

Test di screening e di conferma per la rilevazione delle resistenze antimicrobiche

Corso Precongressuale D
ANTIBIOGRAMMA 2024: «QUO VADIS?»

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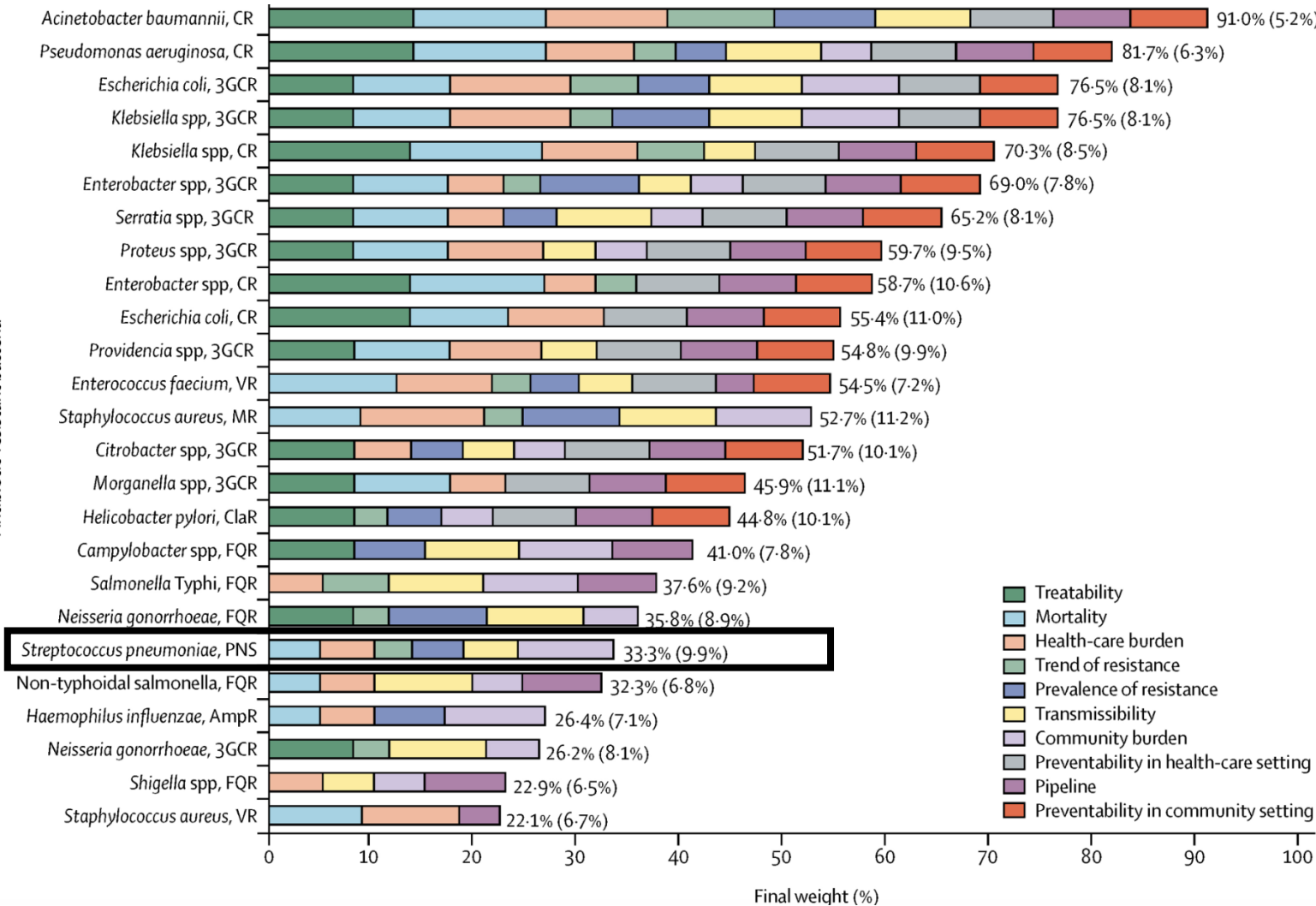


Unità di Microbiologia Diagnostica e Immunologia
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Roma



WHO list of priority pathogens for the research and development for new antibiotics

Antibiotic-resistant bacteria



Priority 1: CRITICAL

- *Acinetobacter baumannii*, carbapenem-resistant
- *Pseudomonas aeruginosa*, carbapenem-resistant
- *Enterobacteriaceae*, carbapenem-resistant, ESBL-producing

Priority 2: HIGH

- *Enterococcus faecium*, vancomycin-resistant
- *Staphylococcus aureus*, methicillin-resistant, vancomycin-intermediate and resistant
- *Helicobacter pylori*, clarithromycin-resistant
- *Campylobacter* spp., fluoroquinolone-resistant
- *Salmonellae*, fluoroquinolone-resistant
- *Neisseria gonorrhoeae*, cephalosporin-resistant, fluoroquinolone-resistant

Priority 3: MEDIUM

- *Streptococcus pneumoniae*, penicillin-non-susceptible
- *Haemophilus influenzae*, ampicillin-resistant
- *Shigella* spp., fluoroquinolone-resistant

Penicillin non-susceptible (non-wild type) *Streptococcus pneumoniae*

***Streptococcus pneumoniae*: Flow chart based on screen tests for beta-lactam resistance mechanisms to reduce the number of specific tests for beta-lactam agents**

**Oxacillin 1 µg zone diameter ≥20 mm
(or benzylpenicillin MIC ≤0.06 mg/L)**

Mechanism: excludes all beta-lactam resistance mechanisms

Report susceptible (S) to beta-lactam agents for which clinical breakpoints are available, including those with "Note", and those with meningitis breakpoints. **Exception:** Cefaclor is reported "susceptible, increased exposure" (I).

No further testing required.

**Oxacillin 1 µg zone diameter <20 mm
(or benzylpenicillin MIC >0.06 mg/L)**

Mechanism: beta-lactam resistance detected

Report: resistant (R) to benzylpenicillin (meningitis) and phenoxymethylpenicillin (all indications).

For benzylpenicillin (indications other than meningitis), perform and interpret MIC according to breakpoints.

For other beta-lactam agents, see below.

Oxacillin 1 µg zone diameter 9-19 mm

Report susceptible (S) without further testing to: ampicillin, amoxicillin and piperacillin (without and with beta-lactamase inhibitor), cefepime, cefotaxime, ceftaroline, ceftobiprole, ceftriaxone, imipenem and meropenem.

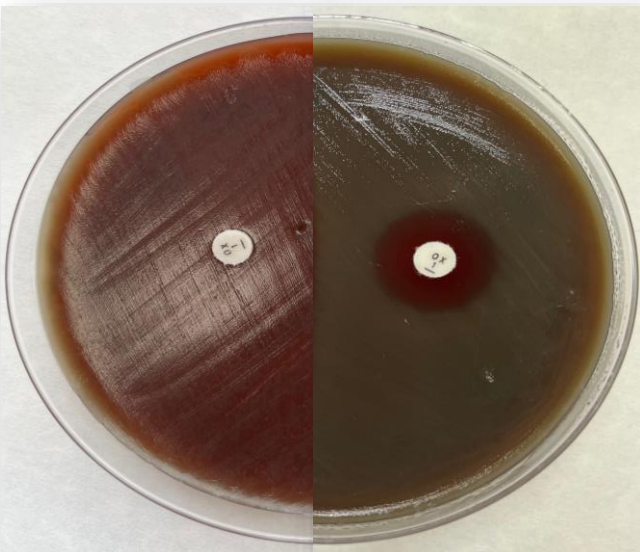
For other beta-lactam agents, perform susceptibility testing for the relevant agent and interpret according to breakpoints.

This guidance is also valid for meningitis breakpoints.

Oxacillin 1 µg zone diameter <9 mm

Perform susceptibility testing for the relevant agent and interpret according to breakpoints.

This guidance is also valid for meningitis breakpoints.



Priority 2: HIGH

- *Staphylococcus aureus*, methicillin-resistant
- *Enterococcus faecium*, vancomycin-resistant

Methicillin resistance in *Staphylococcus aureus*

	MIC breakpoints (mg/L)			Disk content (µg)	Zone diameter breakpoints (mm)		
	S ≤	R >	ATU		S ≥	R <	ATU
Cefoxitin (screen only), <i>S. aureus</i> and coagulase-negative staphylococci except <i>S. epidermidis</i> and <i>S. lugdunensis</i>	Note ^{3,4}	Note ^{3,4}		30	22 ^{A,B}	22 ^{A,B}	
Oxacillin ⁴ , other staphylococci	Note ^{1,4}	Note ^{1,4}			Note ^A	Note ^A	

S. aureus with cefoxitin MIC values >4 mg/L and/or with oxacillin MIC values >2 mg/L are methicillin resistant, mostly due to the presence of the *mecA* or *mecC* gene.

