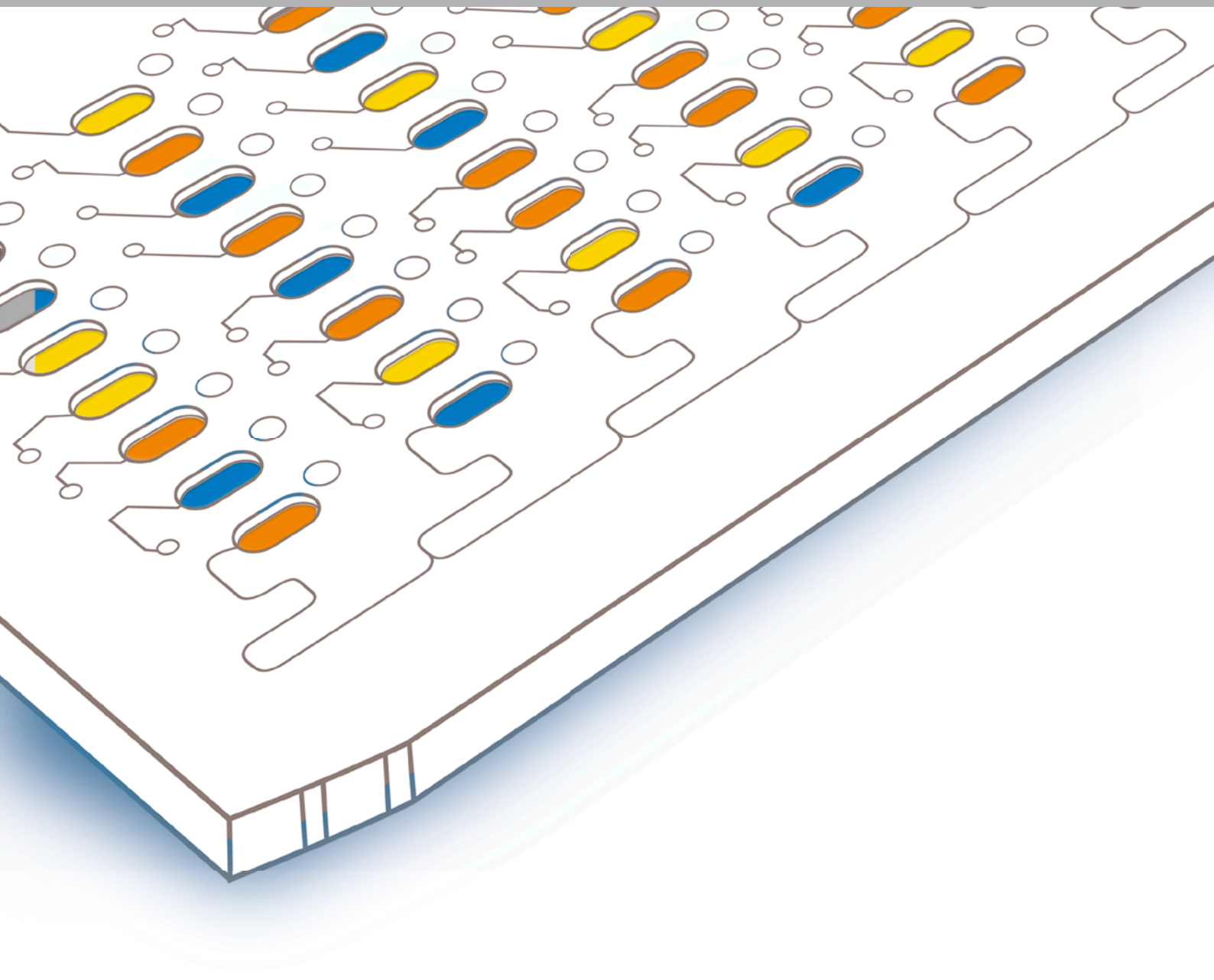
BIOMÉRIEUX

VITEK® 2

Selection of publications

2014 EDITION



PIONEERING DIAGNOSTICS

INTRODUCTION

With the rise of pressing healthcare challenges like **multi-drug resistant organisms (MDRO)**, microbiology labs play an ever-more critical role. When it comes to fighting infectious organisms, **microbial identification (ID)** and **antibiotic susceptibility testing (AST)** are key to providing the right information for targeted clinical responses and better patient-care outcomes.

Combining an **innovative, automated platform** with an expansive database, **VITEK® 2** offers the confidence of fast, accurate results. Its smart design helps ensure better overall laboratory workflow with fewer repetitive tasks, higher safety (closed disposables), improved standardization, and rapid time-to-results and reporting. It provides microbiologists the confidence of **rapid, accurate ID/AST testing through full automation**.

VITEK® 2 uses unique ID and AST cards the size and shape of a playing card. Based on this innovation, VITEK® 2 can provide identification and susceptibility results in as little as 5 hours.

Ready-to-use VITEK® 2 cards offer a comprehensive menu of available tests:

Identification Cards:

- GN (Gram-negative)
- GP (Gram-positive)
- YST (Yeast)
- NH (*Neisseria* and *Haemophilus*)
- ANC (Anaerobe and *Corynebacteria*)

Susceptibility Cards:

- Gram-negative (AST-GN, AST-N)
- Gram-positive (AST-GP, AST-P)
- Anti-fungal (AST-YS)
- Streptococci (AST-ST)

The Advanced Expert System™ sets the VITEK® 2 apart from other systems. The Advanced Expert System™ is an integral part of the VITEK® 2 and **automatically validates every susceptibility test result**. It signals when results are ready, saving time and giving an accurate phenotypic profile of resistance mechanism(s) for each isolate tested. Easy-to-read color-coded indicators help distinguish between results that require further review from those that can be reported. VITEK® 2 generated and Advanced Expert System™ validated ID/AST results assist laboratories in providing clinicians with the information needed to **select the most appropriate antibiotic treatment**.

Designed to **fit the needs of any clinical laboratory**, the VITEK® 2 System helps labs deliver – with confidence – the right analysis **to guide timely, relevant treatment options**.

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Microbial Identification

JOURNAL OF CLINICAL MICROBIOLOGY
2004;42(9):4067-4071

Evaluation of the New VITEK® 2 Card for Identification of Clinically Relevant Gram-Negative Rods.

Funke G. and Funke-Kissling P.

This study evaluated the VITEK® 2 GN Gram negative identification card by comparing it to conventional biochemical testing using 511 fermenters and 144 non-fermenters (655 strains in total), representing 54 taxa. Discrepancies were resolved with API®, Biotype 100, and 16S rRNA gene sequencing.

Isolates from the 655 strains were derived from fresh routine primary isolations (n=157), primary isolation plates which had been stored at 4°C to 8°C for less than 1 week (N=301), and stock cultures (n=197). The VITEK® 2 GN card correctly identified 637 (97.3%) isolates to the species level, 14 (2.1%) were identified with low discrimination, 4 (0.6%) were incorrectly identified, and 0 (0%) were unidentified. Identifications were available for 91.6% of the isolates within 7 hours.

These results demonstrate that the VITEK® 2 GN identification system is robust since isolates were grown on 4 different types of media prior to testing, and good results (96.2% correct identification) were obtained when testing fresh routine isolates with 157 Gram negative rods. Overall, the VITEK® 2 GN identification card appears to be a promising addition to the routine clinical lab for rapid identification of Gram negative rods.

"… more than 97% of the isolates were correctly identified to the species level without the use of additional tests."

KEY POINTS

- ➔ The VITEK® 2 GN card shows good performance for identification of the most frequently found and clinically relevant Gram negative rods.
- ➔ Results were available for > 90% of the isolates tested in 7 hours or less.

VITEK® 2 - MICROBIAL IDENTIFICATION

GRAM-NEGATIVE ORGANISMS

JOURNAL OF CLINICAL MICROBIOLOGY
2005;43(1):84-88

Performance of the New VITEK® 2 GP Card for Identification of Medically Relevant Gram-Positive Cocci in a Routine Clinical Laboratory.

Funke G. and Funke-Kissling P.

This study evaluated the VITEK® 2 GP Gram positive identification card by comparing it to conventional biochemical testing using 217 *Streptococcaceae* and 147 *Micrococcaceae* strains (364 strains in total), representing 31 taxa. Discrepancies were resolved with ID 32 STAPH, rapid ID 32 STREP, and 16S rRNA gene sequencing.

A total of 364 isolates were tested, and of these, 105 were derived from fresh routine primary isolations. The VITEK® 2 GP card correctly identified 344 (94.5%) isolates to the species level, 17 (4.7%) were identified with low discrimination, 1 (0.3%) was incorrectly identified, and 2 (0.5%) were unidentified. Identifications were available for 90.7% of the isolates within 7 hours.

These results demonstrate that the VITEK® 2 GP identification system is robust since isolates were grown on 3 different types of media prior to testing, and good results (97% correct identification) were obtained when testing was performed on 105 Gram positive cocci sourced from primary isolation plates. Overall, the VITEK® 2 GP identification card provides reliable results for the identification of Gram positive cocci in the routine clinical lab.

"Overall, we were impressed by the performance of the system, since more than 94% of the isolates were correctly identified to species level without […] additional tests"

KEY POINTS

- ➔ The VITEK® 2 GP card shows good performance for identification of the most frequently found and clinically relevant Gram positive cocci.
- ➔ Results were available for > 90% of the isolates tested in 7 hours or less.

HAEMOPHILUS, NEISSERIA AND OTHER FASTIDIOUS ORGANISMS

JOURNAL OF CLINICAL MICROBIOLOGY
2008;46(8):2681–2685

Multicenter Evaluation of the New VITEK® 2 *Neisseria-Haemophilus* Identification Card.

Rennie R.P., Brosnikoff C., Shokoples S., Barth Reller L., Mirrett S., Janda W., Ristow K., Krilcich A.

Three clinical laboratories assessed the quality, reproducibility, and accuracy of the VITEK® 2 NH identification card using 16S rRNA sequencing as the reference method. Reproducibility was assessed at each site by testing 9 ATCC® quality control strains 20 times over a period of 10 or more days. In addition, 371 fresh or frozen recently isolated clinical strains and 30 well characterized challenge isolates were tested to determine the quality and accuracy of identification.

Reproducibility testing gave the expected results within a 95% confidence interval, and 98% of the challenge strains yielded an overall correct identification, with 8% being identified with low discrimination, 2% were incorrectly identified, and 0% were unidentified. Regarding the clinical isolates, the VITEK® 2 NH identification card gave an overall correct identification to the species level for 96.5% (358 of 371 isolates), including 10.2% (38 of 371 isolates) with low discrimination, 2.7% (10 of 371 isolates) incorrectly identified, and 0.8% (3 of 371 isolates) unidentified. In addition, 7 of the 10 incorrectly identified clinical isolates gave correct identification results to the genus level. VITEK® 2 NH card results differed from 16S rRNA sequencing results for 27 isolates, all of which are not included in the VITEK® 2 database.

The performance criteria set forth in this clinical trial of >95% overall correct identification, < 25% low discrimination, <2% incorrect identification, and <5% unidentified organisms were met by the VITEK® 2 NH identification card with a >95% confidence interval when compared to the 16S rRNA sequencing reference method. These results indicate that the VITEK® 2 NH identification card is acceptable for routine use in clinical labs.

"With a 95% confidence interval, the VITEK® 2 NH card gave correct results over 95% of the time at all three laboratory test sites."

KEY POINTS

➔ The VITEK® 2 NH card demonstrated excellent performance, and is acceptable for routine use in a clinical microbiology laboratory.

ANAEROBES, *CORYNEBACTERIUM,* etc.

JOURNAL OF CLINICAL MICROBIOLOGY
2009;47(6):1923–1926

Evaluation of the New VITEK® 2 ANC Card for Identification of Medically Relevant Anaerobic Bacteria.

Mory F., Alauzet C., Matuszeswski C., Riegel P., Lozniewski A.

The performance of the VITEK® 2 ANC identification card was assessed by testing 261 anaerobic clinical isolates belonging to 43 medically relevant taxa that had been previously identified using conventional reference identification methods. Discrepant results were resolved with 16S rRNA gene sequencing.

Of the 261 isolates tested, 257 (98.5%) were correctly identified by the VITEK® 2 ANC identification card to the genus level. Only 251 of the 261 isolates tested have species-level claims in the VITEK® 2 ANC database, and of these 217 (86.5%) were correctly identified at the species level, 2 (0.8%) strains were not identified, 8 (3.1%) strains were incorrectly identified, and 24 (9.6%) strains were identified with low discrimination. Furthermore, 17 of the 24 strains identified with low discrimination were correctly identified to the species level by using the recommended additional tests.

The VITEK® 2 ANC identification system is a simple, rapid, and satisfactory method for identification of the most frequently encountered anaerobes in the clinical microbiology lab.

"This system is a satisfactory new automated tool for the rapid identification of most anaerobic bacteria isolated in clinical laboratories."

KEY POINTS

➔ The VITEK® 2 ANC card is a simple, rapid, and satisfactory method for identification of anaerobes.

ANAEROBES, *CORYNEBACTERIUM,* etc.

JOURNAL OF CLINICAL MICROBIOLOGY
2008;46(8):2646-2651

Multicenter Evaluation of the VITEK® 2 Anaerobe and *Corynebacterium* Identification Card.

Rennie R.P., Brosnikoff C., Turnbull L., Barth Reller L., Mirrett S., Janada W., Ristow K., Krilcich A..

The purpose of this study was to validate the performance of the VITEK® 2 ANC identification card for its ability to accurately identify corynebacteria and anaerobic species at three clinical trial laboratories by comparing results to 16S rRNA sequencing as the reference method. Reproducibility was assessed at each site by testing 9 ATCC® quality control strains 20 times over a period of 10 or more days. In addition, 365 fresh or frozen recently isolated clinical strains and 50 well-characterized challenge isolates were tested to determine the quality and accuracy of identification.

Reproducibility testing gave the expected results within a 95% confidence interval, except *Corynebacterium striatum* ATCC® 6940 was incorrectly identified at a single trial site. In addition, 98% of the challenge strains yielded an overall correct identification, when including 5% that were identified with low discrimination, 2% were incorrectly identified, and 0% were unidentified. Regarding the clinical isolates, the VITEK® 2 ANC identification card gave an overall correct identification for 95.1% (347/365), including 4.9% (18/365) with low discrimination, 4.6% (17/365) incorrectly identified, and 0.3% (1/365) unidentified. Fourteen of the 17 incorrectly identified clinical isolates gave correct identification results to the genus level.

All performance criteria were met by the VITEK® 2 ANC identification card with a >95% confidence interval when compared to the 16S rRNA sequencing comparator method. These results indicate that the VITEK® 2 ANC identification card is acceptable for routine use in clinical labs.

"Successful identification of [more] difficult species may have important benefits such as separating pathogens from commensal species and choosing appropriate therapies when required."

KEY POINTS

- ➔ The VITEK® 2 ANC card identifies the large majority of corynebacteria and anaerobes seen in a clinical setting.
- ➔ The VITEK® 2 ANC card demonstrated good performance for all identification claims indicated.

YEASTS

JOURNAL OF CLINICAL MICROBIOLOGY
2007;45(4):1087–1092

Multicenter Evaluation of the New VITEK® 2 Advanced Colorimetric Yeast Identification Card.

Hata J.D., Hall L., Fothergill A.W., Larone D.H., Wengenack N.L.

This multicenter study evaluated the accuracy, reliability, and reproducibility of the VITEK® 2 YST identification card for identification of yeast and yeast-like organisms compared to the API® 20C AUX (API®) system using 12 quality control, 64 challenge, and 623 clinical yeast isolates. Discrepancies were resolved by using API® as the comparator method.

The VITEK® 2 YST identification card correctly identified 100% of the challenge strains, and 98.5% of the clinical isolates. Furthermore, amongst the clinical strains 1.0% of the isolates were incorrectly identified and 0.5% were unidentified, with the YST card resulting in fewer low-discrimination results than the API® comparator method (18.9% versus 30.0%, respectively). Reproducibility testing gave the expected results >95% of the time within a 95% confidence interval.

The VITEK® 2 YST identification card reduced time-to-identification to 18 hours from 48 to 72 hours with API® while producing objective, automated results. It was simple to set up, required less technologist time than API®, is less prone to operator error, and produces timely, accurate identification of medically encountered yeast species in the clinical microbiology laboratory.

"… overall, the VITEK® 2 with the updated colorimetric YST card is a valuable addition in the identification of medically encountered yeast species"

KEY POINTS

- ➔ The VITEK® 2 YST identification card has good performance for identification of clinically significant yeast species.
- ➔ The YST card is simple to set up, requires less hands-on time, is less prone to operator error and has significantly less time to identification than API®.

YEASTS

JOURNAL OF CLINICAL MICROBIOLOGY
2007;45 (4):1343-1346

Evaluation of VITEK® 2 and RapID™ Yeast Plus Systems for Yeast Species Identification: Experience at a Large Clinical Microbiology Laboratory.

Sanguinetti M., Porta R., Sali M., La Sorda M., Pecorini G., Fadda G., Posteraro B.

This study compared the performance of the VITEK® 2 YST identification card to the RapID™ Yeast Plus system using 750 clinical yeast isolates, representing 24 species and 6 genera. 16S rRNA sequence analysis was used as the reference method.

737 of the 750 (98.2%) isolates were correctly identified to the species level by the VITEK® 2 YST card, including isolates identified with low-discrimination that resolved upon supplemental testing. In addition, 2 isolates (0.3%) identified with low discrimination did not resolve with supplemental testing, 8 (1.0%) isolates were misidentified, and 4 isolates (0.5%) were unidentified by the VITEK® 2 YST card. RapID™ Yeast Plus correctly identified 716 of 750 (95 .5%) isolates to the species level including isolates identified with low discrimination that resolved with supplemental testing. Another 18 (2.4%) isolates were misidentified, and 16 (2.1%) isolates were unidentified by RapID™ Yeast Plus.

