Speciation of Enterococcus species: better way to deal with clinical infections at resource limited settings

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Abstract

Background: Enterococcus species are well known for its intrinsic resistance pattern to several antibiotics. Hence, appropriate management and prevention is essential in any healthcare facility. Present study was conducted to establish an accessible biochemical tests to differentiate Enterococcus species at resource limited settings.

Methods: Enterococci isolated from various clinical specimens were speciated using an array of biochemical reactions and antimicrobial susceptibility testing was performed by Kirby-Bauer disc diffusion method. Results were interpreted as per Clinical and Laboratory Standards Institute (CLSI) guidelines.

Results: Out of 107 enterococcal isolates, 63(59%) were E. faecalis, 40(37%) were E. faecium, 2(2%) were E. hirae, 1(0.9%) was E. raffinosus and 1(0.9%) was E. gallinarum. E. faecium and E. faecalis showed 23% and 7% vancomycin resistance respectively, while E. gallinarum showed low level vancomycin resistance.

Conclusions: Enterococcus speciation can be done using simple biochemical reactions and its susceptibility pattern enables to distinguish Van phenotypes too. Hence, it is helpful for management of infections in resource limited settings to a greater extent.

Keywords: Antimicrobial susceptibility, Biochemical reactions, Enterococcus, Phenotypes

Introduction

Since from era of ‘Streptococci of fecal origin’ in late 19th century, Enterococci species was considered commensal organism and have been studied so far. Many species of Enterococci known with clinical significance till date. Amongst them, E. faecalis and E. faecium accounts for upto 90% of clinical infections. However, other species were underestimated because of lack of speciation. But, recently an alarming increase in incidence of clinical infections related to non faecalis and non faecium Enterococci were noted. Amongst these, E. gallinarum and E. casseliflavus were found to be involved in causing serious infections, especially in hospitalized patients. Hence, there is a need of species differentiation because of varied antimicrobial susceptibility pattern of each species. Simple biochemical tests can be used in resource limited settings routinely because even only one phenotypic character can easily differentiates one species from another.

Enterococci are intrinsically resistant to several antimicrobials especially, glycopeptide resistance which is mediated by six van genes. Amongst them, van A and van B are most clinically relevant van C phenotype shows intrinsic, low level resistance to vancomycin and but susceptible to teicoplanin. These genotype is seen in E. gallinarum, E. casseliflavus and E. flavescens. Species identification can be useful in reporting antimicrobial susceptibility pattern which help in differentiation of Van phenotypes also. So, aim of the present study was to make a panel of biochemical
reactions for enterococcal speciation which will help in appropriate interpretation at resource limited settings.

**METHODS**

Retrospective study was conducted at Department of Microbiology after taking approval from ethical committee of institute for the period one year from June 2011 to May 2012.

**Inclusion criteria**

Specimens from all age group patients admitted with complaint of urinary tract infection, skin and soft tissue infections, bacteraemia and meningitis were included.

**Exclusion criteria**

All patients besides above criteria admitted were excluded.

Total 270 specimens were enrolled in study, out of which 107 enterococcal isolates obtained from urine, swab, blood culture, CSF, body fluids and invasive medical devices were during the period of one year. Species differentiation was done by panel of conventional tests. Colony of *Enterococci* isolate was inoculated into 5ml todd-hewitt broth (HiMedia Lab., Mumbai) and incubated overnight at 37°C. This broth was added as an inoculum in all liquid media (ar ginine dihydrolase, pyruvate broth, sugars) and was streaked on tryptic soy agar culture plate for pigment production. Carbohydrate fermentation tests were performed using 1% solution of following sugars: mannitol, raffinose, sucrose and arabinose. All the above inoculated media were incubated at 37°C and results were interpreted after 24 hour. Antimicrobial susceptibility was determined by Kirby Bauer disc diffusion method. Various antibiotics tested were: penicillin (10U/disc), ampicillin (10μg), high level gentamicin (120μg), high level Streptomycin (300μg), ciprofloxacin (5μg), levofoxacin (5μg), vancomycin (30μg), teicoplanin (30μg), linezolid (30μg), tetracycline (30μg) and nitrofurantoin (300μg).