S. aureus with a cefoxitin zone diameter (30 µg disc) <22 mm should be reported as resistant to methicillin.

Methicillin/oxacillin resistance can be detected phenotypically by:

- MIC determination
- Disk diffusion

Different phenotypes emerge based on the sensitivity result of cefoxitin and oxacillin:

	Oxacillin	Cefoxitin	<i>mecA/mecC</i>	
MRSA	R	R	+	Methicillin-resistant <i>Staphylococcus aureus</i>
BORSA/MODSA	R	S	–	Overproduction of β -lactamases or alteration of pre-existing PBPs
HR-MRSA	S	R	+	Heterogeneous expression of the <i>mec</i> gene (<i>mecC</i>)
OS-MRSA	S	S	+	Inactivation of the <i>mecA</i> gene (oxacillin susceptible MRSA)

1% of *mecA*-positive *S. aureus* strains are oxacillin susceptible

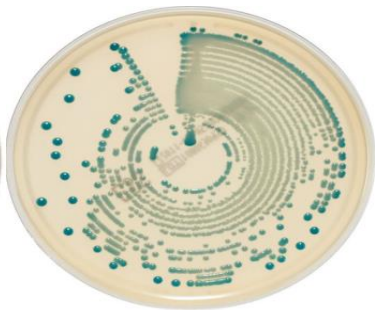
EUCAST does not recommend systematic screening for BORSA

Phenotypic methods for the detection of MRSA

Chromogenic MRSA screening plates



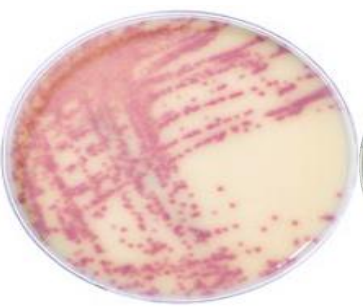
Oxoid Brilliance MRSA 2



BioMérieux chromID MRSA



BD BBL CHROMagar MRSA II

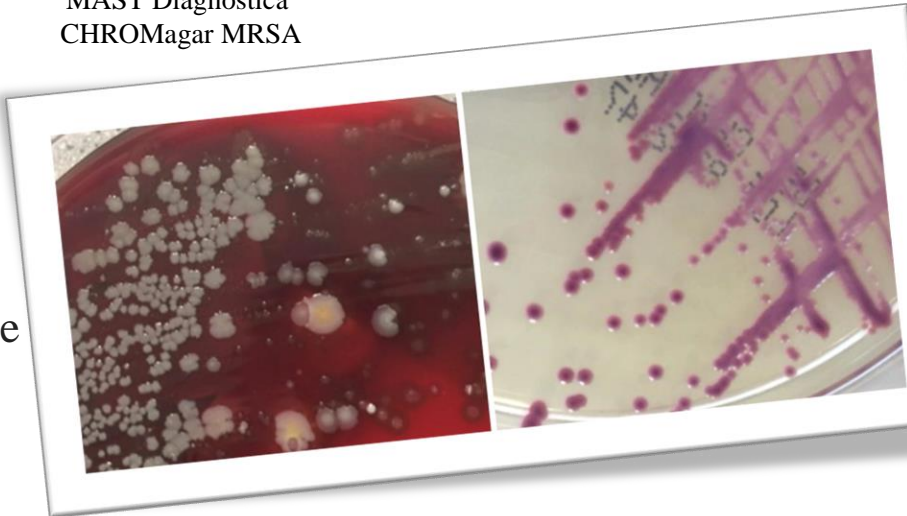


Bio-Rad MRSA Select



MAST Diagnostica
CHROMagar MRSA

Chromogenic agar ^a	No. of isolates (% agreement) with:		
	Normal growth ^b	Reduced growth ^c	No growth
Brilliance MRSA 2	111 (100)	0 (0.0)	0 (0.0)
chromID MRSA	111 (100)	0 (0.0)	0 (0.0)
BBL CHROMagar MRSA II	101 (91.0)	10 (9.0)	0 (0.0)
MRSA Select	105 (94.6)	6 (5.4)	0 (0.0)
CHROMagar MRSA	99 (89.2)	12 (10.8)	0 (0.0)



PBP2a

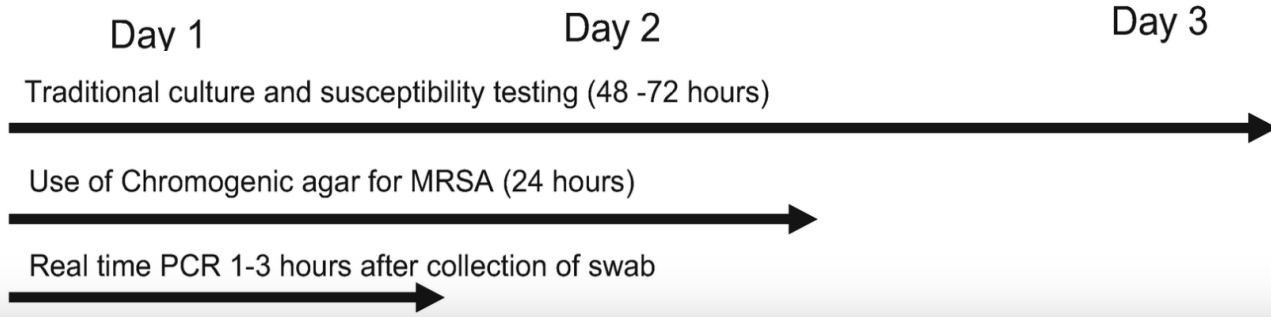


PBP2' latex
agglutination



Clearview™
PBP2a SA
Culture Colony

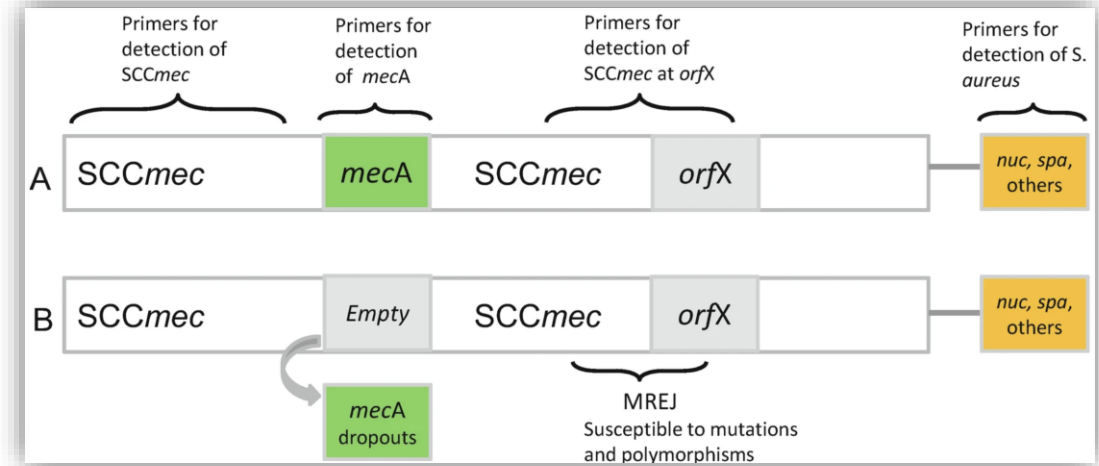
- a nasal swab culture on blood agar plate
- and on BBL CHROM agar MRSA II



Genetic and genomic detection of MRSA

False negative

- ✓ Analytical sensitivity
- ✓ Resistance mechanism other than *mec* genes
- ✓ *SCCmec-orfX* based assays have proved not to be able to detect all MRSA isolates
- ✓ High degree of genetic diversity within the *SCCmec* elements



False positive

- Difficulties associated with the diagnostic algorithm for some *SCCmec-orfX* based assays
- Duration of kit-positive results from specimens from patients who have been successfully treated for MRSA
- Lack of specificity of the assay's proprietary target sequence for MRSA at the *SCCmec-orfX* junction
- The combination of a *mecA* PCR and an *S. aureus*-specific PCR may result in false-positive results
- Difficulties associated with the diagnostic algorithm