Both systems are rapid and accurate methods for identification of yeast species seen in clinical mycology labs.

"98.2% [of isolates] were correctly identified to the species level by the VITEK® 2 system."

KEY POINTS

- ➔ The VITEK® 2 YST identification card is an accurate method for identification of yeast species.
- ➔ Greater than 98% of the most commonly encountered yeast species were correctly identified.

Antimicrobial Susceptibility Testing

GRAM-NEGATIVE ORGANISMS

JOURNAL OF CLINICAL MICROBIOLOGY
2013;51 (6):1924-1926

Comparison of the VITEK® 2, MicroScan®, and ETEST® Methods with the Agar Dilution Method in assessing colistin susceptibility of bloodstream isolates of *Acinetobacter* species from a Korean university hospital.

Lee SY., Shin JH., Lee K., Joo MY., Park KH., Shin MG., Suh SP., Ryang DW., Kima SH.

A total of 213 *Acinetobacter* species bloodstream infection isolates, including 13 colistin-resistant isolates, were used to evaluate the performance of the VITEK® 2, MicroScan WalkAway® 96 Plus, and ETEST® for colistin susceptibility testing using agar dilution according to CLSI guidelines as the reference method.

Overall performance of the VITEK® 2 and ETEST® was good when compared to the agar dilution reference method. The VITEK® 2 exhibited 99.1% category agreement, 0.9% very major errors and no major errors. ETEST® had 99.1% category agreement, no very major errors and 0.9% major errors. MicroScan® had 87.3% category agreement, 0.9% very major errors and 11.7% major errors.

In conclusion, the authors found ETEST® and VITEK® 2 to be useful methods to discern susceptibility of colistin against *Acinetobacter* isolates.

"… ETEST® and VITEK® 2 are useful methods for discrimination of colistin-resistant and –susceptible Acinetobacter isolates."

KEY POINTS

➔ Excellent category agreements were observed using VITEK® 2 and ETEST® as compared to the agar dilution reference method.

GRAM-NEGATIVE ORGANISMS

JOURNAL OF MEDICAL MICROBIOLOGY
2011;49(9):3343-3345

Evaluation of three automated systems for susceptibility testing of Enterobacteria containing *qnrB*, *qnrS*, and/or *aac(6')-Ib-cr*.

Calvo, J., Cano, M.E., Pitart, C., Marco, F., Rodríguez-Martínez, J.M., Pascual, A., Martínez-Martínez, L.

A total of 68 clinical *Enterobacteriaceae* isolates obtained from two hospitals, one located in northern and one in southern Spain, were identified as containing *qnrB*, *qnrS*, and/or *aac(6')-Ib-cr* plasmid-mediated quinolone resistance (PMQR) markers by multiplex PCR and sequencing of the obtained amplicons. The isolates were then tested with the BD Phoenix™, Siemens MicroScan WalkAway®, and bioMérieux VITEK® 2 systems, and the resulting quinolone and aminoglycoside MICs were compared to reference broth microdilution (BMD) using CLSI interpretive criteria.

Category and essential agreement (CA and EA, respectively) for all combinations of agents and automated systems was >90%, with the exception of two cases with the WalkAway® involving EA of nalidixic acid (88%) and ciprofloxacin (75%). MicroScan® had one very major error (VME) resulting in a VME rate of 0.21%, whereas BD Phoenix™ and VITEK® 2 had no VMEs. Major errors were 0.21% for MicroScan®, 0.88% for BD Phoenix™, and 0.59% for VITEK® 2, whereas minor errors were 3.57% for MicroScan®, 5.00% for BD Phoenix™, and 2.06% for VITEK® 2.

In conclusion, the authors considered all systems to be reliable for susceptibility testing of quinolones and aminoglycosides against *Enterobacteriaceae* with the *qnrB*, *qnrS*, and/or aac(6)Ib-cr gene.

"… the three systems […] evaluated in this study (MicroScan®, BD Phoenix™, and VITEK® 2) can be considered reliable for susceptibility testing of quinolones and aminoglycosides against enterobacteria with the qnrB, qnrS, and/or aac(6')-Ib-cr gene."

KEY POINTS

➔ VITEK® 2 accurately predicts aminoglycoside and quinolone susceptibility against *Enterobacteriaceae* isolates.

GRAM-NEGATIVE ORGANISMS

JOURNAL OF CLINICAL MICROBIOLOGY
2006;44(9):3257-3262

Evaluation of the New VITEK® 2 Extended -Spectrum Beta-Lactamase (ESBL) Test for Rapid Detection of ESBL Production in *Enterobacteriaceae* Isolates.

Spanu T., Sanguinetti M., Tumbarello M., D'Inzeo T., Fiori B., Posteraro B., Santangelo R., Cauda R., Fadda G.

In this study 1,129 isolates were used to evaluate the performance of the VITEK® 2 ESBL test to detect ESBL-producing *Enterobacteriaceae** isolates. A total of 312 of the 1,129 isolates tested were ESBL positive by the reference method (identification of beta-lactamase genes by isoelectric focusing and sequencing of PCR amplicons), and were found to harbor one or more SHV, TEM, SHV/TEM, CTX-M, or CTX-M/SHV/TEM genes.

The VITEK® 2 ESBL test results matched the molecular testing reference method for 1,121 (99.3%) of the 1,129 isolates evaluated. In addition, 306 of the 313 ESBL-producing isolates were correctly identified (sensitivity, 98.1%; positive predictive value, 99.3%), whereas 2 of the 817 ESBL-negative isolates were called positive (specificity, 99.7%; negative predictive value, 99.3%) by the VITEK® 2.

The VITEK® 2 ESBL test was found to be reliable for routine identification of ESBL-producing isolates containing various SHV, TEM, SHV/TEM, CTX-M, and CTX-M/SHV/TEM genes. It also produced results in 6 to 13 hours, with a median time to result of 7.5 hours.

* Note that the authors tested other *Enterobacteriaceae*, but the VITEK® 2 ESBL test only has susceptibility performance claims for *E. coli*, *K. pneumoniae*, and *K. oxytoca*.

"… our experience with this large series of Enterobacteriaceae isolates indicates that the VITEK® 2 ESBL test system is a reliable time-saving tool for routine identification of ESBL-producing strains."

KEY POINTS

➔ The VITEK® 2 ESBL test reliably detects ESBL-producing *E. coli, K. pneumoniae*, and *K. oxytoca**.

VITEK® 2 - ANTIMICROBIAL SUSCEPTIBILITY TESTING

➔ ASM / 2013 Poster C-562

GRAM-NEGATIVE ORGANISMS

Evaluation of VITEK® 2 for Antimicrobial Susceptibility Testing of *Enterobacteriaceae*

Bobenchik A.M.[1], Hindler J.A.[2], Maldonado M.[2], Desai H.B.[2], Deak E.[1], Giltner C.L.[1], Humphries R.M.[1]

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[2]UCLA Health System, Los Angeles, CA, USA

REVISED ABSTRACT

Background: VITEK® 2 is a widely used commercial antimicrobial susceptibility testing system. We compared MIC results obtained using VITEK® 2 to those obtained using a CLSI broth microdilution reference method (BMD) for testing *Enterobacteriaceae* clinical isolates.

Materials: VITEK® 2 AST-GN69 and AST-XN06 cards and software version 5.04 (bioMérieux, Durham, NC) were used for testing 258 fresh and stock clinical isolates of *Enterobacteriaceae* selected to represent a variety of susceptibility profiles, including 26 carbapenem-resistant *Enterobacteriaceae* (CRE). In-house prepared panels were used for BMD. Isolates tested included: *Escherichia coli* (N=58), *Klebsiella* spp. (N=64), *Proteus mirabilis* (N=28), *Enterobacter cloacae* complex (N=29), *Enterobacter aerogenes* (N=14), *Serratia marcescens* (N=17), *Providencia stuartii* (N=12), *Morganella morganii* (N=9), *Citrobacter* spp. (N=20), *Proteus vulgaris* (N=4), and *Salmonella* spp. (N=3). Twenty-five antimicrobial agents were evaluated using FDA breakpoints and also CLSI breakpoints for carbapenems, aztreonam, cefazolin, cefotaxime, ceftazidime, and ceftriaxone.

Results: Out of ~ 6,000 drug/organism combinations there were 14 very major errors (VME) and 15 major errors (ME) using FDA breakpoints. 11 of 14 VMEs corrected upon repeat testing, resulting in 1 VME with cefazolin, 1 VME with cefpodoxime, and 1 minor error (mE) with cefotaxime. 4 of 15 MEs corrected upon repeat testing, tresulting in 6 ME and 5 mEs. 11.7%, 10.1% and 7.8% mEs occurred with nitrofurantoin, cefoxitin, and piperacillin-tazobactam, respectively.

VITEK® 2 consistently had the higher MIC value compared to BMD for these mEs. Using CLSI breakpoints, there were 5 mEs for carbapenems among 4 of the 26 CRE isolates. Overall categorical agreement (CA) using FDA breakpoints was 95.8%. Essential agreement (EA) for all drug/organism combinations was 98.9%.

Conclusions: Overall there was excellent CA and EA between the VITEK® 2 and a CLSI reference BMD method. There was 7.8% mEs with the new formulation of piperacillin-tazobactam, but no VME or MEs, and only 1 ME with imipenem (FDA breakpoints). Using 2010 CLSI breakpoints for carbapenems resulted in 5 mEs for the CRE. Both the AST-GN69 and AST-XN06 cards are reliable for testing of clinical isolates of *Enterobacteriaceae*.

MATERIAL AND METHODS

Clinical isolates: 258 fresh and stock clinical isolates of *Enterobacteriaceae*

VITEK® 2: VITEK® 2 AST-GN69 and AST-XN06 cards and software version 5.04 used as recommended by the manufacturer (bioMérieux, Durham, NC)

Reference method: Broth microdilution (BMD) performed according to CLSI guidelines (M07-A8 and M100-S23) using in-house prepared frozen panels.

Data analysis: For the 25 antimicrobial agents evaluated, Essential Agreement (EA), Categorical Agreement (EA), Very Major (VME), Major (ME), and Minor (mE) errors were calculated as previously described (Clark, 2009). Results were evaluated using FDA breakpoints and also CLSI breakpoints for carbapenems, aztreonam, cefazolin, cefotaxime, ceftazidime, and ceftriaxone.

Study design: Each isolate tested concurrently with both methods. Isolates with VME or ME using FDA breakpoints were retested using both methods. Results from repeat testing were used for analysis.

Carbapenem resistant: defined as a meropenem MIC ≥ 2 µg/mL for the purpose of this study.

Organism	N=	Carbapenem Resistant
Citrobacter amalonaticus	1	
Citrobacter freundii	13	3
Citrobacter koseri	6	
Enterobacter aerogenes	14	6
Enterobacter cloacae	29	1
Escherichia coli	58	1
Klebsiella oxytoca	13	1
Klebsiella pneumoniae	51	13
Morganella morganii	9	
Proteus mirabilis	28	
Proteus vulgaris	4	
Providencia stuartii	12	
Salmonella spp.	3	
Serratia marcescens	17	1
TOTALS	**258**	**26**

Reference: Clark, R.B., M.A. Lewinski, M.J. Loeffelholz, and R.J. Thibbetts, 2009. Cumitech 31A, Verification and Validation of Procedures in the Clinical Microbiology Laboratory. Coordinating ed., S.E. Sharp. ASM Press, Washington, D.C.

Evaluation of VITEK® 2 for Antimicrobial Susceptibility Testing of *Enterobacteriaceae*

RESULTS

Performance using FDA breakpoints: There were 14 VME, 15 ME and 258 mEs. 11 of 14 VME and 4 of 15 MEs corrected upon repeat testing (**Table 1**) resulting in 2 VME and 6 MEs: cefazolin (1 VME and 1 ME); cefpodoxime (1 VME); amikacin (1 ME); gentamicin (1 ME); imipenem (1 ME); and meropenem (2 ME) (**Table 2**).

Performance of CLSI carbapenem, aztreonam, cefazolin, cefotaxime, ceftazidime, and ceftriaxone breakpoints in all isolates: There were 10 VME, 5 ME, and 71 mEs. Repeat testing was performed on select isolates (**Table 1**) resulting in 3 VME and 4 MEs: cefazolin (1 VME); ceftazidime (1 VME); ceftriaxone (1 VME); ertapenem (3 ME); imipenem (1 ME) (**Table 1**).

Performance of CLSI carbapenem breakpoints in CRE isolates: There were 5 mEs among 4 of the 26 CRE isolates.

Table 1: Initial Discrepant Results and Outcome of Repeat Testing

		Results		Error with Breakpoints		Method
Antimicrobial	**Organism**	**Initial**	**Repeat**	**FDA**	**CLSI**	**Error Source**
Amikacin	E.cloacae	ME	mE	x		VITEK
	P.stuartii	ME	ME	x		
Aztreonam	E. cloacaea	VME	corrected	x	x	BMD
Cefazolin	K. pneumoniae	VME	VME	x	x	
	E. aerogenes	VME	corrected	x	x	VITEK
	E. aerogenes	VME	corrected	x	x	VITEK
	E. coli	VME	corrected		x	BMD
	K. oxytoca	ME	ME	x		
	E. coli	ME	corrected	x	x	VITEK
Cefpodoxime	K. pneumoniae[b]	VME	VME	x		
Cefotaxime	**E. coli**[c]	VME	mE	x		BMD
	E. cloacae[a]	VME	corrected	x	x	BMD
Ceftazidime	E. cloacae[a]	VME	corrected	x	x	BMD
	P. stuartii	VME	VME		x	
Ceftriaxone	**E. coli**[c]	VME	corrected	x		VITEK
	E. cloacae[a]	VME	corrected	x	x	BMD
	K. pneumoniae	VME	VME		x	
Cefuroxime	P. mirabilis[d]	ME	mE	x		VITEK
	C. amalonaticus	ME	corrected	x		VITEK
	C. koseri	VME	corrected	x		BMD
	M. morganii	ME	mE	x		VITEK
Ertapenem	E. cloacae	ME	ME		x	
	E. cloacae	ME	ME		x	
	E. cloacae	ME	ME		x	
Gentamicin	K. pneumoniae[b]	ME	ME	x		
Imipenem	**E. coli**[c]	ME	ME	x		
	P. mirabilis	ME	corrected	x		VITEK
	P. stuartii	ME	mE	x		VITEK
	E. cloacae	ME	ME		x	
Meropenem	**E. coli**[c]	ME	ME	x		
	K. pneumoniae	ME	ME	x		
Piperacillin-tazobactam	E. coli	ME	mE	x		BMD
Tobramycin	E. coli	VME	corrected	x		VITEK
Trimethoprim-sulfamethoxazole	P. mirabilis[d]	ME	corrected	x		VITEK
	E. coli	VME	corrected	x		VITEK
	K. pneumoniae	VME	corrected	x		BMD

VME= very major error, ME= major error, mE= minor error, BMD= broth microdilution
a-d same isolate, **Bold**= carbapenem resistance (eg, meropenem MIC ≥ 2 µg/mL)

Evaluation of VITEK® 2 for Antimicrobial Susceptibility Testing of *Enterobacteriaceae*

OVERALL PERFORMANCE

Of 258 isolates tested, 1 (0.4%) terminated due to failed growth in the control well. EA and CA were 98.9% and 95.8%, respectively.

