International Journal of Current Advanced Research
ISSN: O: 2319-6475, ISSN: P: 2319-6505, Impact Factor: 6.614
Available Online at www.journalijcar.org
Volume 7; Issue 5(D); May 2018; Page No. 12506-12512
DOI: http://dx.doi.org/10.24327/ijcar.2018.12512.2200

Research Article

MEDICALLY IMPORTANT ENTEROCOCCUS SPECIES FROM ISOLATES OF URINARY TRACT INFECTION WITH THEIR ANTIMICROBIAL SUSCEPTIBILITY

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A R T I C L E I N F O

Article History:

Received 6th February, 2018
Received in revised form 20th March, 2018 Accepted 8th April, 2018
Published online 28th May, 2018

Key words:

Nosocomial infections, UTI, MALDI-TOF, MIC, VRE.

A B S T R A C T

Background: Enterococcus are primarily opportunistic pathogens causing infections in immunocompromised patients with some underlying medical disorder. Recently, enterococci have become one of the most common causes of hospital acquired infections, leading to high mortality and morbdity. Studies indicate that enterococci are the second most common cause of urinary tract infections (UTI) and third most common cause of bacteremia and nosocomial infections.

Materials and methods: The study was performed over a period of two years from January 2016 to December 2017. Urine samples collected in appropriate sterile manner were screened for pus cells and bacteria by routine microscopic examination. This was followed by plating on Mac-conkey's agar and Blood agar. Inoculated plates were incubated overnight at 37^0c. Isolated Enterococcus strains were identified with Matrix assisted laser desorption ionization time of flight mass spectrometry (MALDI-TOF MS) to confirm the speciation. Antibiotic susceptibility was performed by Vitek compact 2 as per CLSI guidelines establishing MIC (Minimum Inhibitory Concentration).

Results: Of the total 1113 isolates of Enterococcus species from urinary tract, *Enterococcus faecalis* (77%) was found to be the most common species followed by *Enterococcus faecium* (21%). Of the 860 strains of *Enterococcus faecalis,* 30 strains were resistant to vancomycin (VRE) with MIC values more than 32. Of the 230 isolates of *Enterococcus faecium* thirty two strains were resistant to vancomycin (VRE). Thirteen isolates of *Enterococcus avium* and 3 isolates of *Enterococcus hirae* were susceptible to vancomycin and teicoplanin. In general *Enterococcus faecium* was found to be more resistant to antimicrobials with higher MIC values.

Discussion: *Enterococcus faecalis* is the most prevalent isolate being associated with 80-90% of human Enterococcal infection. *Enterococcus faecium* ranks second and is isolated from 10-15% of infections. Other species are infrequently isolated from clinical specimens are *E. gallinarum, E. avium, E. casseliflavus*, *E. flavescens,* and *E. hirae*. Enterococci are highly notorious for their drug resistance pattern. In vitro, Enterococci have penicillin MICs 10 to 100 fold higher than that of Streptococci which are uniformly sensitive to penicillin and β lactam group of drugs. Increased level of antimicrobial resistance by different isolates of Enterococcus possesses a threat to nosocomial set up as it tends to limit treatment options.

Conclusion: The identification of and speciation of Enterococcus is of utmost importance. Recently, enterococci have become one of the most common nosocomial pathogens, giving a high mortality and morbidity. Overall, greater understanding of the ability of Enterococcus species to survive stresses and especially of increasing antibiotic resistance, is needed in order to fully appreciate the complexity of Enterococcus species in causing human disease.

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INTRODUCTION

Enterococcus are primarily opportunistic pathogens causing infections in immunocompromised patients with some underlying medical disorder. Recent advances in medical technology and aggressive use of broad spectrum antimicrobial agents in the hospitals has been responsible for emergence of these pathogens as an important cause of nosocomial infections[1]. Since the first report of vancomycin resistant enterococci (VRE) in 1988 by Uttley *et al* the VRE have spread rapidly through the world having more prevalence in western countries[2].

