# Recommendations Regarding the Use of Blood Culture Identification (BCID) Panel Data

The Clinical Microbiology laboratory at Nebraska Medicine utilizes an FDA approved test called the BioFire® FilmArray® Blood Culture Identification Panel (BCID). This test uses a PCR-based approach to amplify DNA targets directly from positive blood cultures allowing rapid identification of pathogens and earlier transition to most appropriate therapy. A recent update to this test, known as BCID2, expands the number of targets that can be detected from the previous version. This test identifies 30 different gram-negative, gram-positive, and yeast pathogens (**Table 1**). It also detects 10 genes associated with antimicrobial resistance, including those responsible for methicillin resistance in staphylococci, vancomycin resistance in enterococci, carbapenem-resistance in gram-negative bacteria, and one of the genes encoding an extended-spectrum β-lactamase. Additionally, the BCID2 detects some pathogens as a complex (*A. baumanii* complex), group (*K. pneumoniae* group), or genus (*Proteus* spp). Targets detected are listed in **Table 5**.

**Table 1: List of Pathogens and Resistance Genes Detected**

| Gram-Positive Bacteria | Gram-Negative Bacteria | Yeast | Resistance Genes |
|---|---|---|---|
| *Enterococcus faecalis** | *Acinetobacter baumannii complex* | *Candida albicans* | Carbapenemases |
| *Enterococcus faecium** | *Bacteroides fragilis** | *Candida auris** | *-IMP** |
| *Listeria monocytogenes* | *Enterobacterales* Order | *Candida glabrata* | *-KPC* |
| *Staphylococcus* genus | *Enterobacter cloacae* complex | *Candida krusei* | *-OXA-48*-like* |
| *Staphylococcus aureus* | *Escherichia coli* | *Candida parapsilosis* | *-NDM** |
| *Staphylococcus epidermidis** | *Klebsiella aerogenes** | *Candida tropicalis* | *-VIM** |
| *Staphylococcus lugdunensis** | *Klebsiella oxytoca* | *Cryptococcus neoformans/gattii** | Colistin Resistance |
| *Streptococcus* genus | *Klebsiella pneumoniae* group | | *-mcr-1** |
| *Streptococcus agalactiae* | *Proteus* spp. | | ESBL |
| *Streptococcus pneumoniae* | *Salmonella* spp.* | | *-CTX-M** |
| *Streptococcus pyogenes* | *Serratia marcescens* | | Methicillin Resistance |
| | *Haemophilus influenzae* | | *-mecA/C* |
| | *Neisseria meningitidis* | | *-mecA/C* and MREJ (MRSA)* |
| | *Pseudomonas aeruginosa* | | Vancomycin Resistance |
| | *Stenotrophomonas maltophilia** | | *-vanA/B* |

* Indicates new target on the BCID2 Panel

The microbiology lab notifies clinicians of positive blood culture gram-stain results immediately after they are performed. The BCID2 assay is subsequently performed, and results are typically available within One Chart in <2 hours. The rapid reporting of these data allows for early adjustment of antimicrobials to the most appropriate therapy. A list of recommended antibiotic treatment choices is outlined in **Table 3**. The Antimicrobial Stewardship Team developed these recommendations based on an analysis of the institutional antibiogram. Relevant information on susceptibility is provided for gram-negative pathogens where the activity of agents is variable. Within the *Enterobacteriales*, resistance to expanded spectrum cephalosporins is mediated via multiple β-lactamases. While CTX-M is the most common extended-spectrum beta-lactamase (ESBL) encountered, even if it is not detected, the isolate can still be resistant to expanded-spectrum cephalosporins and cefepime via other β-lactamases not detected by the BCID2 panel. Occasionally, the detection of a resistance gene does not equate to confirmation of resistance when susceptibility testing is performed. Standard susceptibility testing is required to determine final antimicrobial susceptibility and should be used to guide final therapy decisions. When blood culture Gram stain and BCID results are known, current antimicrobial therapy should be evaluated considering the clinical picture and adjusted to the most appropriate single agent if possible. In addition, when full susceptibility results become available, therapy should be adjusted to the narrowest spectrum appropriate agent.