Table 2: Essential and Categorical Agreement using FDA Breakpoints

		EA		CA		VME		ME		mE	
Antimicrobial	**N=**	**N=**	**%**	**N=**	**%**	**N=**	**%**	**N=**	**%**	**N=**	**%**
Amikacin	257	254	(98.8)	243	(94.6)	0	(0)	**1**/249	(0.4)	**13**/257	(5.1)
Amoxicillin-clavulanic acid	257	256	(99.6)	249	(96.9)	0	(0)	0	(0)	**8**/257	(3.1)
Ampicillin-sulbactam	257	255	(99.2)	245	(95.3)	0	(0)	0	(0)	**12**/257	(4.7)
Ampicillin	257	257	(100)	255	(99.2)	0	(0)	0	(0)	**2**/257	(0.8)
Aztreonam	257	254	(98.8)	243	(94.6)	0	(0)	0	(0)	**14**/257	(5.4)
Cephalothin	257	256	(99.6)	239	(92.9)	0	(0)	0	(0)	**18**/257	(7.0)
Cefazolin	257	254	(98.8)	254	(98.8)	**1**/139	(0.7)	**1**/117	(0.9)	**1**/257	(0.4)
Cefepime	257	252	(98.1)	247	(96.1)	0	(0)	0	(0)	**10**/257	(3.9)
Cefotaxime	257	253	(98.4)	237	(92.2)	0	(0)	0	(0)	**20**/257	(7.8)
Cefoxitin	257	249	(96.9)	231	(89.9)	0	(0)	0	(0)	**26**/257	(10.1)
Cefpodoxime	231	231	(100)	227	(98.3)	**1**/84	(1.2)	0	(0)	**3**/231	(1.3)
Ceftazidime	257	255	(99.2)	242	(94.2)	0	(0)	0	(0)	**15**/257	(5.8)
Ceftriaxone	257	256	(99.6)	246	(95.7)	0	(0)	0	(0)	**11**/257	(4.3)
Cefuroxime	257	254	(98.8)	239	(92.9)	0	(0)	0	(0)	**17**/257	(6.6)
Ciprofloxacin	257	257	(100)	253	(98.4)	0	(0)	0	(0)	**4**/257	(1.6)
Doripenem	204	200	(98.0)	201	(98.5)	0/25	(0)	0	(0)	**3**/204	(1.5)
Ertapenem	257	254	(98.8)	251	(97.7)	0/24	(0)	0	(0)	**6**/257	(2.3)
Gentamicin	257	255	(99.2)	252	(98.1)	0	(0)	**1**/206	(0.5)	**4**/257	(1.6)
Imipenem	257	247	(96.2)	247	(96.1)	0/13	(0)	**1**/238	(0.4)	**9**/257	(3.5)
Levofloxacin	257	257	(100)	253	(98.4)	0	(0)	0	(0)	**4**/257	(1.6)
Meropenem	257	254	(98.8)	253	(98.4)	0/17	(0)	**2**/238	(0.8)	**2**/257	(0.8)
Nitrofurantoin	257	255	(99.2)	227	(88.3)	0	(0)	0	(0)	**30**/257	(11.7)
Piperacillin-tazobactam	257	247	(96.2)	237	(92.2)	0/43	(0)	0	(0)	**20**/257	(7.8)
Tobramycin	257	257	(100)	251	(97.6)	0	(0)	0	(0)	**6**/257	(2.3)
Trimethoprim-sulfamethoxazole	257	257	(100)	257	(100)	0	(0)	0	(0)	**0**/257	(0)
Totals		**98.9**		**95.8**		**2**		**6**		**258**	**(4.0)**

EA= essential agreement, CA= categorical agreement, VME= very major error (total number of resistant isolates is the denominator), ME= major error (total number of susceptible isolates is the denominator), mE= minor error (total number of isolates is the denominator)

Total number of resistant isolates using CLSI breakpoints; doripenem (25); ertapenem (27); imipenem (27); meropenem (22)

CONCLUSIONS

- There was excellent EA (98.9%) and CA (95.8%) between the VITEK® 2 and the CLSI reference BMD method.
- There were 2 MEs with meropenem and 1 ME with imipenem in 2 CRE isolates using FDA breakpoints. These isolates all had a BMD MIC of 4 µg/mL (FDA interpretation S) and a VITEK® 2 MIC of 16 µg/mL (FDA interpretation R). Implementation of 2010 CLSI breakpoints for these antimicrobials (MIC ≤ 1 µg/mL interpretation S) would correct these errors.
- There were 3 MEs with ertapenem and 1 ME with imipenem in 4 non-CRE isolates using CLSI breakpoints.
- There was 7.8% mEs with the new formulation of piperacillin-tazobactam and no VME or MEs. The mE trend was consistent with an intermediate BMD and a resistant VITEK® 2 result, the EA was 96.2%.
- Both the AST-GN69 and AST-XN06 cards are reliable for testing of clinical isolates of *Enterobacteriaceae*.

VITEK® 2 - ANTIMICROBIAL SUSCEPTIBILITY TESTING

➔ ASM 2013 **Poster C-564**

GRAM-NEGATIVE ORGANISMS

VITEK® 2 Reliability for Antimicrobial Susceptibility Testing of non-*Enterobacteriaceae*

Deak E.[1], Hindler J.A.[2], Bobenchik A.M.[1], Maldonado M.[2], Desai H.B.[2], Humphries R.M.[1]

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[2]UCLA Health System, Los Angeles, CA, USA

REVISED ABSTRACT

Background: VITEK® 2 is widely used for routine antimicrobial susceptibility testing. We compared MIC results obtained using VITEK® 2 to those obtained using a CLSI broth microdilution reference method (BMD) for testing non-*Enterobacteriaceae*.

Materials: VITEK® 2 AST-GN69 and AST-XN06 cards and software version 5.04 (bioMérieux, Durham, NC) were used for testing 125 fresh and stock clinical isolates of non-*Enterobacteriaceae* selected to represent a variety of susceptibility profiles. In-house prepared panels were used for BMD. Isolates tested included: *Pseudomonas aeruginosa* (N=95), *Acinetobacter baumannii* (N=28), and *Stenotrophomonas maltophilia* (N=11). Twelve, 14 and 2 antimicrobial agents were evaluated for *P. aeruginosa, A. baumannii, and S. maltophilia*, respectively.

Results: For *P. aeruginosa*, there was 1 very major error (VME) and 2 major errors (MEs) for ticarcillin-clavulanate, 2 MEs for doripenem, 1 ME for piperacillin-tazobactam. Five additional MEs were found for piperacillin-tazobactam, but 2 of these resulted in minor errors (mEs), and 3 were corrected upon repeat testing. All drugs tested for *P. aeruginosa* produced <10% mEs except for gentamicin (16.8%) and ceftazidime (10.5%), where VITEK® 2 MICs were consistently higher than BMD MICs. There was categorical agreement (CA) of 92.7% and essential agreement (EA) of >99% for all drugs with *P. aeruginosa* and 2 isolates did not grow in the VITEK® 2. For the 28 *A. baumannii* there was 1 VME (tobramycin) and 27 mEs including multiple for the cephalosporins: ceftazidime (4), cefepime (4), and ceftriaxone (7). No VMEs or MEs and only 1 mE were seen for *S. maltophilia*. Overall, categorical agreement (CA) using FDA breakpoints was 91.0%. Essential agreement (EA) for all drug/organism combinations was 96.5%.

Conclusions: Overall, there was excellent CA and EA between the VITEK® 2 and a CLSI reference BMD method. There was 6.8% mEs with the new formulation of piperacillin-tazobactam and only 1 ME (FDA breakpoints). Both the AST-GN69 and AST-XN06 cards are reliable for testing of clinical isolates of non-*Enterobacteriaceae*.

MATERIAL AND METHODS

Clinical isolates: 134 fresh and stock clinical isolates of *non-Enterobacteriaceae*

VITEK® 2: VITEK® 2 AST-GN69 and AST-XN06 cards and software version 5.04 used as recommended by the manufacturer (bioMérieux, Durham, NC). All drugs cleared by FDA for testing *P. aeruginosa*, *A. baumannii*, and *S. maltophilia* were included.

Reference method: Broth microdulution (BMD) performed according to CLSI guidelines (M07-A8 and M100-S23) using in-house prepared frozen panels

Data Analysis: Essential Agreement (EA), Categorical Agreement (EA), Very Major (VME), Major (ME), and Minor (mE) errors were calculated as previously described (Clark, 2009) for the 14 agents.

Study Design: Each isolate tested concurrently with both methods. Isolates with VME or ME using FDA breakpoints were retested using both methods. Results from repeat testing were used for analysis.

Organism	N=
Pseudomonas aeruginosa	**95**
Piperacillin-tazobactam Resistant	20
Meropenem Resistant	35
Amikacin Resistant	3
Acinetobacter baumannii	**28**
Meropenem Resistant	10
Stenotrophomonas maltophilia	**11**
Trimethoprim-sulfamethoxazole Resistant	2
Total Number of Isolates Tested	**134**

Note: Resistance was based on FDA breakpoints.

VITEK® 2 Reliability for Antimicrobial Susceptibility Testing of *non-Enterobacteriaceae*

RESULTS

Performance using FDA breakpoints: For *P. aeruginosa*, there was 1 VME, 9 MEs and 51 mEs. 5 of the 9 MEs were corrected upon repeat testing (**Table 1**) resulting in 1 VME and 5 MEs: ticarcillin-clavulanic acid (1 VME and 2 MEs); doripenem (1 ME); piperacillin-tazobactam (1 ME) (**Table 2**). For *A. baumannii*, there were 6 VMEs, 1 ME, and 27 mEs. 5 of the 6 VMEs and the ME were corrected upon repeat testing (**Table 1**) resulting in 1 VME: tobramycin (**Table 2**).

Performance of CLSI doripenem, imipenem, meropenem, and piperacillin-tazobactam breakpoints for *P. aeruginosa* isolates: There were 3 MEs and 24 mEs; 1 ME was corrected upon repeat testing resulting in 2 MEs in doripenem.

Overview: For the 1028 drug-*P. aeruginosa* combinations tested, EA and CA were 99.2% and 92.7%, respectively. For the 364 drug-*A. baumannii* combinations tested, EA and CA were 90.3% and 84.8%, respectively. For the 22 drug-*Stenotrophomonas maltophilia* combinations tested, EA and CA were 100% and 95.5%, respectively.

Table 1: Initial Discrepant Results and Outcome of Repeat Testing

		Results		Error with Breakpoints		Method
	Antimicrobial	Initial	Repeat	FDA	CLSI	Error Source
Pseudomonas aeruginosa	Doripenem	ME	ME		x	
		ME	ME	x	x	
	Imipenem	ME	mE		x	BMD
	Piperacillin-Tazobactam	ME	corrected	x		BMD
		ME	corrected	x		BMD
		ME	corrected	x		
		ME	mE	x		BMD
		ME	ME	x		
	Ticarcillin-Clavulanic Acid	ME	ME	x		
		ME	ME	x		
		VME	VME	x		
	Ciprofloxacin	ME	mE		x	VITEK
Acinetobacter baumannii	Ampicillin-Sulbactam	VME	corrected		x	BMD
	Ciprofloxacin	VME	corrected		x	BMD
	Levofloxacin	VME	corrected		x	BMD
	Piperacillin-tazobactam	ME	corrected		x	VITEK
	Tobramycin	VME	VME		x	
	Trimethoprim-Sulfamethoxazole	VME	corrected		x	BMD
		VME	corrected		x	BMD

VME= very major error, ME= major error, mE= minor error, BMD= broth microdilution

Reference: Clark, R.B., M.A. Lewinski, M.J. Loeffelholz, and R.J. Thibbetts, 2009. Cumitech 31A, Verification and Validation of Procedures in the Clinical Microbiology Laboratory. Coordinating ed., S.E. Sharp. ASM Press, Washington, D.C.

OVERALL PERFORMANCE

Table 2: Essential and categorical agreement

			EA	CA	VME	ME	mE	
	Antimicrobial	N=	N= %	N= %	N= %	N= %	N=	%
Pseudomonas aeruginosa	Amikacin	95	95 (100)	95 (100)	0/3 (0)	0/87 (0)	0/95	(0)
	Ceftazidime	95	95 (100)	85 (89.5)	0/18 (0)	0/69 (0)	10/95	(10.5)
	Cefepime	95	95 (100)	87 (91.6)	0/15 (0)	0/62 (0)	8/95	(8.4)
	Ciprofloxacin	94	94 (100)	89 (94.7)	0/26 (0)	0/63 (0)	4/94	(4.3)
	Doripenem	93	88 (94.6)	83 (89.2)	0/16 (0)	2/55 (2.2)	8/93	(8.6)
	Gentamicin	95	93 (97.9)	79 (83.2)	0/12 (0)	0/82 (0)	16/95	(16.8)
	Imipenem	91	91 (100)	83 (91.2)	0/33 (0)	0/53 (0)	8/91	(8.8)
	Levofloxacin	93	93 (100)	85 (91.3)	0/25 (0)	0/56 (0)	8/93	(8.6)
	Meropenem	92	92 (100)	89 (96.7)	0/35 (0)	0/56 (0)	3/92	(3.3)
	Piperacillin-tazobactam	90	88 (97.8)	82 (91.1)	0/20 (0)	1/61 (1.8)	5/90	(5.6)
	Tobramycin	95	95 (100)	94 (98.9)	0/10 (0)	0/85 (0)	1/95	(1.1)
	Ticarcillin-Clavulanic Acid	95	95 (100)	91 (95.8)	1/40 (1.1)	2/12 (2.1)	4/95	(4.2)
		1123	99.2	92.7	1/253 (0.3)	5/741 (0.7)	75/1123	(6.7)
Acinetobacter baumannii	Ampicillin-Sulbactam	28	28 (100)	22 (78.6)	0/7 (0)	0/17 (0)	6/28	(21.4)
	Cefepime	28	24 (85.7)	24 (85.7)	0/10 (0)	0/12 (0)	4/28	(14.3)
	Cefotaxime	28	28 (100)	28 (100)	0/14 (0)	0/8 (0)	0/28	(0)
	Ceftazidime	28	27 (96.4)	24 (85.7)	0/14 (0)	0/10 (0)	4/28	(14.3)
	Ceftriaxone	28	27 (96.4)	21 (75.0)	0/25 (0)	0/0 (0)	7/28	(25.0)
	Ciprofloxacin	28	28 (100)	28 (100)	0/14 (0)	0/14 (0)	0/28	(0)
	Gentamicin	28	28 (100)	28 (100)	0/11 (0)	0/17 (0)	0/28	(0)
	Imipenem	28	28 (100)	28 (100)	0/10 (0)	0/18 (0)	0/28	(0)
	Levofloxacin	28	28 (100)	28 (100)	0/14 (0)	0/14 (0)	0/28	(0)
	Meropenem	28	28 (100)	28 (100)	0/10 (0)	0/17 (0)	0/28	(0)
	Piperacillin-tazobactam	28	28 (100)	25 (89.3)	0/13 (0)	0/10 (0)	3/28	(10.7)
	Tobramycin	28	27 (96.4)	25 (89.3)	1/9 (3.6)	0/18 (0)	3/28	(10.7)
	Trimethoprim-sulfamthoxazole	28	28 (100)	28 (100)	0/13 (0)	0/15 (0)	0/28	(0)
		364	90.3	84.8	1/164 (0.6)	0/170 (0)	27/364	(7.4)
Stenotrophomonas maltophilia	Levofloxacin	11	11 (100)	10 (90.9)	0/1 (0)	0/10 (0)	1/11	(9.1)
	Trimethoprim-sulfamthoxazole	11	11 (100)	11 (100)	0/2 (0)	0/9 (0)	0/11	(0)
		22	100	94.4	0/3 (0)	0/19 (0)	1/22	(4.5)
	Total	**1509**	**96.5**	**91.0**	**2/420 (0.4)**	**5/930 (0.5)**	**103/1509**	**(6.8)**

EA= essential agreement, CA= categorical agreement, VME= very major error, ME= major error, mE= minor error

CONCLUSIONS

- There was 96.5% EA and 91.0% CA when testing those drugs approved by the FDA for *P. aeruginosa, A. baumannii,* and *S. maltophilia* when testing fresh clinical and stock isolates including those with specific resistance phenotypes.
- For *P. aeruginosa*, there was 99.2% EA and 92.7% CA.
- There was 97.8% EA and 91.1% CA for piperacillin-tazobactam with *P. aeruginosa*. There were no VMEs and only 1 ME (1.8%).
- Overall, there was 1 VME and 5 MEs for *P. aeruginosa* and 1 VME (tobramycin) for *A. baumannii*.
- Both the AST-GN69 and AST-XN06 cards are reliable for testing of clinical isolates of non-*Enterobacteriaceae*.

JOURNAL OF CLINICAL MICROBIOLOGY
2014;52(11):4087-4089

Evaluation of the Automated VITEK® 2 System for the Detection of Various Mechanisms of Macrolides and Lincosamides Resistance in *Staphylococcus aureus*.

Filippin L, Roisin S, Nonhoff C, Vandendriessche S, Heinrichs A, Denis O.

Clinical and Laboratory Standards Institute (CLSI) and the European Committee on Antimicrobial Susceptibility Testing (EUCAST) both recommend the double disk diffusion method (D-zone test) for the phenotypic detection of macrolide-inducible resistance to clindamycin. This study compared the performance of VITEK® 2 to the D-zone test for the detection of various macrolide, lincosamide, and streptogramin (MLS) resistance mechanisms. A total of 67 methicillin-resistant Staphylococcus aureus (MRSA), and 43 methicillin-sensitive S. aureus (MSSA) non-duplicate isolates well characterized by 16S rRNA PCR for the presence of various methylases or an efflux system were tested.

VITEK® 2 and D-zone test results had 100% agreement for the detection of MLS resistance in S. aureus. VITEK® 2 also had complete agreement with genotypic testing. The D-zone test had a median time to final susceptibility reporting of 18 hours, whereas the VITEK® 2 accomplished the same task in a median time of 8hr 15 min.

To summarize, the VITEK 2 successfully differentiated between inducible-clindamycin resistance (ICR) due to the inducible Macrolide-Lincosamide-Streptogramin B ($iMLS_B$) phenotype and MLS resistance due to an efflux system.

"The fully automated VITEK® 2 ICR [test] is a good alternative to the D-zone test providing faster results in a working day."

KEY POINTS

- ➔ VITEK® 2 is reliable for phenotypic detection of various macrolide, lincosamide, and streptogramin (MLS) resistance mechanisms, including inducible-clindamycin resistance (ICR).
- ➔ VITEK® 2 ICR test results are available significantly sooner than D-zone test results (8hr 15 min versus 18hr).

JOURNAL OF CLINICAL MICROBIOLOGY
2014;52(2):392-397

Performance of VITEK® 2 for Antimicrobial Susceptibility Testing of *Staphylococcus* spp. and *Enterococcus* spp.

Bobenchik A.M., Hindler J.A., Giltner C.L., Saeki S., Humphries R.M.

The study compared MIC results obtained by VITEK® 2 software version V2S 5.01 to those obtained by the CLSI broth microdilution (BMD) reference method for 134 staphylococcal and 84 enterococcal isolates. Nineteen antibiotics were included in the study. Resistant organisms tested included methicillin-resistant *Staphylococcus aureus* (MRSA) (N=58), *S. aureus* with inducible clindamycin resistance (N=30), SXT resistant MRSA (N=10), vancomycin resistant *Enterococci* (N=37), high-level gentamicin resistant *Enterococci* (N=15), linezolid resistant *Enterococcus* (N=5), and daptomycin non-susceptible *Enterococcus faecalis* (N=6).

