isolates reported an MIC90 value of 0.03 mg/L for ME1036, a value two dilutions lower than the MIC90 value determined in this study against multidrug-resistant strains belonging to troublesome serotypes exhibiting higher amoxicillin than penicillin MIC. MIC90 values determined for ME1036 by broth microdilution against a small number (11 strains) of penicillin-resistant S. pneumoniae isolates in a previous study showed values similar to those in the present study.

In conclusion, ME1036 exhibited excellent intrinsic activity against penicillin-resistant S. pneumoniae belonging to serotypes 9V, 14, 6B and 19A, exhibiting higher amoxicillin than penicillin MIC. The spread of multidrug resistance that includes β-lactams (including penicillins, second- and third-generation cephalosporins and previous carbapenems) may challenge empirical hospital treatment of lower respiratory tract infections. The high intrinsic activity of ME1036 against resistant strains of S. pneumoniae may represent an advantage when broad-spectrum activity is required.

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Transparency declarations
D. B. is an employee of Cerexa Inc. Others authors: none to declare.

References

In vitro activity of tigecycline against Gram-positive cocci: a multicentre study in Greece
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Keywords: resistance, staphylococci, enterococci, streptococci, pneumococci

Sir,
Tigecycline, a new glycyclycline antibiotic with broad-spectrum activity against aerobic and anaerobic Gram-positive and Gram-negative bacteria, appears to be a therapeutic option for serious infections caused by multidrug-resistant organisms.1 The purpose of this study was firstly to evaluate the in vitro activity of this drug against Gram-positive cocci in Greek hospitals and secondly to define a baseline for monitoring possible future emergence of resistance to tigecycline in our clinical settings.

From January 2006 to December 2007, a total of 10 420 Gram-positive cocci were tested for their susceptibility to tigecycline. The numbers of isolates of the various genera and species
tested are shown in Table 1. The isolates were recovered from clinically significant specimens (blood, pus, pleural fluid etc.) in 10 Greek hospitals, located in different areas of the country (Northern, Central and Southern Greece). Each participant institution was requested to collect a minimum of 700 Gram-positive cocci, equally distributed during the study period, that were sent to the Department of Microbiology of the University Hospital of Larissa for susceptibility testing. Isolates were identified at each participating laboratory using routine methodology and were sent in transport swabs (Culturette; Becton-Dickinson Microbiology Systems, Sparks, MD, USA) to the coordinating laboratory at the University Hospital of Larissa. Upon receipt, isolates were subcultured onto 5% sheep blood agar to ensure purity, while identification was confirmed with SlideX Staph, SlideX Strepto, SlideX Pneumo, ID 32 STAPH, ID 32 STREP (bioMérieux, Marcy l’Etoile, France). The clonality of the isolates was tested by PFGE, after digestion of chromosomal DNA by Smal, while the interpretation of the results was based on the criteria of Tenover et al.\textsuperscript{2}

The MICs of tigecycline were first determined by an agar-dilution method; the wells were prepared in-house using fresh Mueller–Hinton agar (Difco Laboratories, Detroit, MI, USA), containing the following serial 2-fold dilutions from 0.008 to 2 mg/L.\textsuperscript{3} For testing streptococci, 5% sheep blood was also added. In addition, all MICs were re-determined by using Etest strips (AB Biodisk, Solna, Sweden). Based on the US-FDA criteria, the isolates were categorized as susceptible and resistant; a tigecycline-susceptible breakpoint of ≤0.5 mg/L was used for \textit{Staphylococcus aureus}, including methicillin-resistant strains, whereas ≤0.25 mg/L was used for the interpretation of vancomycin-susceptible \textit{Enterobacter faecalis} and streptococci other than \textit{Streptococcus pneumoniae}. In the absence of agreed US-FDA breakpoints for coagulase-negative staphylococci (CoNS), the breakpoints for staphylococci were used, whereas for \textit{S. pneumoniae}, viridans streptococci and the various enterococcal species, including vancomycin-resistant strains, the criteria for \textit{E. faecalis} were used. Susceptibility testing for selected comparator agents (ampicillin, cefoxitin, erythromycin, linezolid, minocycline, oxacillin, penicillin, quinupristin/dalfopristin, teicoplanin, tetracycline and vancomycin) was done by the disc diffusion method, according to the CLSI guidelines.\textsuperscript{3} The following quality control organisms were concurrently tested: \textit{E. faecalis} ATCC 29212, \textit{S. aureus} ATCC 29213 and \textit{S. pneumoniae} ATCC 49619.

