-sulbactam, and 1st-3rd generation cephalosporins. **Cefepime** should be first-line therapy if susceptible.

- **Citrobacter koseri** is not associated with having *AmpC* gene, and narrow spectrum antibiotics should be prescribed if susceptible.
## ORGANISM IDENTIFICATION

### Pseudomonas aeruginosa

- **No CTX-M, KPC, IMP, VIM, NDM, OXA detected:**
  - Cefepime
- **CTX-M positive:**
  - Meropenem
- **KPC positive:**
  - Meropenem-vaborbactam + Polymyxin B
- **IMP, VIM, or NDM positive:**
  - Aztreonam + Polymyxin B
- **OXA positive:**
  - Cefepime + Polymyxin B

### Acinetobacter baumanii

- **No CTX-M, KPC, IMP, VIM, NDM, OXA detected:**
  - Cefepime
- **CTX-M positive:**
  - Meropenem
- **KPC positive:**
  - Meropenem-vaborbactam + Polymyxin B
- **IMP, VIM, or NDM positive:**
  - Minocycline + Polymyxin B
- **OXA positive:**
  - Meropenem + Polymyxin B

## SUSCEPTIBILITIES

Narrow antibiotic selection based on susceptibility results, clinical status, concomitant infections.

- If Pseudomonas isolate is resistant to cefepime, piperacillin-tazobactam, meropenem, imipenem, aztreonam, levofloxacin and ciprofloxacin, request **ceftolozane-tazobactam**, **ceftazidime-avibactam**, and **meropenem-vaborbactam** susceptibilities from microbiology lab (phone number 6-6831)

- Double coverage of Pseudomonas is not indicated after susceptibilities are available, unless isolate is resistant to all beta-lactam antibiotics, cystic fibrosis patient, or decompensating on susceptible antibiotics

- ID consult is encouraged for patients with Pseudomonas bacteremia

Narrow antibiotic selection based on susceptibility results, clinical status, concomitant infections.

- There is no evidence double coverage of Acinetobacter improves outcomes. The decision to double cover should be made based on source of bacteremia, severity of infection, and patient’s medical history.
**GRAM STAIN**

*Gram-negative bacilli:
Cefepime (add metronidazole for intra-abdominal infections)*

*Evaluate if patient has history of resistance to cefepime with prior year and modify therapy accordingly*

**GRAM STAIN**

*Gram-positive rod:
Most likely the result of skin flora contamination of blood culture*

Consider treatment in HD unstable, prosthetic material with suspected infection, BMT, solid organ transplant, neutropenia: **Vancomycin**

If concern for Listeria: **Ampicillin**

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**ORGANISM IDENTIFICATION**

*Achromobacter:*
Piperacillin-tazobactam
Life-threatening PCN allergy: **Meropenem**

(Avoid cefepime unless susceptibility is verified)

**Stenotrophomonas:**
Trimethoprim-sulfamethoxazole
Sulfa-allergy: **Levofloxacin + minocycline**

(Piperacillin-tazobactam and cefepime do not have activity against Stenotrophomonas)

**Bacillus, Lactobacillus, and Corynebacterium** spp. are possible contaminants, consider treatment in HD unstable, prosthetic material with suspected infection, BMT, solid organ transplant, neutropenia

**Bacillus or Corynebacterium** spp.: **Vancomycin**

**Lactobacillus:** **Piperacillin-tazobactam**

**Listeria:** **Ampicillin**

Patients with multiple positive sets of blood cultures are more likely true infection. Consider ID consult.

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**SUSCEPTIBILITIES**

Narrow antibiotic selection based on susceptibility results, clinical status, concomitant infections.

- Achromobacter is frequently multi-drug resistant, and ID consult is encouraged to guide appropriate management of these infections

Narrow antibiotic selection based on susceptibility results, clinical status, concomitant infections.

- Susceptibilities will not be routinely performed by the microbiology lab. Please call to request susceptibilities if strong suspicion for infection