For the *Staphylococci*, there was 98.9% category agreement (CA) between the VITEK® 2 and BMD, 98.8% essential agreement (EA), 1.7% very major error (VME), 0.2% major error (ME) and 0.8% minor error (mE). There was 1 VME for gentamicin and a *S. hominis*, 6 VMEs for inducible clindamycin resistance in *S. aureus*, and 2 MEs for daptomycin in a *S. aureus* and a *S. epidermidis*. For *enterococci*, there was 97.3% CA, 99.5% EA, 0.7% VME, 0.5% ME and 2% mE. There were 2 VMEs for daptomycin in *E. faecalis* and 2 MEs, 1 for high-level gentamicin resistance and 1 for nitrofurantoin, both in *E. faecium*.

Overall CA for all organisms studied and all antibiotics tested was 98.3% with 99% EA agreement. Eight of the 218 (3.7%) isolates tested terminated due to insufficient growth in the positive control well and one isolate terminated because the species was not included in the AST database. These results show that VITEK® 2 is very comparable to the BMD reference method for susceptibility testing of *Staphylococcus* and *Enterococcus*.

"Overall the VITEK® 2 AST-GP71 and GP72 performed comparably to BMD. Performance was reliable for organisms with significant resistant phenotypes such as MRSA, high-level gentamicin-resistant enterococci, and vancomycin resistant Enterococcus."

KEY POINTS

- ➔ VITEK® 2 is reliable for antimicrobial susceptibility testing of *Staphylococci* and *Enterococci*.

JOURNAL OF CLINICAL MICROBIOLOGY
2013;51(8):2732-2734

Use of VITEK® 2 antimicrobial susceptibility profile to identify *mec*C in methicillin-resistant *Staphylococcus aureus*.

Cartwright E.J., Paterson G.K., Raven K.E., Harrison E.M., Gouliouris T., Kearns A., Pichon B., Edwards G., Skov R.L., Larsen A.R., Holmes M.A., Parkhill J., Peacock S.J., Török M.E.

Methicillin resistant *Staphylococcus aureus* (MRSA) harboring the *mec*C gene present a potential diagnostic problem, because they produce negative results both by the latex agglutination test and by the polymerase chain reaction (PCR) assay for *mec*A. The ability of the VITEK® 2 to detect *mec*C MRSA is unknown. A collection of 896 *S. aureus* isolates comprised of 455 MRSA (*mec*A positive), 62 MRSA (*mec*C positive), and 379 MSSA (*mec*A/ *mec*C negative) were used to assess the ability of the VITEK® 2 to identify *mec*C and *mec*A positive MRSA strains. Genome sequencing was considered the gold standard.

The VITEK® 2 was found to have a sensitivity of 88.7% and a specificity of 99.5% for the identification of *mec*C MRSA isolates when using an oxacillin susceptible and cefoxitin resistant profile, whereas the specificity and sensitivity of identifying *mec*A/ *mec*C negative MSSA was 98.9% (4 false positives out of 379 MSSA tested) and 100% (no false positives), respectively.

MRSA strains were predicted using VITEK® 2 with a high level of sensitivity based on the combined interpretation of the oxacillin MIC and cefoxitin screen test results. Of the 62 *mec*C positive strains tested, 87.7% were susceptible to oxacillin and resistant to cefoxitin, and 11.3% were resistant to both oxacillin and cefoxitin. Of the 455 *mec*A positive strains tested, 0.9% were oxacillin susceptible and cefoxitin resistant, 98.0% were resistant to both cefoxitin and oxacillin, and 1.1% were oxacillin resistant and cefoxitin susceptible.

"… the VITEK® 2 system […] could provide a zero-cost screening method for identification of mecC positive MRSA strains, and could potentially be used to monitor changes in the prevalence of mecC positive MRSA over time."

KEY POINTS

- ➔ The VITEK® 2 reliably detects MRSA.
- ➔ Both *mec*A and *mec*C MRSA strains can be predicted using VITEK® 2 AST cards.

JOURNAL OF CLINICAL MICROBIOLOGY
2009;47(9):2879-2882

BD Phœnix™ and VITEK® 2 Detection of *mec*A-Mediated Resistance in *Staphylococcus aureus* with Cefoxitin.

Junkins A.D., Lockhart S.R., Heilmann K.P., Dohm C.L., Von Stein D.L., Winokur P.L., Doern G.V., Richter S.S.

This study examined the accuracies of the BD Phoenix™ and the VITEK® 2 systems for the detection of *mecA*-mediated resistance in *Staphylococcus aureus* using 620 clinically significant isolates (448 MRSA and 172 MSSA). Results were compared to oxacillin MICs determined by BMD following Clinical and Laboratory Standards Institute (CLSI) guidelines and *mecA* gene detection by PCR.

The two comparative methods had 100% agreement with each other. Category agreement was 99.8% for the BD Phoenix™ and 99.7% for VITEK® 2 relative to the comparative methods. Each instrument had a single very major error (VME) with different MRSA isolates, and the VITEK® 2 had one major error (ME). Also, 9 isolates on the BD Phoenix™ and 7 on the VITEK® 2 had susceptible oxacillin MICs, but were changed to resistant by the expert systems on the basis of the cefoxitin result.

The presence of cefoxitin on the BD Phoenix™ and VITEK® 2 test panels improves detection of MRSA in these systems. The combination of cefoxitin and oxacillin used by these systems affords reliable detection of MRSA when testing isolates typically found in a clinical laboratory.

"Our findings demonstrate the improved accuracy of the BD Phoenix™ and VITEK® 2 systems with the addition of cefoxitin to the test panels for the detection of mecA-mediated resistance among S. aureus isolates."

KEY POINTS

- ➔ The VITEK® 2 reliably detects MRSA.

GRAM-POSITIVE ORGANISMS

JOURNAL OF CLINICAL MICROBIOLOGY
2008; 46(12):4114-4115

Evaluation of the VITEK® 2 AST-P559 Card for Detection of Oxacillin Resistance in *Staphylococcus aureus*.

Torres E., Pérez S., Villanueva R., Bou G.

In this study 301 *Staphylococcus aureus* isolates were evaluated with the VITEK® 2 AST-P549 card and results were compared to *mec*A PCR for the detection of MRSA. A total of 51 of these isolates were found to be *mec*A negative, whereas the remaining 250 where *mec*A positive by PCR.

Sensitivity and specificity of VITEK® 2 to predict *mec*A status was demonstrated to be 98.8% and 100%, respectively. The positive and negative predictive values were 100% and 94%, respectively. The values for all parameters increased to 100% when the discrepant strains (total of 3) were analyzed with the VITEK® 2 after induction (preincubation with agar containing 6 µg/ml of cefoxitin).

The VITEK® 2 AST-P549 card contains both the cefoxitin screen and oxacillin, and as a result, the Advanced Expert System™ (AES) utilizes the results of both to determine *mec*A status. This card also offers the advantage of simultaneously providing susceptibility information for a number of antimicrobials against gram-positive microorganisms.

"The main advantage of the card is its promptness in detecting methicillin resistance, as it is possible to interpret the results of a cefoxitin screen after 4 h of card inoculation."

KEY POINTS

- ➔ The VITEK® 2 reliably detects MRSA.
- ➔ Cefoxitin screen results are obtained in as little as 4 hours with the VITEK® 2.

➔ ICAAC 2013 **Poster D-590**

GRAM-POSITIVE ORGANISMS

Evaluation of the VITEK® 2 AST-ST01 Card for *Streptococcus pneumoniae* Susceptibility Testing Compared to ETEST® and Broth Microdilution

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ABSTRACT

Background: Antimicrobial resistance in *Streptococcus pneumoniae* is increasingly becoming a major concern. Accurate antimicrobial susceptibility testing (AST) is essential for appropriate antimicrobial treatment and most laboratories are currently using manual, labor-intensive AST methods.

Method: The performance of the automated VITEK® 2 AST-ST01 card (bioMérieux) was compared to those of ETEST® (bioMérieux) for AST of 74 clinical isolates of *Streptococcus pneumoniae* mostly collected through the Canadian Bacterial Surveillance Network (CBSN). Discordant results were resolved by the broth microdilution method (BMD). Interpretation was performed using CLSI criteria (CLSI M100-S23).

Results: The overall essential agreement (EA) between VITEK® 2 and the reference method was 98.3%. The overall essential agreement (EA) between ETEST® and the reference method was 98.5%. For VITEK® 2, the EAs of individual antimicrobial agents ranged from 95.9 % (all penicillin criteria) to 100% (erythromycin, levofloxacin, and vancomycin). The EA of ETEST® ranged from 89.2% (TMP-SMX) to 100% (penicillin, ceftriaxone, erythromycin and vancomycin). The categorical agreements (CA) of VITEK® 2 and ETEST® are respectively: penicillin (oral) 89.2% and 95.9%, penicillin (meningitis) 100% and 95.9%, ceftriaxone (meningitis) 98.6% and 97.3%, ceftriaxone (non-meningitis) 97.3% and 100 %, TMP-SMX 98.6% and 97.3% No very major error (VME) were observed with both methods. The overall CA for VITEK® 2 was 97.3% (1 major error (ME) and 17 minor errors (miE)), that for ETEST® was 98.0% (3 ME and 10 miE). Erythromycin and vancomycin were in perfect agreement.

Conclusion: The VITEK® 2 AST-ST01 card results demonstrated a high degree of agreement with ETEST® and BMD. Fewer ME were observed with the VITEK® 2 than ETEST®, but VITEK® 2 had high number of miE for oral penicillin. Performance was excellent for both methods for ceftriaxone, vancomycin, and erythromycin.

INTRODUCTION

Antimicrobial resistance in *Streptococcus pneumoniae* is increasingly becoming a major concern. Accurate antimicrobial susceptibility testing (AST) is essential for appropriate antimicrobial treatment and most laboratories are currently using manual, labor-intensive AST methods for SP. VITEK® 2 is a well-established automated system for AST of commonly encountered bacteria but standard cards cannot be used for *S. pneumoniae* because of it's particular growth requirements. A new card (AST-ST01) was recently introduced to determine the susceptibility of *S. pneumoniae*, beta-hemolytic Streptococcus and *viridans* Streptococcus. The purpose of this study was to evaluate the AST-ST01 card performance against *S. pneumoniae* and to assess its clinical interest.

METHODS

Strains: We tested 74 *Streptococcus pneumoniae* clinical strains isolated mostly through the Canadian Bacterial Surveillance Network (CBSN 2005, 2007 and 2011). We completed the panel with reference strains chosen for their resistance profile. MIC distribution are presented in **Table 1**. Each strain was passaged three times. AST was determined in parallel by ETEST® and VITEK® 2. Discrepant results were test subsequently by Broth Microdilution method (BMD). MICs were interpreted as being in susceptible, intermediate or resistant categories according to the breakpoints recommended by the CLSI standards (M100-S23).

Table 1: MIC distribution of strains used in this study

Antibiotic (abbreviation)	Average MIC (mcg/mL)	MIC range (mcg/mL)	ST-01 Calling range (mcg/mL)
Penicillin (PCN)	0.73	<= 0.015 - 4	<= 0.06 - >=8
Ceftriaxone (CTX)	0.53	<=0.03 - 8	<= 0.12 - >=8
Erythromycin (EMC)	1.53	<= 0.03 - >=256	<= 0.12 - >=8
Levofloxacin (LVX)	1.51	<= 0.5 - >=256	<= 0.25 - >=16
TMP-SMX (SXT)	0.25/4.75	<=0.5/9.5 - >=32/608	<=0.5/9.5 - >=32/304
Vancomycin (VAN)	0.47	<=0.12-1	<= 0.12 - >=8

ETEST: Overnight cultures isolates were adjusted to a 0.5 McFarland standard suspension in a Mueller-Hinton broth. Mueller-Hinton agar plates with 5% sheep blood (BD Diagnostics Systems) were inoculated with the suspension. The ETEST® strips (bioMérieux) were applied to the inoculated agar surface. All plates were incubated at 35°C with 5% CO_2 for 20 to 24 hours. MIC values were determined by the point where the edge of the inhibition ellipse intersects with the side of the strip.

Broth Microdilution (BMD): BMD was performed according to the Clinical and Laboratory Standards Institute (CLSI) standards (M07-A9). Microdilution panels were prepared in-house and contained the antibiotic concentrations in serial twofold dilutions.

Evaluation of the VITEK® 2 AST-ST01 Card for *Streptococcus pneumoniae* Susceptibility Testing Compared to ETEST® and Broth Microdilution

VITEK® 2: Overnight cultures plates of the isolates were adjusted to a McFarland standard of 0.5 to 0.63 in 0.45% sodium chloride using the VITEK® DensiChek densitometer. AST-ST01 cards (bioMérieux) were inoculated with the suspension vial using the Smart Carrier Station and loaded into the VITEK® 2 automated reader-incubator (software version 4.02). AST-ST01 calling ranges are reported in **Table 1**.

Analysis: Performance was established by comparing the VITEK® 2 and ETEST® methods. Discrepant results were asserted by BMD. Essential agreement (EA), category agreement (CA), very major errors (VME), major errors (ME), and minor errors (miE) were determined for all strains. Essential agreement occurs when the MIC is within a two-fold dilution of the comparative method. Category agreement occurs when the interpretive result is in agreement with the comparative method. VME, ME and miE were determined as indicated in **Table 2**.

Table 2: Error definitions

BMD Reference method	VITEK® 2 or ETEST®	Discrepancy
R	S	Very Major Error (VME)
S	R	Major Error (ME)
S or R	I	Minor error (miE)
I	S or R	Minor error (miE)

RESULTS

Table 3 lists the percent (%) correlation of VITEK® 2 and ETEST® results to the reference results for EA, VME, ME, miE and overall CA.

Table 3: Correlation (%) of VITEK® 2 and ETEST® to Reference Method

	Overall	Penicillin parenteral (nonmeningitis)	Penicillin parenteral (meningitis)	Penicillin oral	Ceftriaxone (nonmeningitis)	Ceftriaxone (meningitis)	Erythromicyn	Levofloxacin	TMP-SMX	Vancomycin
EA ETEST	98.5	100	100	100	100	100	100	97.3	89.2	100
EA VITEK 2	98.3	95.9	95.9	95.9	98.6	98.6	100	100	100	100
VME ETEST	0	0	0	0	0	0	0	0	0	0
ME ETEST	0.5	0	4.1	0	0	0	0	0	0	0
miE ETEST	1.5	4.1	0	4.1	0	2.7	0	0	2.7	0
VME VITEK 2	0	0	0	0	0	0	0	0	0	0
ME VITEK 2	0.2	0	0	0	1.4	0	0	0	0	0
miE VITEK 2	2.6	4.1	0	10.8	1.4	1.4	0	4.1	1.4	0
CA VITEK 2	97.3	95.9	100	89.2	97.3	98.6	100	95.9	98.6	100
CA ETEST	98.0	95.9	95.9	95.9	100	97.3	100	100	97.3	100

The overall essential agreement (EA) for VITEK® 2 and ETEST® were similar (98.3% and 98.5% respectively). However the two methods performed differently for EA with some antibiotics. ETEST® performed better for beta-lactams EA (PCN 100% vs 95.9%, CTX 100% vs 98.6%) whereas VITEK® 2 was superior for SXT (EA 100% vs 89.2%) and LVX (EA 100% vs 97.3%).

Overall no very major error (VME) was observed with both methods. The categorical agreements (CA) of VITEK® 2 and ETEST® for oral penicillin were 89% and 96%, respectively and the CA of VITEK® 2 and ETEST® for meningitis penicillin were 100% and 96%. The categorical agreements (CA) of VITEK® 2 and ETEST® for ceftriaxone (meningitis) were 98.6% and 97.3 %, respectively and the CA of VITEK® 2 and ETEST® for non-meningitis ceftriaxone were 97.3% and 100 %. The overall CA for VITEK® 2 was 97.3% (no VME, 1 major error (ME) and 17 minor errors (miE)), that for ETEST® was 98.0% (no VME, 3 ME and 10 miE). Erythromycin and vancomycin were in perfect agreement.

The lower CA of VITEK® 2 for oral penicillin is worrisome since 10% of strains would have been misclassified because of minor errors. VITEK® 2 also had a lower EA for penicillin. We feel this is a clinically important aspect since penicillin is cornerstone in *S. pneumoniae* treatment.

CONCLUSIONS

- **The VITEK® 2 AST-ST01 card results demonstrated a high degree of agreement with ETEST and BMD.**
- **Fewer ME were observed with the VITEK® 2 than ETEST®, but VITEK® 2 had high number of miE for oral penicillin.**
- **ETEST performance was lower for SXT.**
- **Performance was excellent for both methods for ceftriaxone, vancomycin, and erythromycin.**

REFERENCES:

Methods for Dilution Antimicrobial Susceptibility Tests for Bacteria That Grow Aerobically; Approved Standard–Eighth Edition, M07-A8, Vol. 29, No. 2, January 2009. Clinical and Laboratory Standards Institute, Wayne, PA.

Performance Standards for Antimicrobial Susceptibility Testing; Twenty-third Informational Supplement, M100-S23, January 2013. Clinical and Laboratory Standards Institute, Wayne, PA.

➔ ICAAC 2010 **Poster D-172**

GRAM-POSITIVE ORGANISMS

New *Streptococcus* AST Product on an Automated System

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REVISED ABSTRACT

Background: The VITEK® 2 Systems provide rapid, automated susceptibility testing for a wide variety of clinical bacterial isolates including *Streptococcus pneumoniae* and *S. agalactiae*. With the increasing prevalence of antimicrobial resistance, the ability to quickly and easily perform susceptibility testing on other species of streptococci is becoming more important. The purpose of this study was to develop chloramphenicol (C), gentamicin (GM), meropenem (MEM), moxifloxacin (MXF), rifampicin (RA), teicoplanin (TEC), and tigecycline (TGC) MIC tests* for the VITEK® 2 Systems for the following streptococci: *S. pneumoniae* (SPN), S. viridans group (VIR) and beta-hemolytic streptococci (BS).