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Enterococci are gram positive, catalase negative bacteria under family enterococcaceae which occur in singles, pairs or short chains. They hydrolyze esculin in the presence of 40% bile with black discoloration and known to have high salt tolerance (some species can tolerate up to 10% of salt). Around 35 species have been identified so far and widely distributed in nature of which only few are of medical importance. They are normally found in the intestine, oral cavity, genital tract of humans and animals[3]. Those organisms are facultative anaerobic. Enterococci can able to proliferate in wide temperature range (5 °C-65 °C) and pH (4.5-10.0)[4]. These characteristics differentiate them from streptococci. A systematic review conducted on bacterial nosocomial infections showed that, enterococci were among 3rd to 4th leading cause of nosocomial infections worldwide. Among the isolates, multiple antimicrobial resistant enterococci were

more prevalent including vancomycin resistant[5]. For many years Enterococcus species were believed to be harmless to humans and considered unimportant medically. Because they produce various bacteriocins, Enterococcus species have been used widely over the last decade in the food industry as probiotics or as starter cultures[6]. Recently, enterococci have become one of the most common causes of hospital acquired infections, with patients having a high mortality and morbdity[7]. Studies indicate that enterococci are the second most common cause of urinary tract infections (UTI) and third most common cause of bacteremia and nosocomial infections[8]. According to the National Healthcare Safety Network summary report, between 2009 and 2010, enterococci were the second common cause of nosocomial infections. The report showed enterococci were 14%, next to S aureus (16%) and among these, 3% enterococci were vancomycin resistant[9]. A systematic review and meta-analysis had shown the prevalence of nosocomial infections in developing countries. The result showed enterococci were among the leading cause of nosocomial infections and they are next to *Staphylococcus aureus* and coagulase-negative Staphylococci. According to this review, high prevalence of enterococci was isolated from high risk patients, surgical site infections and blood stream infections[10]. Another systematic review on health care associated infections in Africa shows enterococci were next to *S. aureus,* from Gram positive bacteria[11]. Enterococci have naturally low level resistance to some antimicrobial agents and have high ability to acquire antibiotic resistant determinates. In spite of those multiple antimicrobial resistant enterococci are emerging as the leading cause of hospital acquired infections. Especially, *E. faecalis* and *E. faecium* have become causes of international concern from this genus[12]. A study conducted in Gondar, Ethiopia indicated that 5.5% of the study participants had VRE; 7.8% of which were from HIV positive and 3.1% were from HIV negative study subjects[13]. Previous administration of antibiotics, concurrent infections, surgery, catheterizations, duration of hospital stay, presence of pervious hospitalization and underlying diseases like cancer, HIV and diabetis are among the risk factors associated with the spread of enterococcal infection[14]. Enterococci cause infections mainly in immune compromised patients. However, increasing number of immune compromised individuals, because of different reasons, increases the spread and risk of enterococci infections. Prevalence, antimicrobial susceptibility patterns and associated factors of enterococci infections were reported in some countries of America, Europe, Asia and Africa. In spite of this organism being among the leading cause of hospital acquired infection in the world, documented data about the prevalence, their antimicrobial susceptibility patterns and associated factors of enterococci infections are scarce in this study area. This study was conducted to identify the different species of enterococci causing urinary tract infection and to determine their antimicrobial susceptibility patterns.

MATERIALS AND METHODS

All the urine (midstream, catheter) specimens collected from patients suspected to have UTI were cultured on blood agar and MacConkey's agar in the Department of Microbiology, Metropolis healthcare limited, Mumbai, India. During the study period (January 2016 to December 2017), Gram-positive catalase negative cocci with alpha, beta or non-haemolytic colonies isolated in significant counts (>1×105cfu/ml) in pure culture were included in the study. The records of the patients whose urine samples grew vancomycin resistant Enterococci (VRE) with MIC values more than 32 µg/ml in significant numbers were retrospectively reviewed for demography, clinical findings, underlying medical problems, surgical procedures, invasive devices, and treatment with antimicrobial agents and outcome. UTI was defined as the presence of any one of the following symptoms: fever, burning, urgency, frequency of micturition, supra pubic tenderness and growth of $>1\times10^5$cfu/ml of Entercoccus species from urine specimen. Objective of this study was to determine different species of Enterococci causing urinary tract infection. In addition, to determine the antibiotic susceptibility pattern of the isolated strains to provide appropriate treatment for reduction of morbidity & mortality. This study was performed with patients admitted in a tertiary care hospital, developing symptoms suggestive of UTI at least after 48 hours of admission. Some patients from community acquired infection have also been included with symptoms suggestive of UTI. Cases of urinary tract infection with established nonbacterial etiology (fungal UTI) excluded from the study. Urine samples collected in appropriate sterile manner were screened for pus cells and bacteria by routine microscopic examination. This was followed by plating on Mac-conkey's agar media (differential & partially selective media: aids in isolation of gram negative isolates, Enterococci give small pin point lactose fermenting translucent colonies), Blood agar (enriched media for Enterococci isolation, Enterococci produce mostly non-hemolytic colonies in sheep blood agar). Inoculated plates were incubated overnight at 37^0c. Isolated Enterococcus strains were identified with Matrix assisted laser desorption ionization time of flight mass spectrometry (MALDI-TOF MS) to confirm the speciation. Antibiotic susceptibility was performed by VitekCompact^{TM2} (Biomeuriux, France) as per CLSI guidelines establishing MIC (Minimum Inhibitory Concentration) of the tested antibiotics.