Molecular Method Used	Principle of the Method	On Culture/on Clinical Sample	TAT 1	Brief Advantages/Disadvantages +/-	No. and Type of <i>S. aureus</i> Analyzed 2	Major Diagnostic Performance 3
Xpert ® SA Nasal Complete (Cepheid)	Real-time PCR for <i>mecA/C</i> , <i>spa</i> and <i>SCCmec-orfX</i>	Nasal samples	3 h	+ Clinical outcomes analyzed – 56 invalid results not further analyzed	10 MRSA in 605 nasal samples	Sensitivity 100% Specificity 98.8% PPV 58.8% NPV 100% TAT 41 h shorter
			85 m	– Unusual reference method	27 MRSA in 500 nasal samples	Sensitivity 51.8% Specificity 100%
Xpert ® MRSA/SA BC Assay (Cepheid)	Real-time PCR for <i>mecA/C</i> , <i>spa</i> and <i>SCCmec-orfX</i>	Positive blood cultures	1.7 h	+ Clinical outcomes analyzed – More resistant isolates needed	1 MRSA 38 MSSA in 264 blood cultures	Sensitivity 100% specificity 100% TAT 24 h shorter, earlier changes in patient management
			n.a.	+ Clinical outcomes analyzed – Sensitivity/specificity not calculated	37 MRSA 64 MSSA	Time to optimal therapy 20 h shorter, duration of vancomycin therapy 18 h shorter
Xpert ® MRSA/SA SSTI (Cepheid)	Real-time PCR for <i>mecA/C</i> , <i>spa</i> and <i>SCCmec-orfX</i>	BAL samples	68 m	+ Clinical outcomes analyzed – Method not validated in BAL samples	23 MRSA 25 MSSA in 247 BAL samples	Sensitivity 95.7% specificity 98.2% Time of linezolid/vancomycin treatment 40 h shorter
Hologic Panther Fusion ® MRSA	PCR and Invader chemistries for <i>mecA/C</i> , <i>gap</i> and <i>SCCmec-orfX</i>	Nasal samples	<3 h	+ Can analyze 350 samples in 8 h – Need comparison with a similar method	30 MRSA 112 MSSA in 434 nasal swabs	Sensitivity 86.7%, specificity 98.8%, CA 97.9%
MRSA/SA ELITe MGB assay (ELITechGroup)	Real time PCR for <i>mecA/C</i> and a <i>S. aureus</i> specific sequence	Sputum, tracheal aspirate, BAL	<3 h	+ Accurate – Do not target <i>SCCmec-orfX</i> junction	23 MRSA 60 MSSA in 113 respiratory samples	Sensitivity 95.7% specificity 96.7% PPV 91.7% NPV 98.3%
Unyvero HPN Application	Multiple PCRs	BAL fluids	5 h	+ Detect 21 species and 19 resistance genes; mixed cultures detection – More resistant isolates needed	2 MRSA 1 MSSA in 84 BAL fluids	Sensitivity 100% specificity 98.7%
Eazyplex ® MRSA	LAMP targeting <i>S. aureus</i> , <i>S. epidermidis</i> , <i>mecA/C</i>	Positive blood cultures	1 h	+ Portable; faster than similar methods – Need optimization for CONS	32 MRSA 199 MSSA in 797 blood cultures	Sensitivity 100%, specificity 99.7%, TAT 17 h shorter



Organism detected	Assay	Company	Analysis platform	Probes	Target sequences	Specimen type	Time to result
<i>S. aureus</i> and MRSA from positive blood cultures	Xpert MRSA/SA BC	Cepheid	GeneXpert System	TaqMan ^R probes	<i>spa</i> , <i>SCCmec</i> and <i>mecA</i> gene	Blood culture	<1 h
	BC–GP ^a Panel	Luminex	Verigene	Gold nanoparticles	<i>gyrB</i> , <i>mecA</i> gene	Blood culture	2.5 h
	FilmArray ^b BCID Panel	BioFire BioMerieux	FilmArray	Nested PCR and melting curve analysis	<i>mecA</i> gene ^c	Blood culture	<1 h

Priority 2: HIGH

- *Staphylococcus aureus*, methicillin-resistant
- *Enterococcus faecium*, **vancomycin-resistant**

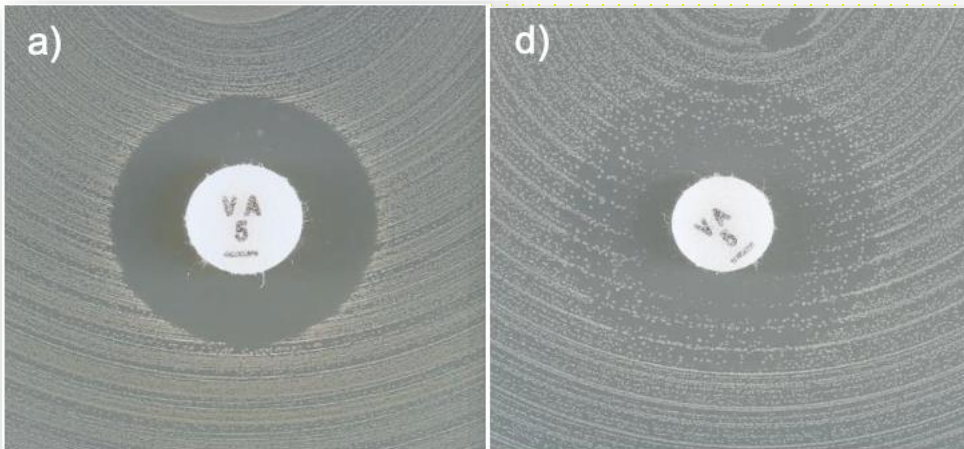
Vancomycin resistance in *Enterococcus*

Vancomycin resistance can be detected phenotypically by:

- MIC determination
- disk diffusion
- breakpoint agar method

Glycopeptides and lipoglycopeptides	MIC breakpoints (mg/L)			Disk content (µg)	Zone diameter breakpoints (mm)		
	S ≤	R >	ATU		S ≥	R <	ATU
Dalbavancin	IE	IE			IE	IE	
Oritavancin	IE	IE			IE	IE	
Teicoplanin	2	2		30	16	16	
Telavancin	IE	IE			IE	IE	
Vancomycin *	4	4		5	12 ^A	12 ^A	

* Enterococci other than *E. casseliflavus* and *E. gallinarum*



If the zone edge is fuzzy or colonies grow within the zone, then perform confirmatory testing with PCR or report resistant even if the zone diameter is ≥ 12 mm.

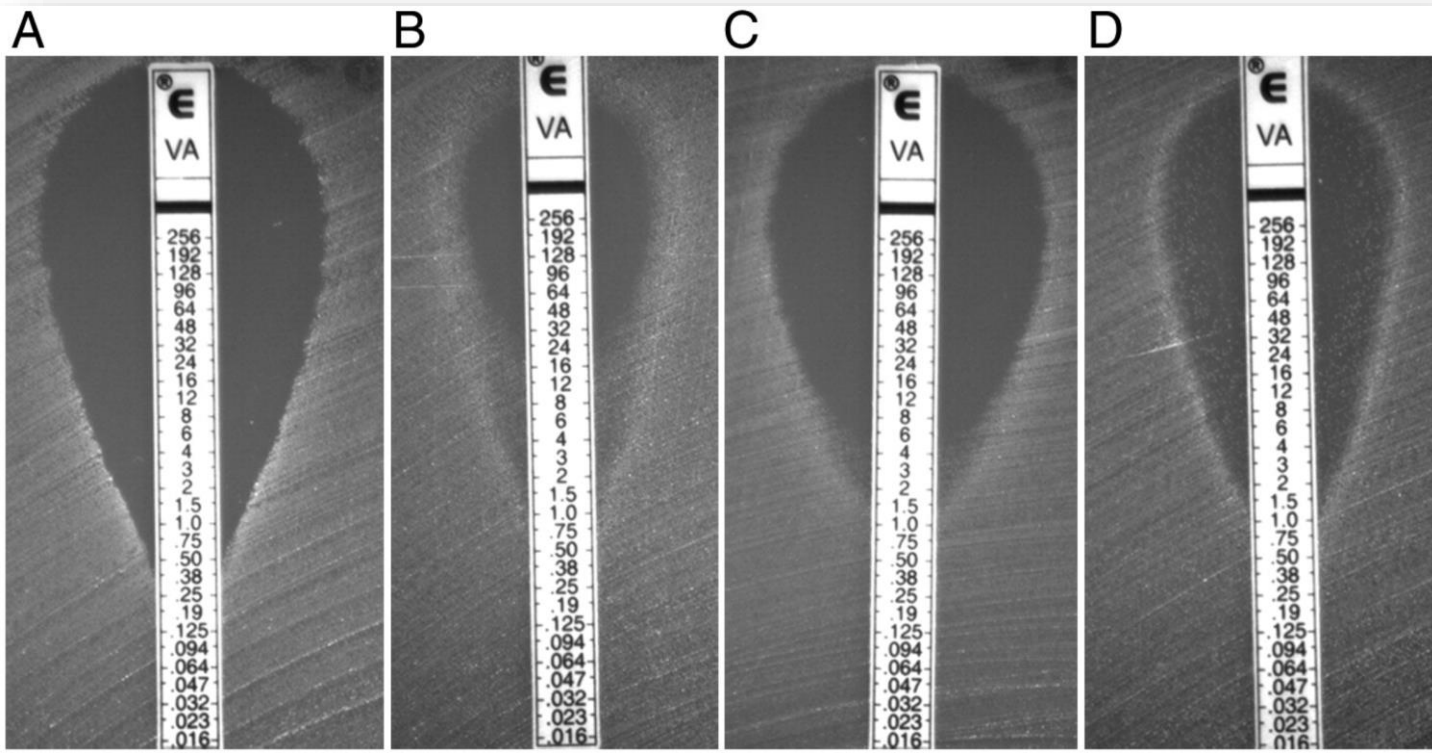
Types of resistance to glycopeptides resistance in enterococci