**Final pathogen susceptibilities are usually available in 24-72 hours and should always be reviewed to determine if therapy adjustments should be made.**

Evidence Demonstrating the Benefit of BCID Use

IDSA guidelines advocate for the use of rapid diagnostic testing on blood specimens to optimize antibiotic therapy and improve clinical outcomes.[2] Multiple studies, including a large meta-analysis, have shown that rapid pathogen identification when coupled with stewardship interventions can result in improved antibiotic use, shorter hospital stays, reduced cost, and decreased patient mortality (OR 0.64; 95% CI 0.51-0.79; NNT 17).[2-4] Review of BCID implementation at Nebraska Medicine demonstrated earlier implementation of active therapy (6 hours earlier) and more rapid transition to the narrowest spectrum effective therapy (12 hours earlier). The utility and cost-effectiveness of such testing is dependent upon clinicians reacting to the data. The antimicrobial stewardship team currently reviews these data during business hours and contacts the treating team if they feel adjustments in therapy are needed, but it is strongly recommended that these data be utilized in making treatment decisions at the time it is available.

BCID2 Performance

The clinical performance of the BCID2 Panel was established with a prospective multi-center study (comparator was standard manual and automated microbiological/biochemical identification methods) that was supplemented with archived and seeded positive blood culture specimens. Aggregate data suggests that BCID2 has 99% sensitivity and 99.8% specificity. The BCID2 test is highly accurate in monomicrobial bacteremia but in the rare incidence of polymicrobial bacteremia it may suffer from some degradation in accuracy. Polymicrobial Gram stain results and BCID2 results with multiple organisms detected should be interpreted with caution.

Certain infections may be polymicrobial in nature and the isolation of a single pathogen from the blood culture, while allowing narrowing of therapy, should not result in over-narrowing. An example would be complicated intra-abdominal infections where anaerobes are frequently present and therapy active against these pathogens should generally be included until definitive cultures of the site of infection have returned.

## Common Misinterpretation of Results from Rapid Blood Culture Identification Panel

Similar to the BCID, the BCID2 will identify pathogens to the genus (*Staphylococcus, Streptococcus*) and multiple family-level pathogens of the *Enterobacterales* order (formerly *Enterobacteriaceae*). Some confusion has been reported particularly with interpretation of genus-level analytes and markers of antimicrobial resistance. A genus includes numerous bacterial species. For example, the *Staphylococcus* genus PCR detects numerous species of staphylococci including *S. aureus*, *S. epidermidis*, *S. hominis* and others. When *S. aureus* is present, the *Staphylococcus* genus and *S. aureus* analytes will both be detected. Similarly, when *S. epidermidis* is present both the *Staphylococcus* genus and the *S. epidermidis* markers will be positive. But when a coagulase-negative staphylococcus such as *S. hominis* is present, only the *Staphylococcus* genus analyte will be detected.

Further, the *mecA/C* genes confer resistance to β-lactam antibiotics such as oxacillin in all staphylococci and therapy should be adjusted to account for these results. However, for oxacillin resistance to be detected in *S. aureus* (MRSA), both the *mecA/C* gene and the MREJ target (which detects the far-right extremity of *SCCmec* and *orfX* and is a *S. aureus* specific target) need to be detected. Thus, detection of MRSA via *mecA/C*/MREJ suggests vancomycin or daptomycin should be used as therapy (see **Table 2**). The *mecA* gene is reported when *S. epidermidis* and *S. lugdunensis* are detected and predicts beta-lactam susceptibility. When only the Staphylococcus target is detected without any of the species-specific markers the *mecA* gene is not reported. It should be noted that >70% of coagulase negative Staphylococci are resistant to beta-lactams and so these strains should be presumed to be resistant until proven otherwise.

Another area of confusion is with the *Enterobacterales* order (formerly *Enterobacteriaceae*). Families within this order encompasses many gram-negative organisms including *E. coli*, *Klebsiella* species, *Enterobacter* species, *Proteus* species and *Citrobacter* species, among others. Thus when *E. coli* is present in the blood culture, both the *Enterobacterales* and *E. coli* analytes will be positive. If an *Enterobacterales* order member that does not have a species-specific PCR target is present (e.g. *Citrobacter species*), only the *Enterobacterales* analyte will be positive.

Occasionally the BCID2 panel will be completely negative. In those cases, please refer to the Negative BCID result document for potential pathogens and antibiotic recommendations.