Interpretation was done after 24 hours of incubation and zones were read using transmitted light for vancomycin as per CLSI guidelines. MIC of vancomycin greater than or equal to 32μg/ml was considered resistant, which was done by using HiComb™ MIC test (HiMedia Laboratories Pvt. Ltd., Mumbai). All required dehydrated media and antibiotic discs were procured from HiMedia Laboratories Pvt. Ltd. (Mumbai) and *E faecalis ATCC 29212* used for quality control was procured from Microbiologics (USA).

**RESULTS**

Total 107 *Enterococci* isolated were speciated by using biochemical reactions. Amongst them, 63(59%) were *E. faecium*, 40(37%) were *E. fecaalis*, 2(2%) were *E hirae*, 10(9.9%) was *E. raffinosus* and 1(0.9%) was *E. gallinarum* (Figure 1).

*E. faecium* was found to be more resistant to beta-lactams, fluoroquinolones, tetracycline and high level aminoglycosides including 23% vancomycin resistance while 7% vancomycin resistance in *E. fecaalis*. 1 isolate of *E. faecium* was resistant to both vancomycin and teicoplanin indicating Van A phenotype. *E. hirae* showed resistance to penicillin (50%) and ampicillin (50%). However, *E. raffinosus* was resistant to beta lactams (100%) and High level streptomycin (100%). Besides, *E. gallinarum* which was identified by pigment production on tryptic soy agar was resistant to beta-lactams, fluoroquinolones, tetracycline and high level aminoglycosides with low level resistance to vancomycin having MIC of 8 - 16 μg/ml (Figure 2).

**Figure 1: Distribution of enterococcus species isolated from various specimens.**

**Figure 2: Prevalence of Van phenotype among Enterococcus species.**

On basis of biochemical reactions, *E. faecium* were identified by arginine dihydrolase test, mannitol and sucrose fermentation while *E. fecaalis* by arginine dihydrolase test, pyruvate utilisation test and mannitol, arabinose, raffinose and sucrose fermentation.
Amongst other species, *E. hirae* was identified by arginine dihydrolase test, raffinose and sucrose fermentation. *E. raffinosus* by pyruvate utilisation and mannitol, arabinose, raffinose and sucrose fermentation and *E. gallinarum* by pigment production on tryptic soy agar (Table 1).

Table 1: Panel of biochemical tests used for identification of enterococcal speciation.

<table>
<thead>
<tr>
<th>Enterococci spp.</th>
<th>Arginine deamination</th>
<th>Pyruvate utilisation</th>
<th>Mannitol fermentation</th>
<th>Arabinose fermentation</th>
<th>Raffinose fermentation</th>
<th>Sucrose fermentation</th>
<th>Pigment on tryptic soy agar</th>
<th>Motility</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>E. faecalis</em></td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><em>E. faecium</em></td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>V</td>
<td>+</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><em>E. avium</em></td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><em>E. hirae</em></td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><em>E. raffinosus</em></td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td><em>E. dispar</em></td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><em>E. durans</em></td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><em>E. mundtii</em></td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><em>E. casseliflavus</em></td>
<td>V</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td><em>E. gallinarum</em></td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>+</td>
</tr>
</tbody>
</table>

**DISCUSSION**

Species differentiation is helpful in clinical infections because of the naturally occurring differences in the susceptibility pattern of *Enterococcus* species. Also, it was helpful for epidemiologic surveillance within hospitals. Most of the studies from India had reported *E. faecalis* and *E. faecium* as the only prevalent species.11-14 In present study, *E. faecium* (59%) and *E. fæcalis* (37%) were predominant isolates followed by *E. hirae* (2%), *E. raffinosus* (0.9%) and *E. gallinarum* (0.9%). Mohanty et al used the same panel of biochemical reactions for enterococcal speciation and isolated *E. mundtii, E. dispar, E. durans, E. avium, E. raffinosus* and *E. gallinarum*.15 While, Bekhit et al reported *E. fæcalis, E. faecium, E. avium, E. hirae, E. casseliflavus* and *E. gallinarum* by using API strep.16 These *Enterococci* species were less frequently isolated but had a major clinical significance because of resistance to commonly used antibiotics.

Table 2: Antimicrobial susceptibility pattern of Enterococcal spp. by Kirby Bauer disc diffusion method.