Methods: Approximately 600 isolates representing 34 species were tested in VITEK® 2 investigational use only (IUO) cards containing varying concentrations of the different antimicrobials. All strains were tested with both IUO cards and the CLSI broth microdilution reference method. Growth data were collected from the VITEK® 2 cards and compared to the reference results. Analyses were then developed using these data.

Results: Essential agreement for the development isolates is shown in Table 1.

Table 1

%EA	C	GM	MEM	MXF	RA	TEC	TGC
SPN	*97.9*	100	98.2	98.9	100	100	100
VIR	*99.5*	100	94.2	96.8	NA	100	96.3
BS	*98.0*	100	99.3	98.0	97.3	100	95.3
Combined	*98.4*	100	97.2	97.8	99.1	100	97.8

Conclusion: The combined essential agreement for all antimicrobials exceeded 97%. These development data indicate that the VITEK® 2 Systems can accurately determine MICs for the abovementioned antimicrobials for various *Streptococcus sp*.

INTRODUCTION

In the current healthcare environment, it is increasingly important for rapid and accurate diagnosis of infectious diseases. The VITEK® 2 is an automated system designed to provide rapid and accurate identification and susceptibility results for common clinically encountered bacteria and yeast strains.

The VITEK® 2 System rapidly determines an MIC by applying a unique algorithm to growth kinetics monitored by the system.

Antimicrobial resistance has been increasing in streptococci. The purpose of this study was to evaluate if an AST card for streptococci could be incorporated into the current VITEK® 2 system menu for automated susceptibility testing.

MATERIALS AND METHODS

Bacterial strains. Approximately 630 streptococcal isolates were tested. The strains tested were from the bioMérieux stock collection and fresh clinical isolates from the development trial at Washington University School of Medicine in St. Louis, MO.

Antimicrobial susceptibility tests. Each organism was prepared from a pure culture of bacteria cultivated for 18-24 hours on trypticase soy agar with 5% defibrinated sheep blood at 35ºC. Suspensions were prepared in sterile saline (aqueous 0.45% NaCl) to a turbidity equal to a 0.5 McFarland standard. The same suspension was used for both the reference methods and the VITEK® 2 method.

Broth Microdilution (BMD). This method was performed according to CLSI guidelines(1). Microdilution panels were prepared in-house and contained the following concentrations in serial twofold dilutions : C 0.125-64 g/ml, GM 2-512 g/ml, MEM 0.015-8 g/ml, MXF 0.015-8 g/ml, RA 0.008-8 g/ml, TEC 0.008-8 g/ml, and TGC 0.008-8 g/ml.

VITEK® 2 method. A dilution in sterile saline was prepared for card inoculation. Sixty-four well IUO cards were then loaded into the VITEK® 2 instrument. Cards were filled and read automatically, and the data expressed as MICs.

Quality control. The CLSI quality control (QC) strain *Streptococcus pneumoniae* ATCC 49619 was used for BMD testing. QC was performed each day of comparative testing. Test results were accepted only if the QC results were within the acceptable limits as published by the CLSI(2).

Analysis of results. Performance was established by comparing the VITEK® 2 results to the broth microdilution reference results. Essential agreement (EA), category agreement (CA), very major errors (VME), major errors (ME), and minor errors (mE) were then determined for all strains. Essential agreement occurs when the VITEK® 2 MIC result is within a two-fold dilution of the reference result. Category agreement occurs when the interpretive result of the VITEK® 2 test is in agreement with the interpretive result of the reference method. Minor, Major and Very Major Errors were determined as indicated in **Table 2.**

Table 2. Error Definitions

Reference	VITEK® 2	Discrepancy
R	S	Very Major Error
S	R	Major Error
S	I	Minor Error
R	I	Minor Error
I	R, S	Minor Error

REFERENCES

1. Methods for Dilution Antimicrobial Susceptibility Tests for Bacteria That Grow Aerobically; Approved Standard–Eighth Edition, M07-A8, Vol. 29, No. 2, January 2009. Clinical and Laboratory Standards Institute, Wayne, PA.

2. Performance Standards for Antimicrobial Susceptibility Testing; Twentieth Informational Supplement, M100-S20, January 2010. Clinical and Laboratory Standards Institute, Wayne, PA.

New *Streptococcus* AST Product on an Automated System

RESULTS

Table 3 lists the streptococci species that will be claimed on the VITEK® 2 susceptibility card.

Table 3. AST-ST Claims

Streptococcus agalactiae	*Streptococcus infantarius ssp coli*
Streptococcus alactolyticus	*Streptococcus infantarius ssp infantarius*
Streptococcus anginosus	*Streptococcus intermedius*
Streptococcus canis	*Streptococcus mitis*
Streptococcus constellatus	*Streptococcus mitis / Streptococcus oralis*
Streptococcus constellatus ssp. constellatus	*Streptococcus mutans*
Streptococcus constellatus ssp. pharyngis	*Streptococcus oralis*
Streptococcus cristatus	*Streptococcus parasanguinis*
Streptococcus downei	*Streptococcus pneumoniae*
Streptococcus dysgalactiae ssp. *dysgalactiae*	*Streptococcus pneumoniae ATCC 49619*
Streptococcus dysgalactiae ssp. *equisimilis*	*Streptococcus pyogenes*
Streptococcus equi ssp. *equi*	*Streptococcus salivarius*
Streptococcus equi ssp. *zooepidemicus*	*Streptococcus sanguinis*
Streptococcus equinus	*Streptococcus sobrinus*
Streptococcus gallolyticus ssp gallolyticus	*Streptococcus suis*
Streptococcus gallolyticus ssp pasteurianus	*Streptococcus suis* I
Streptococcus gordonii	*Streptococcus suis* II
Streptococcus Group A	*Streptococcus thermophilus*
Streptococcus Group B	*Streptococcus uberis*
Streptococcus Group C	*Streptococcus vestibularis*
Streptococcus *Group G*	Streptococcus viridans group except *S. pneumoniae*

Performance. The interpretive breakpoints listed in **Table 4** were used to evaluate performance.

Table 4.

Antibiotic	Committee	Organism groups	<=S	I	>=R	Calling range
C	CLSI	*S. pneumoniae*	4	-	8	1-16
	CLSI	Beta and Viridans	4	8	16	
GM	EUCAST	All streptococci	128	-	256	64-512
MEM	FDA	*S. pneumoniae*	0.12	-	-	0.06-4
	FDA	Beta	0.5	-	-	
	CLSI	Viridans	0.5	-	-	
MXF	FDA	All streptococci	1	2	4	0.06-4
RA	EUCAST	*S. pneumoniae*	0.06	0.12-0.5	1	0.06-4
	EUCAST	Beta	0.06	0.12-0.5	1	
TEC	EUCAST	All streptococci	2	-	4	0.125-4
TGC	FDA	*S. pneumoniae*	0.06	-	-	0.06-1
	FDA	Beta and Viridans	0.25	-	-	

Table 5 lists the percent (%) correlation of VITEK® 2 MIC results to the reference results for CA, EA, mE, ME and VME. (Note: Errors listed are EA errors only.)

Table 5. Correlation of VITEK® 2 MICs to Reference.

%	C	GM, HL	MEM	MXF	RA	TEC	TGC
CA	98.7 (623/631)	99.8 (634/635)	96.2 (611/635)	98.1 (622/634)	91.2 (394/432)	100 (635/635)	99.4 (631/635)
EA	98.4 (621/631)	100 (635/635)	97.2 (617/635)	97.8 (620/634)	99.1 (428/432)	100 (635/635)	97.8 (621/635)
EA mE	0 (0/631)	NA	NA	0.2 (1/634)	0.9 (4/432)	NA	NA
EA ME	0.3 (2/574)	0 (0/633)	0.4 (2/485)	0 (0/603)	0 (0/371)	0 (0/635)	0.5 (3/631)
EA VME	0 (0/55)	0 (0/2)	0 (0/150)	0 (0/17)	0 (0/1)	0 (0/0)	0 (0/4)

Time to Call. Table 6 describes the percentage of streptococcal isolates that finalized by hour 8. The lower percentage for viridans is due to the fact that although species such as *S. mitis* grow quickly, microaerophilic strains such as *S. intermedius* require a longer incubation time.

Table 6. Isolates (%) completed in <=8 hours.

%	C	GM, HL	MEM	MXF	RA	TEC	TGC
SPN	86.3	97.9	85.9	97.2	98.2	97.9	82.0
VIR	50.0	61.4	55.0	74.1	not claimed	61.4	39.7
BS	85.0	88.7	88.6	94.0	89.1	88.7	57.7

The development data for the first 12 tests for the new VITEK® 2 AST-ST card were presented in part in an abstract for the European Congress of Clinical Microbiology and Infectious Diseases (ECCMID) in April 2010. The EA results from that study are in Table 7. The tests are : amoxicillin (AMX), cefotaxime (CTX), ceftriaxone (CRO), clindamycin (CM), erythromycin (E), inducible clindamycin resistance test (ICR), levofloxacin (LEV), linezolid (LNZ),penicillin (P), trimethoprim/sulfamethoxazole (SXT), tetracycline (TE), and vancomycin (VA).

Table 7. Performance of previously developed AST-ST tests

% EA	AMX	CTX	CRO	CM	E	ICR	LEV	LNZ	P	SXT	TE	VA
SPN	94.5	95.6	99.3	95.8	98.9	NA	99.6	100	100	97.9	99.6	97.7
VIR	98.4	97.4	94.7	98.5	99.5	NA	100	100	97.4	NA	95.5	93.3
BS	100	99.4	100	97.6	98.2	100	98.8	100	100	98.5	95.1	97.6

CONCLUSIONS

Based on the results from this development study:

- The new VITEK® 2 Streptococcus AST tests showed excellent correlation with the broth microdilution reference method.
- Although most streptococci are susceptible to many antibiotics, isolates that were considered resistant to chloramphenicol, meropenem and moxifloxacin by the reference method were also called resistant by the VITEK® 2 tests.
- The rapid time-to-call allows early institution of effective antimicrobial therapy along with the implementation of appropriate infection control precautions.

VITEK® 2 - ANTIMICROBIAL SUSCEPTIBILITY TESTING

YEASTS

JOURNAL OF CLINICAL MICROBIOLOGY
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Multicenter Evaluation of the New VITEK® 2 Yeast Susceptibility Test Using New CLSI Breakpoints for Fluconazole.

Pfaller MA., Diekema DJ., Procop GW., Wiederhold NP.

In this study the performance of the VITEK® 2 AF03 Investigation Use Only (IUO) yeast susceptibility card* was validated against the CLSI broth microdilution (BMD) method using the new species-specific clinical breakpoints and epidemiologic cutoff values for fluconazole and *Candida* spp. The evaluation was conducted in 3 independent labs with a broad range of 746 *Candida* isolates and 44 *Cryptococcus neoformans* isolates, including an additional 10 reproducibility strains. Notably, 82 *Candida* and 4 *C. neoformans* isolates were either resistant or non-wildtype to fluconazole using the new CLSI species-specific interpretive criteria.

Essential agreement (within 2 doubling dilutions) was 94% for *Candida* spp. and 86.4% for *C. neoformans* when comparing the VITEK® 2 to BMD against fluconazole. On the other hand, category agreement between the VITEK® 2 and BMD was 92% for *Candida* spp. with 0.3% very major errors (VMEs) and 2.6% major errors (MEs), whereas category agreement for *C. neoformans* was 84.1% with 4.5% VMEs and 11.4% MEs. Intra- and inter-laboratory reproducibility was 100% for all 10 reproducibility strains. Mean time to results for the VITEK® 2 system was 9.1 hours (range of 7.5 to 11.2 hours) and 12.1 hours for *Candida* spp. and *C. neoformans*, respectively.

The VITEK® 2 AF03 IUO yeast susceptibility card was found to have excellent essential and category agreement with the reference BMD method in three independent laboratories, while reliably identifying fluconazole resistance among *Candida* species isolates. The use of the VITEK® 2 system provides a highly automated, rapid, and standardized means of performing antifungal susceptibility testing in the clinical microbiology laboratory.

* Note, the version of fluconazole (flu02n) used in this paper is not available as of the time of this writing. Contact your bioMérieux representative for availability.

"The VITEK® 2 AF03 IUO yeast susceptibility test […] reliably identifies fluconazole resistance among Candida spp. and demonstrates excellent quantitative and qualitative agreement with the reference BMD method…"

KEY POINTS

- ➔ The VITEK® 2 performs antifungal susceptibility testing in a highly automated, rapid, and standardized way.
- ➔ The VITEK® 2 reliably identifies fluconazole resistance among *Candida* species isolates.
- ➔ Mean time to result was 9.1 hours (range of 7.5 to 11.2 hours) for *Candida* species.

JOURNAL OF CLINICAL MICROBIOLOGY
2011;49(5):1765-1771

Multicenter Comparison of the VITEK® 2 Antifungal Susceptibility Test with the CLSI Broth Microdilution Reference Method for Testing Caspofungin, Micafungin, and Posaconazole against *Candida* spp.

Peterson J.F., Pfaller M.A., Diekema D.J., Rinaldi M.G., Riebe K.M., Ledeboer N.A.

Three clinical sites compared VITEK® 2 caspofungin and micafungin susceptibility results to reference broth microdilution (BMD) using 112 challenge strains and 755 clinical *Candida* isolates. In addition, another 452 clinical *Candida* albicans isolates were tested with the VITEK® 2 against posaconazole and compared to BMD. Caspofungin and micafungin BMD MIC determinations were taken after 24 hours of incubation, whereas posaconazole BMD MIC determinations were taken after 48 hours of incubation.

Essential agreement between the VITEK® 2 and BMD for caspofungin, micafungin, and posaconazole was 99.5%, 98.6%, and 95.6%, respectively. Overall category agreement was 99.8%, 98.2%, and 98.1% between the VITEK® 2 and BMD for caspofungin, micafungin, and posaconazole, respectively. All drug-organism combinations, with the exception of micafungin and *C. parapsilosis* (84.1%), had categorical agreement in excess of 98%. Mean time to results for the VITEK® 2 was 8.2 hours (range of 5.6 to 19.2 hours), 8.4 hours (range of 5.5 to 19.2 hours), and 9.0 hours (range of 8.2 to 13.6 hours) with caspofungin, micafungin, and posaconazole, respectively.

The VITEK® 2 antifungal susceptibility test was found to provide highly reproducible and accurate MICs compared to BMD. It is a fully automated system that eliminates the inherent bias of manual MIC determination while producing timely results.

"… , the VITEK® 2 system provides […] MICs for caspofungin and micafungin against Candida spp. and for posaconazole against C. albicans, […] thus eliminating the subjectivity that is inherent in systems relying on visual MIC determination."

KEY POINTS

- ➔ The VITEK® 2 performs antifungal susceptibility testing in a highly automated, rapid, and standardized way.
- ➔ The VITEK® 2 reliably generates MICs for caspofungin, micafungin, and posaconazole for *Candida* isolates.
- ➔ Mean time to result was 8.2, 8.4, and 9.0 hours with caspofungin, micafungin, and posaconazole, respectively for *Candida* species.

JOURNAL OF CLINICAL MICROBIOLOGY
2007; 45(3):796-802

Multicenter Comparison of the VITEK® 2 Yeast Susceptibility Test with the CLSI Broth Microdilution Reference Method for Testing Fluconazole against *Candida* spp.

Pfaller M.A., Diekema D.J., Procop G.W., Rinaldi M.G.

This study evaluated the performance of the VITEK® 2 compared to CLSI reference broth microdilution (BMD) with 426 *Candida* spp. in three independent clinical laboratories against fluconazole. Fluconazole BMD MIC determinations were taken after 24 and 48 hours of incubation.

Excellent essential agreement (within two doubling dilutions) was observed between the VITEK® 2 and the 24- and 48-hour BMD MICs with overall essential agreement of 97.9% and 93.7%, respectively. Overall categorical agreement between VITEK® 2 and BMD was observed to be 97.2% and 88.3% for the 24-hour and 48-hour BMD, respectively. The lower 88.3% categorical agreement for 48-hour BMD was mostly due to minor errors arising due to a shift in the MICs for *C. glabrata* from susceptible at 24 hours to susceptible dose dependent at 48 hours with the BMD method. Reproducibility of the VITEK® 2 was excellent with an intra- and interlaboratory agreement of 100%. In addition to highly reproducible results, the VITEK® 2 produced results with a range of 10 to 26 hours, and a mean of 13 hours.

The VITEK® 2 was found to have excellent qualitative and quantitative agreement relative to BMD for fluconazole with *Candida* spp. Also, it eliminates subjectivity and minimizes the effect of trailing growth that compromises the performance of methods that rely on visual MIC determination.

"… the MICs of fluconazole can be determined […] in less than 15 h for most species of Candida with the VITEK® 2 yeast susceptibility test. […] each test is performed in a highly standardized manner and provides quantitative MIC results that are reproducible and accurate."

KEY POINTS

- ➔ The VITEK® 2 system reliably identifies fluconazole resistance among *Candida* spp.
- ➔ The VITEK® 2 provides accurate results with excellent reproducibility and standardization.
- ➔ The VITEK® 2 was rapid with mean time to results of 13 hours for fluconazole against *Candida* spp.