**Table 2: Interpretations of *Staphylococcus* and *Enterobacterales* BCID2 Results**

| Bacterial Marker | Result | Interpretation |
|---|---|---|
| *Staphylococcus*<br>*S. aureus, S. epidermidis, S. lugdunensis* | Detected<br>Not detected | Presumed Methicillin-resistant Coagulase-negative *Staphylococcus species*<br><br>The *mecA* analyte is not reported for non-*S. epidermidis* and *S. lugdunensis* coagulase-negative species (e.g. *S. hominis, S. simulans, S. capitis,* among others*).* Presume beta-lactam resistance. |
| *Staphylococcus* detected<br>*S. epidermidis*<br>*S. aureus, S. lugdunensis*<br>*mecA* | Detected<br>Detected<br>Not Detected<br>Not Detected | Methicillin-susceptible *Staphylococcus epidermidis* |
| *Staphylococcus*<br>*S. aureus*<br>*S. epidermidis, S. lugdunensis*<br>MREJ and *mecA* | Detected<br>Detected<br>Not Detected<br>Detected | Methicillin-resistant *S. aureus* (MRSA) |
| *Staphylococcus*<br>*S. aureus*<br>*S. epidermidis, S. lugdunensis*<br>MREJ and *mecA* | Detected<br>Detected<br>Not Detected<br>Not Detected | Methicillin-susceptible *S. aureus* (MSSA) |
| *Enterobacterales*<br>*E. coli*<br>*CTX-M* | Detected<br>Detected<br>Detected | Presumed ESBL producing *E. coli** |
| *Enterobacterales*<br>*Klebsiella pneumoniae*<br>*CTX-M* | Detected<br>Detected<br>Not Detected | *Klebsiella pneumonia** (unlikely to have ESBL present) |
| *Enterobacterales*<br>*Enterobacter cloacae*<br>*KPC* | Detected<br>Detected<br>Detected | Presumed Carbapenem Resistant *Enterobacter cloacae** |
| *Enterobacterales*<br>All other species | Detected<br>Not Detected | *Enterobacteriaceae* species lacking specific marker on the BCID2 panel (see Table 5) |

* There is very small chance that both the specific pathogen and another *Enterobacteriaceae* which cannot be not detected specifically by the BCID are present, but the therapy recommended should generally cover these pathogens as well

**Table 3: Blood Pathogen Panel Results and Recommended Therapy**

Use this table to select the most appropriate empiric therapy for treating a blood stream infection (BSI). Patients who have responded clinically to a narrow spectrum agent do not need to be escalated and should continue their current therapy, even if this guideline recommends a broader spectrum agent. Patients who have not clinically responded to initial therapy (persistent fever, lack of improvement, etc.) may have their therapy adjusted to a more active regimen based on the guideline. Allergies, organ dysfunction, and risk factors for or personal history of antimicrobial resistance should be considered when choosing therapy. Data on susceptibility for various gram-negative pathogens was derived from the 2020 institutional antibiograms including a bloodstream infection specific antibiogram (see **Table 4**). Double coverage of gram-negative pathogens is not generally recommended and can usually be discontinued based on pathogen identification although there are certain pathogens where it may be considered. These are noted within the guideline below.

| BCID2 Result | Preferred Therapy | Comments |
|---|---|---|
| **Gram Positive Pathogens** | | |
| ***Enterococcus faecalis*** | | |
| *Van A/B* negative | Ampicillin 2g IV q4h | Ampicillin 100% susceptible<br>Life threatening PCN allergy: Vancomycin |
| *Van A/B* positive= VRE (uncommon) | Ampicillin 2g IV q4h | Evaluation for endocarditis recommended |
| ***Enterococcus faecium*** | | |
| *Van A/B* negative | Vancomycin 15 mg/kg q12h | Vancomycin 100% susceptible in Van A/B negative isolates |
| *Van A/B* positive= VRE (common) | Linezolid 600 mg q12h | Linezolid 100% susceptible<br>Daptomycin is an alternative with less activity.<br>**Consider ID consult.** |
| ***Listeria monocytogenes*** | Ampicillin 2g IV q4h | Life threatening PCN allergy: TMP/SMX |
| ***Staphylococcus* genus with all other Staph species negative**<br>(*S. aureus, epidermidis, lugdunensis*)<br>Blood Culture (BCX) result: | | |
| 1 of 2 positive | **Do not start antibiotics or draw repeat blood cultures** as likely contaminant. | In severely ill patients already on antibiotics continue current therapy until more definitive results return |
| 2 of 2 positive | Vancomycin 15 mg/kg q12h | The *mecA* analyte is not reported for non-*S. epidermidis* and *S. lugdunensis* coagulase-negative species (e.g. *S. hominis, S. simulans, S. capitis,* among others*)*. Presume beta-lactam resistance. |
| ***Staphylococcus aureus*** *(Staph species +)* | | **ID consult required by hospital policy** |
| *mecA* and MREJ negative = MSSA | Cefazolin 2g q8h | Oxacillin 2g q4h is an alternative |
| *mecA* and MREJ positive = MRSA | Vancomycin 15 mg/kg q12h | Daptomycin is an alternative to vancomycin |
| ***Staphylococcus epidermidis*** *(Staph species +)*<br>Blood Culture (BCX) result: | | |
| 1 of 2 positive | **Do not start antibiotics** as likely contaminant. **DO NOT** draw repeat BCX | In severely ill patients already on antibiotics continue current therapy until more definitive results return. |
| 2 of 2 positive | | |
| mecA negative | Cefazolin 2g q8h | Oxacillin 2g q4h is an alternative |
| mecA positive | Vancomycin 15 mg/kg q12h | Daptomycin is an alternative to vancomycin |