<table>
<thead>
<tr>
<th>Antibiotic tested</th>
<th><em>E. fæcalis</em> (n=63)</th>
<th><em>E. faecium</em> (n=40)</th>
<th><em>E. hirae</em> (n=2)</th>
<th><em>E. raffinosus</em> (n=1)</th>
<th><em>E. gallinarum</em> (n=1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Penicillin (10 units)</td>
<td>60 (95)</td>
<td>40 (100)</td>
<td>1 (50)</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Ampicillin (10 µg)</td>
<td>60 (95)</td>
<td>39 (97)</td>
<td>1 (50)</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>High level gentamicin (120 µg)</td>
<td>54 (85)</td>
<td>33 (82)</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>100</td>
</tr>
<tr>
<td>High level streptomycin (300 µg)</td>
<td>49 (77)</td>
<td>24 (60)</td>
<td>0 (0)</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>Ciprofloxacin (5 µg)</td>
<td>60 (95)</td>
<td>31 (77)</td>
<td>0 (0)</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>Levofloxacin (5 µg)</td>
<td>60 (95)</td>
<td>31 (77)</td>
<td>0 (0)</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>Linezolid (30 µg)</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Vancomycin (30 µg)</td>
<td>15 (23)</td>
<td>3 (7)</td>
<td>0 (0)</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>Teicoplanin (µg)</td>
<td>1 (1)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Tetracycline (30 µg)</td>
<td>52 (82)</td>
<td>31 (77)</td>
<td>0 (0)</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Nitrofurantoin (300 µg)</td>
<td>23 (36)</td>
<td>1 (2)</td>
<td>0 (0)</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

*Enterococci* are intrinsically resistant to several antimicrobials. Especially, glycopeptide resistance which is mediated by six *van* genes. Amongst them, *vanA* and *vanB* are most clinically relevant because they are associated with transposons, hence easily transferred from one to other organisms. *Van A* gene mediates high
level resistance to vancomycin and teicoplanin while vanB genotype have acquired inducible resistance to vancomycin but susceptible to teicoplanin. Besides these, vanC phenotype, which is chromosomal in origin shows intrinsic, low level resistance to vancomycin and but susceptible to teicoplanin. These genotype is seen in E. gallinarum, E. casseliflavus and E. flavescens.

Biochemical reactions like pigment production and motility test are helpful to distinguish species with acquired resistance to vancomycin (Van A and Van B) from those with intrinsic intermediate level resistance (Van C), such as in E. gallinarum and E. casseliflavus. In present study, 95% E. faecium were resistant to beta lactams and fluoroquinolones, 51% were resistant to high level aminoglycoside, 82% and 36% were resistant to tetracycline and nitrofurantoin respectively. While, E. faecalis showed less resistance as compared to E. faecium. Similarly, E. raffinosus was resistant to beta lactam, high level aminoglycosides and tetracycline but susceptible to fluoroquinolones. On contrary, E. hirae was resistant to beta lactams only. Above all, E. gallinarum showed intermediate level resistance to vancomycin and showed resistance to beta lactam, fluoroquinolones, tetracycline and high level aminoglycosides (Table 2). Resistance among Enterococcus species were higher in present study as compared to previous study in Jordan and Saudi Arabia. Bekhit et al also reported Van C in 3 isolates of E. gallinarum.

Speciation will help to distinguish species with acquired resistance to vancomycin observed in E. faecium and E. faecalis from those with intrinsic intermediate level resistance such as in E. gallinarum and E. casseliflavus. It is also necessary to perform biochemical reactions when isolates show vancomycin MICs 8-16µg/ml. This panel of tests will help resource limited settings to manage enterococcal infections more effectively.

Present study had limitation that sample size was very less. More enterococcal isolates were needed to be studied for better correlation of biochemical reactions and antibacterial drug susceptibility pattern. Also, teicoplanin resistance was given by disk diffusion method which should be further confirmed by MIC method.

**CONCLUSION**

Increasing resistance among Enterococcus species highlights the significance of rapid and accurate identification up to the species level. Therefore, developing simple and reliable tests for speciation and its antimicrobial susceptibility pattern is a need of present day therapeutics. Present study is a guide to resource limited settings so they too can contribute in antimicrobial stewardship.

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**Conflict of interest:** None declared

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**Ethical approval:** The study was approved by the Institutional Ethics Committee

**REFERENCES**


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