Table 1 Minimum inhibitory concentrations of antimicrobials used for Enterococcus species causing urinary tract infections adapted from CLSI. Performance Standards for Antimicrobial Susceptibility Testing. 27th ed. CLSI supplement M100. Wayne, PA: Clinical and Laboratory Standards Institute; 2017.
S= Susceptible; I= Intermediate; R= Resistant.

Antimicrobial	MIC µg/ml			Comments
	S	I	R	
Vancomycin	<=4	8-16	>=32	When testing vancomycin against enterococci, organisms with intermediate zones should be tested by an MIC method as. For isolates for which the vancomycin MICs are 8-16 µg /mL, perform biochemical tests for identification.
Teicoplanin	<=8	16	>=32	
Linezolid	<=2	4	>=8	
Tetracycline	<=4	8	>=16	
Ciprofloxacin	<=1	2	>=4	
Levofloxacin	<=2	4	>=8	
Fosfomycin	<=64	128	>=256	For testing and reporting of *E. faecalis* urinary tract isolates only. Not routinely reported on isolates from the urinary tract.
Erytrhromycin	<=0.5	1-4	>=8	
Daptomycin	<=4	-	-	
Penicillin	<=8	-	>=16	Enterococci susceptible to penicillin are predictably susceptible to ampicillin, amoxicillin, ampicillin-sulbactam, amoxicillin-clavulanate, and piperacillin-tazobactam for non-β-lactamase-producing enterococci. However, enterococci susceptible to ampicillin cannot be assumed to be susceptible to penicillin.

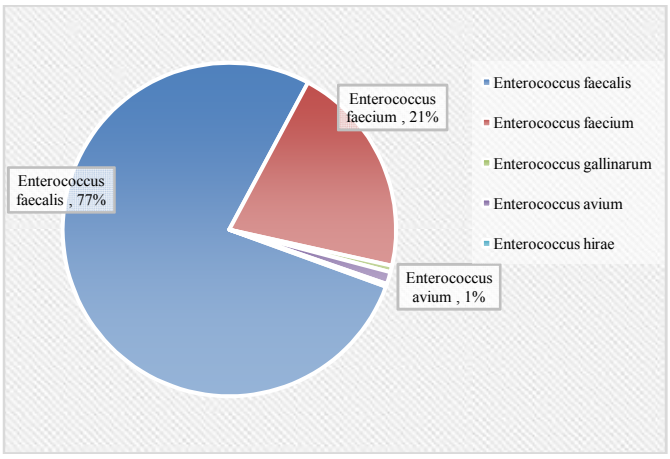
Those strains of Enterococci were resistant to vancomycin by VitekCompact^{TM2} (Biomeuriux, France) including *E. gallinarum* (intrinsically resistant to vancomycin), with MIC greater than 32 µg/ml, these strains were re-tested with vancomycin E strips (Biomeriux, France) to confirm the MIC values. Results were analyzed according to standard statistical method.

RESULTS

Table 2 Susceptibility pattern of different species of Enterococci from urinary tract isolates.