| | | |
|---|---|---|
| ***Staphylococcus lugdunensis*** *(Staph species +)*<br>mecA negative= oxacillin susceptible<br><br>mecA positive= oxacillin resistant | Cefazolin 2g q8h<br><br>Vancomycin 15 mg/kg q12h | Oxacillin 2g q4h is an alternative<br><br>**Consider ID Consult.** Although a coagulase-negative species, infections are more like *S. aureus*. If 1 of 2 BCX positive, may still be a contaminant, but favor treatment and repeating BCX. |
| ***Streptococcus*** **genus with all other Strep species** (*S. agalactiae, S. pneumoniae, S. pyogenes* results) **negative**<br>Blood Culture (BCX) result:<br>1 of 2 positive<br><br>2 of 2 positive | <br><br>Consider withholding therapy as likely contaminant<br><br>Ceftriaxone 2g q24h | <br><br>In severely ill patients consider starting/continuing therapy until more definitive results return<br><br>Vancomycin in severe beta-lactam allergy |
| ***Streptococcus pyogenes*** (Group A Strep) and ***Streptococcus agalactiae*** (Group B Strep) | Penicillin 3 million units q4h or<br>Ampicillin 2g IV q4h or<br>Cefazolin 2g IV Q8h | Beta-hemolytic strep are routinely susceptible to penicillin<br><br>Severe PCN allergy: Ceftriaxone |
| ***Streptococcus pneumoniae***<br>Source of Infection:<br>Pneumonia<br><br>CNS Infection | <br><br>Penicillin 3 million units q4h or<br>Ampicillin 2g IV q4h<br><br>Ceftriaxone 2g q12h + Vancomycin 15 mg/kg q12h | <br><br>PCN highly active against pneumococcus<br>Severe PCN allergy: Ceftriaxone<br><br>Continue vancomycin until susceptibilities return |
| **Gram Negative Pathogens** | | |
| ***Enterobacterales*** **order only**<br><br>*CTX-M* + = Possible Extended-Spectrum Beta-Lactamase (ESBL) present<br><br>*KPC, IMP, VIM, NDM, OXA-48* + = Possible carbapenemase present | CTX-M Negative: Cefepime 1g q6h or Piperacillin/tazobactam 4.5 g q8h<br><br>CTX-M Positive or Nosocomial Onset: Ertapenem 1g q24h or Meropenem 500mg q6h<br><br>**Carbapenemase positive consult ID** | Formerly *Enterobacteriaceae*. Note this is a group of possible enteric Gram-negative organisms, not a specific bacterial genus.<br><br>See Table 5 for potential pathogens included in this group. |
| ***Acinetobacter baumannii*** **complex** | Meropenem 500 mg IV q6h | Meropenem: 100% susceptible (cumulative)<br>Levofloxacin: 92% susceptible (cumulative)<br>Cefepime: 84% susceptible (cumulative)<br><br>If severely ill or non-responding consult ID |
| ***Bacteroides fragilis*** | Metronidazole 500 mg q8h | Anerobic organism usually part of underlying infection (i.e. intra-abdominal, etc.)<br>Piperacillin/tazobactam alternative to metronidazole |
| ***Enterobacter cloacae*** **complex**<br><br>*CTX-M* + = Possible Extended-Spectrum Beta-Lactamase (ESBL) present<br><br>*KPC, IMP, VIM, NDM, OXA-48* + = Possible carbapenemase present | CTX-M Negative: Cefepime 1 g IV q6h<br><br>CTX-M Positive or Nosocomial-onset: Meropenem 500 mg IV q6h<br><br>**Carbapenemase positive consult ID** | Cefepime: 85-94% susceptible<br>• 94% CO susceptible (blood)<br>• 85% NO susceptible (blood)<br>Meropenem: 100% susceptible<br>Levofloxacin: 98-100% susceptible<br>Ertapenem: 70-92% susceptible<br>• 92% CO susceptible (blood)<br>• 70% NO susceptible (blood)<br>Pip/tazo: (65-86%) susceptible<br>• 86% CO susceptible (blood)<br>• 65% NO susceptible (blood) |

