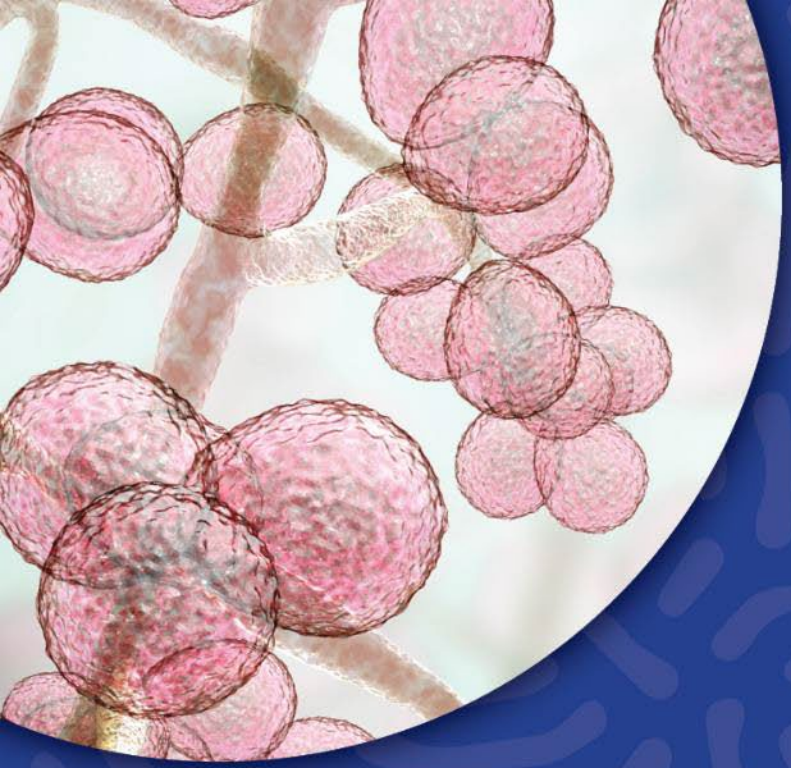

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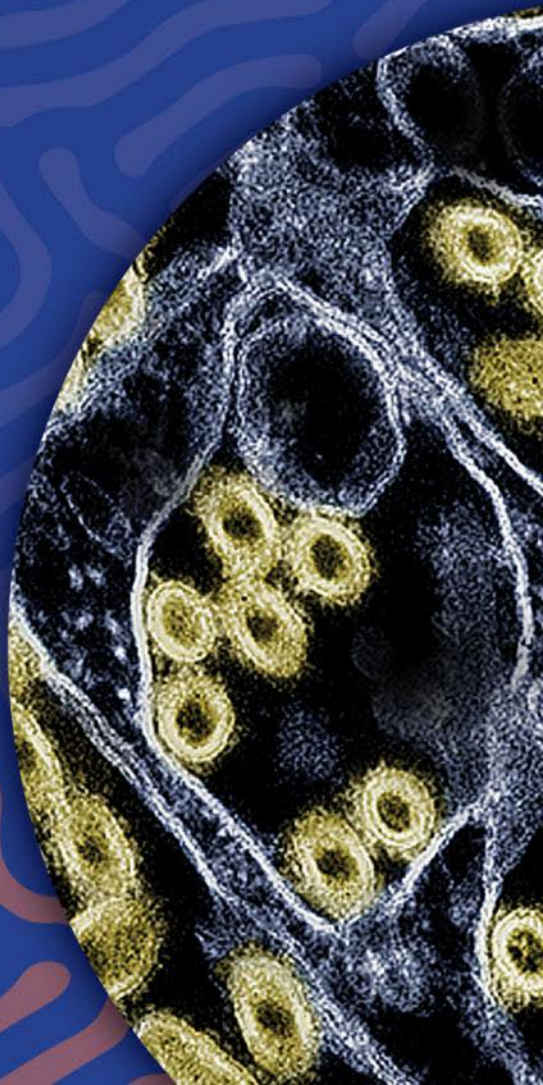

Phenotypic vs. Genotypic

Recommendations for AMR Testing

Jean B. Patel, PhD, D(ABMM)

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Disclosures

Nothing to disclose

Poll Everywhere

PollEv.com/nikkimarchan322

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Phenotypic Antimicrobial Susceptibility Tests (AST) vs Resistance Mechanisms (RMs)

Q: Do we need both types of data?

A: With increasing frequency, the answer is yes!

Q: Do I need both results all of the time?

A: No, just some of the time.

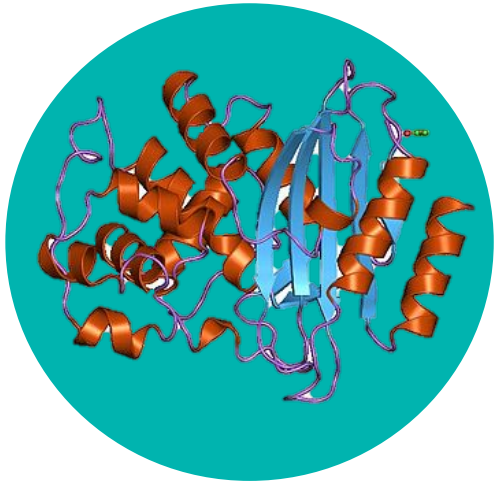
Q: Should I report both result when I have the data?

A: Not necessarily. Reporting needs to be done in a way to drive clinical decision making with minimal confusion.

Q: Is it possible to only perform resistance mechanism testing?

A: Rarely. This could change in the future.

Most Common Methods to Detect RMs



Molecular Assays	Immunoassays	Phenotypic
mec genes	(PBP2a) *mec*A	Penicillinases
van genes	Carbapenemases	ESBLs, Carbapenemases
ESBLs, Carbapenemases		Inducible clindamycin resistance

Useful Applications of RM Testing

1. Early treatment decisions
   - ✓ A RM test result correlates well with phenotypic resistance
   - ✓ The presence of a RM indicates alternative therapy needed

2. More accurate therapy decisions when phenotypic resistance fails to detect antimicrobial resistance of clinical or epidemiological relevance.

3. Improved empiric therapy decisions

Good Correlation of RM and Phenotypic Results

Staphylococcus aureus

- Mec genes account for nearly 100% of methicillin-resistant *Staphylococcus aureus*
- Alternative therapy for serious infections: Vancomycin

***Enterococcus* spp.**

- Van genes account for 100% of vancomycin-resistant *Enterococcus*
- Alternative therapy: Daptomycin or linezolid

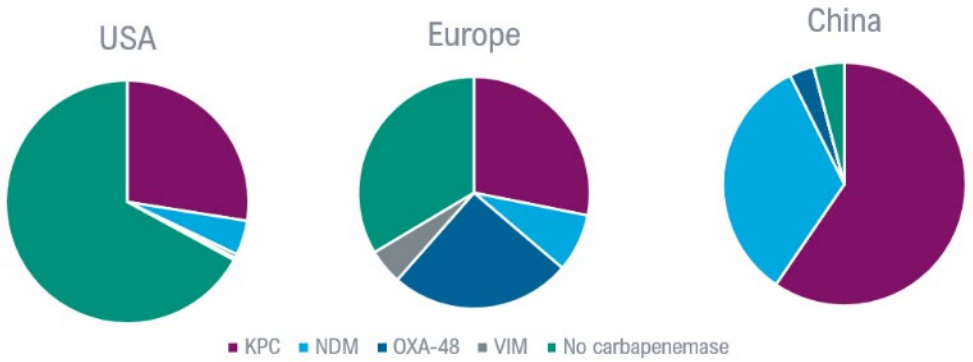
Rapid RM tests for these pathogens usually enables effective patient management