YEASTS

JOURNAL OF CLINICAL MICROBIOLOGY
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Multicenter Comparison of the VITEK® 2 Antifungal Susceptibility Test with the CLSI Broth Microdilution Reference Method for Testing Amphotericin B, Flucytosine, and Voriconazole against *Candida* spp.

Pfaller M.A., Diekema D.J., Procop G.W., Rinaldi M.G.

VITEK® 2 was compared to CLSI reference broth microdilution (BMD) with 426 *Candida* spp. isolates in three independent clinical laboratories against amphotericin B*, flucytosine, and voriconazole. BMD MIC determinations were taken at both 24- and 48-hours.

Good essential agreement (within 2 doubling dilutions) was observed between the VITEK® 2 and the 24- and 48-hour BMD MICs for all three antifungal agents with overall agreement of 99.1% and 97% for amphotericin B, respectively; 99.1% and 98.8% for flucytosine, respectively; and 96.7% and 96% for voriconazole, respectively. Overall categorical agreement between VITEK® 2 and 24-hour and 48-hour BMD was observed to be 98.1% and 96.9% for flucytosine and 98.6% and 97.4% for voriconazole. CLSI lacks interpretive breakpoints for amphotericin B making it necessary to forego assessment of category agreement for this antifungal agent. Highly reproducible MIC results were generated by the VITEK® 2 with intra- and interlaboratory agreement of >98% for all three antifungal agents. Mean time to result for the drugs tested ranged from 12 to 15 hours, with a minimum and maximum time to result of 9.1 and 27.1 hours, respectively.

The VITEK® 2 was found to have excellent qualitative and quantitative agreement relative to BMD for the generation of amphotericin B, flucytosine, and voriconazole susceptibility data with *Candida* spp. It produces highly reproducible, rapid results that reliably produce MICs that are comparable to BMD while ensuring that each test is performed in a highly standardized fashion.

* Amphotericin not available in the US

"… the MICs of amphotericin B, flucytosine, voriconazole, and fluconazole can now be determined […] in less than 15 h for most species of Candida with the VITEK® 2 system."

KEY POINTS

- ➔ The VITEK® 2 has excellent performance with amphotericin B, flucytosine, and voriconazole against *Candida* spp.
- ➔ The VITEK® 2 provides accurate results with excellent reproducibility and standardization.
- ➔ The VITEK® 2 was rapid with mean time to results for the drugs tested ≤15 hours.

Advanced Expert System™

White Paper,
2011

Maximizing the Use of the Advanced Expert System™ to improve Patient Care.

LaBombardi V.J.

Laboratories are continually striving to improve the quality of susceptibility data being provided to the clinician. In addition, the need to have this information quickly is becoming more and more obvious. This paper examines how the Advanced Expert System™ (AES) can be used by laboratories to help improve the quality of susceptibility data.

Automatically releasing a preliminary report based on the AES review of the results (auto-posting) reduces the time to report AST results to the clinician. This practice has the ability to impact the quality of patient care by decreasing turn-around time for identification and susceptibility results. By auto-posting results that show consistency between the identification and susceptibility profiles obtained, time to report results was reduced from 54.3 hours to 34.9 hours for positive blood cultures. When comparing the time required to identify non-albicans *Candida* species, the time to result was reduced from 91 hours to 44 hours by changing from conventional methods of identification to the use of VITEK® 2 and auto-posting VITEK® 2 results.

In addition to auto-posting, the AES gives microbiologists tools that they need to manage the ever increasing plethora of resistance mechanisms. Using a simple traffic light (red, yellow, green) approach, it allows them to sort results where the identification and susceptibility profiles are consistent with expected results from those requiring further workup and the expertise of the microbiologist. Since the results have been thoroughly checked by the extensive AES database, the microbiologist can feel comfortable releasing a preliminary result. Auto-posting is a way to provide faster results to clinicians.

"The decrease in turn-around-time (TAT) is significant and has been acknowledged by our clinicians."

KEY POINTS

- ➔ The Advanced Expert System™ can help improve quality of results and can reduce the time it takes to get results to clinicians.
- ➔ By implementing auto-posting, significant reduction in reporting time can be accomplished.

JOURNAL OF ANTIMICROBIAL CHEMOTHERAPY
2002;49(2):289-300

Multicentre evaluation of the VITEK® 2 Advanced Expert System™ for interpretive reading of antimicrobial resistance tests

Livermore DM., Struelens M., Amorim J., Baquero F., Bille J., Canton R., Henning S., Gatermann S., Marchese A., Mittermayer H., Nonhoff C., Oakton KJ., Praplan F., Ramos H., Schito GC., Van Eldere J., Verhaegen J., Verhoef J., Visser MR.

This study evaluated the Advanced Expert System™ (AES), which automatically performs interpretive reading* of the MICs generated by the VITEK® 2 System. Ten European laboratories tested 42 reference strains and 76-106 of their own strains with important resistance mechanisms and compared the AES results to the genotypic data.

Interpretive reading by the VITEK® 2 AES achieved full agreement with genotype data for 88-89% of strains, with the correct mechanism identified as one of two possibilities for an additional 5-6%. Of the organisms tested, AES showed 90% agreement with reference data for methicillin resistance in *Staphylococci*, glycopeptide resistance in *enterococci*, quinolone resistance in *Staphylococci* and *Enterobacteriaceae*, AAC(6')-APH(2")-mediated aminoglycoside resistance in Gram-positive cocci, *erm*-mediated macrolide resistance in *Pneumococci*, extended-spectrum beta-lactamases (ESBLs) in *Enterobacteriaceae* and *Pseudomonas aeruginosa*, acquired penicillinases in *Enterobacteriaceae*. VanA, VanB and VanC phenotypes in *Enterococci* were distinguished reliably, and ESBL production was accurately inferred in AmpC-inducible species as well as *Escherichia coli* and *Klebsiella* spp.

Mechanisms identified, but only as possibilities among several, included IRT-type beta-lactamases and individual aminoglycoside-modifying enzymes in *Enterobacteriaceae*. Disagreements with reference data were seen in *Pneumococci* that were found to have high-level penicillin resistance by the AES but had been previously shown to have intermediate resistance phenotypically.

AES will suggest editing the antibiogram based on the inferred resistance mechanism. When ESBL production was inferred in *E. coli* and *Klebsiella*, the AES modified susceptible results for cephalosporins to be resistant; when an acquired penicillinase was inferred in *Enterobacteriaceae*, piperacillin results were modified to resistant; and when *Staphylococci* were found to be methicillin resistant, resistance was reported for all beta-lactams.

* Interpretive reading refers to analyzing the complete resistance profile of an organism to multiple antibiotics and inferring the resistance mechanisms present.

"… this study demonstrated the capacity of VITEK® 2 to detect and interpret resistance mechanisms with a high level of accuracy and standardization."

KEY POINTS

- ➔ The Advanced Expert System™ demonstrates good performance in inferring the resistance mechanism present for a number of common, clinically important resistance mechanisms.
- ➔ Following the recommendations of antimicrobial standards committees, AES is able to make recommended editing to reports when resistance is detected.

JOURNAL OF CLINICAL MICROBIOLOGY
2001;39(7):2379-2385

Potential Impact of the VITEK® 2 System and the Advanced Expert System™ on the Clinical Laboratory of a University-Based Hospital.

Sanders CC., Peyret M., Moland ES., Cavalieri SJ., Shubert C., Thomson KS., Boeufgras JM., Sanders WE.

This study was designed to assess the impact of the VITEK® 2 and the associated Advanced Expert System™ (AES) in detecting resistance in bacterial isolates in a typical university-based hospital. A total of 259 consecutive, non-duplicate isolates of *Enterobacteriaceae*, *Pseudomonas aeruginosa*, and *Staphylococcus aureus* were collected and tested by the VITEK® 2 System for identification and antimicrobial susceptibility. The results were analyzed by the AES and by a human expert to determine the resistance phenotype present.

Of the 259 isolates tested, 245 (94.6%) were correctly identified with little input from the microbiologist. For 194 (74.9%) isolates, no inconsistencies between the identification and the susceptibility were detected by the AES, thus no input was needed from the microbiologist.

The AES suggested one or more corrections to results obtained to remove inconsistencies with 65 strains. The human expert thought that most of these corrections were appropriate. Resistance phenotypes given by the AES for beta-lactams, aminoglycosides, quinolones, macrolides, tetracyclines, and glycopeptides were similar to those assigned by the human expert for 95.7 to 100% of strains. These results indicate that the VITEK® 2 system and AES can provide accurate information for most of the clinical isolates examined and remove the need for human analysis of results for many isolates.

"… these new systems remove the need for human analysis of results for many isolates, freeing personnel for other activities and improving the overall quality of the information generated, especially in laboratories without a human expert."

KEY POINTS

➔ VITEK® 2 and AES provide accurate results for the majority of clinical isolates that are found in the university-based hospital.

Impact of Rapid Reporting

EUROPEAN JOURNAL OF CLINICAL MICROBIOLOGY AND INFECTIOUS DISEASES
2012;31 (9):2445-2452

Clinical and economic impact of rapid reporting of bacterial identification and antimicrobial susceptibility results of the most frequently processed specimen types.

Galar A., Yuste J.R., Espinosa M., Guillén-Grima F., Hernáez-Crespo S., and Leiva J.

This study evaluated the medical and economic impact of rapid microbiological identification and susceptibility reporting on the most frequently encountered specimens isolated in the clinical microbiology lab. The scope of testing was limited to hospitalized patients with bacterial infections. The VITEK® 2 System was used for both identification and susceptibility testing throughout the evaluation, and testing was divided into two groups: 1) the control group in which results were reported the day following the analysis, and 2) the test group with workflow resulting in same-day (rapid) reporting.

The median time needed to report results by sample type for the control and rapid reporting "test" group were as follows:

	Control Group	Rapid Reporting Group	P Value
Wound/Abscess	23.5 hours	9.5 hours	<0.001
Blood	23.5 hours	9.2 hours	<0.001
Urine	23.4 hours	9.3 hours	<0.001

Though the mortality rates did not differ significantly between the two groups, the faster reporting seen with the rapid "test" group was associated with a significant reduction in length of hospital stay (>2.5 days) and an overall cost savings by up to 40% (5,695€ or $6,982 USD* versus 9,367€ or $11,484 USD*) for patients hospitalized with urine and wound/abscess infections, but not sepsis infections. Length of hospital stay and hospital cost savings likely were not significant for sepsis patients in this study because the lab routinely reported Gram stain results directly to the physician responsible for the patient at the moment at which the automated system detected a positive blood culture.

* USD calculated using exchange rate of $1.226 USD per 1.0€

"Faster reporting of ID/AST results was associated with a significant reduction in hospital stay and overall costs for patients from whom wound, abscess and urine specimens were analyzed."

KEY POINTS

➔ Faster reporting reduced length of hospital stay by more than 2.5 days and total hospital costs by up to 40%.

JOURNAL OF INFECTION
2012;65(4):302-309

Clinical and economic evaluation of the impact of rapid microbiological diagnostic testing.

Galar A., Leiva J., Espinosa M., Guillén-Grima F., Hernáez S., Yuste JR.

This study evaluated the clinical and economic impact of rapid reporting of results from the clinical microbiology lab. It included 574 hospitalized patients with bacterial infections, 284 of which were included in a control group where the laboratory's normal practice made results available to clinicians one day after the analysis was initiated. The remaining 290 patients made up the experimental group, and they had their respective microbiology results reported to clinicians the same day of the analysis using a rapid, same-day workflow. The VITEK® 2 System was used for both identification and antimicrobial susceptibility testing for all results in this study.

The data generated showed that reporting microbiology results faster allowed the clinician to provide antibiotic treatment sooner (P<0.001). For the group whose results were reported according to the rapid protocol, there was significant reduction in the duration of hospital stay, decreased reporting turnaround time (17.6 hours), a reduction in the number of tests performed, and lower intubation rates for patients. Additionally, costs incurred for the patients including those associated with microbiology testing, antibiotic costs, length of hospitalization, and miscellaneous patient costs were lower (mean savings of 3,588€ or $4,542 USD* per patient) for the group of patients whose results were reported via the rapid protocol. Mortality rates did not differ significantly between the two groups.

In conclusion, the authors described that rapid reporting of microbiology results was associated with quality improvement as seen by earlier optimization of patient antibiotic therapy, an improved clinical outcome and financial benefits.

* USD calculated using exchange rate of $1.226 USD per 1.0€

"… significant savings […] observed in antibiotic expenses […] coupled with the reduction in the length of hospital stay and the number of microbiological and biochemical tests performed, support the usefulness of earlier reporting of microbiological results."

KEY POINTS

➔ Rapid microbiology results from the VITEK® 2 significantly reduced hospital costs, improved clinical outcome, and reduced length of stay

JOURNAL OF CLINICAL MICROBIOLOGY
1999;37(5):1415-1418

Clinical and Financial Benefits of Rapid Bacterial Identification and Antimicrobial Susceptibility Testing.

Barenfanger J., Drake C., and Kacich G.

This study evaluated the clinical and financial benefits attributed to rapid reporting of bacterial identification and susceptibility results. The analysis compared culture results obtained utilizing the laboratory's standard methods versus those obtained more rapidly due to a minor change in workflow.

Using the standard laboratory methodology technologists were available to process samples using a VITEK® system* during a daily 8-hour shift (7am to 3:30pm), and results for a given work day could only be reported for isolates that completed testing during this time frame. Alternatively, the rapid susceptibility testing methodology differed from the aforementioned standard laboratory methodology in that a technologist on the evening shift verified and reported results that became available after 3:30pm, thus resulting in same day result reporting.

For patient samples tested with the VITEK® system using the rapid reporting workflow, the majority of bacterial identification and antimicrobial susceptibility testing results (>90%) were reported on the same day the instrument's analysis was complete. In contrast, only approximately 50% of the cultures processed in the routine manner were reported on the same day of susceptibility testing.

The findings associated with samples tested utilizing rapid reporting methods versus those tested using the routine workflow are as follows:

	Rapid Reporting	Routine Workflow	P Value
Average Turn Around Time for AST Reporting	39.2 hours	44.4 hours	.001
Mortality Rates	7.9%	9.6%	.45
Average Length of Stay	10.7 days	12.6 days	0.006
Average Variable Cost per Patient	$4,927	$6,677	0.001

Additionally, clinicians were able to initiate antimicrobial therapy sooner for patients whose samples were tested using the rapid reporting workflow (P value =0.006). Moreover, the institution extrapolated their average variable costs using rapid versus routine reporting methods over the time period of one year and calculated a savings at $4,000,000 USD.

* Note that this evaluation used a VITEK® instrument which has since been replaced with the VITEK® 2 instrument. This study remains relevant for the VITEK® 2 since the concept of same-day versus next-day reporting remains valid.

"[Rapid reporting utilizing the VITEK® system] results in over $4 million in savings in variable costs per year in our hospital."

KEY POINTS

- ➔ Average turnaround time for reporting AST results was 5.2 hours faster using the rapid reporting workflow compared to the routine workflow.
- ➔ Mortality rates using the rapid reporting workflow were 1.7% lower than those seen with routine reporting methods.
- ➔ Average length of stay was reduced 1.9 days for patients in the rapid reporting group.
- ➔ Average variable cost was $1,750 USD lower per patient when microbiology results were reported via the rapid instead of the routine workflow.

Workflow Analysis

WHITE PAPER,
2008

Ergonomic Analysis Comparison of the VITEK® 2 and VITEK® 2 Compact with the Microscan WalkAway® 96 and Phoenix™ For Work Flow Efficiency and the Likelihood of Distal Upper Extremity Strain.

Heller-Ono A.

The purpose of this study was to evaluate and compare the ergonomic risk factors, number of steps, and the time needed to prepare isolates on the VITEK® 2, VITEK® 2 Compact, MicroScan WalkAway® 96, and Phoenix™ instruments. A specialized test called "strain index" was used to measure repetitive and exertional stress of the set up process of each instrument. The resulting data was used to predict the risk of distal upper extremity muscle strain to technicians.

Data was collected from 19 laboratory scientists and 4 laboratory assistants from different facilities to assess the setup preparation steps for both identification and susceptibility testing for each instrument. Results were as follows:

	VITEK® 2	VITEK® 2 Compact	Phoenix™	MicroScan WalkAway® 96
Number of Users	11 laboratory scientists	3 laboratory scientists	3 laboratory scientists	2 laboratory scientists 4 laboratory assistants
Average Number of Steps in Test Setup	9	11	18	21*
Average Time to Complete a Work Cycle for one isolate (sec)	60	64	72	90*
Average "Strain Index" Score: 0-1 hour use 1-2 hour use 2-4 hour use	 2.25 4.5 6.75	 0.75 2.25 Not assessed-	 7.5 26.5 Not assessed	 Not assessed 6.75 (laboratory scientists) 60.75 (laboratory assistants)

*Cumulative results for both laboratory scientists and laboratory assistants performing the setup

The VITEK® 2 and VITEK® 2 Compact demonstrated 40-50% fewer steps compared to the Phoenix™ and MicroScan WalkAway® 96 instruments. As a result, the "strain index" analysis showed that technicians using a Phoenix™ or MicroScan WalkAway® 96 instrument were at a significantly higher risk of muscle strain (e.g. repetitive motion injury) relative to those using VITEK® 2 instruments. Furthermore, the reduced number of steps seen with the VITEK® 2 systems translated to an average productivity gain of 8-30 seconds per work cycle (i.e. 12-30% more efficient work cycle setup time).

"The results indicate that the VITEK® 2 and VITEK® 2 Compact offer more efficient work cycles with less exposure to ergonomic risk factors resulting in a reduced risk of injury to laboratory staff."