| | | |
|---|---|---|
| ***Escherichia coli***<br><br>*CTX-M* + = Possible Extended-Spectrum Beta-Lactamase (ESBL) present<br><br>*KPC, IMP, VIM, NDM, OXA-48* + = Possible carbapenemase present | CTX-M Negative: Ceftriaxone 2g q24h<br><br>CTX-M Positive or Nosocomial Onset: Ertapenem 1g q24h or Meropenem 500mg q6h<br><br>**Carbapenemase positive consult ID** | Ceftriaxone: 73-88% susceptible<br>• 88% CO susceptible (blood)<br>• 73% NO susceptible (blood)<br>Pip/tazo: 73-86% susceptible<br>• 86% CO susceptible (blood)<br>• 73% NO susceptible (blood)<br>Cefepime: 76-89% susceptible<br>• 89% CO susceptible (blood)<br>• 76% NO susceptible (blood)<br>Levofloxacin: 61-78% susceptible<br>• 78% CO susceptible (blood)<br>• 61% NO susceptible (blood)<br>Ertapenem: 99-100% susceptible |
| ***Klebsiella (Enterobacter) aerogenes***<br><br>*CTX-M* + = Possible Extended-Spectrum Beta-Lactamase (ESBL) present<br><br>*KPC, IMP, VIM, NDM, OXA-48* = Possible carbapenemase present | CTX-M Negative: Cefepime 1 g IV q6h<br><br>CTX-M Positive: Ertapenem 1g q24h or Meropenem 500mg q6h<br><br>**Carbapenemase positive consult ID** | Cefepime: 100% susceptible (blood)<br>Ertapenem: 100% susceptible (blood)<br>Levofloxacin: 93-100% susceptible (overall) |
| ***Klebsiella oxytoca***<br><br>*CTX-M* + = Possible Extended-Spectrum Beta-Lactamase (ESBL) present<br><br>*KPC, IMP, VIM, NDM, OXA-48* + = Possible carbapenemase present | CTX-M Negative:<br>Cefepime 1g IV q6h<br><br>CTX-M Positive or Nosocomial-onset: Ertapenem 1g q24h or Meropenem 500mg q6h<br><br>**Carbapenemase positive consult ID** | Cefepime: 70-95% susceptible<br>• 95% CO susceptible (blood)<br>• 70% NO susceptible (blood)<br>Pip/tazo: 64-88% susceptible<br>• 88% CO susceptible (blood)<br>• 64% NO susceptible (blood)<br>Ertapenem: 100% susceptible<br>• 100% CO & NO susceptible (blood)<br>Levofloxacin: 95-100% susceptible<br>• 95% CO susceptible (blood)<br>• 100% NO susceptible (blood)<br>Ceftriaxone: 64-89% susceptible<br>• 86% CO susceptible (blood)<br>• 64% NO susceptible (blood) |
| ***Klebsiella pneumoniae* group**<br><br>*CTX-M* + = Possible Extended-Spectrum Beta-Lactamase (ESBL) present<br><br>*KPC, IMP, VIM, NDM, OXA-48* + = Possible carbapenemase present | CTX-M Negative: Ceftriaxone 2g q24<br><br>CTX-M Positive or Nosocomial Onset: Ertapenem 1g q24h or Meropenem 500mg q6h<br><br>**Carbapenemase positive consult ID** | Ceftriaxone: 70-89% susceptible<br>• 87% CO susceptible (blood)<br>• 70% NO susceptible (blood)<br>Pip/tazo: 60-87% susceptible<br>• 83% CO susceptible (blood)<br>• 60% NO susceptible (blood)<br>Cefepime: 75-89% susceptible<br>• 87% CO susceptible (blood)<br>• 75% NO susceptible (blood)<br>Levofloxacin: 85-92% susceptible<br>• 91% CO susceptible (blood)<br>• 85% NO susceptible (blood)<br>Ertapenem: 97-100% susceptible |
| ***Proteus* spp.**<br><br>*CTX-M* + = Possible Extended-Spectrum Beta-Lactamase (ESBL) present<br><br>*KPC, IMP, VIM, NDM, OXA-48* = Possible carbapenemase present (see guidance below) | CTX-M Negative: Ceftriaxone 2g q24<br><br>CTX-M Positive: Ertapenem 1g q24h or Meropenem 500mg q6h<br><br>**Carbapenemase positive consult ID** | Ceftriaxone: 94% cumulative<br>• 89% susceptible (blood) |
| ***Salmonella* spp.**<br><br>*CTX-M* + = Possible Extended-Spectrum | CTX-M Negative: Ceftriaxone 2g q24<br><br>CTX-M Positive: Ertapenem 1g q24h or | |