- Ref

Poor Correlation of RM and Phenotypic Results

Enterobacterales

- The presence of a carbapenemase is a subset of carbapenem-resistant isolates.
- The % attributable resistance varies by population



- Identifying resistance and alternative therapies requires phenotypic testing

Rapid RM tests are most informative if positive. Additional rapid phenotypic testing is needed to drive effective therapy

References:
Zhang, Y; et al. 2018. Antimicrobial Agents & Chemotherapy 62 (2)
Nordmann, P; et al. 2019. Clin Infect Dis 69 (Suppl 7)
CDC (Carbapenem-Resistant Enterobacterales | A.R. & Patient Safety Portal (cdc.gov)

https://www.idsociety.org/practice-guideline/amr-guidance/
https://doi.org/10.1093/ofid/ofad287
PMID: 34380549

RM Tests Indicates Therapy Escalation

Extended-spectrum β-lactamase (ESBL)-producing *Escherichia coli* in a urine specimen

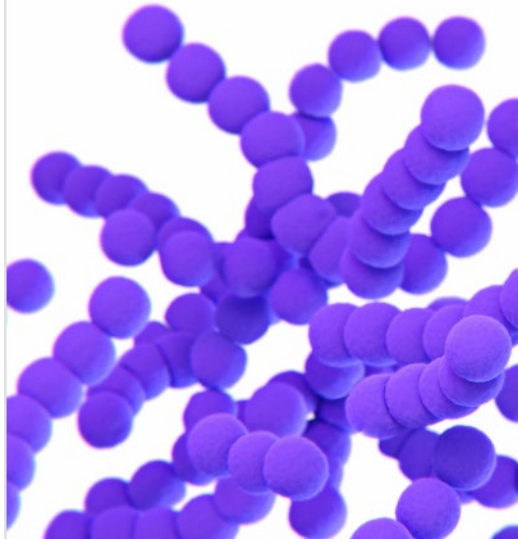
- *E. coli* is the #1 cause of outpatient urinary tract infection (~80%)
- With increasing frequency, these are ESBL-producing isolates (~24% in U.S.)
- IDSA MDRO treatment guideline recommends the following for treatment of uncomplicated UTI cause by ESBL-producing *E. coli*

  A. Trimethoprim-sulfamethoxazole, nitrofurantoin, ciprofloxacin or levofloxacin (Note: These drugs are effective for multiple pathogens, but resistance rates can be high.)

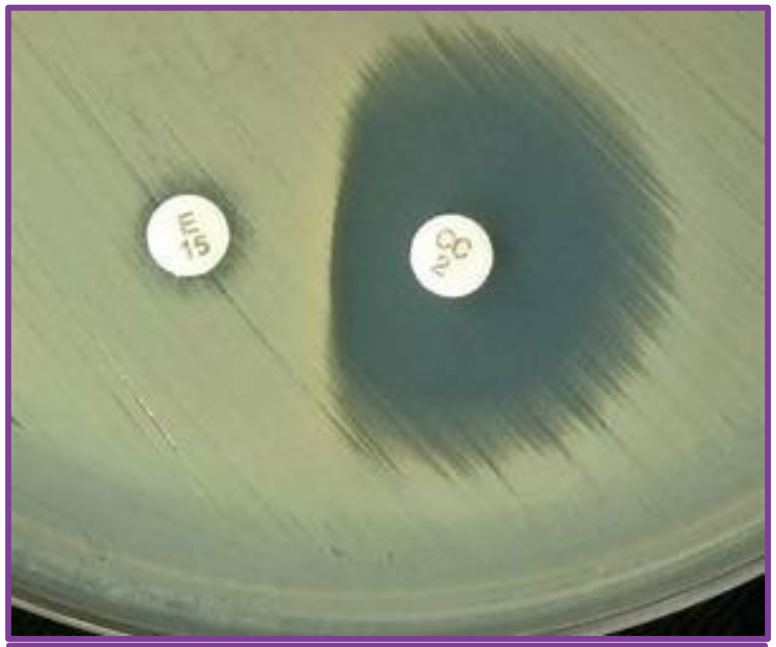
  B. Aminoglycosides or Fosfomycin (Note: Aminoglycosides are IV antibiotics and fosfomycin is effective for *E. coli* UTI only.)

These recommendations introduce a new dependence upon diagnostic testing for outpatient UTIs because ID, AST, and ESBL testing is needed for treatment of a very common infection.

Phenotypic Testing Fails to Detect Resistance



- Inducible clindamycin resistance in *Staphylococcus* and *Streptococcus*.
- This occurs when bacteria acquire *erm* genes, which confers resistance to clindamycin and macrolides (e.g., erythromycin) when fully expressed.
- Isolates test resistant to erythromycin but susceptible to clindamycin during low expression but can convert to high level expression when clindamycin is used clinically.
- Erythromycin can induce gene expression



Solution:

Test susceptibility to clindamycin alone, erythromycin alone and a combination of both drugs.

Clindamycin: susceptible

Erythromycin: resistant

Both drugs: positive growth

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CLSI. Methods for Dilution Antimicrobial Susceptibility Tests for Bacteria That Grow Aerobically 12th ed. CLSI standard M07. Clinical and Laboratory Standards Institute; 2024.

Improved Empiric Treatment Decisions

Adding RM data to an antibiogram provides better information for empirical treatment regimens.

XYZ Institution
Microbiology Laboratory
1 January - 31 December 2021 Cumulative Antimicrobial Susceptibility Test Data - Antibiogram

		PERCENTAGE (%) SUSCEPTIBLE*														
		Aminoglycosides			β-Lactams						Quinolones		Others			
	# Isolates Tested	Amikacin	Gentamicin	Tobramycin	Oxacillin	Ampicillin	Piperacillin/ Tazobactam	Ceftazidime	Ceftriaxone	Meropenem	Ciprofloxacin	Levofloxacin	Clindamycin	Nitrofurantoin§	Chloramphenicol	Trimethoprim sulfamethoxazole
GRAM NEGATIVE																
Escherichia coli	**670**	99	53	92	-	50	97	92	93	99	28	-	-	90	-	72
Klebsiella sp.	**300**	99	72	94	-	R	52	60	61	68	50	-	-	50	-	54
Proteus mirabilis	**75**	100	70	93	-	53	58	61	63	95	55	-	-	R	-	79
Salmonella enterica ser. Typhi (blood isolates only)	**50**	-	-	-	-	50	-	-	69	-	90	-	-	-	22	86
Pseudomonas aeruginosa	**187**	97	70	83	-	R	45	53	R	76	60	-	-	-	-	R
GRAM POSITIVE																
Staphylococcus aureus **ALL**	**850**	-	-	-	66	-	-	-	-	-	-	-	81	-	-	97
Staphylococcus aureus **MRSA**	**289**	-	-	-	0	-	-	-	-	-	-	-	32	100#	-	96
Staphylococcus aureus **MSSA**	**561**	-	-	-	100	-	-	-	-	-	-	-	82	100	-	97

* %S for each organism/antimicrobial combination generated by including first isolate of organism encountered in a given patient
§ Nitrofurantoin data for urine isolates only R = intrinsic resistance (-) drug not routinely tested or indicated for this organism

This can improve antibiotic use when:

1. A rapid RM test is used
2. The patient is likely to be infected with a resistant pathogen

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The Clinical and Laboratory Standards Institute (CLSI) Analysis and Presentation of Cumulative Antimicrobial Susceptibility Test Data. 5th ed. CLSI guideline M39. Clinical and Laboratory Standards Institute, USA, 2022.