According to the results obtained by the agar-dilution method, 99.97% of the isolates tested were considered susceptible to tigecycline. No discrepancies in the characterization of the isolates were observed between the agar-dilution method and Etest, indicating that Etest is a reliable method and could be easily applied in the clinical microbiological laboratory. During the 2 year study period, no differences in the tigecycline susceptibility results between hospitals were observed.

Table 1 summarizes the MICs at which 50% and 90% of the isolates were inhibited (MIC\textsubscript{50} and MIC\textsubscript{90}, respectively) and the MIC distribution. No differences in the MICs were observed between the susceptible isolates and those with characterized resistance determinants (vancomycin and linezolid resistance for enterococci, glycopeptide-intermediate resistance for staphylococci and penicillin resistance for pneumococci). As shown in Table 1, tigecycline showed excellent activity against \textit{S. pneumoniae}, \textit{Streptococcus agalactiae}, \textit{Streptococcus pyogenes} and viridans group streptococci. In addition, all \textit{S. aureus} and coagulase-negative isolates were found to be susceptible to tigecycline, except 10, clonally unrelated, methicillin-resistant CoNS (6 \textit{Staphylococcus epidermidis} and 4 \textit{Staphylococcus haemolyticus}) that had MICs of 1 mg/L. Among enterococci, 10 \textit{E. faecalis} and 12 \textit{Enterobacter faecium} strains had MICs >0.25 mg/L. In more detail, among \textit{E. faecalis}, three and seven strains had MICs of 0.512 and 1 mg/L, respectively, whereas among \textit{E. faecium}, eight and four strains had MICs of 0.512 and 1 mg/L, respectively; no clonal relatedness was observed. Repetition of MICs by both the agar-dilution method and Etest revealed that these strains had reduced susceptibility to tigecycline. The mechanism of resistance is under investigation. The tigecycline non-susceptible staphylococci and enterococci of our collection also exhibited resistance to minocycline; ~8.5% of the isolates of our collection were minocycline-resistant.

Since 2007, tigecycline has been occasionally used in Greek intensive care units. Previous studies conducted in various countries have demonstrated that the agent is active against Gram-positive bacteria;\textsuperscript{4,5} our data also verify that tigecycline is

| Table 1. MIC distribution, MIC\textsubscript{50} and MIC\textsubscript{90} against a large collection of Gram-positive cocci isolated in Greek hospitals |
|-----------------------------|-------------------|-------------------|-------------------|
| Isolates (number tested) | MIC range (mg/L) | MIC\textsubscript{50} (mg/L) | MIC\textsubscript{90} (mg/L) |
| MRSA (1500) | 0.016–0.512 | 0.07 | 0.11 |
| MSSA (2100) | 0.064–0.256 | 0.08 | 0.11 |
| CoNS-MR (1320) | 0.064–1 | 0.08 | 0.15 |
| CoNS-Ms (480) | 0.064–0.512 | 0.10 | 0.14 |
| E. faecalis (2280) | 0.064–1 | 0.16 | 0.18 |
| E. faecium (1000) | 0.064–1 | 0.12 | 0.20 |
| S. pneumoniae (480) | 0.032–0.128 | 0.06 | 0.08 |
| S. agalactiae (490) | 0.032–0.128 | 0.05 | 0.07 |
| S. pyogenes (600) | 0.016–0.128 | 0.04 | 0.07 |
| Viridans group streptococci (170) | 0.032–0.128 | 0.06 | 0.07 |