Resistance	Acquired								Intrinsic
	High		Variable	Moderate	Low			Low	
Phenotype	VanA	VanM	VanB	VanD	VanE	VanG	VanL	VanN	VanC
Vancomycin MIC (mg/L)	64–1,000	>256	4–1,000	64–128	8–32	≤16	8	16	2–32
Teicoplanin MIC (mg/L)	16–512	96	0.5–1	4–64	0.5	Sensitive	≤0.5	≤0.5	0.5–1
Modification	D-Ala-D-Lac	D-Ala-D-Lac	D-Ala-D-Lac	D-Ala-D-Lac	D-Ala-D-Ser	D-Ala-D-Ser	D-Ala-D-Ser	D-Ala-D-Ser	D-Ala-D-Ser
Location	Plasmid or chromosome	Plasmid or chromosome	Plasmid or chromosome	Plasmid or chromosome	Chromosome	Chromosome	Chromosome	Plasmid	Chromosome
Transferrable	Yes	Yes	Yes	No	No	Yes	No	Yes	No
Expression	Inducible	Inducible	Inducible	Constitutive or inducible	Inducible	Inducible	Inducible	Constitutive	Constitutive or inducible
Main Species	<i>E. faecalis</i> , <i>E. faecium</i>	<i>E. faecium</i>	<i>E. faecalis</i> , <i>E. faecium</i>	<i>E. faecalis</i> , <i>E. faecium</i>	<i>E. faecalis</i>	<i>E. faecalis</i>	<i>E. faecalis</i>	<i>E. faecium</i>	<i>E. gallinarum</i> , <i>E. casseliflavus</i>

	Teicoplanin	Vancomycin	Resistance gene
<i>vanA</i>	R	R	<i>vanA</i>
<i>vanB</i>	S	R	<i>vanB</i>
<i>vanA</i> genotype with <i>vanB</i> phenotype	S	R	<i>vanA</i>
<i>vanC</i>	S	R	<i>vanC</i>
VVE	S	S	<i>vanA</i>
Low-MIC VRE	S	S	<i>vanB</i>

Vancomycin-variable enterococci (VVE)

- Vancomycin-susceptible enterococci
- Not detected by conventional selective culture methods
- *vanA*-positive
- Ability to revert to a costitutive VRE phenotype **under exposure to vancomycin**
- Genotypic testing of invasive vancomycin-susceptible enterococci by *vanA*-PCR is advised

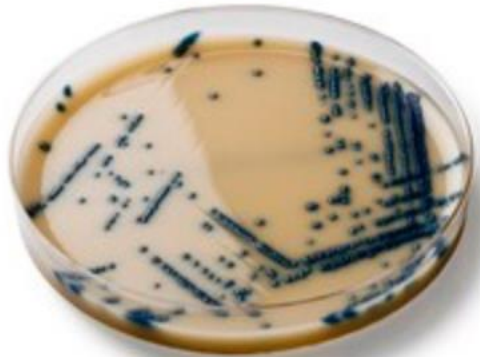


Etest® Vancomycin phenotypes of *Enterococcus faecium* isolates on Mueller-Hinton agar.

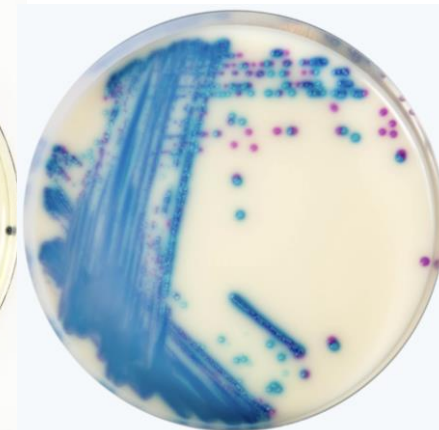
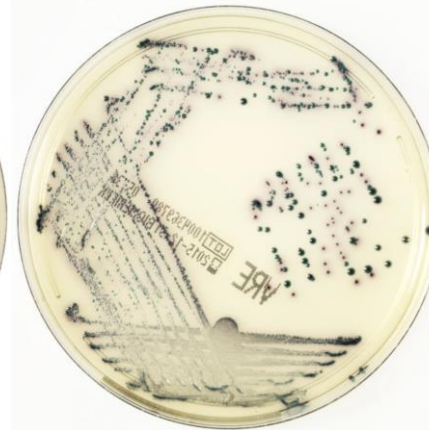
- (A) Sharp inhibition zone of *vanA/vanB*-negative, vancomycin-susceptible strains;
- (B) atypical inhibition zone with shady growth showing resistant MICs in *vanB*-type *E. faecium*;
- (C) atypical inhibition zone with shady growth showing susceptible MICs in *vanB*-type *E. faecium*;
- (D) growth of microcolonies inside the inhibition zone in some *vanB*-type *E. faecium* (heteroresistance phenotype)

Sensitivity: ~ 98%
Specificity: ~ 85%

Chromogenic VRE screening plates



Spectra™ VRE



CHROMID® VRE

CHROMMagar™ VRE

Sensitivity: ~ 98%
Specificity: ~ 98%

Faron ML. et al., J Clin Microbiol. 2016

Klare I. Diagn Microbiol Infect Dis. 2012

Method	Resistance genes
Alifax Molecular Mouse System GRAM POS RESIST	vanA, vanB
BioFire FilmArray Blood Culture Identification 2 (BCID2), Pneumonia plus (PNplus) panels and Joint Infection (JI) Panel	vanA/B
Eplex BCID-GN Panel	vanA, vanB
Eurospital Sepsis Flow Chip Kit Eurospital MDR Flow Chip Kit	vanA, vanB
Unyvero Cartridge (Blood Culture, Hospitalized Pneumonia, Implant & Tissue Infection, Intra-Abdominal Infection, Urinary Tract Infection)	vanA, vanB
Verigene Gram-Positive Blood Culture test	vanA, vanB
Eazyplex VRE	vanA, vanB

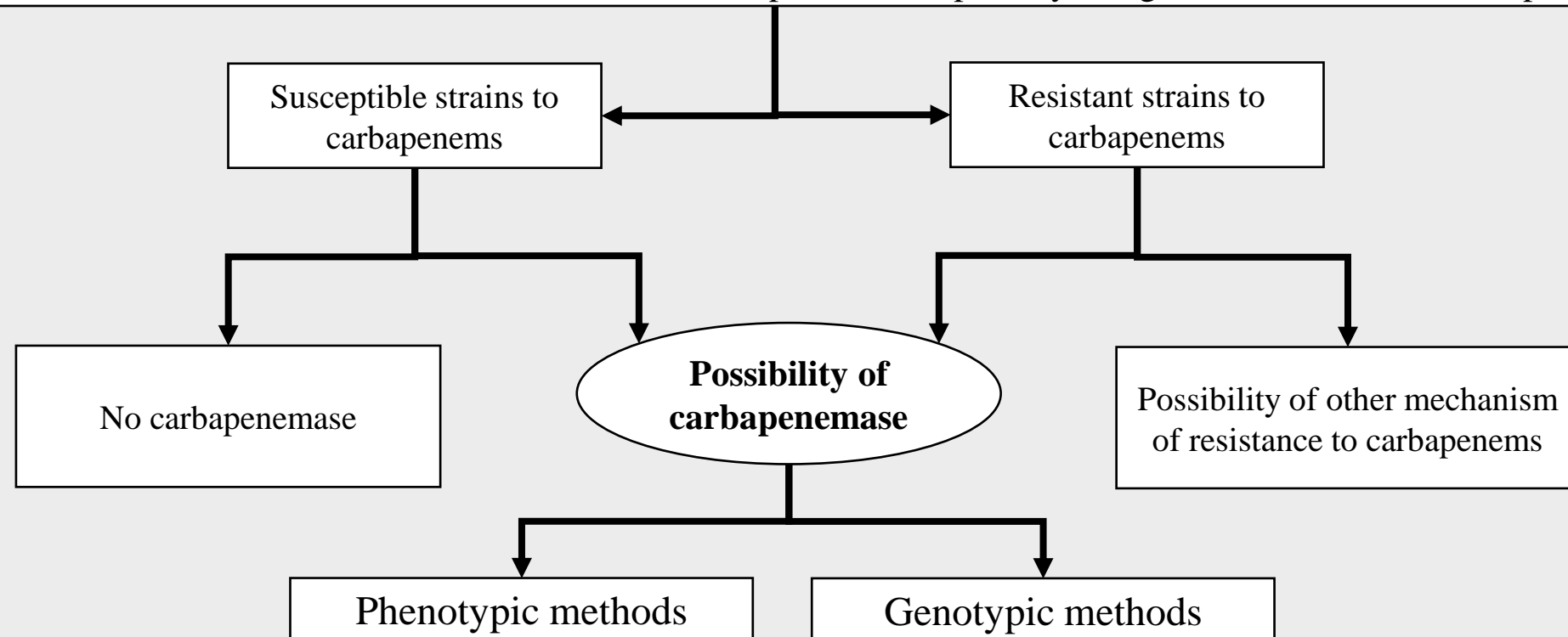
Molecular assays for detection of VRE

Priority 1: CRITICAL

- *Acinetobacter baumannii*, carbapenem-resistant
- *Pseudomonas aeruginosa*, carbapenem-resistant
- *Enterobacterales*, carbapenem-resistant, ESBL-producing