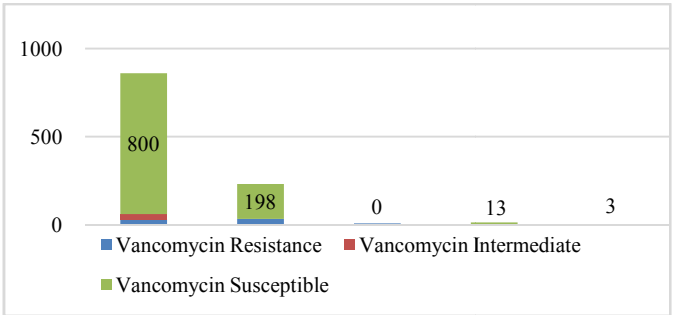
Organism (N=1113) /	Enterococcus faecalis (N=860)			Enterococcus faecium (N=230)			Enterococcus gallinarum (N=7)			Enterococcus avium (N=13)			Enterococcus hirae (N=3)		
Drugs	S	I	R	S	I	R	S	I	R	S	I	R	S	I	R
Vancomycin	800	30	30	198	0	32	0	0	7	13	0	0	3	0	0
Teicoplanin	822	17	21	201	0	29	7	0	0	13	0	0	3	0	0
Linezolid	830	20	10	220	2	8	7	0	0	11	1	1	3	0	0
Tetracycline	140	0	720	82	0	148	4	0	3	3	0	10	3	0	0
Ciprofloxacin	294	24	542	13	2	215	5	0	2	5	0	8	3	0	0
Levofloxacin	313	20	527	14	1	215	5	0	2	4	2	7	3	0	0
HLG	449	0	411	64	0	166	7	0	0	9	0	4	3	0	0
Daptomycin*	90	0	0	-	-	-	-	-	-	-	-	-	-	-	-
Penicillin	796	0	64	25	0	205	5	0	2	5	0	8	3	0	0

S= Susceptible; I= Intermediate; R= Resistant; HLG= High level Gentamicin resistance Daptomycin* has been tested only for 90 isolates of *Enterococcus faecalis.*



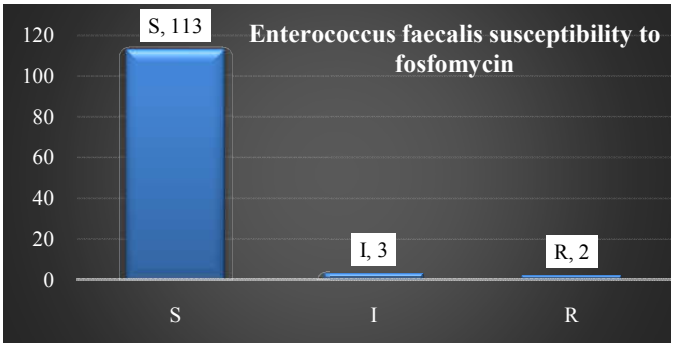
Graph 1 Percentage isolation of various Enterococcus species from urinary tract.

Of the total 1113 isolates of Enterococcus species from urinary tract, *Enterococcus faecalis* (77%) was found to be the most common species followed by *Enterococcus faecium* (21%). In general *Enterococcus faecium* was found to be more resistant to antimicrobials with higher MIC values.



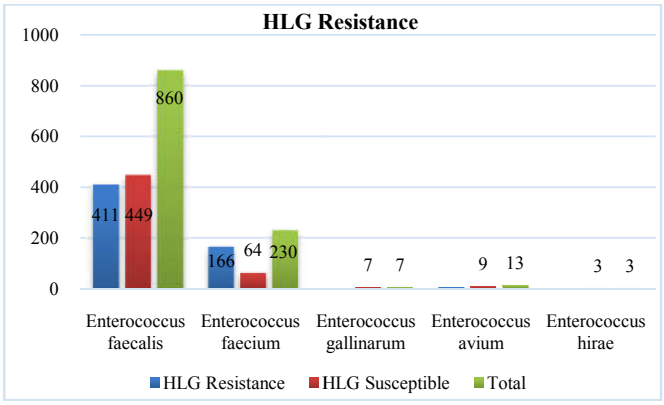
Graph 2 Susceptibility to vancomycin

Of the 860 strains of *Enterococcus faecalis,* 30 strains were resistant to vancomycin with MIC values more than 32. Of the 230 isolates of *Enterococcus faecium* thirty two strains were resistant to vancomycin. Note that *Enterococcus gallinarum* is intrinsically resistant to vancomycin. Thirteen isolates of *Enterococcus avium* and 3 isolates of *Enterococcus hirae* were susceptible to vancomycin and teicoplanin.