| | | |
|---|---|---|
| Beta-Lactamase (ESBL) present<br><br>*KPC, IMP, VIM, NDM, OXA-48* = Possible carbapenemase present (see guidance below) | Meropenem 500mg q6h<br><br>**Carbapenemase positive consult ID** | |
| ***Serratia marcescens***<br><br>*CTX-M* + = Possible Extended-Spectrum Beta-Lactamase (ESBL) present<br><br>*KPC, IMP, VIM, NDM, OXA-48* = Possible carbapenemase present (see guidance below) | CTX-M Negative: Cefepime 1g q6h<br><br>CTX-M Positive: Ertapenem 1g q24h or Meropenem 500mg q6h<br><br>**Carbapenemase positive consult ID** | Cefepime: 100% susceptible<br>Levofloxacin: 100% susceptible<br>Sulfa/Trim: 98-100% susceptible<br>Ertapenem: 93-100% susceptible |
| ***Haemophilus influenzae*** | Ampicillin/sulbactam 3g q6h or Ceftriaxone 2g q24h | |
| ***Neisseria meningitidis*** | Ceftriaxone 2g q12h | |
| ***Pseudomonas aeruginosa*** | Piperacillin/tazobactam 4.5 g q8h infused over 4h +/- tobramycin 7 mg/kg daily (pharmacy to dose) | Cefepime: 86-93% susceptible<br>Pip/tazo: 87-90% susceptible<br>Meropenem: 86-90%% susceptible<br>Levofloxacin: 78-91% susceptible<br><br>Consider tobramycin addition in severely ill or non-responding patients |
| ***Stenotrophomonas maltophilia*** | Sulfamethoxazole/trimethoprim 15-20 mg/kg (TMP component) in three divided doses daily | Sulfa/Trim: (100%) susceptible<br>Levofloxacin: (94%) susceptible |
| **Yeast Pathogens** | | |
| ***Candida albicans*** | Micafungin 100mg OR Fluconazole 12mg/kg load, 6mg/kg daily | 97% susceptible or dose- dependent susceptible to fluconazole<br>Consider micafungin if previous azole exposure |
| ***Candida auris*** | Micafungin 100 mg q24h | **Consult ID**<br>Emerging yeast pathogen that is often drug resistant, requires enhanced contact isolation |
| ***Candida glabrata*** | Micafungin 100mg q24h | 99% susceptible micafungin |
| ***Candida krusei*** | Micafungin 100mg q24h | 100% susceptible micafungin (100% susceptible to voriconazole) |
| ***Candida parapsilosis*** | Micafungin 100mg q24h OR Fluconazole 12mg/kg load, 6mg/kg daily | 97% susceptible or dose- dependent susceptible to fluconazole<br><br>Consider high dose micafungin if previous azole exposure |
| ***Candida tropicalis*** | Micafungin 100mg q24h | 100% susceptible micafungin |
| ***Cryptococcus neoformans/gattii*** | Liposomal amphotericin B 3mg/kg daily | **Consult ID to determine need for flucytosine** |
| **Gram Negative Resistance Genes** | | |
| ***IMP, KPC, OXA-48-like, NDM, VIM*** | **Consult ID** | Markers for carbapenem-resistance in gram negative pathogens (i.e. CRE) |
| ***mcr-1*** | **Consult ID** | Marker for colistin resistance, a drug used in multi-drug-resistant gram-negative infections |

| | | |
|---|---|---|
| ***CTX-M*** | Ertapenem 1g qday or<br>Meropenem 500mg q6h | Marker for most common extended spectrum β-lactamase (ESBL) found in gram-negative pathogens (esp. *E. coli* and *Klebsiella sp*.)<br><br>ESBLs hydrolyze expanded spectrum cephalosporins (ceftriaxone, cefepime) and piperacillin/tazobactam<br><br>A negative result does not exclude the presence of other ESBL enzymes or other beta-lactamases |
| **Gram Positive Resistance Genes** | | |
| ***mecA/C***<br><br>***mecA/C and* MREJ** | Vancomycin | *mecA/C* is a marker for methicillin/oxacillin-resistance in non-*S. aureus Staphylococci (*i.e.= MRSE). Only reported in *S. epidermidis* and *S. lugdunensis.*<br><br>MREJ is only evaluated in *S. aureus* and when present with *mecA/C* is specific for MRSA. |
| ***vanA/B*** | Linezolid 600mg q12h | Marker for vancomycin-resistant Enterococcus (i.e.= VRE) |

Abbreviations: CO= community onset, NO= nosocomial onset

**Table 4: Nebraska Medicine Bloodstream Infection Antibiograms**

Antibiogram generated using positive blood culture results from admitted patients between January 1st, 2019 and June 30th, 2021 (30 months). Data represents pooled community onset and nosocomial onset infections.