Screening

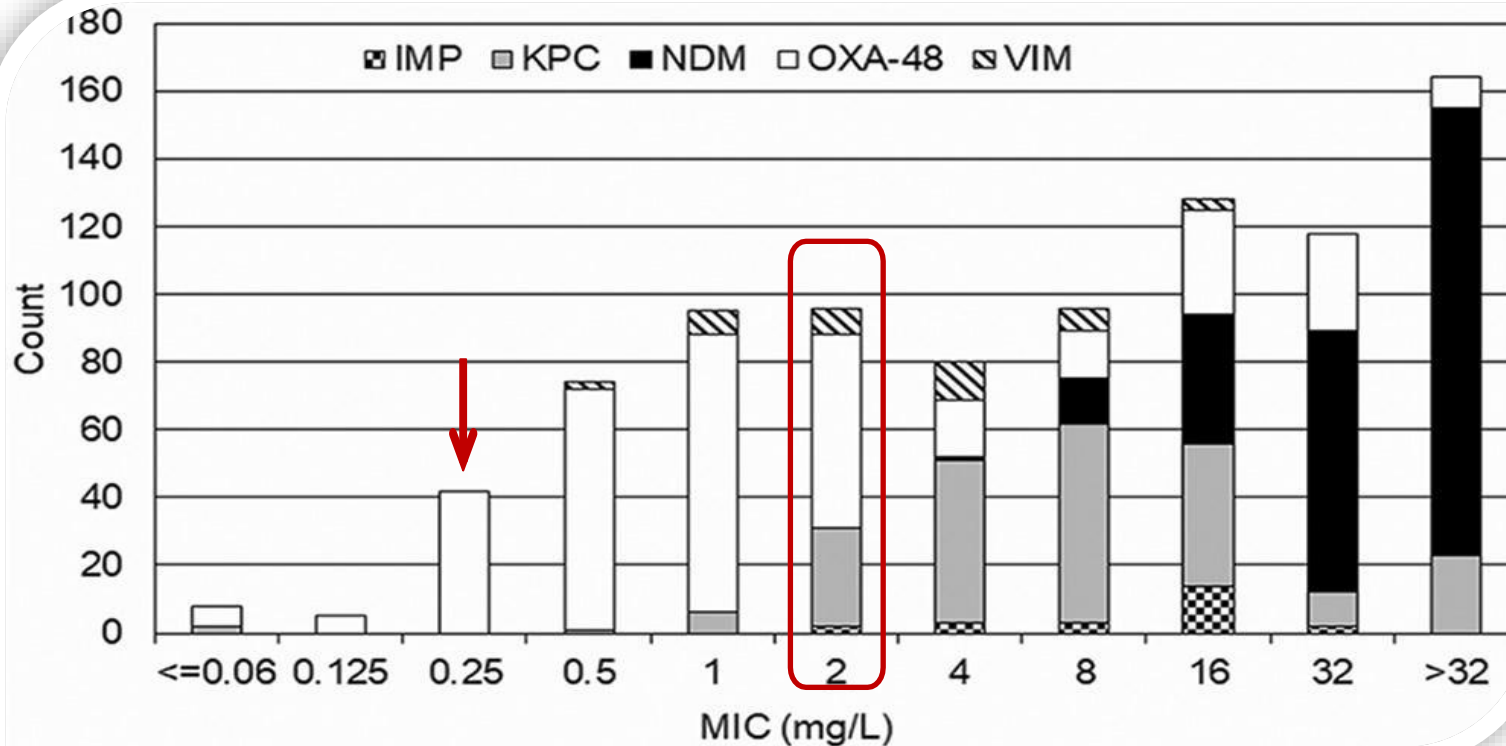
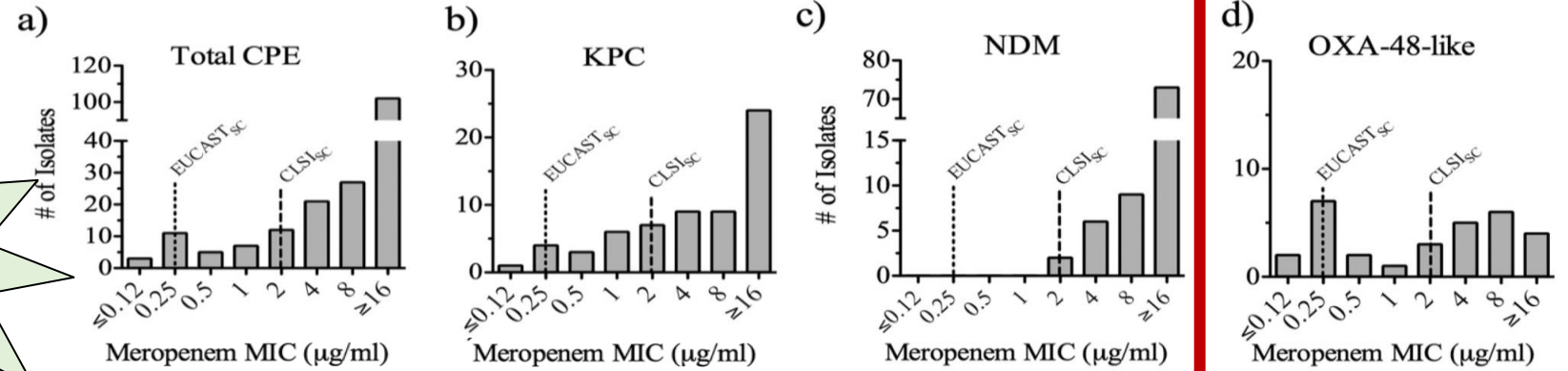
Enterobacterales, Pseudomonas and Acinetobacter carbapenem susceptibility using EUCAST or CLSI breakpoints



What Is the MIC of Meropenem for screening of carbapenemase-producing Enterobacterales?

