TABLE

BREAKPOINT SOURCES FOR & RESISTANCE TO COMMON ANTIMICROBIALS

This table provides antimicrobials commonly found on small animal culture and susceptibility reports and is organized according to antimicrobial classification and a general preference for order of use. Breakpoint information is derived from CLSI performance standards for veterinary isolates.[7]

Antimicrobial	Breakpoint Source (Canine, Feline, Human)	Intrinsic Resistance	Notes
PENICILLINS			
Ampicillin	Canine: *Escherichia coli* in dermal, soft tissue, and urinary tract infections; *Staphylococcus pseudintermedius* and *Streptococcus canis* in dermal and soft tissue infections Human: *Enterococcus* spp	*Klebsiella* spp, *Proteus vulgaris*, *Serratia marcescens*, *Enterobacter* spp, *Pseudomonas aeruginosa*	• Susceptibility to ampicillin indicates susceptibility to amoxicillin. • Aminopenicillins are inactivated by most β-lactamases, but sufficient concentrations are achieved in urine to overcome low-level resistance; therefore, amoxicillin is recommended as empiric treatment for UTIs even if reported as R.[13]
Amoxicillin–clavulanic acid	Canine and feline: *E coli*, *Staphylococcus* spp, and *Streptococcus* spp in dermal, soft tissue, and urinary tract infections	*S marcescens*, *Enterobacter* spp, *P aeruginosa*	• Resistance indicates extended-spectrum β-lactamase–producing (ESBL) bacteria, which are typically susceptible to amoxicillin–clavulanic acid but resistant to third- and fourth-generation cephalosporins.[14] • As a result of high urine concentrations of amoxicillin, amoxicillin alone is recommended as the first-line treatment of UTIs. • The combination of amoxicillin with clavulanic acid is required for effective treatment of methicillin-susceptible staphylococcal superficial bacterial folliculitis/pyoderma.[15]
Oxacillin	Human: *Staphylococcus* spp	Most gram-negative bacteria	• Used solely to determine methicillin resistance in *S pseudintermedius* • Disk-diffusion (ie, Kirby-Bauer) testing is not reliable for *Staphylococcus aureus*; cefoxitin disks should be used to determine methicillin resistance.[7]
Penicillin	Human: *Enterococcus* spp and *Staphylococcus* spp	Most gram-negative bacteria	• All β-hemolytic streptococci are susceptible. • Clinical use in small animals is limited due to available formulations.
Piperacillin	Human: *P aeruginosa*	N/A	• An antipseudomonal penicillin • Clinical use is limited due to available formulations.

CLSI = Clinical and Laboratory Standards Institute
ESBL bacteria = extended-spectrum β-lactamase–producing bacteria

Antimicrobial	Breakpoint Source (Canine, Feline, Human)	Intrinsic Resistance	Notes
CEPHALOSPORINS			
Cephalothin or Cefazolin	Canine: *E coli*, *Pasteurella multocida*, *S aureus*, *S pseudintermedius*, and β-hemolytic *Streptococcus* spp in dermal, respiratory, soft tissue, and urinary tract infections Human: Enterobacteriaceae	*Enterococcus* spp, *P vulgaris*, *S marcescens*, *Enterobacter* spp, *P aeruginosa*	• Generally indicates susceptibility to cephalexin and cefadroxil • Human breakpoints for cephalothin are used for other first-generation cephalosporins to treat Enterobacteriaceae infections, but cefazolin should be tested separately.
Cefoxitin	Human: *Staphylococcus* spp	*Enterococcus* spp, *P aeruginosa*	• A second-generation human-approved cephalosporin with excellent activity against anaerobes • Cefoxitin resistance is an indicator of methicillin-resistance in *S aureus* but is not reliable for *S pseudintermedius*; oxacillin resistance is the preferred indicator.[16] • Indicates ESBL-producing bacteria, which are susceptible to cefoxitin but resistant to third-generation cephalosporins[17]
Cefpodoxime	Canine: *E coli*, *Proteus mirabilis*, *P multocida*, *S aureus*, *S pseudintermedius*, and *S canis* in wounds and abscesses	*Enterococcus* spp, *P aeruginosa*	• Generally indicates susceptibility to third-generation cephalosporins, including cefovecin and ceftiofur • Indicates ESBL-producing bacteria, which are often resistant to these cephalosporins but still susceptible to amoxicillin–clavulanic acid[18]
TETRACYCLINES			
Doxycycline	Canine: S *pseudintermedius* in dermal and soft tissue infections Human: *Enterococcus* spp	*P aeruginosa*	• Frequently active against methicillin-resistant staphylococci[9]
Minocycline	Proposed Canine: *S pseudintermedius* in dermal and soft tissue infections	*P aeruginosa*	• May be considered in the treatment of methicillin-resistant staphylococci when resistance to doxycycline has been documented
Tetracycline	Canine: *Staphylococcus* spp in dermal and soft tissue infections Human: *Enterococcus* spp	*Proteus* spp, *P aeruginosa*	• Susceptibility indicates susceptibility to oxytetracycline. • Staphylococci with reduced susceptibility to tetracycline or oxytetracycline may be susceptible to doxycycline or minocycline.[9]

