Detection of Resistance Mechanisms (General)

Mechanisms of resistance include production of inactivating enzymes, alteration of drug targets, and altered drug uptake or efflux. Find enclosed in the table below the antibiotics recommended to detect certain resistance mechanisms (1).

Antibiotic (Neo-Sensitabs)	**Phenotype**	**Mechanism of resistance**	**Bacteria**
1) Beta-lactams			
Penicillin + pH indicator (Beta-lactamase - D.T.)	Penicillin resistance	Penicillinase	Staphylococci, Haemophilus, Gonococci
Oxacillin 1 µg res.	Resistance to all beta-lactams	Additional PBP	Staphylococci
Cefoxitin res.	Resistance to all beta-lactams	mecA	Staphylococcus aureus
Ampicillin res.	a)Resistance to penicillins and beta-lactams inhibitor comb.	Altered PBPs	Enterococci
Oxacillin 1 µg (zone < 20 mm) (zone < 14 mm) (zone < 12 mm)	Penicillin resistance	PBP alteration	Pneumococci, Streptococci, Gonococci
Ceftizoxime res.	Resistance to third generation cephalosporins	PBP alteration	Pneumococci
Ampicillin 2.5 µg (zone < 20 mm)	Resistance to AMP,AMX, AM+CL, CCLOR, CEFUR (BLNAR strains)	PBP alteration	Haemophilus
Amoxycillin and Amoxycillin+Clavulanate	b) Penicillin resistance AM+CL synergy	Beta-lactamase (BRO-1, BRO-2)	Moraxella catarrhalis
Ceftazidime, Ceftriaxone (zone < 24 mm)		Screening ESBL	Klebsiella spp, E. coli, Salmonella
Cefpodoxime I/R		Screening ESBL	E. coli, Klebsiella Salmonella
Cefotaxime, Ceftriaxone Ceftazidime/Cefepime and Amoxycillin+Clavulanate	c) Synergy between CTX, CTR, CAZ and AMC, CP+CL, (double disk synergy)	Extended spectrum beta-lactamase (ESBL)	Enterobacteriaceae d)
Ceftazidime+Clavulanate	CAZ+CL zone ≥ 5 mm than CAZ alone	ESBL	Enterobacteriaceae
Cefepime and Amoxycillin + Clavulanate	Synergy between FEP and AMC	ESBL	Enterobacter, Serratia, Citrobacter freundii
Cefepime+Clavulanate	FEP+CL zone ≥ 5 mm than FEP alone	ESBL (confirmatory)	Enterobacteriaceae
Cefotaxime+Clavulanate	CTX+CL zone ≥5 mm than CTX alone	ESBL	Enterobacteriaceae
Cefoxitin + Cephalosporins Imipenem + Cephalosporins	Antagonism, indicates cephalosporin resistance	Inducible cephalosporinase AmpC	Enterobacteriaceae
Cefepime+Clavulanate Cefoxitin/3rd gen. cepha.	No synergy No antagonism Cefoxitin R, Ceftazidime R	Plasmid mediated AmpC	Enterobacteriaceae
Amoxycillin+Clavulanate I/R Cefazolin	Amoxycillin+Clavulanate R Cefazolin S	Inhibitor resistant TEM ß-lactamase	E. coli Klebsiella

Antibiotic (Neo-Sensitabs)	Phenotype	Mechanism of resistance	Bacteria
Cefotaxime+Boronic Ceftazidime+Boronic	zone ≥5 mm than CTX or CAZ alone	AmpC beta lactamase	Enterobacteriaceae
Cefoxitin res.	Antibiotic resistance	Porin alteration	E. coli Klebsiella
Aztreonam, Ceftazidime, Cefepime and Ticarcillin + Clavulanate	Synergy between TC+Cl and AZT, FEP, CAZ.	ESBL	Ps. aeruginosa
Imipenem+EDTA Meropenem+DPA	Synergy between Imipenem and EDTA Synergy MRP and DPA	Metallo-ß-lactamase	Ps. aeruginosa Acinetobacter E. coli
Cloxacillin	Synergy between cefotaxime, ceftazidime and cloxacillin	AmpC beta-lactamase	Enterobacteriaceae
Dipicolinic acid	Synergism with Meropenem and/or Imipenem	Metallo-ß-lactamase	Enterobacteriaceae Non-fermenters
Boronic acid	Synergism with Cefotaxime and/or Ceftazidime	AmpC beta-lactamase	Enterobacteriaceae
Meropenem+Boronic Meropenem+Cloxa	Synergy (≥5mm) No synergy	KPC beta lactamase	K.pneumoniae P.aeruginosa
Meropenem+Boronic Meropenem+Cloxa	Synergy synergy	AmpC+porin loss	Klebsiella Enterobacter
2) Aminoglycosides			
Kanamycin res.	Amikacin and Isepamicin resistance	APH(3'), ANT(4')	Staphylococci
Gentamicin res.	Resistance to aminoglycosides except streptomycin	APH(2")-AAC(6')	Staphylococci
Kanamycin 500 µg (zone < 14 mm)	HLR to amikacin (no synergy with penicillins)	APH(3'), ANT(4')	Enterococci (HLR)
Gentamicin 250 µg (zone < 14 mm)	HLR to all aminoglycosides	APH(2")-AAC(6')	Enterococci (HLR)
Streptomycin 500 µg (zone < 14 mm)	Streptomycin resistance		Enterococci (HLR)
Amikacin + Tobramycin res.	Resistance to aminoglycosides	APH(3')-VI	Acinetobacter
Netilmicin + Tobramycin res.	Resistance to aminoglycosides	AAC(3)	Pseudomonas
3) Others			
Erythromycin + Clindamycin	Inducible MLS resistance (antagonism)	Ribosomal methylation	Staphylococci, Streptococci,
Nalidixan I/R	Reduced sensitivity to quinolones	DNA gyrase	Enterobacteriaceae Vibrio cholerae Haemophilus/Moraxella
Nalidixan I/R	Reduced sensitivity to quinolones	DNA gyrase	Gonococci Meningococci
Ciprofloxacin 0.5 µg (zone < 20 mm)	Quinolone resistance	DNA-gyrase	Gonococci, Haemophilus
Vancomycin Teicoplanin	Vancomycin resistance 2+18 hours' prediffusion	Van A, Van B VISA, hVISA	Enterococci, Staphylococci
Metronidazole	Imidazole resistance	Reductase	Anaerobes

a) for non beta-lactamase producing enterococci.

b) Synergy: AM+CL zone > 5 mm larger than AMOXY (resistance to penicillin, amoxycillin and ampicillin, susceptible to amoxycillin+clavulanate).

c) Beta-lactam resistance (except cephamycins and carbapenems).

d) Except Proteus penneri and P. vulgaris.

Note: The mentioned zone sizes are valid for McFarland 0.5 inoculum.

References:
1) Clinical Microbiology and Infection. Vol 2. Suppl. 1. December 1996.
2) Hakonen A. et al: Detection of decreased fluoroquinolone susceptibility in Salmonellas and validation of Nalidixic acid screening test. J. Clin. Microbiol., 37, 3572-77, 1999.