What if Phenotypic and RM Results Disagree?

CLSI M100 Appendix G. Using Molecular Assays for Resistance Detection

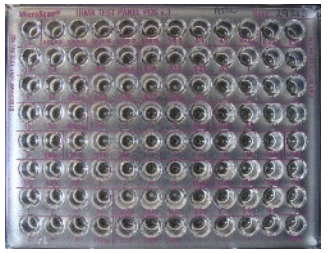
- Table G1: Methicillin (Oxacillin) vs *Staphylococcus aureus*
- Table G2: Vancomyicn vs *Enterococcus* spp.
- Table G3: Detection of ESBLs or carbapenemases in *Enterobacterales*

Table G1. Strategies for Reporting Methicillin (Oxacillin) Results When Using Molecular and Phenotypic AST Methods for *S. aureus*

Indication	Resistance Mechanism(s)	Methods	Specimen Types	Results		Suggestions for Resolution	Consider Reporting as[a]:	Comments[b]
				Resistance Mechanism(s) Detected	Phenotypic AST (if tested)			
Detecting methicillin (oxacillin) resistance in *S. aureus*	PBP2a	Latex agglutination, immuno-chromatography	Colony	PBP2a positive	Cefoxitin R	N/A	Methicillin (oxacillin) R	1
				PBP2a negative	Cefoxitin S	N/A	Methicillin (oxacillin) S	1
				PBP2a positive	Cefoxitin S	Confirm isolate identification, repeat latex agglutination and AST, and consider *mecA* colony NAAT, if available.	If discrepancy is not resolved by suggested testing, report as methicillin (oxacillin) R.	1–2

https://clsi.org/all-free-resources/

When to Detect RMs & Commonly Used Tests



	Direct from specimen	Direct from Positive Blood Culture (PBC)	Initial subculture	Built into AST	Post AST
	Early treatment decisions	Early treatment decisions	Early treatment decisions	Detect Rms not reliably detection using phenotypic methods	Confirm or characterize phenotypic resistance for treatment or epidemiological purposes.
Blood LRTI	T2 Diagnostics BioFire FilmArray System cobas eplex system Verigene System	BioFire Film Array System cobas eplex system Verigene System Xpert MRSA/SA	Molecular Assay Systems: Roche cobas system Cepheid Xpert BD Max ClearView PBP2a NG-Test CARBA 5	Vitek 2 Vitek Reveal BD Phoenix MicroScan SeLux	Same as initial subculture
Rectal Swab	BD Max CPO Xpert Carba-R				
Nasal Swab	Cobas MRSA/SA Xpert MRSA/SA BD Max MRSA/SA				

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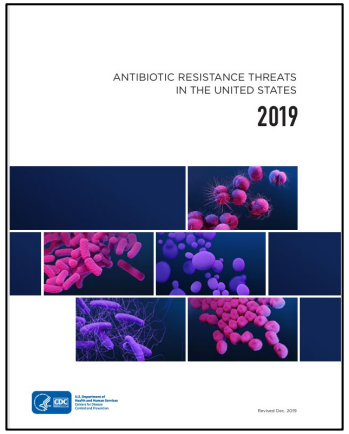
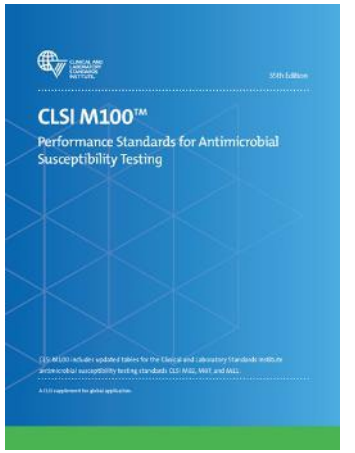
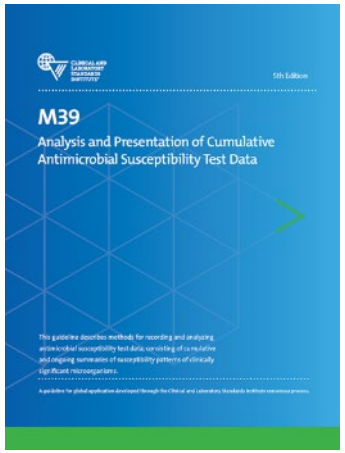
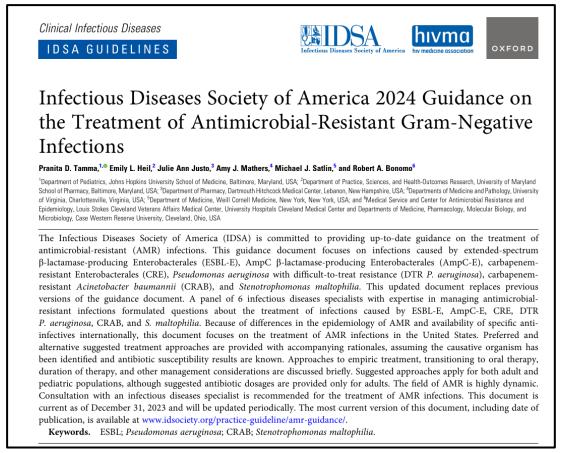
Resources

- CDC – The epidemiology of AMR threats
- CLSI – Testing and reporting recommendations
- IDSA – Treatment Recommendations








Clinical Infectious Diseases
IDSA GUIDELINES

Infectious Diseases Society of America 2024 Guidance on the Treatment of Antimicrobial-Resistant Gram-Negative Infections

Pranita D. Tamma,[1,a] Emily L. Heil,[2] Julie Ann Justo,[3] Amy J. Mathers,[4] Michael J. Satlin,[5] and Robert A. Bonomo[6]

[1]Department of Pediatrics, Johns Hopkins University School of Medicine, Baltimore, Maryland, USA; [2]Department of Practice, Sciences, and Health-Outcomes Research, University of Maryland School of Pharmacy, Baltimore, Maryland, USA; [3]Department of Pharmacy, Dartmouth-Hitchcock Medical Center, Lebanon, New Hampshire, USA; [4]Departments of Medicine and Pathology, University of Virginia, Charlottesville, Virginia, USA; [5]Department of Medicine, Weill Cornell Medicine, New York, New York, USA; and [6]Medical Service and Center for Antimicrobial Resistance and Epidemiology, Louis Stokes Cleveland Veterans Affairs Medical Center, University Hospitals Cleveland Medical Center and Departments of Medicine, Pharmacology, Molecular Biology, and Microbiology, Case Western Reserve University, Cleveland, Ohio, USA

The Infectious Diseases Society of America (IDSA) is committed to providing up-to-date guidance on the treatment of antimicrobial-resistant (AMR) infections. This guidance document focuses on infections caused by extended-spectrum β-lactamase-producing Enterobacterales (ESBL-E), AmpC β-lactamase-producing Enterobacterales (AmpC-E), carbapenem-resistant Enterobacterales (CRE), *Pseudomonas aeruginosa* with difficult-to-treat resistance (DTR *P. aeruginosa*), carbapenem-resistant *Acinetobacter baumannii* (CRAB), and *Stenotrophomonas maltophilia*. This updated document replaces previous versions of the guidance document. A panel of 6 infectious diseases specialists with expertise in managing antimicrobial-resistant infections formulated questions about the treatment of infections caused by ESBL-E, AmpC-E, CRE, DTR *P. aeruginosa*, CRAB, and *S. maltophilia*. Because of differences in the epidemiology of AMR and availability of specific anti-infectives internationally, this document focuses on the treatment of AMR infections in the United States. Preferred and alternative suggested treatment approaches are provided with accompanying rationales, assuming the causative organism has been identified and antibiotic susceptibility results are known. Approaches to empiric treatment, transitioning to oral therapy, duration of therapy, and other management considerations are discussed briefly. Suggested approaches apply for both adult and pediatric populations, although suggested antibiotic dosages are provided only for adults. The field of AMR is highly dynamic. Consultation with an infectious diseases specialist is recommended for the treatment of AMR infections. This document is current as of December 31, 2023 and will be updated periodically. The most current version of this document, including date of publication, is available at www.idsociety.org/practice-guideline/amr-guidance/.