**Gram Negative Organisms**

| | ***E. cloacae*** **(N=76)** | ***E. coli*** **(N=520)** | ***K. oxytoca*** **(N=63)** | ***K. pneumoniae*** **(N=148)** | ***K. aerogenes*** **(N=16)** | ***P. aeruginosa*** **(N=105)** | ***P. mirabilis*** **(N=37)** | ***S. marcescens*** **(N=28)** |
|---|---|---|---|---|---|---|---|---|
| **Amikacin** | 100 | 99 | 100 | 100 | 100 | 98 | 100 | 100 |
| **Amp/Sul** | R | 54 | 71 | 77 | R | R | 83 | R |
| **Aztreonam** | 75 | 86 | 80 | 85 | 68 | 78 | 86 | 60 |
| **Cefazolin** | R | 66 | 18 | 75 | R | R | 70 | R |
| **Cefepime** | 92 | 87 | 88 | 86 | 100 | 90 | 91 | 100 |
| **Ceftazidime** | 77 | 86 | 90 | 85 | 62 | 90 | 91 | 51 |
| **Ceftriaxone** | 73 | 86 | 80 | 85 | 56 | R | 89 | 60 |
| **Cefuroxime** | R | 74 | 66 | 72 | R | R | 89 | R |
| **Ertapenem** | 86 | 99 | 100 | 99 | 100 | R | 100 | 96 |
| **Gentamicin** | 100 | 87 | 96 | 93 | 100 | 89 | 94 | 100 |
| **Levofloxacin** | 100 | 75 | 96 | 91 | 93 | 80 | 70 | 100 |
| **Meropenem** | 100 | 100 | 100 | 99 | 100 | 88 | 100 | 96 |
| **Pip/Tazo** | 81 | 84 | 82 | 81 | 68 | 91 | 91 | 57 |
| **TMP/SMX** | 93 | 69 | 93 | 81 | 93 | R | 70 | 100 |
| **Tetracycline** | 89 | 73 | 90 | 77 | 87 | R | R | 7 |
| **Tobramycin** | 100 | 87 | 96 | 89 | 100 | 96 | 94 | 92 |

**Gram Positive Organisms**

| | **E. faecalis (N=157)** | **E. faecium (N=59)** | **S. aureus (N=522)** | **CoNS (N=299)** | **S. epidermidis (N=269)** | **S. lugdunensis (N=15)** | **S. pneumoniae (N=34)** | **S.viridians (N=117)** |
|---|---|---|---|---|---|---|---|---|
| **Ampicillin** | 100 | 13 | 0 | - | - | - | - | 75 |
| **Cefepime** | R | R | - | - | - | - | 100 | 94 |
| **Ceftriaxone** | R | R | 69 | 31 | 25 | 93 | 100 | 93 |
| **Cefuroxime** | R | R | - | - | - | - | 96 | - |
| **Gentamicin** | - | - | 99 | 68 | 64 | 100 | - | - |
| **Levofloxacin** | 87 | 11 | 74 | 46 | 40 | 100 | 100 | 75 |
| **Meropenem** | - | - | - | - | - | - | 97 | 100 |
| **TMP/SMX** | - | - | 99 | 53 | 47 | 100 | 81 | - |
| **Tetracycline** | 34 | 23 | 94 | 92 | 91 | 93 | 93 | 76 |
| **Clindamycin** | - | - | 74 | 60 | 56 | 93 | 100 | 90 |
| **Daptomycin** | 99 | 49 | 100 | 100 | 100 | 100 | - | 100 |
| **Linezolid** | 98 | 100 | 100 | 100 | 100 | 100 | - | - |
| **Oxacillin** | - | - | 69 | 31 | 25 | 93 | - | - |
| **Penicillin** | 100 | 13 | 23 | 12 | 8 | 66 | 100 | 71 |
| **Vancomycin** | 98 | 44 (100 excluding VRE) | 100 | 100 | 100 | 100 | 100 | 100 |

Not all isolates tested against every antibiotic listed.