KEY POINTS

- ➔ VITEK® 2 and VITEK® 2 Compact use 40-50% fewer steps than other systems to prepare isolates for testing.
- ➔ The average time to set up an isolate was 8 to 30 seconds faster with VITEK® 2 systems relative to other systems resulting in a 12-30% efficiency gain.
- ➔ Laboratory staff have a reduced risk of injury when using VITEK® 2 and VITEK® 2 Compact as opposed to other systems.

VITEK® 2 - WORKFLOW ANALYSIS

➔ ECCMID 2013

Poster P-1536

WORKFLOW

Comparison of bioMerieux VITEK® 2 XL, BD Phoenix™, and Siemens MicroScan Walkaway® 96 plus: Choosing an Identification and Antimicrobial Susceptibility Testing System for a Medium Sized Microbiology Laboratory

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[1] Interior Health-Kelowna BC, [2] University of Victoria BC, [3] University of British Columbia-Okanagan, [4] University of British Columbia-Vancouver, Canada

ABSTRACT

Objectives: Performance of an automated identification (ID) and antimicrobial susceptibility testing (AST) instrument is not limited to accuracy of ID and AST results. Other parameters must also be taken into consideration. This study evaluated three automated systems (bioMèrieux VITEK® 2 XL [VTK], BD Phoenix® [PHX] and Siemens MicroScan Walkaway96 plus® [MS]) based on inoculum preparation, test menu, requirement for manual testing, time to reporting, biohazardous waste, space requirements and environmental footprint.

Methods: All three instruments were evaluated simultaneously over a 2 month period at the Larissa Yarr Microbiology Laboratory at Kelowna General Hospital, British Columbia, Canada. Set up time and biohazardous waste results were determined using groups of 10 isolates to simulate a typical workflow situation.

Results: Inoculum preparation time (in minutes for 10 samples) was 18.5 for VTK, 19.3 for MS and 21.5 for PHX. For the MS, its most rapid sample preparation method was used (PROMPT™) and for the PHX extra time required for the AP system to prepare dilutions and add AST indicator was not included (as more samples or other work could be done during this time). No manual testing was required for VTK or PHX, for MS oxidase or beta-lactamase tests were routinely required. Time to result of final ID/AST was 4-18h for VTK, 4-16h for PHX and 16 or 24h for MS (preliminary ID resulted earlier for both VTK and PHX).

The VTK produced the least biohazardous waste in kg per samples (0.048) with an estimated annual cost in CAD of $2628.00, the PHX was 0.109 ($5967.50) and the MS 0.122 ($6679.50). The PHX instrument with the AP system required the most bench space. The PHX and the MS required more storage space for their ID/AST panels and reagents/ supplies than the VTK. The VTK has a larger ID test menu including aerobic Gram-positive (GP) and Gram-Negative (GN) organisms along with fastidious GNs, anaerobes and yeast while the PHX does not include fastidious GN, anaerobes or yeast and the MS test menu includes aerobic GP cocci, and aerobic GN and fastidious GN.

Conclusions: Accuracy of ID/AST was similar for all three systems. The VTK was deemed the best fit for a medium sized clinical microbiology laboratory given its larger ID test menu, rapid inoculum preparation, minimal manual testing, ability to use inoculum for offline testing, time to resulting, ability to test ID and AST separately, reduced biohazard waste cost and favorable environmental footprint.

INTRODUCTION

In British Columbia, laboratories are mandated to justify their choice of automated instruments through a rigorous process not limited to accuracy and cost but also by parameters such as impact on workflow, continuous quality improvement and environmental footprint. The purpose of this study was to determine which automated ID/AST instrument was the best fit for the Larissa Yarr Microbiology Laboratory, a medium sized clinical microbiology laboratory in Kelowa, BC. The instruments evaluated in this study were the bioMèrieux VITEK® 2 XL (VTK), the BD Phoenix® (PHX) and the Siemens MicroScan Walkaway96 plus® (MS). Accuracy of Identification(ID) and antimicrobial susceptibility testing (AST) were evaluated along with sample preparation time (TTP), test menu, workflow, ergonomics, requirements for manual testing, ergonomics, time to reporting (TTR), production of bio-hazardous waste, storage and space requirements and environmental footprint.

METHODS

All three instruments were evaluated simultaneously throughout the summer of 2012 at the Larissa Yarr Microbiology Laboratory, Kelowna, Canada. All organisms were collected from frozen clinical and study isolates and sub-cultured twice to ensure purity prior to setting up on all three instruments simultaneously. ID and AST results were compared to the previously reported results by VITEKII (current system at Larissa Yarr laboratory) as well as multiple previously characterized isolates (16sRNA). Any discrepant results due to operator error (e.g. insufficient growth in positive control well, contaminant on purity plate etc.) were re-set up. Set up time and biohazard waste results were determined using groups of 10 isolates to simulate a typical workflow situation.

RESULTS

All three systems tested were reliable for the identification of *Staphylococcus spp*. (VTK-100% [27/27], PHX- 95.7% [22/23], MS- 96.2% [25/26]) and for *Enterobacteriaceae* (VTK-92.4% [61/66], PHX- 92.4 [61/66], MS- 89.4% [59/66]). All three instruments had limitations in Streptococcus speciation. There were inconsistencies for all three instruments in ID of previously characterized unusual/ fastidious GN organisms; however VTK had a slight advantage given its more extensive test menu. (Table 3). Overall AST results were comparable for all three systems especially for *Staphylococci spp* while VTK and PHX were marginally better for *Enterobacteriaceae* and MS had an advantage for *Streptococci spp*. Inoculum preparation time per 10 samples was 18.5min for VTK,19.3min for MS (using (PROMPT™

Comparison of bioMerieux VITEK® 2 XL, BD Phoenix™, and Siemens MicroScan Walkaway® 96 plus: Choosing an Identification and Antimicrobial Susceptibility Testing System for a Medium Sized Microbiology Laboratory

preparation method) and 21.5min for PHX. Although the PHX requires extra time for preparation of dilutions by AP system and adding AST indicator, this was not included in inoculum preparation time as more samples or other work could be done during this time. Annual cost difference in technologist time for organism inoculation is shown in Table 1. Ergonomically the VTK was easiest to use followed by the PHX and then MS. Time to reporting (TTR) in hours was 4-16 (PHX) 4-18 (VTK) and 16-24h(MS). Biohazard reagents are used routinely for MS but not by other systems (Table 3). There was a significant difference in biohazard waste (per 10 tests) between the three systems (VTK- 0.048kg, PHX- 0.109kg and MS- 0.122kg). Annual cost for disposing of this biohazard waste is shown in Table 2. In order of most refrigerator space required VTK required the most (all ID/AST panels), followed by MS (3% Laked Horse Blood in Mueller Hinton broth used for MicroStrep, peptidase and indole reagents, HNID and RNID3 panels) Refrigerator space is minimal for PHX (AST indicator). Requirement for extra manual /off line was significant for MS but not for VTK or PHX. Bench space requirements were most significant for PHX followed by MS then VTK.

Table 1. Comparison of Annual Cost in Technologist Time for Inoculum Preparation.

Instrument	Time/ test (min)*	Annual Time (120 tests/ day)	Cost ($) Technologist salary
Vitek II	1.845	1346.85	40,405.50
Phoenix	2.153	1571.93	47,157.90
MicroScan	1.928	1407.68	42,230.40

Table 2. Comparison of Annual Cost of Biohazardous Waste

Instrument	Weight/10 tests (kg)	Annual mass (kg) (120 tests/day)	Annual Cost ($)***
Vitek II	0.048	2102.4	2628.00
Phoenix	0.109	4774.2	5967.50
MicroScan	0.122	5343.6	6679.50

Table 3. Comparison of Major Differences Between VTK, PHX and MS Systems

	Instrument		
	Vitek II	Phoenix	MicroScan
Test Menu	Gram positive cocci Gram negative bacilli Fastidious Gram negative bacilli Gram positive bacilli Anaerobes Yeast	Gram positive cocci Gram negative bacilli	Gram positive cocci Gram negative bacilli Fastidious Gram negative bacilli Anaerobes Yeast
Set up Time/ Sample	1.845 min	2.153 min	1.928 min
Biohazard Waste / Sample	0.048 kg	0.109 kg	0.122 kg
Required Reagents	None	AST indicator	Kovacs Reagent, a-Napthol, KOH, Sulfanic acid, N-N-dimethyl-a-Napththylamine, Ferric Chloride, NaOH, Peptidase Reagent, Xylene, Ehrlichs Reagent, Iodine Reagent, Rapid indole reagent, HNID indole reagent

DISCUSSION

Although accuracy and cost are important factors in the selection of ID/AST instruments for clinical microbiology laboratories, other factors affect the choice of instrument selecti®on.

The MS offers the ability to set up manual offline testing in the event of instrument failure and the PROMPT™ system can fit well into lab work-flow. However, the number of reagents required with their biosafety concern were deemed as a disadvantage as were the slower sample set up time (1.93min), the slowest TTR (18-24h) and the most biohazard waste produced per sample (0.122kg/sample).

The PHX had excellent TTR (4-16h), limited need for extra reagents (only AST indicator) leading to less biosafety concerns and capability for automated sample dilution preparation (except for Strep panels). The major disadvantages of the PHX included the slowest sample set up time (2.15min), the limited test menu, the significant bench space requirement for the AP instrument and the significant biohazard waste produced (0.109kg/sample).

The VTK demonstrated the fastest set up time (1.845min), no need for extra reagents, the least biohazard waste produced per sample (0.048kg), the most extensive test menu and the least bench space requirement. The availability of separate ID and AST panels was also deemed an advantage. The major disadvantage was the requirement for storing all ID/AST panels in the refrigerator.

CONCLUSIONS

Although accuracy of all three systems were relatively similar, the bioMerieux VITEK® 2 XL was deemed the best fit for the medium sized Larissa Yarr Microbiology Laboratory in Kelowna, BC Canada.

➔ ECCMID 2007 **Poster P-1727**

WORKFLOW

Analysis of the comparative worflow and accuracy of the VITEK® 2 Compact and the combination mini-API® / Agar Diffusion SIRSCAN® Method.

Doat V. [1], Roubille M.[1], Turner R.[2]

[1] CH Pierre Oudot, Laboratoire de Biologie Polyvalente, Bourgoin Jallieu, France, [2] bioMérieux, St Louis, USA

INTRODUCTION

The aim of this study was to analyse the impact of introducing the VITEK® 2 Compact (V2C), (bioMérieux, France), an automated identification (ID) and susceptibility testing (AST) system into a laboratory that is currently using manual (chromogenic media) and semi-automated (mini-API®) identification methods and AST by SIRSCAN® (SIR) (i2a Perols, France) agar diffusion.

MATERIAL AND METHODS

We performed this prospective study in a general laboratory of a 390-bed hospital from January to April 2006. Routine isolates were tested using the manual method or mini-API for ID and SIRSCAN agar diffusion AST method. The results were compared to results obtained by the V2C. One microbiologist, trained on all techniques, performed the comparative study in "real time". The systems were given alternating priority and results were interpreted independently. Quality control was performed according to the manufacturers' recommendations. Data were collected on three study parameters.

I - Workflow

An independent industrial productivity consultant audited and performed chronometric time studies of the laboratory's current workflow process with the API/SIR and with the introduction of the V2C. Each step in the workflow process was timed. This included workbench organization, inoculum preparation, panel or card set-up, introduction of panels or cards into the instruments, result validation (including expert system analysis) and referral. Five strains were repeated three times for both systems on the same day by the same operator, i.e. the microbiologist performing the study, to measure these times.

II - ID, AST and expert system performance

Primary identifications were performed with routine manual methods, e.g. chromogenic media, latex, rapidec-STAPH, etc., or mini-API and with V2C. Repeat testing with each method was performed if either system gave no identification result. At the end of the study period, the results from all methods were compared.

AST testing was performed by SIR and V2C and results were analyzed by each system's expert software [(reading of the inhibition zone diameters by the SIR camera and expertised by the SIR software (DOS Version 1999) and the V2C Advanced Expert System™ (Version 1.01)]. The result proposals from both systems - resistance phenotype and antibiotic category changes - were analysed. Repeat testing was performed with each method if either system gave no result. All AST and phenotype results were compared and the microbiologist, who was designated as the expert, resolved any discrepancies.

III - Patient benefit of rapid results

The benefit of rapid results on patient management was estimated by a retrospective analysis of 10 patient files in collaboration with an infectious disease physician.

RESULTS

In total, 300 routine isolates were included in the study - 175 of the IDs were performed on both systems. This included 90 (51%) *Enterobacteriaceae* (ENB), 14 (8%) non-Fermenters and 71 (41%) Gram-positive cocci (GPC). Rapid manual methods were used to perform 125 IDs.

ASTs were performed for 300 strains on both systems: 160 (53%) *Enterobacteriaceae*, 30 (10%) non-Fermenters and 110 (37%) GPC.

I. Workflow

Table 1: Hands on time to perform one ID/AST test (min)

Steps	VITEK 2 compact		API / SIR	
1	Go to the V2C menu and start the program (virtual cassette mode)	0.74	Remove the material from storage: API strips, susceptibility agar	2.05
2	Remove ID and AST card from -4°C, organise work bench, label purity plates, Dispense 3 ml saline into each of 2 tubes, Label ID tube with accession # and place tube into cassette + second tube for AST	0.36	Open strips, label ID strip and susceptibility plate, strain tube and saline tube	4.00
3	Take the colony with a transfer pipette. Prepare a homogenized ID suspension, Adjust with the Densicheck to appropriate McFarland	1.19	Prepare bacterial suspension for ID in ID medium (2ml), Adjust the inoculum with the Densimat, Transfer the necessary ID suspension volume to the saline tube	1.54
4	Inoculate conservation agar	0.23	Inoculate conservation agar	0.24
5	Place the tubes into rack. Place pipette tip on correct pipettor. Transfer appropriate amount of ID suspension to AST tube	0.10	Inoculate the ID strip , add paraffin oil if necessary, put the cover on the strip	1.22
6	Open pouche, place card in cassette	0.35	Mix the diluted solution, inoculate the 5 susceptibility agar (in 3 directions) and allow to dry	0.94
7	Enter the ID/AST card barcodes	0.12	Place the susceptibility disks on each agar plate with the semi-automated applicator and tweezers (Augmentin)	0.75
8	Link ID/AST card by entering isolate number, Save the work list	0.19	Put the ID strips in a closed box (to maintain humidity), Put the ID strips and the susceptibility agar in the incubator	1.65
9	Take cassette to V2C filler, introduce cassette, press fill button	0.11	Remove the ID strips from the incubator	0.84
10	Remove cassette and place into reader incubator	0.12	Remove the lid, add reagents if needed respecting the reaction time (max 10 minutes)	0.65
11	Put the tubes in the incubator	0.39	Start the miniAPI system, put the ID strips in the API reader and follow the reading procedure, print the results	5.11
12	Remove cassette from reader and through the tubes away	0.18	Remove the lid and put the susceptibility plate in the SIR reader, and follow the reading procedure, perform the Cefinase test if needed	2.61
13	Validate the results	0.85	Verify final result 1 (verification by the biologist : comparison plate and SIR result), sign all the pages, throw away the plate	0.59
14	Print and transmit the results to the Informatics department	2.07	Archive the laboratory reports and transmit the originals to the office	2
		7.00		24.26

Analysis of the comparative worflow and accuracy of the VITEK® 2 Compact and the combination mini-API® / Agar Diffusion Sirscan® Method.

II. ID, AST and expert system performance

A-ID performance

The percentage of overall ID results between the two systems is not significantly different. (see **Tables 2** and **3** below)

GPC	Total*	Overall correct ID	Low discrimination
mini API	70	67 (96%)	3 (4%)
V2C	70	68 (97%)	2 (3%)

*One *Staphylococcus* strain for which the identification result was discrepant (*S. aureus* by Rapidec Staph and *S. lugdunensis* by V2C) was tested by molecular methods, considered as the reference method. The result obtained was a *S. aureus* with an atypical phenotype (manitol and lactose negative strain). Retesting with API 32 Staph gave *S. hominis* and V2C gave *S. aureus*.

ENB	Total*	Overall correct ID	Low discrimi-nation	Mis ID
mini API	90	87 (97%)	1 (1,1%)	2 (2.2%)
V2C	90	87 (97%)	0 (0%)	3 (3.3%)

The ID performance showed 100% agreement for the 14 non-Fermenters tested.

B-AST and expert system performance

AST and Expert System results are represented in the **Table 4**:

Microorganisms	Number of strains	Number of antibiotics tested	Number of antibiotics in agreement	Number of antibiotics with minor disagreement	Number of antibiotics with major disagreement
Non-Fermenters	30	480	456 (95%)	22 (4.6%)	2 (0.4%)
Enterobacteriaceae	160	2560	2495 (97.5%))	53 (2%)	12 (0.5%)
Gram-positive cocci	110	1760	1736 (98.6%)	15 (0.9%)	9 (0.5%)
Total	300	4800	4687 (97.6%)	90 (1.9%)	23 (0.5%)

III. Patient benefit of rapid results

Providing that result accuracy is maintained, rapid availability to the clinician offers significant benefits in patient treatment. Therapeutic choice is guided by these results. In our study, we retrospectively examined 10 cases where results were delivered rapidly - 7 patients' results were delivered within 2 days and 3 results were delivered within 3 days of specimen receipt. In 7 cases, a treatment was initiated or changed to more tailored therapy based on the availability of the results. Two of these changes were made because the AST results showed the causative agent was resistant to the current treatment. In 1 case, appropriate therapy was initiated based on the AST results. For 4 patients, the current treatment was maintained because the bacteria was sensitive. Two patients were removed from unnecessary preventive isolation, and 2 patients were moved to preventive isolation due to infection with multi-resistant organisms.