Keywords. ESBL; *Pseudomonas aeruginosa*; CRAB; *Stenotrophomonas maltophilia*.

www.cdc.gov, www.clsi.org, www.idsociety.org

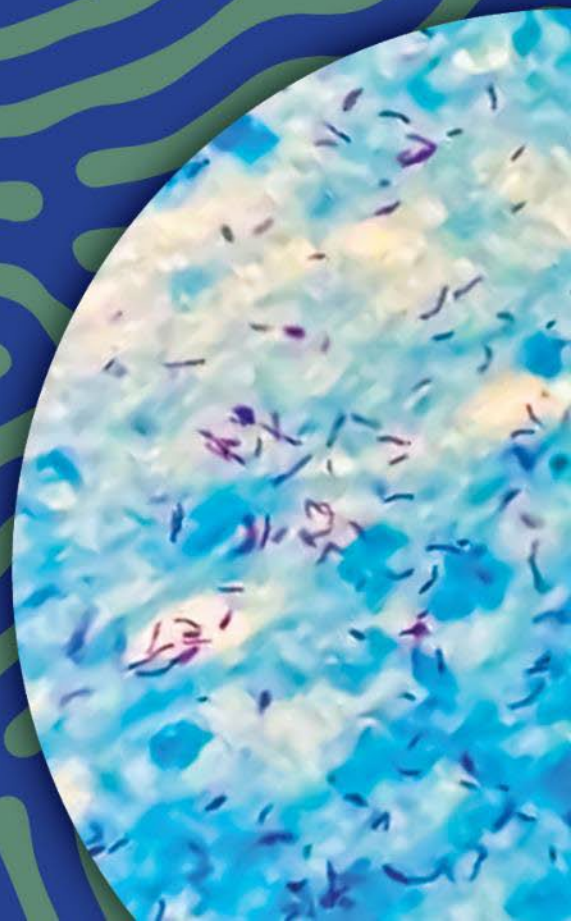
Evolving Thoughts on RM Testing Over Time

The mechanism doesn't matter. We just need to know the MIC.

RM testing is useful for infection control and epidemiological purposes only.

RM testing is important for early treatment decisions and better empiric therapy.

Recommendations will continue to evolve as resistance increases and new diagnostics come to market.



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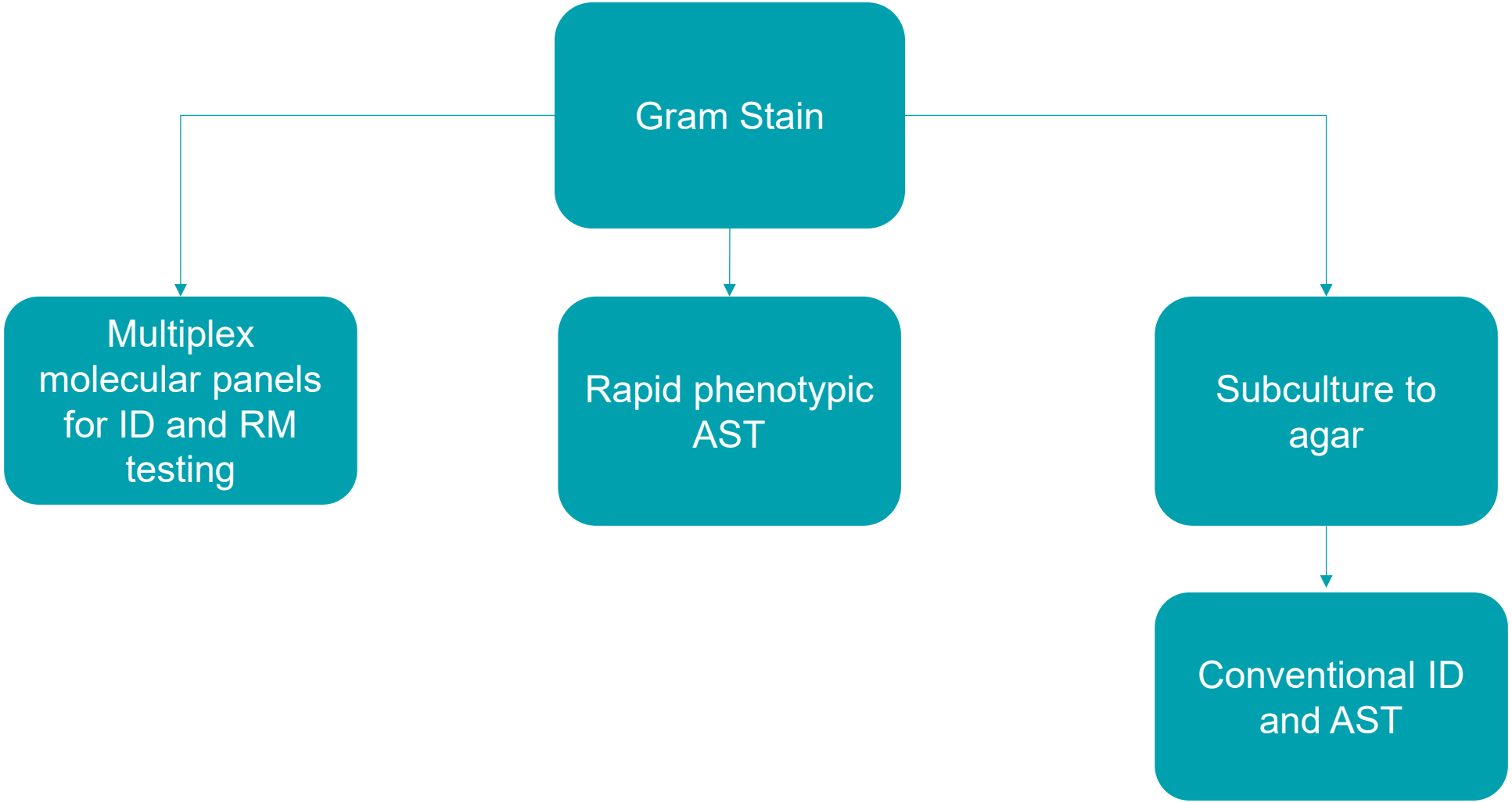
Case Study #1

Case 1: Native Valve Endocarditis

- A 77-year-old woman was hospitalized with a 1-week history of progressive shortness of breath, cough and lower limb edema. She had a prior history of arterial hypertension.
- The patient was febrile, tachycardic, and had a low oxygen saturation on air. White blood cells were elevated. Chest Xray and transthoracic echocardiogram suggested endocarditis.
- Blood cultures were collected, and the patient was started on vancomycin and gentamicin.
- The blood culture bottles were positive and tested using the lab's standard protocol.

Case based upon: Dias T, de Almeida J, Santos A, Santos RM, Carvalho A EJCRIM 2019;6: doi:10.12890/2019_001054.