**Table 5: Pathogens Detected by BCID2**

| Genus Specific Assay | Pathogens Detected | | Pathogens Not Detected |
|---|---|---|---|
| *Enterococcus*<br><br>BCID included a genus level assay for *Enterococcus*. BCID2 does **not** include this genus assay, only including species specific detection for the 2 major species associated with blood stream infections. | *E. faecium**<br>*E. faecalis** | | *E. avium*<br>*E. casseliflavus*<br>*E. durans*<br>*E. gallinarum*<br>*E. hirae*<br>*E. dispar*<br>*E. saccharolyticus*<br>*E. raffinosus*<br>*E. mundtii* |
| *Staphylococcus* genus | It is predicted that only 5 species will not be detected. Of those, only *S. equorum* has been reported in a clinical setting. | | *S. equorum*<br>*S. fluerettii*<br>*S. lentus*<br>*S. muscae*<br>*S. rostri* |
| *Streptococcus* genus<br><br>Designed to detect most Viridians group species and non-Group A/B beta hemolytic streptococci. | All species within the Streptococcus genus should be amplified by one or more of the assays on the panel at positive blood culture levels.<br><br>Some species may not be detected if present in a blood culture at low levels or if they have variant sequences (see right). | | *S. equi*<br>*S. entericus*<br>*S. halitosis*<br>*S.hyovaginalis*<br>*S. minor*<br>*S. pantholopis*<br>*S. oralis*<br>*S. sobrinus*<br>*S. suis*<br>*S. uberis* |
| *Enterobacterales*<br><br>Designed to detect less common gram-negative bacteria within multiple families of the order Enterobacterales.<br><br>Information about the detection of specific subspecies, strains, isolates, or serotypes of gram-negative bacteria is provided in the product instructions for use (Table 98 – Table 112) available at www.biofiredx.com/support/documents. | *Cedeceae* spp.<br>*Citrobacter* spp.<br>*Cosenzaea* spp.<br>*Cronobacter* spp.<br>*Edwardsiella* spp (In silico predication)<br>*Enterobacter* spp.<br>*Escherichia* spp.<br>*Erwinia* spp.<br>*Hafnia* spp.<br>*Klebsiella* spp.<br>*Kluyvera* spp.<br>*Kosakonia* spp.<br>*Leclercia* spp.<br>*Lelliottia* spp.<br>*Mixta* spp.<br>*Morganella* spp.*<br>*Pantoea* spp.<br>*Phytobacter* spp.<br>*Plesiomonas* spp.<br>*Pluralibacter* spp. | *Providencia* spp.*<br>*Proteus* spp.<br>*Pseudoescherchia* spp.<br>*Rahnella* spp.*<br>*Raoultella* spp.<br>*Salmonella* spp.*<br>*Serratia* spp.<br>*Sodalis* spp.<br>*Shigella* spp.<br>*Tatumella* spp.*<br>*Trabulsiella* spp.<br>*Yersinia* spp.*<br>*Serratia* spp.<br>*Sodalis* spp.<br>*Shigella* spp.<br>*Tatumella* spp.<br>*Trabulsiella* spp.<br>*Yersinia* spp.<br>*Yokanella* spp. | *Providencia heimbachae*<br>*Photorhabdus asymbiotica*<br>*Arsenophonus nasoniae* |

*Indicates new species group detected by the BCID2 Panel

**Document updated by:** Jeremy Tigh, PharmD; September 2021
**Reviewed by:** Trevor Van Schooneveld MD, Scott Bergman, PharmD, Bryan Alexander, PharmD, Andrew Watkins, PharmD, Paul Fey, PhD, Jasmine Marcelin, MD, Erica Stohs, MD, Macy Wood, PhD

**References**


1. Barlam TF, Cosgrove SE, Abbo LM, et al. Implementing an Antibiotic Stewardship Program: Guidelines by the Infectious Diseases Society of America and the Society for Healthcare Epidemiology of America. Clin Infect Dis. 2016;62(10):e51-e77. doi:10.1093/cid/ciw118
2. Timbrook TT, Morton JB, McConeghy KW, Caffrey AR, Mylonakis E, LaPlante KL. The Effect of Molecular Rapid Diagnostic Testing on Clinical Outcomes in Bloodstream Infections: A Systematic Review and Meta-analysis. Clin Infect Dis. 2017;64(1):15-23. doi:10.1093/cid/ciw649
3. Pardo J, Klinker KP, Borgert SJ, Butler BM, Giglio PG, Rand KH. Clinical and economic impact of antimicrobial stewardship interventions with the FilmArray blood culture identification panel. Diagn Microbiol Infect Dis. 2016;84(2):159-164. doi:10.1016/j.diagmicrobio.2015.10.023
4. Messacar K, Hurst AL, Child J, et al. Clinical Impact and Provider Acceptability of Real-Time Antimicrobial Stewardship Decision Support for Rapid Diagnostics in Children With Positive Blood Culture Results. J Pediatric Infect Dis Soc. 2017;6(3):267-274. doi:10.1093/jpids/piw047
5. BioFire® Blood Culture Identification 2 (BCID2) Panel [product labeling: instructions for use]. BioFire Diagnostics, Salt Lake City, UT; updated June 2020.