Meropenem-based screening approaches

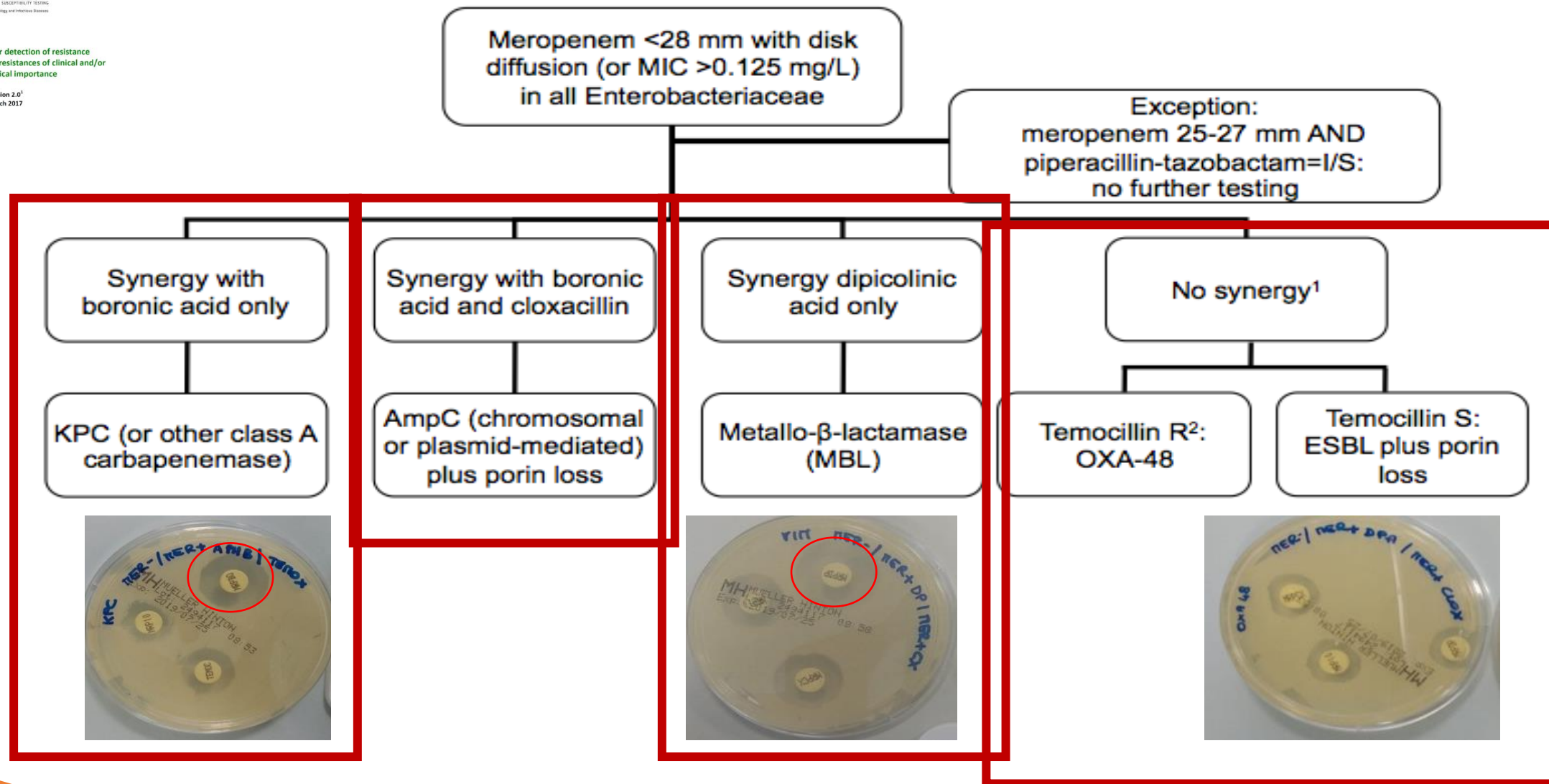
0.25



MIC distribution of meropenem for carbapenemase-producing isolates

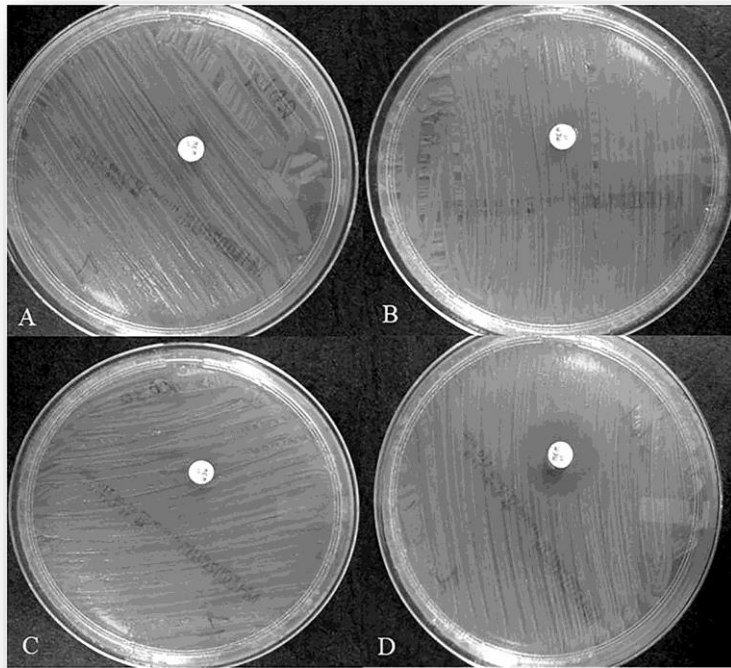
EUCAST: Meropenem MIC breakpoints: susceptible, ≤ 2 μg/ml; resistant, >8 μg/ml

CLSI: Meropenem MIC breakpoints: susceptible, ≤1 μg/ml; resistant, ≥4 μg/ml

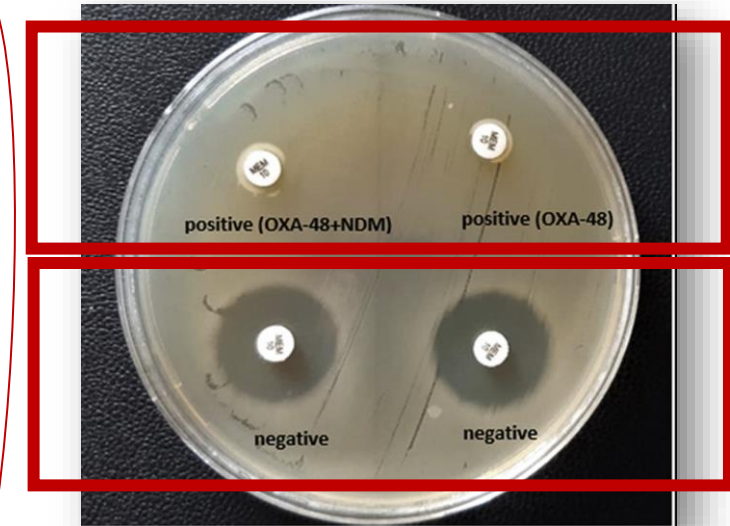


Algorithm for carbapenemase detection

Phenotypic methods for detection of carbapenemase production

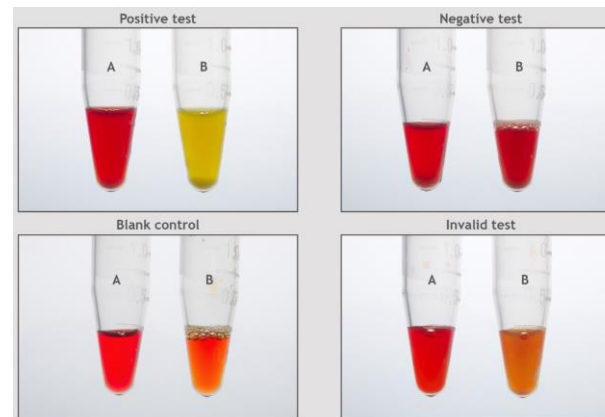


CIM: Sensitivity, 91-94% (**problems with OXA-type e MBL producers**);
Specificity, 99-100%
mCIM: Sensitivity, 93-100%;
Specificity, 97-100%
rCIM: Sensitivity, 97-99%;
Specificity, 95-100%
CIM plus: Sensitivity, 96-98%;
Specificity, 95-100%



Overall, colorimetric assays based on hydrolysis of carbapenems

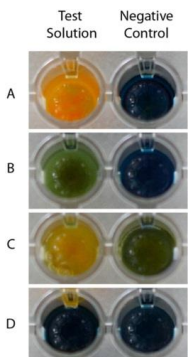
Sensitivity: 85.3%
Specificity: 100%



Carba NP

RAPIDEC®
CARBA NP

β-Carba



Blue-Carba

Chromogenic CRE screening plates



Oxoid Brilliance ESBL



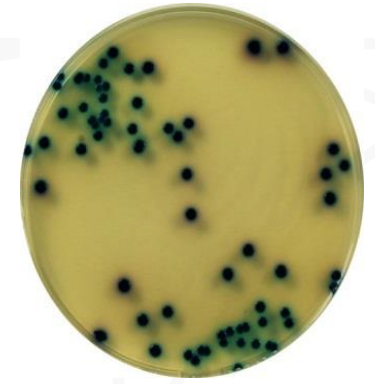
Brilliance CARBA chromID



Carba e Carba Smart

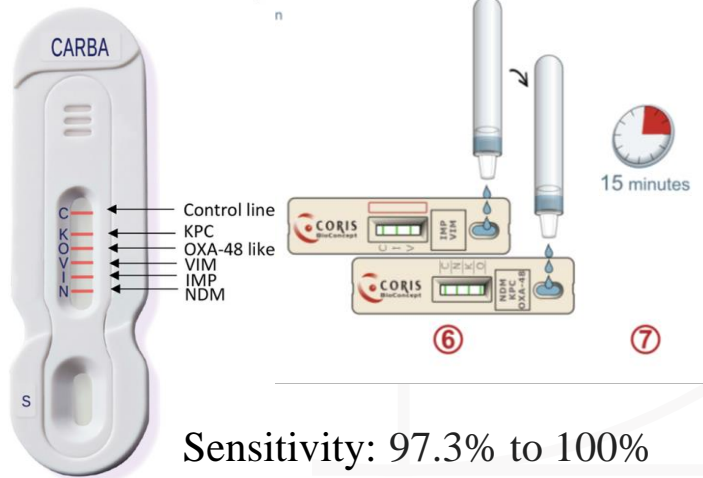


EO Labs Colorex C3Gr e KPC



Antigenic rapid detection of Carbapenemases

Lateral Flow Immunoassay



Sensitivity: 97.3% to 100%
Specificity: 96.1% to 100%



URINE

2 h preincubation *

Sensitivity: 85.7–100
Specificity: 99.4–100



BLOOD
CULTURE

2 min

Sensitivity: 88–100
Specificity: 100



RECTAL
SWAB

overnight incubation

Sensitivity: 66.6–100
Specificity: 100

Fernandez-Pittol M. et al., J Clin Microbiol. 2024 - Volland H. et al., J Antimicrob Chemother. 2022