Positive Blood Culture Testing Protocol



Diagnostic Results – Rapid Molecular Panel

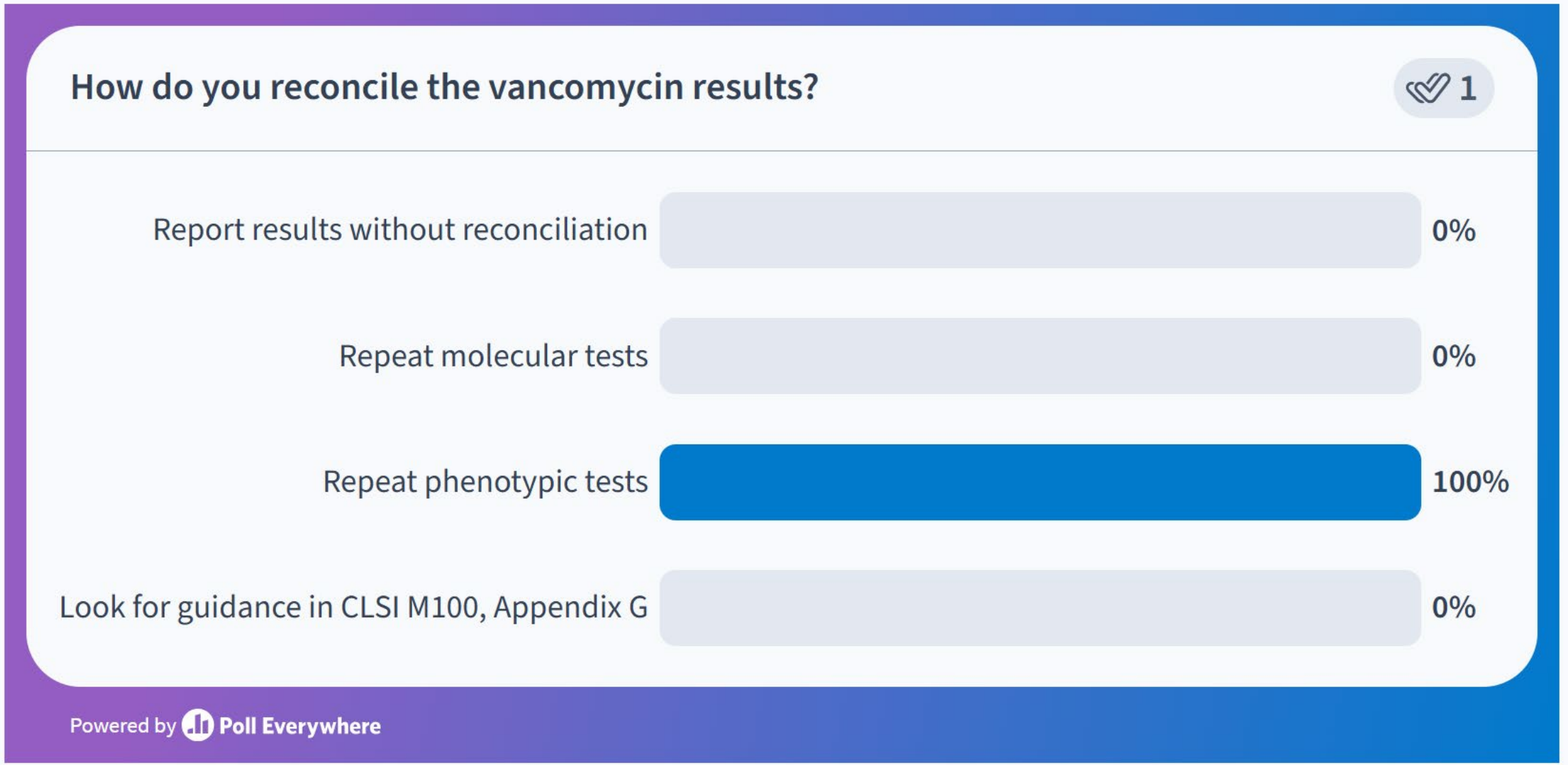
Target	Result
Staphylococcus lugdunensis	**Not Detected**
Streptococcus	**Not Detected**
Streptococcus pneumoniae	**Not Detected**
Streptococcus agalactiae	**Not Detected**
Streptococcus anginosus group	**Not Detected**
Streptococcus pyogenes	**Not Detected**
Bacillus cereus group	**Not Detected**
Bacillus subtilis group	**Not Detected**
Bacillus cereus group	**Not Detected**
Cutibacterium acnes	**Not Detected**
Enterococcus	**DETECTED**
Enterococcus faecalis	**Not Detected**
Enterococcus faecium	**Not Detected**

Target	Result
Lactobacillus	**Not Detected**
Listeria	**Not Detected**
Listeria monocytogenes	**Not Detected**
Micrococcus	**Not Detected**
Staphylococcus	**Not Detected**
Staphylococcus aureus	**Not Detected**
Staphylococcus epidermidis	**Not Detected**
mecA	**Not Detected**
mecC	**Not Detected**
vanA	**Not Detected**
vanB	**Not Detected**

Rapid Phenotypic AST Results for *Enterococcus* spp.

Drug	Interpretation
Ampicillin	S
Ceftaroline	S
Daptomycin	S
Linezolid	S
Vancomycin	I

The molecular test results are negative for *vanA* and *vanB*, but the phenotypic test indicates vancomycin non-susceptibility. This is a discrepancy that should be addressed because the patient may be on the wrong therapy.


How do you reconcile the vancomycin results?
1
Report results without reconciliation
0%
Repeat molecular tests
0%
Repeat phenotypic tests
100%
Look for guidance in CLSI M100, Appendix G
0%
Powered by Poll Everywhere

Consult M100, Appendix G

Indication	Resistance Mechanism(s)	Methods	Specimen Types	Results		Suggestions for Resolution	Report as:	Comments[a]
				Resistance Mechanism(s) Detected	Phenotypic AST (If tested)			
Detection of VRE	*vanA* *vanB*	NAAT or array hybridization technology	Blood culture broth or surveillance cultures	*vanA* and/or *vanB* detected	Vancomycin R	N/A	Report phenotypic result as found (if available); consider reporting presence of molecular target per institutional protocol.	1–3
				vanA and/or *vanB* not detected	Vancomycin S	N/A	Report phenotypic result as found (if available); consider reporting presence of molecular target per institutional protocol.	
				vanA and/or *vanB* detected	Vancomycin S	Confirm isolate identification to species level (eg, *E. faecalis*) and repeat AST. If mixed culture, test isolates individually.	If discrepancy is not resolved by suggested testing, report as vancomycin R.	1–3
				vanA and/or *vanB* not detected	Vancomycin R	Confirm isolate identification to species level (eg, *E. faecalis*) and repeat AST. If mixed culture, test isolates individually.	If discrepancy is not resolved by suggested testing, report as vancomycin R.	4

Comments

(1) *vanA* may be present in nonenterococcal species.[13]

(2) Vancomycin-variable *E. faecium* isolates have been isolated in Canada. They carry wild-type *vanA* but initially test as vancomycin susceptible with a culture-based method. They can convert to a resistant phenotype during vancomycin treatment.[14 15]

(3) The *vanB* gene has been found in several commensal nonenterococcal bacteria, which may lead to misclassification of vancomycin-susceptible enterococci as resistant in surveillance cultures containing mixed bacterial species.[16]

(4) Constitutive low-level vancomycin resistance can be detected phenotypically (2–32 µg/mL) from the presence of *vanC*, an intrinsic resistance characteristic of *E. gallinarum* (*vanC1*) and *E. casseliflavus* (*vanC2–C4*).[17]

(5) Targeting *vanA* only may miss regional *vanB*-carrying VRE.[18]

Enterococcus gallinarum

Epidemiology of Vancomycin-Resistant *Enterococcus*

Table 1 Characteristics of glycopeptide resistance phenotypes in *Enterococcus*

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	*E. faecalis*, *E. faecium*	*E. faecium*	*E. faecalis*, *E. faecium*	*E. faecalis*, *E. faecium*	*E. faecalis*	*E. faecalis*	*E. faecalis*	*E. faecium*	*E. gallinarum*, *E. casseliflavus*

Notes: Data from Boyd et al,[28] Lebreton et al,[29] McKessar et al,[30] and Xu et al.[31] Adapted from Courvalin P. Vancomycin resistance in Gram-positive cocci. *Clin Infect Dis*. 2006;42(Suppl 1):S25–S34, by permission of Oxford University Press.[27]

Abbreviations: MIC, minimum inhibitory concentration; D-Ala-D-Lac, D-alanine-D-lactate; D-Ala-D-Ser, D-alanine-D-serine.