Availability of the AST results in a shorter period of time allows clinicians to make better judgment and initiate or tailor therapy as appropriate. This helps improve patient outcome, reduce the possibility of hospital acquired infections, as well as providing cost savings for the hospital.

DISCUSSION

For ID, V2C gave very good identification for 97% of microorganisms (3% low discrimination for coagulase negative staphylococci and 3% mis-ID for 90 strains of *Enterobacteriaceae*). For AST, V2C is in agreement with agar diffusion for 98% of the antibiotics tested. The V2C performance is comparable to mini-API/SIRSCAN taking into account the limitations of AST by agar diffusion for the GPC and the non-Fermenters.

The benefits of introducing V2C are as follows:
- rapid results and rapid on-line result validation,
- one third less manipulation time,
- reduced cost of reagents and consumables,
- reduction of waste disposal,
- reduced risk of biohazard exposure.

Rapid result availability to the clinician is of interest especially in cases of *S. aureus* and P. aeruginosa in severe infections. Rarely isolated in blood cultures, the multi-resistant *Enterobacteriaceae* are not yet a major problem in our hospital.

CONCLUSION

- **Both systems gave good results for the majority of strains encountered in our medium size hospital.**
- **The reduced manipulation times, rapid time to results, as well as the easy-to-use platform of the VITEK® 2 Compact provide benefits for both the laboratory and the patient.**
- **Time saved is dependent on the laboratory organization and direct communication with the wards.**
- **The advantages of V2C contributes towards the control of infections and the optimization of risk management in our hospital.**

➔ ASM 2006 **Poster C-123**

WORKFLOW

Analysis of the Comparative Workflow and ID/ AST Test Result Accuracy of the VITEK® 2 compact and the Phoenix™ Systems

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REVISED ABSTRACT

Objectives: The aim of this study was to analyse the impact of introducing into our laboratory the VITEK® 2 compact (V2C), (bioMérieux, France), a new automated identification (ID) and susceptibility testing (AST) system. The study consisted of two parts i) measurement of potential productivity gain, time and cost and; ii) analysis of ID and AST accuracy after Expert Systems validation. Methods: In total, 390 routine clinical isolates were tested: 215 Gram-negative (55%), 175 Gram-positive (45%) using our in-house method, Phoenix™ (PHX; Becton Dickinson, U.S.A), in parallel with the V2C. The strains were isolated from routine clinical samples; urine and blood cultures, stools, throat and genital samples. The following parameters were studied:

Productivity: Consultants audited the laboratory and performed time measurement of the general laboratory routine: from specimen reception, culture set up, ID/AST set-up and result validation. ID and AST accuracy: tests were performed in parallel on both systems and discordant results were tested by molecular technique and E-test (bioDisk). AST results were validated using the PHX Expert rule software and V2C Advanced Expert System™(AES) for results agreement. The medical microbiologist expertise provided final results on any discordant results.

Results: The global process time difference between V2C and PHX was mainly due to mean time to result for V2C being 7-13 h compared to 10-16 h for PHX. ID/AST test manipulation time was (1.53 min vs. 3.20 min). The overall identification agreement between the systems was greater than 97% for Gram-negative and 97% for Gram-positive. AST overall category agreement was more than 98% with both systems.

Conclusion: The VITEK® 2 compact provided labor gains in our routine setting due to less manipulation steps and a faster time to result. Performance between two systems were comparable.

OBJECTIVE

MVZ im Sonnenblock is a private laboratory that accepts specimens from both hospitalized patients as well as outpatients from physician office practices. In the interest of patient care and due to the transit time for the specimens, rapid reporting is important in this setting. Therefore, we began this study to assess the impact of the new automated VITEK® 2 compact (V2C) to reduce time to results and compare the accuracy of the ID and AST results to the currently used PHOENIX (PHX) system.

The study is presented in two parts measuring the impact on laboratory organization (process and productivity), and ID and AST results accuracy, including Advanced Expert System™ (AES) validation.

MATERIAL AND METHODS

We tested 215 Gram-negative (55%), 175 Gram-positive (45%) routine isolates in parallel using the PHX (V4.05W) and V2C systems for ID and AST performance.
The panel set up was given alternating priority between the two instruments and results were interpreted independently for each system. Quality control was performed according to each manufacturer's recommendations.

Laboratory organization

a) Process

Independent industrial productivity consultants audited and performed time measurement of the laboratory's current workflow process with the PHX and the V2C. Each step of the process was timed. The consultants were asked to suggest laboratory organizational changes for productivity improvements using the V2C.

b) Productivity

The consultants timed by stopwatch the individual steps for each system. This included panel set up, result validation and referral. Set up time was measured and averaged for 15 isolates in 3 separate runs of 5 isolates each: [*E. coli, E. coli, E. coli, E. coli, K. pneumoniae*]; [*M. morganii, S. aureus, S. aureus, E. coli, E. coli*]; [*E. coli, Streptococcus Group B, Enterococcus, Streptococcus Group B, S. aureus*].

Identification performance

Primary identifications were performed with the PHX and V2C and routine manual methods, e.g., chromogenic media, latex, etc. Repeat testing was performed if either system gave no identification result or the results between the two systems did not agree. Simple identification methods were performed in cases where the primary identification result was low discrimination. At the end of the study period, the results from both systems were compared and all discrepant IDs were tested by molecular methods, which was considered the reference method.

AST and Expert system performance

AST test results were analyzed by the systems' expert software: the PHX Epicenter (V4.01A/V3.81C) and V2C AES (version 1.02). Test results from both systems including phenotype and antibiotic category changes were analyzed. Repeat testing was performed if either system gave no result or the results between the two systems did not agree.The VITEK® and E-test® were used as back up methods when the primary AST result discrepancies were not resolved. All AST and phenotype results were compared and the microbiologist, designated as expert, resolved any discrepancies. Minor discrepancies were considered acceptable and were not studied further.

Analysis of the Comparative Workflow and ID/ AST Test Result Accuracy of the VITEK® 2 compact and the Phoenix™ Systems

RESULTS

Laboratory organization

a) Process

In the current organization and using the PHX system, specimens arrive on Day 0 at T0 (11:00 AM) and final paper copies of the ID/ AST results are sent throughout Day 3 (T0 +71h30m). With the V2C, results can be obtained from 8:30 PM on Day 2, but the current organization does not allow for validation and referral until Day 3 (T0 +71h30m) (**Figure 1**).

By implementing the suggested organizational changes (concurrent inoculation and reading of plates), test results can be referred starting from 2:00 PM on Day 1 with V2C (**Figure 1**). This allows for a 37h30min reduction in time to result with the V2C. The majority of this time savings is due to the reduced incubation time [mean detection time of 6.49 – 11.57 hours for V2C versus 9.33 to 15.58 hours for PHX for 95% of 363 strains tested (**see table 4**)].

b) Productivity

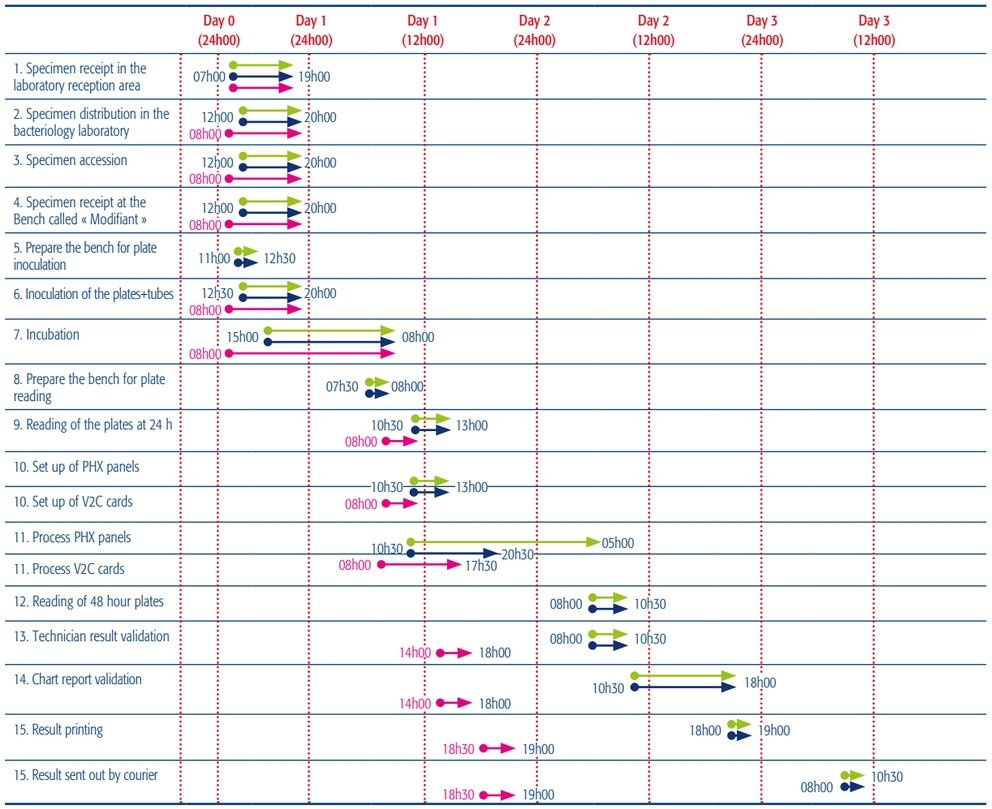
Time to perform the set up of one ID/AST test is 3.20 min for the PHX and 1.53 min for the V2C (**Table 1**). Based on our daily average workload (100 ID/AST) this represents a savings of 2.4 hours of technical hands on time per day.

Figure 1. Diagram of current and future organizational settings

Phoenix in the current organization setting

VITEK® 2 Compact in the current organization setting

Suggestion for a future organizational setting with VITEK® 2 Compact



Analysis of the Comparative Workflow and ID/ AST Test Result Accuracy of the VITEK® 2 compact and the Phoenix™ Systems

Table 1. Hands on time to perform one ID/AST test

Step	VITEK 2 compact	Step		PHOENIX	
1	Remove ID and AST card from -4°C, organise work bench, label purity plates	00:12	1	Organise bench, label purity plates	00:09
		00:00	2	Remove AST indicator and leave on bench to come to RT	00:04
2	Dispense 3 ml saline into each of 2 tubes and place into rack	00:08	3	Take out combo panel, ID broth and AST broth	00:06
3	Label ID tube with accession # & place tube into cassette	00:10	4	Label ID tube with accession #, place into inoculation station	00:00
4	Prepare isolate using applicator stick, suspend bacteria in saline, adjust with Densi Check	00:23	5	Using applicator stick, inoculate bacteria into ID broth, adjust inoculum with Crystal Spec, votex, wait for bubbles to dispense, place into tray	00:36
	Subtotal	**00:54**		**Subtotal**	**00:56**
5	Place pipette tip on pipet tor, transfer ID suspen-sion to AST tube	00:08	6	Add 1 drop of indicator in AST broth to the tube (AST broth predi spensed in screw cap tube)	00:12
6	Open pouche, place card in cassette position and discard trash	00:13	7	Close cap and invert tube	00:05
		00:00	8	Open pouche, place panel on tray, remove rubbi sh	00:13
		00:00	9	Open bag of caps, remove 1, label it with accession number, place loosely on the panel	00:09
		00:00	10	Pipette 25ul from ID broth to AST broth, invert tube, put tube back into tray. Inoculate purity plate with tip	00:29
		00:00	11	Pour isolate ID suspension in ID section of panel , AST broth into AST panel and wait for filling, then wipe off any droplets on exterior of port	00:18
		00:00	12	Place caps on ID and AST sections to seal	00:04
		00:00	13	Visually inspect to ensure properfilling & place panel in transport tray	00:04
		00:00	14	Place AST indicator in refrigerator	00:04
	Subtotal	**01:15**		**Subtotal**	**02:33**
7	At the PC, start worklist, scan cassette number	00:03	15	Carry transport tray to Phoenix instrument	00:01
8	Scan ID/ AST card barcodes	00:02	16	Press the Login icon	00:00
9	Link ID/AST card by typing isolate number ; save worklist	00:13	17	Scan panel, type accession number, put panel back into tray, press accept icon	00:14
10	Take cassette to V2C filler, enter cassette, press fill button	00:01	18	Press the Load Panel icon for reader access	00:00
11	Remove cassette and place into reader incubator	00:01	19	Place panel into reader and close door	00:05
12	Remove cassette from reader	00:01	20		00:00
13	Prepare purity plates with pipette tips	00:06	21		00:00
	Subtotal	**01:41**		**Subtotal**	**02:53**
		00:00	22	Press Unload Panel icon & and open door	00:04
		00:00	23	Remove completed panel	00:00
	Subtotal	**01:41**		**Subtotal**	**02:57**
23	Go to navigation tree and select results to	00:13	24	At PHX operating screen - press icon to send all panel data to Epicenter	00:06
24	Print results and deliver to different benches	00:00	25	At Epicenter, modify/ accept results	00:00
25	Send validated to LIS (batch)	00:00	26	Print results for review and deliver to different benches	00:12
		00:00	27	Send validated to LIS (batch)	00:04
	Total	**01:53**		**Total**	**03:20**

VITEK® 2 - WORKFLOW ANALYSIS

Analysis of the Comparative Workflow and ID/ AST Test Result Accuracy of the VITEK® 2 compact and the Phoenix™ Systems

Identification performance

The % of overall correct ID results between the two systems is not significantly different (**Tables 2 and 3**).

Table 2. Identification performance for GN

GN	Total	Overall correct ID (includes low discrim)	Low Discrimination	Mis ID	No ID
PHOENIX	215*	208 (97.6%)	3 (1.4%)	5 (2.4%)	0
VITEK 2 compact	215*	209 (98.1%)	4 (1.9%)	4 (1.9%)	0

* two isolates were removed from the calculation as they could not be resolved by molecular methods

Table 3. Identification performance for GP

GN	Total	Overall correct ID (includes low discrim)	Low Discrimination	Mis ID	No ID
PHOENIX	175*	169 (97.1%)	0	5 (2.9%)	0
VITEK 2 compact	175*	173 (99.4%)	5 (2.9%)	1 (0.5%)	0

* one isolate was removed from the calculation as it could not be resolved by molecular methods

Table 4. Time to result for AST testing in hours for 95% of 363 strains tested

	Total	PHOENIX			VITEK 2 compact		
		min.	mean time	max.	min.	mean time	max.
Enterobacteriaceae	172	6.58	9.62	15.92	5.00	6.49	13.50
Non-Enterics	31	12.35	15.58	16.00	7.50	11.57	14.25
Staphylococci	77	6.19	12.04	16.10	5.75	6.70	8.50
Enterococci	41	5.96	9.33	18.90	6.25	9.35	10.50
S. agalactiae	24	8.08	11.97	16.02	6.00	7.11	9.75

AST and Expert system performance

AST and Expert results are shown in **Tables 5, 6, 7 and 8**.

The % of overall correct AST expertized results between the two systems is not significantly different.

Table 5. AST performance for GN

GN AST	Total	Agreement	Disagreement	No Result
PHOENIX	2590*	2581 (99.6%)	7 (0.3%)	2 (0.1%)
VITEK 2 compact	2590*	2558 (98.7%)	2 (0.1%)	30** (1.2%)

*7 strains removed from calculation, no result by one or both instruments
** VITEK 2 compact gave only SXT result for *S. maltophilia*

Table 6. AST performance for GP

GP AST	Total	Agreement	Disagreement	No Result
PHOENIX	1738	1723 (99.1%)	9 (0.5%)	6 (0.3%)
VITEK 2 compact	1738	1718 (98.8%)	4 (0.2%)	16 (0.9%)

Table 7. MRSA performance for *S. aureus*

S. aureus	PHOENIX	VTK 2 compact	mec A gene
MRSA	31	32	32
MRSA	50	49	49

Table 8. ESBL performance for E. coli and Klebsiella

E. coli / Klebs	PHOENIX	VTK 2 compact	Synergy screen
ESBL +	4	3	3
ESBL -	125	126	126

CONCLUSIONS

- The VITEK® 2 compact provided significant labor savings in our routine setting due to less manual manipulation during test set up.
- A faster time to result was realized due to faster set up and shorter instrument incubation periods.
- Performance between the two systems was comparable.
- The industrial productivity consultants clearly demonstrated that positive benefits can be obtained even with minor but realistic changes to our processes.
- In our organisation, using the VITEK® 2 compact, workflow benefits were accompanied by confidence in the quality of ID/ AST results referred.

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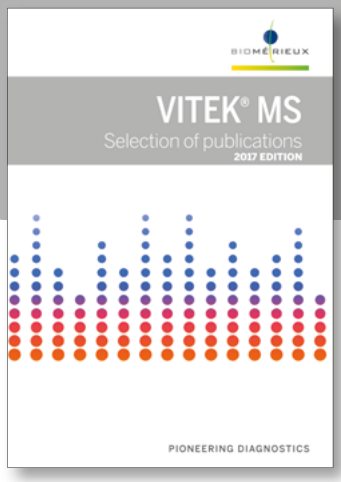

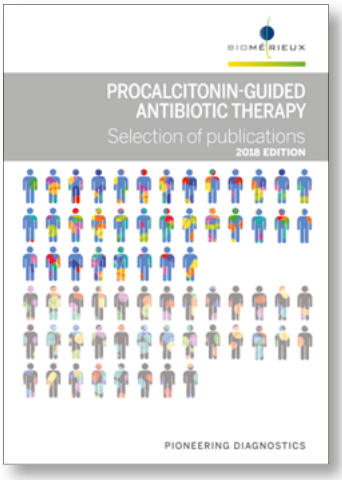

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