Boutal H. et al., Diagnostics (Basel). 2022

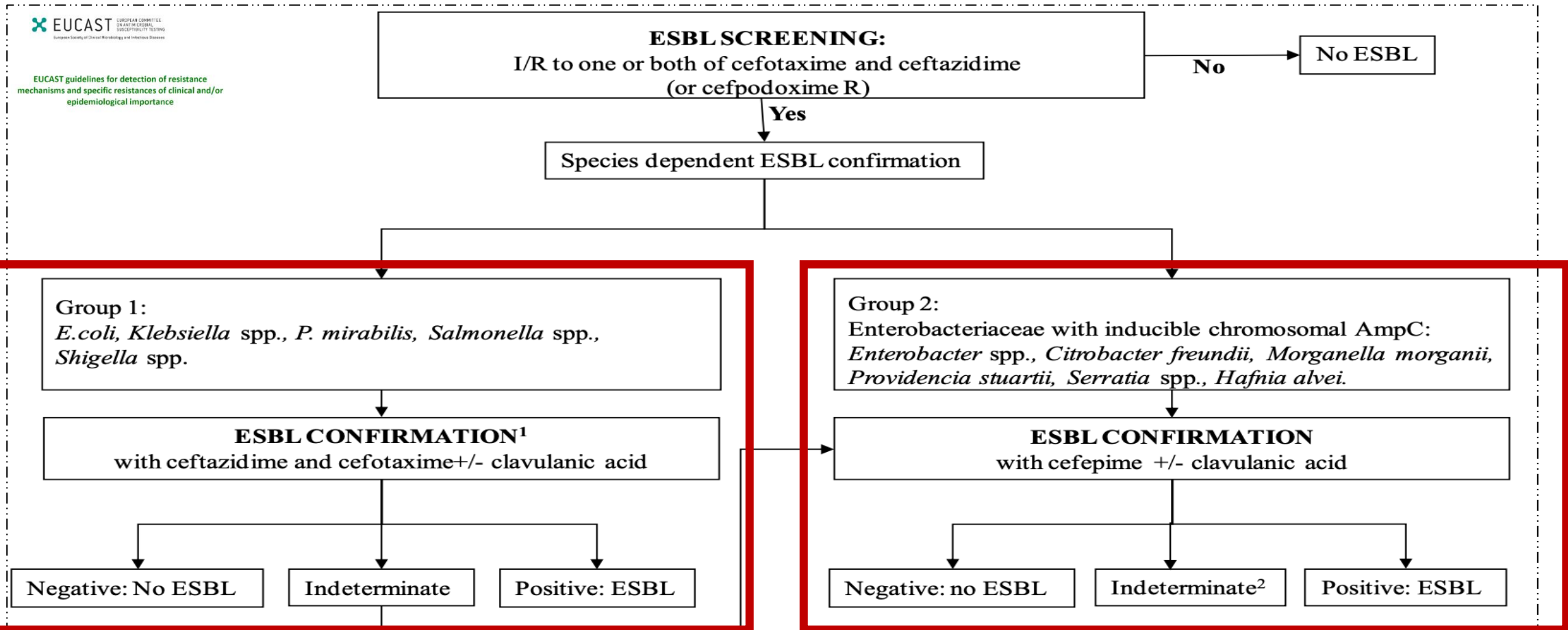
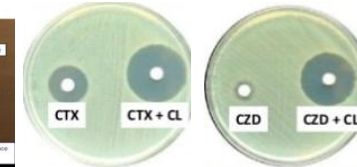
Glupczynski Y. et al. Journal of Antimicrobial Chemotherapy 2017

Priority 1: CRITICAL

• *Enterobacterales*, ESBL-producing

- ESBL gradient test
- Combination disk diffusion test (CDT)
- Broth microdilution
- Double disk synergy test (DDST)

Extended-spectrum β -lactamase (ESBL) producing *Enterobacterales*



ESBL phenotype



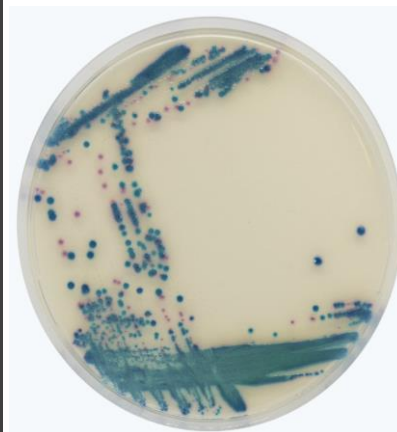
Presence of other combined mechanisms of cephalosporins resistance



Rapid ESBL NP

Sensitivity: 92%
Specificity: 100%

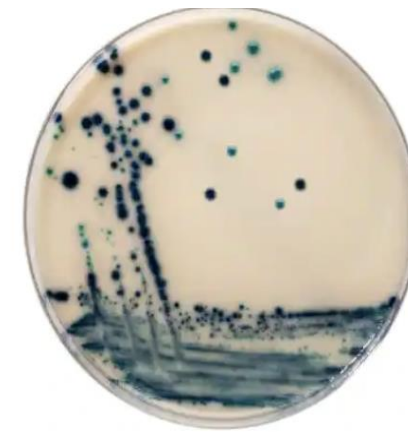
Chromogenic ESBL screening plates



CHROMagar™ ESBL



ChromID® ESBL



Brilliance™ ESBL Agar

Antigenic rapid detection of ESBLs



CTX-M ESBL phenotype

Non-CTX-M ESBL phenotype



URINE

2 h preincubation *

Sensitivity: 84.0–100
Specificity: 98.7–100



BLOOD CULTURE

2 min

Sensitivity: 90.9–100
Specificity: 99.6–100



RECTAL SWAB

overnight incubation

Sensitivity: 75.8–100
Specificity: 98.4–100

Sensitivity: 92%
Specificity: 100%

Can be used also as chromogenic AmpC screening plates

Fernandez-Pittol M. et al., J Clin Microbiol. 2024

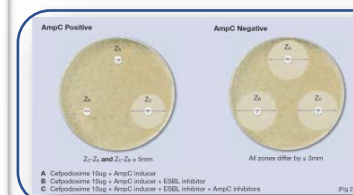
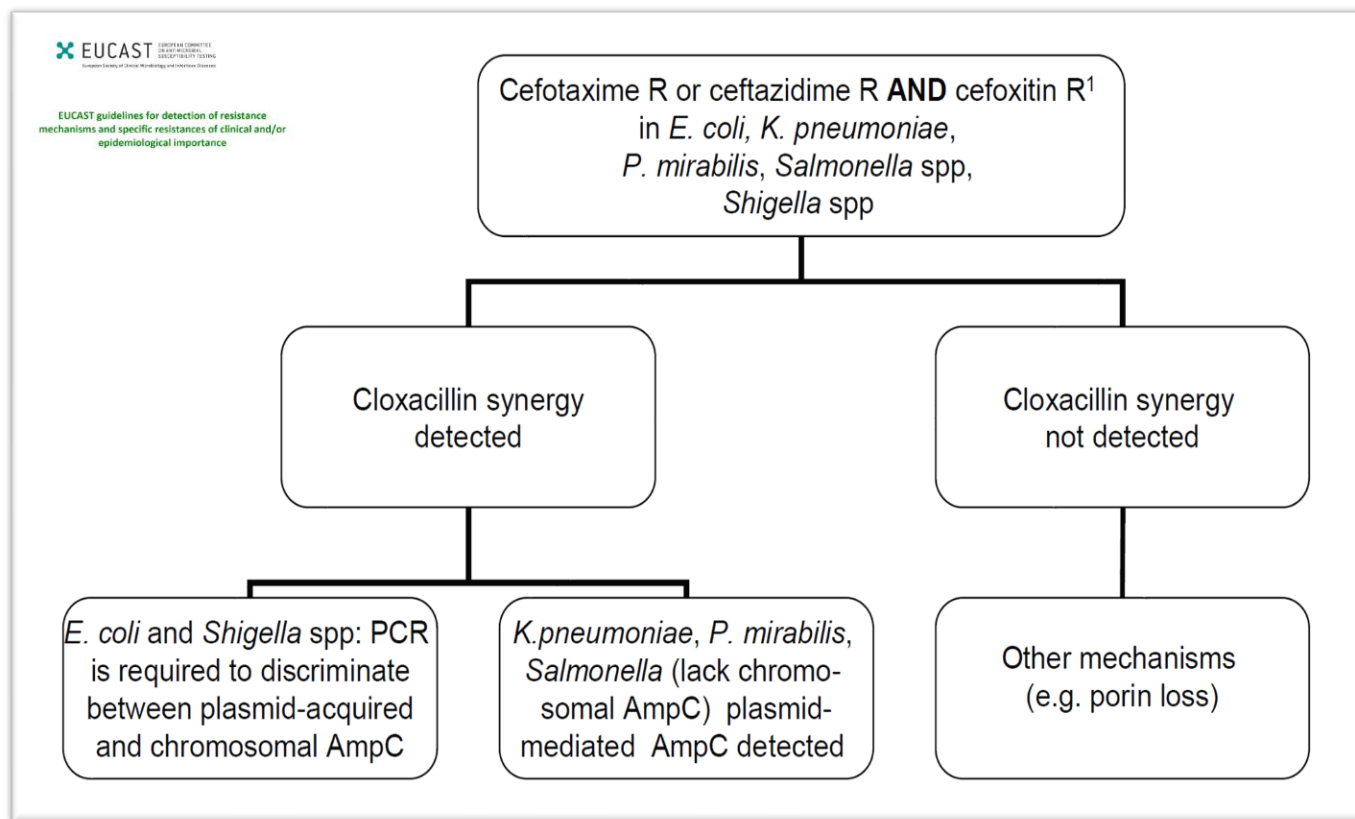
Volland H. et al., J Antimicrob Chemother. 2022

Sandrine Bernabeu et al. Diagnostics 2020

Boattini M. et al., Eur J Clin Microbiol Infect Dis. 2022

Acquired AmpC β -lactamase producing *Enterobacterales*

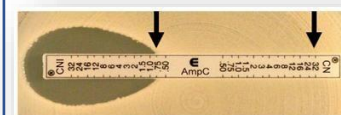
Algorithm for AmpC detection



Mast AmpC detection disc set:

Sensitivity: 96-100%;

Specificity: 98-100%



AmpC gradient test:

Sensitivity: 84-93%;

Specificity: 70-100%



Rosco test:

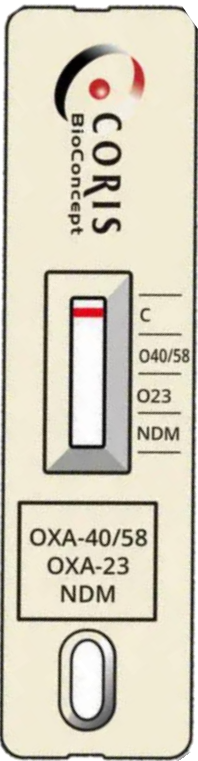
Sensitivity: 96%;