Reasons why RM testing may miss vancomycin resistance:

- Isolates of *E. faecalis* and *E. faecium* may contain van genes other than *vanA* and *vanB*.
- The isolate may be a species with intrinsic vancomycin resistance, *vanC*.

Infection and Drug Resistance 2015:8 217–230

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Case Study #2

Case 2: Ventilator-Associated Pneumonia (VAP)

- A 62 yo male diagnosed with ischemic stroke was admitted to the intensive care unit of the hospital.
- The patient was unresponsive and demonstrated low oxygen saturation on room air. He was immediately intubated and placed on mechanical ventilation to maintain adequate oxygenation.
- On day 5 of ICU admission, the patient developed fever, purulent sputum production and increased respiratory secretions with worsening oxygenation indicating VAP.
- The patient was already receiving empiric therapy with piperacillin-tazobactam, which was escalated to a combination of meropenem and vancomycin.

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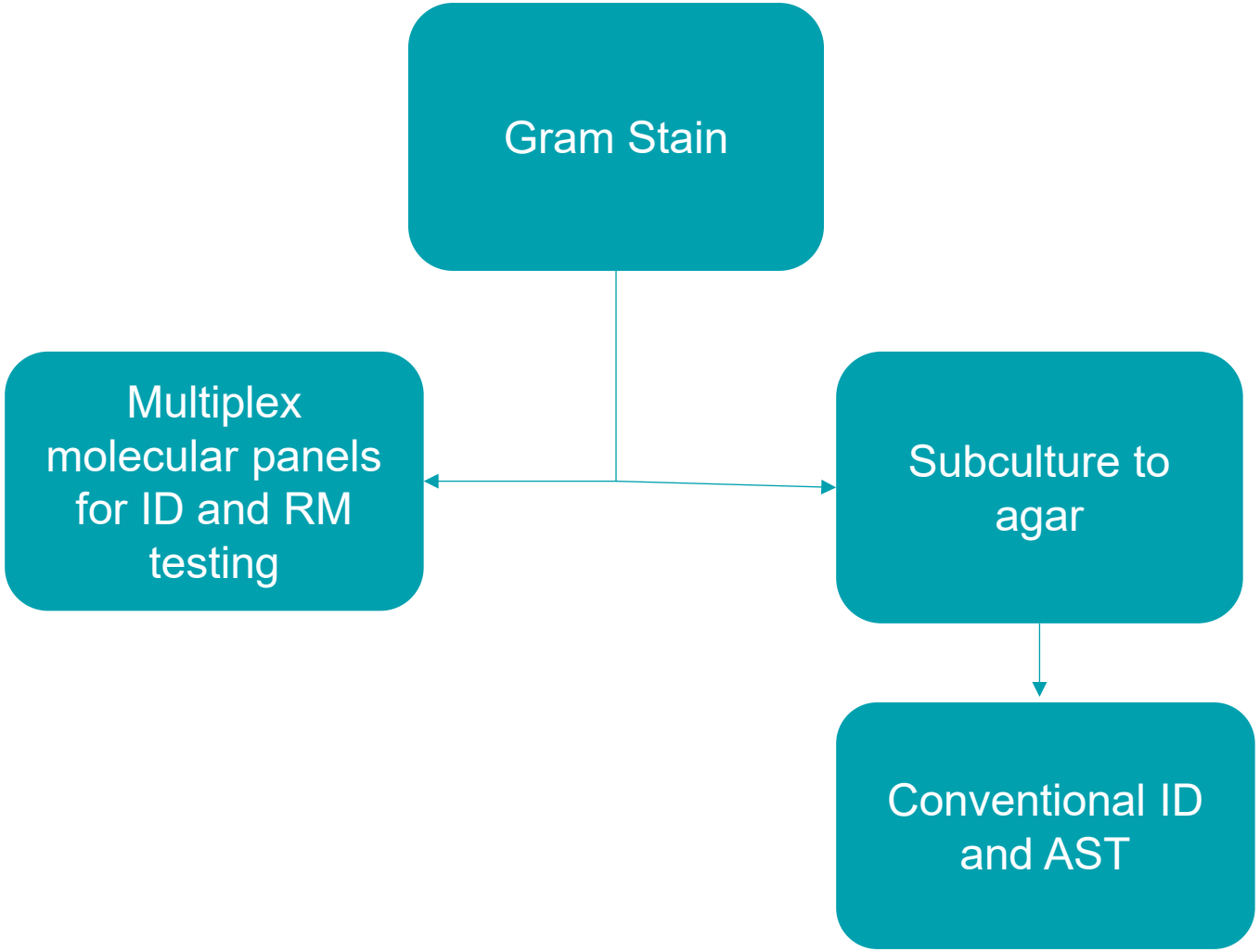
Case based upon: Explor Med. 2025;6:1001271 **DOI:** https://doi.org/10.37349/emed.2025.1001271.

Sputum Testing Protocol



Rapid Molecular Panel Results

Target	Result
Acinetobacter calcoaceticus-baumannii complex	**DETECTED**
Bacteroides fragilis	**Not Detected**
Enterobacter cloacae complex	**Not Detected**
Escherichia coli	**Not Detected**
Klebsiella aerogenes	**Not Detected**
Klebsiella oxytoca	**Not Detected**
Klebsiella pneumoniae group	**Not Detected**
Proteus spp.	**Not Detected**
Serratia marcescens	**Not Detected**
Haemophilus influenzae	**Not Detected**
Pseudomonas aeruginosa	**Not Detected**
Serratia marcescens	**Not Detected**

Target	Result
CTX-M	**Not Detected**
IMP	**Not Detected**
KPC	**Not Detected**
mcr-1	**Not Detected**
NDM	**Not Detected**
OXA-48-like	**Not Detected**
VIM	**Not Detected**

Question 2: Is this isolate carbapenem resistant?

A doctor calls the laboratory and wants to know if the *Acinetobacter* isolate is carbapenem resistant based upon molecular testing. She says this is very important to know because she wants to treat the patient with sulbactam-durlobactam, a new drug for treating VAP caused by *Acinetobacter* spp., but the pharmacy only allows for the drug to be used when carbapenem-resistance is known.

Based upon the molecular results, you can say….