MRSA, methicillin-resistant \textit{S. aureus}; MSSA, methicillin-susceptible \textit{S. aureus}; CoNS-MR, methicillin-resistant coagulase-negative staphylococci; CoNS-Ms, methicillin-susceptible coagulase-negative staphylococci. Among \textit{E. faecalis} tested, 118 were vancomycin-resistant and 20 linezolid-resistant; among \textit{E. faecium} tested, 120 were vancomycin-resistant and 25 linezolid-resistant, and among \textit{S. pneumoniae} tested, 67 were not penicillin-susceptible.
highly active against staphylococci, enterococci, pneumococci and streptococci. However, the appearance of some staphylococci and enterococci with decreased susceptibility to tigecycline must be an alarm for a future emergence of tigecycline-resistant Gram-positive bacteria in our country.6

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References


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Use of antibacterial consumer products containing quaternary ammonium compounds and drug resistance in the community

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Sir,

Quaternary ammonium compounds (QACs), such as benzalkonium chloride (BAC), are broad-spectrum antimicrobials widely used for decades to disinfect environmental surfaces in clinical and industrial settings. Reports examining the relationships between biocide use and bacterial resistance among isolates from the community setting are limited.1 We assessed the effect of antibacterial product usage in the home environment on susceptibility to BAC to determine whether there is a correlation between BAC and triclosan MICs and antibiotic resistance.

Data were collected as part of a longitudinal double-blind, randomized clinical trial conducted in a Northern Manhattan neighbourhood.2 Participant enrolment began in October 2000, with a 12 month follow-up period. At baseline, 238 households were enrolled, and 224 (94.1%) households completed the study. Households were randomly assigned to receive either antibacterial or non-antibacterial personal hygiene and household cleaning products. Households randomized to the antibacterial group received a liquid kitchen spray containing QACs (0.08% alkyl dimethyl benzyl ammonium chlorides and 0.02% alkyl benzyl ammonium chlorides), an ‘all-purpose’ surface cleaner containing QACs (2.7% alkyl benzyl ammonium chlorides) and an antimicrobial handwashing soap containing 0.2% triclosan. The non-antibacterial group received similar products lacking antimicrobial ingredients. Informed consent was obtained from each household, and The Institutional Review Board of Columbia University Medical Center approved the study.

At the beginning (baseline) and at the end of the follow-up period, a culture was obtained from a randomly selected hand of the primary caregiver in the household. The hand culture was taken before and after washing with the assigned liquid hand-washing product.

The sample collection and bacterial culture methods have been described in detail previously.3 Antibiotic susceptibility was determined using MicroScan WalkAway 96 SI (Dade Behring, Deerfield, IL, USA) and classified using the recommendations from the CLSI. All Gram-negative bacteria were tested against gentamicin, imipenem and ciprofloxacin. Additional tested antibiotics that were only applicable to certain species included: amikacin and ticarcillin/clavulanate for Acinetobacter baumannii and Acinetobacter lwoffi; trimethoprim/sulfamethoxazole for Enterobacter agglomerans and Enterobacter cloacae; trimethoprim/sulfamethoxazole, pipercillin/tazobactam and ceftriaxone for Klebsiella pneumoniae, and pipercillin/tazobactam and ceftazidime for Pseudomonas fluorescens/pseud

Antibiotic resistance was defined as resistance or intermediate resistance to at least one antimicrobial agent among all agents tested. Staphylococcal species were tested against oxacillin to ascertain methicillin resistance. The MICs for each isolate of Bacillus/Micrococcus species were tested against ceftriaxone for

Additional tested antibiotics that were only applicable to certain species included: amikacin and ticarcillin/clavulanate for Acinetobacter baumannii and Acinetobacter lwoffi; trimethoprim/sulfamethoxazole for Enterobacter agglomerans and Enterobacter cloacae; trimethoprim/sulfamethoxazole, pipercillin/tazobactam and ceftriaxone for Klebsiella pneumoniae, and pipercillin/tazobactam and ceftazidime for Pseudomonas fluorescens/pseud.