Specificity: 92%

Priority 1: CRITICAL

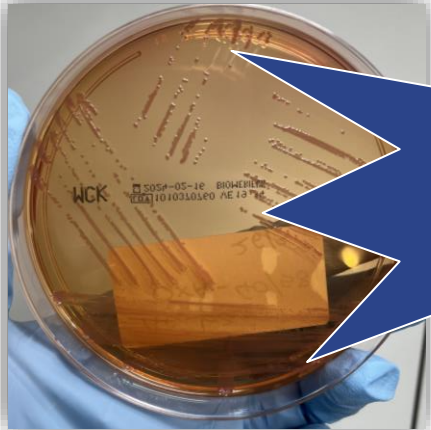
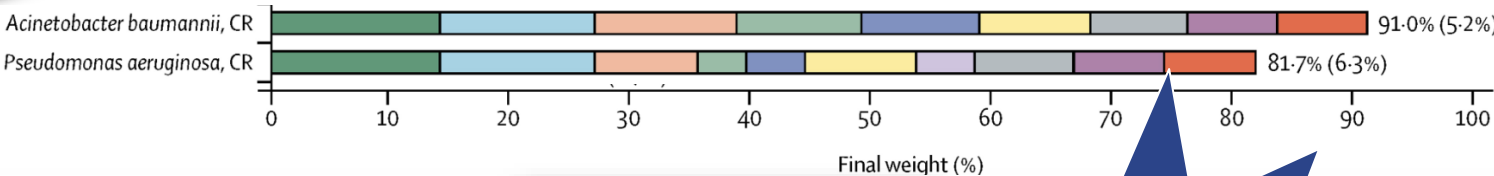
- Acinetobacter baumannii, carbapenem-resistant

Antigenic rapid detection of OXA-23 and OXA-23, OXA-40, OXA-58, NDM



Acinetobacter spp.	Carbapenemase group	n	RESIST ACINETO-ICT test zone					
			OXA-23		OXA-40/58		NDM	
A. baumannii	OXA-23	3	+	(3/3)	-		-	
	OXA-40	11	-		+	(11/11)	-	
	OXA-58	8	-		+	(8/8)	-	
	NDM-1	3	-		-		+	(3/3)
	OXA-23, NDM-1	1	+	(1/1)	-		+	(1/1)
	OXA-23, OXA-58, NDM-1	1	+	(1/1)	+	(1/1)	+	(1/1)
A. pittii	OXA-23	1	+	(1/1)	-		-	
	OXA-40	1	-		+	(1/1)	-	
	OXA-58	2	-		+	(2/2)	-	
A. nosocomialis	OXA-23	1	+	(1/1)	-		-	
	OXA-58	1	-		+	(1/1)	-	
A. radioresistens*	OXA-23	1	+	(1/1)	-		-	
		Σ= 34						

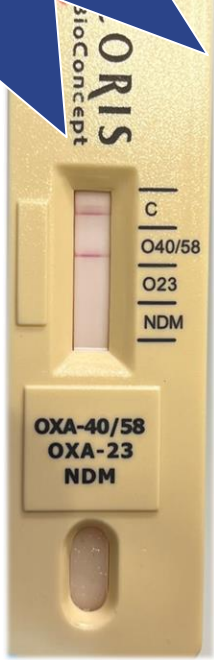
*carbR strains with intrinsic OXA-23 associated with ISAcra1



WGS:
OXA-72

Oxa-40/58-producing A.baumannii

ANTIBIOTICI	MIC	CAT
Amikacina	(>32)	-
Ciprofloxacina	>2	R
Colistina	(1)	-
Imipenem	>16	R
Meropenem	>16	R
Tobramicina	(>32)	-
Trimetoprim/sulfametoxazolo	8/152	R
Gentamicina	(8)	-
Piperacillin /Tazobactam	32	IE



Mancini S. et al., J Antimicrob Chemother. 2023
Bouvier M. et al., Diagn Microbiol Infect Dis. 2023
Mertins S. et al., J Med Microbiol. 2023

Method	Resistance genes
Alifax Molecular Mouse System GRAM NEG RESIST	bla _{CTX-M} , bla _{SHV} , bla _{CMY-1/MOX} , bla _{CMY-2} , bla _{IMP} , bla _{NDM} , bla _{KPC} , bla _{VIM} , bla _{OXA-23} , bla _{OXA-48} , mcr-1, mcr-2
BioFire FilmArray Blood Culture Identification 2 (BCID2), Pneumonia plus (PNplus) panels and Joint Infection (JI) Panel	bla _{CTX-M} , bla _{NDM} , bla _{KPC} , bla _{VIM} , bla _{IMP} , bla _{OXA-48} , mcr-1
Eplex BCID-GN Panel	bla _{CTX-M} , bla _{NDM} , bla _{KPC} , bla _{VIM} , bla _{IMP} , bla _{OXA-23} bla _{OXA-48}
Eurospital Sepsis Flow Chip Kit Eurospital MDR Flow Chip Kit	bla _{CTX-M} , bla _{CMY-1/MOX} , bla _{SHV} , bla _{CMY} , bla _{DHA} , bla _{IMP} , bla _{NDM} , bla _{KPC} , bla _{VIM} , bla _{OXA-23} , bla _{OXA-48} , bla _{NCM/IMI} , bla _{GIM} , bla _{OXA-23} , bla _{OXA-24} , bla _{OXA-51} , bla _{OXA-58} , mcr-1, mcr-2
Unyvero Cartridge (Blood Culture, Hospitalized Pneumonia, Implant & Tissue Infection, Intra-Abdominal Infection, Urinary Tract Infection)	bla _{CTX-M} , bla _{SHV} , bla _{TEM} , bla _{NDM} , bla _{KPC} , bla _{VIM} , bla _{IMP} , bla _{OXA-23} , bla _{OXA-24/40} , bla _{OXA-48} , bla _{OXA-58}
Verigene Gram-Negative Blood Culture test	bla _{CTX-M} , bla _{NDM} , bla _{KPC} , bla _{VIM} , bla _{IMP} , bla _{OXA-48}
Cefeide Xpert Carba-R	bla _{NDM} , bla _{KPC} , bla _{VIM} , bla _{IMP} , bla _{OXA-48}
Eazyplex® SuperBug CRE	bla _{NDM} , bla _{KPC} , bla _{VIM} , bla _{OXA-48} , bla _{OXA181} , bla _{CTX-M-1} , bla _{CTX-M-9}
Eazyplex® SuperBug complete C	bla _{CTX-M} , bla _{NDM} , bla _{KPC} , bla _{VIM} , bla _{IMP} , bla _{OXA-48} , bla _{OXA181}
Eazyplex® SuperBug AmpC	bla _{acc} , bla _{DHA} , bla _{CMYII} , bla _{MOX}
Hologic Novodiag® CarbaR+ Assay	bla _{NDM} , bla _{KPC} , bla _{VIM} , bla _{IMP} , bla _{OXA-48/181} , bla _{OXA23} , bla _{OXA24} , bla _{OXA51} , bla _{OXA58} , mcr-1

Molecular-genetic techniques for detection of resistance genes

Priority 1: CRITICAL

• *Pseudomonas aeruginosa*, carbapenem-resistant

Organism **DETECTED**/
NONE AMRG DETECTED

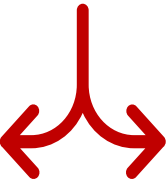
Run Summary

Sample ID:
Organisms Detected: *Pseudomonas aeruginosa*
Applicable Antimicrobial
Resistance Genes Detected: None

Run Date:
Controls:

Note: Antimicrobial resistance can occur via multiple mechanisms. A Not Detected result for antimicrobial resistance gene(s) does not indicate antimicrobial susceptibility. Subculturing is required for species identification and susceptibility testing of isolates.

ANTIBIOTICI	MIC	CAT
Amikacina	(≤4)	-
Aztreonam	4	I
Cefepime	2	I
Ceftazidime	2	I
Ceftazidime/avibactam	2	S
Ceftolozane/tazobactam	1	S
Ciprofloxacina	0,12	I
Colistina	(1)	-
Levofloxacin	1	I
Gentamicina	1	IF
Imipenem	2	I
Meropenem	≤0,25	S
Piperacillina/tazobactam	4	I
Tobramicina	(≤1)	-



ANTIBIOTICI	MIC	CAT
Amikacina	(≤4)	-
Aztreonam	>32	R
Cefepime	16	R
Ceftazidime	16	R
Ceftazidime/avibactam	16	R
Ceftolozane/tazobactam	2	S
Ciprofloxacina	0.25	I
Colistina	(1)	-
Levofloxacin	1	I
Gentamicina	1	IF
Imipenem	16	R
Meropenem	16	R
Piperacillina/tazobactam	16	I
Tobramicina	(>8)	-

The present and near future in which we find ourselves is a 'post-antibiotic era', where the therapeutic arsenal we have is unable to combat the bacterial infections that are emerging.

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***Thank you
for your attention***

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