Based upon the molecular results, you can say:

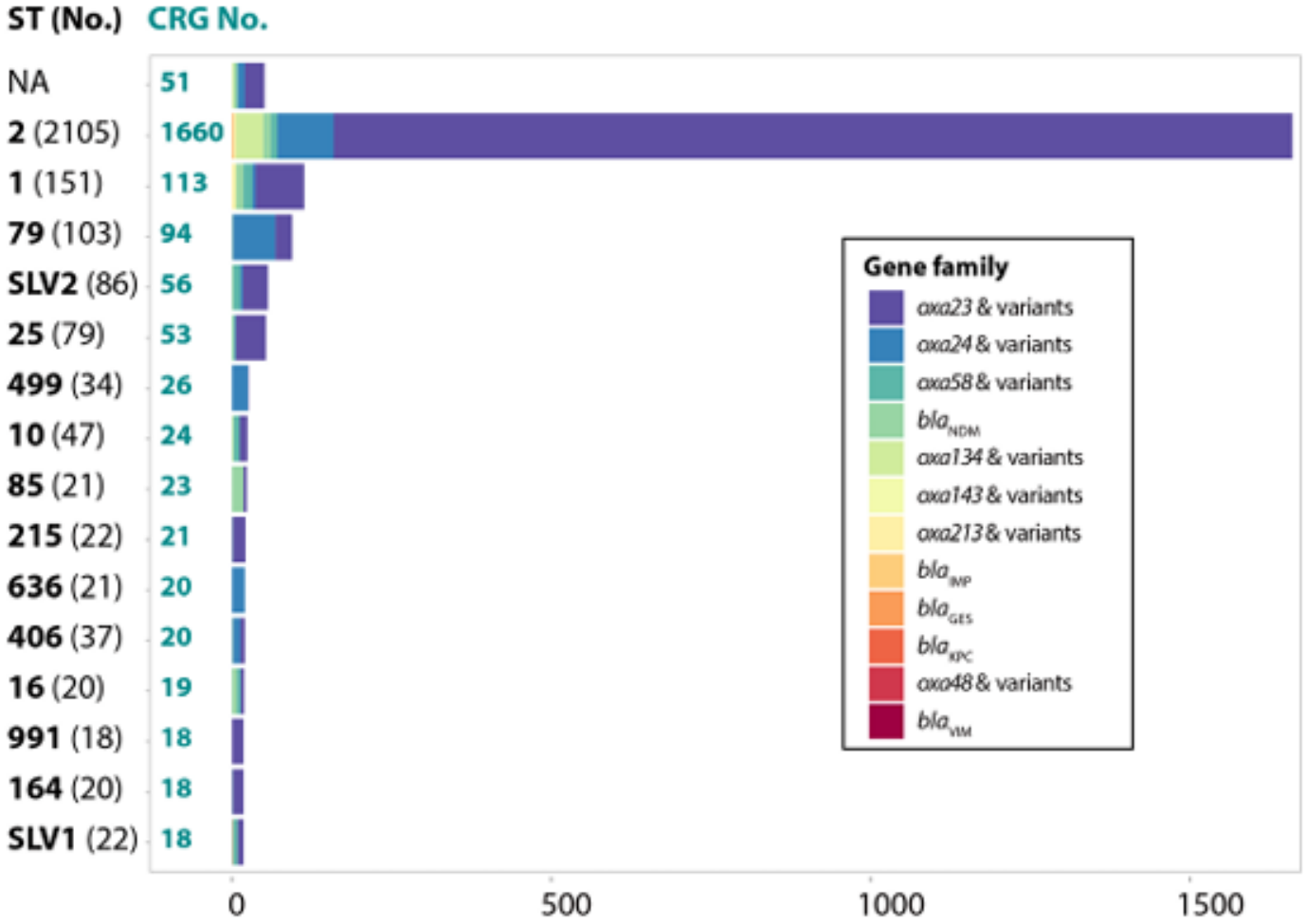
We need to wait for the phenotypic AST results to know if the isolate is carbapenem resistant	0%
The isolate is likely to be carbapenem susceptible.	0%
The isolate is likely to be carbapenem resistant	0%

Phenotypic AST is Needed to Define Resistance

- Response A is correct. Most molecular assays do not accurately predict carbapenem-resistance because they lack molecular markers for *Acinetobacter* spp.
- Cobas eplex can detect OXA-23, a common *Acinetobacter* plasmid-medicated resistance mechanism.
- It is not possible to accurately predict carbapenem susceptibility of *Acinetobacter* healthcare-associated infections (44% of *Acinetobacter* healthcare-associated infections are carbapenem resistant per NHSN).

Infect Control Hosp Epidemiol. 2020 January ; 41(1): 1–18. doi:10.1017/ice.2019.296

The Epidemiology of Carbapenem-Resistant *Acinetobacter*

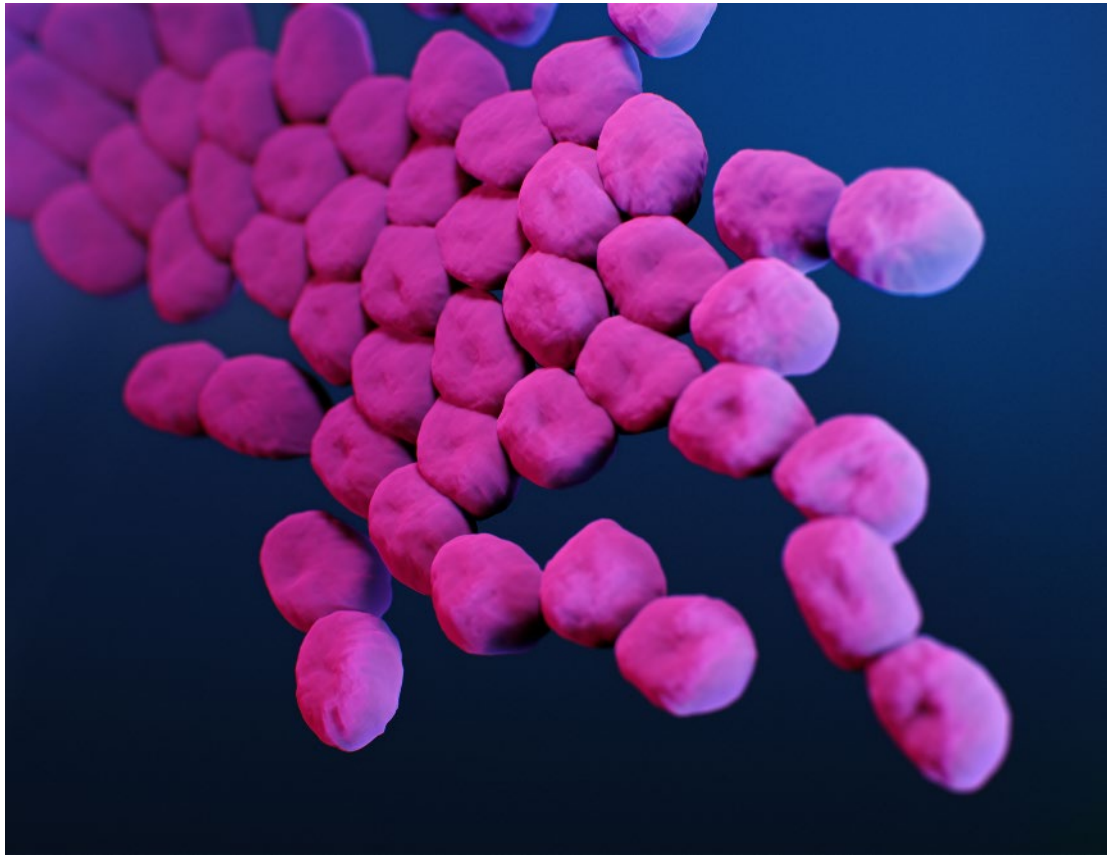


- All CARB isolates harbor a carbapenemase. Most are a OXA variant.
- Efflux and permeability mechanisms can contribute to beta-lactamase-mediated resistance.
- KPC, NDM and VIM carbapenemases are rare, but important

Hamidian and Nigro, Microbial Genomics 2019;5 DOI 10.1099/mgen.0.000306

Rapid Results for *Acinetobacter* spp.