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Antimicrobial	Breakpoint Source (Canine, Feline, Human)	Intrinsic Resistance	Notes
SULFONAMIDES			
Sulfisoxazole	Human: Enterobacteriaceae, *Staphylococcus* spp	*Enterococcus* spp, *P aeruginosa*	• Susceptibility indicates general susceptibility to all sulfonamides.[11]
Trimethoprim–sulfamethoxazole	Human: Enterobacteriaceae, *Staphylococcus* spp	*Enterococcus* spp, *P aeruginosa*	• Susceptibility indicates general susceptibility to sulfonamides in combination with trimethoprim.[11]
MACROLIDES/LINCOSAMIDES			
Clindamycin	Canine: β-hemolytic *Streptococcus* spp in dermal and soft tissue infections	Enterobacteriaceae[11]	• Susceptibility indicates susceptibility to lincomycin. • Active against respiratory gram-negative pathogens but not gram-negative enteric bacteria • If staphylococci are reported as susceptible to clindamycin but resistant to erythromycin, disk-diffusion test should be performed to check for inducible resistance that renders clindamycin ineffective.[19]
Erythromycin	Human: *Streptococcus* spp	Enterobacteriaceae	• Susceptibility indicates general susceptibility to azithromycin and clarithromycin. • Active against respiratory gram-negative pathogens but not gram-negative enteric bacteria
PHENICOLS			
Chloramphenicol	Canine: *P multocida* in dermal and soft tissue infections Human: *Enterococcus* spp	*P aeruginosa*	• Chloramphenicol is generally active against staphylococci (including methicillin-resistant isolates), enterococci, and *E coli* (including ESBL-producing isolates).[20,21] • Toxicity limits treatment to only a short duration in cats. • Clinical use in small animals is limited due to human health concerns (eg, aplastic anemia).

ESBL bacteria = extended-spectrum β-lactamase–producing bacteria

Antimicrobial	Breakpoint Source (Canine, Feline, Human)	Intrinsic Resistance	Notes
FLUOROQUINOLONES			
Enrofloxacin	Canine: Enterobacteriaceae, *Staphylococcus* spp, and *Streptococcus* spp in dermal, respiratory, soft tissue, and urinary tract infections Feline: Enterobacteriaceae, *P aeruginosa*, and *Streptococcus* spp in dermal and soft tissue infections	Anaerobes	• Susceptibility indicates general susceptibility to veterinary fluoroquinolones, including marbofloxacin, difloxacin, and orbifloxacin. • Ciprofloxacin (in humans) has the greatest activity of all the fluoroquinolones against *Pseudomonas* spp, but it has less ideal pharmacokinetics than veterinary fluoroquinolones.
Pradofloxacin	Canine: Enterobacteriaceae, *S pseudintermedius* in dermal and urinary tract infections Feline: Enterobacteriaceae, *P multocida*, *S pseudintermedius*, *S aureus*, *Staphylococcus felis*, and *S canis* in dermal, respiratory, and urinary tract infections	N/A	• Pradofloxacin is active against anaerobic bacteria. • Many pathogens remain susceptible to pradofloxacin while testing resistant to other fluoroquinolones.[22]
AMINOGLYCOSIDES			
Amikacin	Canine: *E coli*, *P aeruginosa*, *Staphylococcus* spp, *Streptococcus* spp	*Enterococcus* spp,[11] anaerobes	• Amikacin is active against gram-negative enteric bacteria and staphylococci, including methicillin-resistant isolates.[23] It is less active against streptococci but more active against *Pseudomonas* spp than other aminoglycosides. • Clinical use in small animals is limited by pharmacokinetic properties and toxicity.
Gentamicin	Canine: Enterobacteriaceae, *P aeruginosa*	*Enterococcus* spp,[6,11] anaerobes	• Gentamicin is active against gram-negative enteric bacteria and staphylococci, including some methicillin-resistant isolates.[23] • Usually active against *Pseudomonas* spp but is more susceptible to enzymatic resistance than is amikacin. • Clinical use in small animals is limited by pharmacokinetic properties and toxicity.

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Antimicrobial	Breakpoint Source (Canine, Feline, Human)	Intrinsic Resistance	Notes
LIMITED-USE ANTIMICROBIALS			
Nitrofurantoin	Human: *Enterococcus* spp, Enterobacteriaceae	*P mirabilis*[11]	• Used exclusively to treat uncomplicated UTIs • Usually active against *E coli* (including ESBL-producing isolates), enterococci, and staphylococci, including methicillin-resistant isolates[24]
Mupirocin	There are no veterinary breakpoints for topical antimicrobial product; human breakpoints are questionable.	N/A	• Topical product used for the treatment of methicillin-resistant staphylococci • It is assumed that drug concentrations are high at the application site; however, for most topical agents, measured drug concentrations at the site are not known, nor is the length of time for which those concentrations are maintained. The decision to use is based on clinical experience of efficacy.
Fusidic acid	Human: *Staphylococcus* spp	N/A	• Topical product used for the treatment of methicillin-resistant staphylococci[25] • See ***Mupirocin*** for limitations in susceptibility testing.
Rifampin	Human: *Staphylococcus* spp	N/A	• Rifampin is generally active against methicillin-resistant staphylococci. • Use is limited due to hepatotoxicity. • Should not be used as monotherapy, as resistance rapidly emerges with this type of use
Imipenem	Human: Enterobacteriaceae, *P aeruginosa*	N/A	• Susceptibility indicates susceptibility to carbapenems, including meropenem. • Methicillin-resistant staphylococci are resistant to imipenem. • Imipenem should be a last resort treatment in human medicine; use in veterinary medicine should be strictly limited.
Vancomycin	Human: *Enterococcus* spp, *S aureus*, coagulase-negative *Staphylococcus* spp	N/A	• Vancomycin should be a last resort treatment for gram-positive infections (eg, enterococci, methicillin-resistant staphylococci) in humans; use in veterinary medicine should be strictly limited.

ESBL bacteria = extended-spectrum β-lactamase–producing bacteria

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Suggested Reading

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