- Antibiotic stewardship programs may choose to restrict use of new drugs for two reasons:
  1. To preserve the activity of the new drug
  2. To conserve costs; use off-patent drugs rather than new drugs
- Molecular test to predict resistance in *Acinetobacter* demonstrate poor correlation with phenotype.
- When rapid results are needed for *Acinetobacter* susceptibility, then a rapid phenotypic test is best.
- We need rapid phenotypic AST for specimens other than positive blood cultures.



#IDLabCon

Case Study #3

Case 3: Healthcare-Associated Urinary Tract Infection

- A 76-year-old male with extensive medical history including chronic kidney disease presented to the emergency department with generalized weakness, pain, and confusion. The ED placed a catheter and drained a liter of purulent urine. He was started on empiric ceftriaxone.
- The care team subsequently learned that the patient recently returned from a trip to Israel and Dubai. While in Dubai, the patient fell ill, requiring a 4-week hospitalization during which he was treated for COVID-19 pneumonia.
- During his 4-week hospitalization he received various broad-spectrum antibiotics including piperacillin/tazobactam, linezolid, meropenem, amikacin, and ceftriaxone.

Case based upon: https://www.health.mil/News/Articles/2023/08/01/E-coli-case-report

ID and Phenotypic AST Results from Urine Culture

- The patient's urine culture upon admission grew extensively drug-resistant *E. coli*.

Antibiotic	MIC (µg/ml)	MIC interpretation[a]	DD zone (mm)	DD interpretation
Amikacin[b]	4	S		
Ampicillin[b]	≥32	R		
Cefazolin[b]	≥64	R		
Cefiderocol[c]	≥64	R		
Cefepime[b]	≥64	R		
Ceftazidime[b]	≥64	R		
Ceftriaxone[b]	≥64	R		
Ceftazidime/avibactam[d]	≥32	R		
Ceftolozane/tazobactam[d]	≥8	R		
Ciprofloxacin[b]	≥4	R		
Colistin[d]	≤0.25	I		
Ertapenem[b]	≥8	R		
Fosfomycin[b]			26	S
Gentamicin[b]	≤1	S		
Imipenem[b]	8	R	7	R
Imipenem/relabactam[d]	≥32/4	R		
Levofloxacin[b]	≥8	R		
Meropenem[b]			8	R
Meropenem/vaborbactam[d]	≥64/4	R		
Nitrofurantoin[b]	32	S		
Tobramycin[b]	≥16	R		
Trimethoprim/sulfamethoxazole[b]	≥320	R		

Should the mechanism of resistance be determined?

Yes, carbapenem RM should be characterized regardless of infection site, but testing can be delayed because it is not important for an immediate therapy decision.	0%
Yes, carbapenem RM should be characterized regardless of infection site and testing should be done in a timely manner because results could be important for patient care and infection prevention.	0%
No, RM testing is not needed because some drugs tested susceptible.	0%

Identify RM for Carbapenem-R *Enterobacterales* (CRE)

- Testing should be performed in a timely manner because carbapenemases can impact therapy decisions and are an infection prevention concern
- Methods for RM testing of isolates from culture include PCR and antigen testing.
- IDSA treatment recommendations for complicated UTI caused by CRE
  A. Trimethoprim-sulfamethoxazole, ciprofloxacin or levofloxacin
  B. Ceftazidime-avibactam, meropenem-vaborbactam, imipenem-relebactam, and cefiderocol
  C. Aminoglycosides are an alternative treatment option

- Ref

Final Results

TABLE 2. Antibiotic Resistance Genes Carried by the Sequence Type 410 *Escherichia coli* Isolated from the Initial Urinary Culture, Tripler Army Medical Center

Antimicrobial resistance gene[a]	Predicted phenotype[b]
aac(6')-Ib-cr5	Aminoglycosides: amikacin, tobramycin. Quinolones: ciprofloxacin
aadA2	Aminoglycosides: streptomycin
aadA5	Aminoglycosides: streptomycin
blaNDM-5[c]	β-lactams: carbapenems
blaCMY-2	β-lactams: cephalosporins
blaEC-15	β-lactams: cephalosporins
blaCTX-M-15[c]	β-lactams: extended-spectrum cephalosporins, monobactams
blaOXA-1	β-lactams: penicillins, early cephalosporins
blaTEM-1	β-lactams: penicillins, early cephalosporins
sul1	Sulfonamides
tet(B)	Tetracyclines
dfrA12	Trimethoprim
dfrA17	Trimethoprim

[a]Best hit gene based on sequence identity and coverage.

[b]Predicted resistance pattern based on antibiotic resistance gene product.

[c]Most important genes driving responsible for extended-spectrum β-lactamases and c
Enterobacterales resistance mechanisms

- This isolate harbors a metallo-beta-lactamase encoding gene, *bla*$_{NDM}$
- Treatment options are:

  Aztreonam-avibactam (FDA approved)

  Cefepime-taniborbactam (FDA approval expected in 2026)
- Infection prevention efforts
  - Place patient in contact precautions and in a single patient room if possible.
  - Test for colonization among contacts

Susceptibility can be determined by with a ceftazidime-avibactam, aztreonam broth test. Susceptibility testing of aztreonam-avibactam commercial tests are expected by end of 2025.

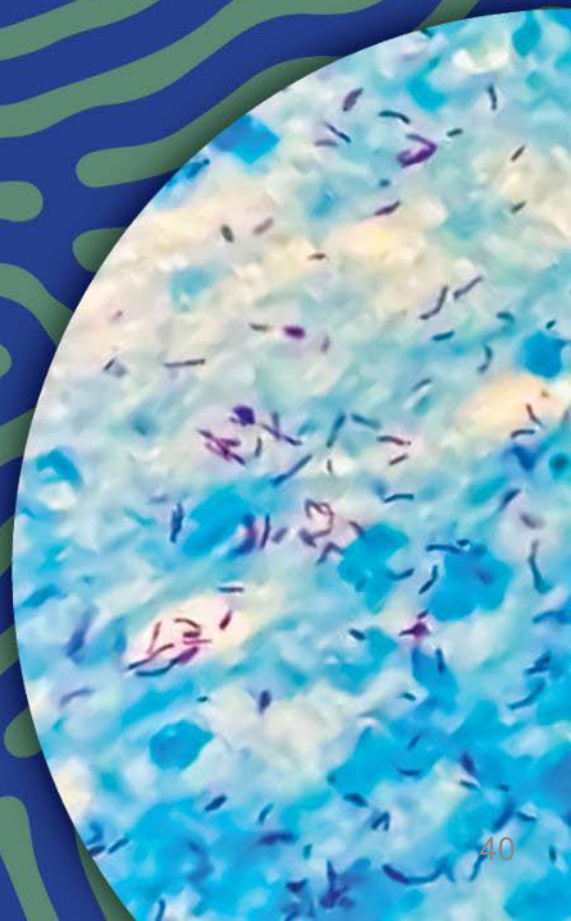
RM testing and reporting recommendations will continue to evolve as resistance increases and new diagnostics come to market.

Trends to watch:

1. An increasing number of beta-lactam, beta-lactamase drugs on the market. This is likely to drive RM testing.

2. An increasing amount of RM testing in the hospital microbiology laboratory

3. Public health labs will still need to provide high resolution characterization of MDRO to complement to gaps in hospital lab testing.



Thank You!