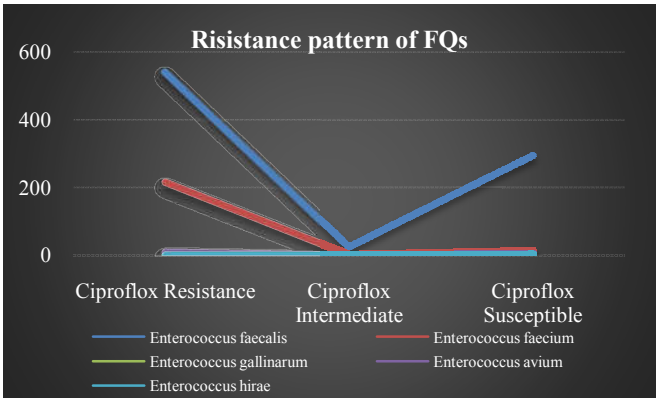
Graph 3 Susceptibility of fosfomycin with *Enterococcus faecalis*

Of the total 860 isolates of *Enterococcus faecalis,* only 118 strains have tested against fosfomycin with routine Kirby Bauer disk diffusion method. As per CLSI guidelines, *E. faecalis* is tested for fosfomycin from urinary tract isolates only. 113 were susceptible to fosfomycin, three were intermedaite and two strains were resistant with zone diameter more than 16 mm. Resistant and intermedaite strains were not confirmed with broth dilution method.



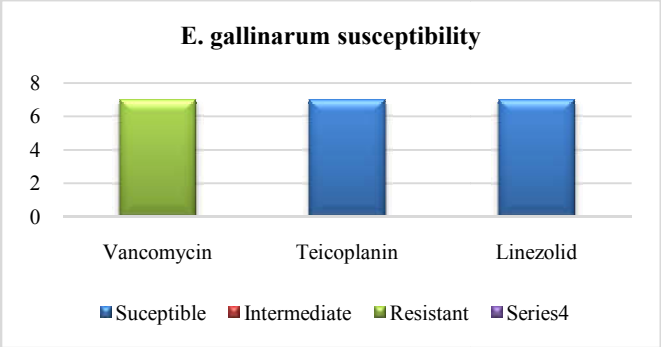
Graph 4 Determination of High Level Gentamicin (HLG) resistance.

Of the total 860 isolates of *Enterococcus faecalis,* 411 were resistant to HLG and 449 were susceptible. Of the total 230 isolates of *Enterococcus faecium,* 64 were susceptible to HLG and 166 were resistant indicating high prevalce of HLG resistance in *E. faecium.* All the seven strains of *E. gallinarum* and 3 strais of *E. hirae* were susceptible to HLG. Interpretation of HLG with other antimicrobial agents acting on the cell wall is critical particularly in cases with bacterial endocarditis caused by Enterococcus species.



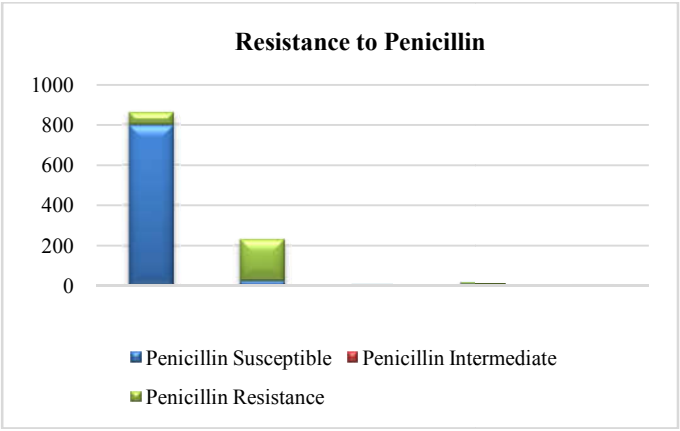
Graph 5 Susceptibility pattern of fluoroquinolones (FQs) with different species of Enterococci.

Of the 860 isolates of *E. faecalis,* 542 were resistant to ciprofloxacin and 527 were resistant to levofloxacin. All the three isolates of *E. hirae* were sensitive to both ciprofloxacin and levofloxacin. Gatifloxacin and moxifloxacin can be tested only from urinary isolates of Enterococcus species as per CLSI.



Graph 6 Susceptibility of *E. gallinarum* to vancomycin, teicoplanin and linezolid

E. gallinarum has very high MIC values (>32 µg/ml) due to intrinsic resistance. Teicoplanin and linezolid can be safely used in urinary isolates of *E. gallinarum.* Intrinsic vanC resistance is specific to *E. gallinarum, E. casseliflavus and E. flavescens,* and the vanC operon is chromosomally located and is not transferable.



Graph 7 Penicillin susceptibility to Enterococcus species

Of the 860 isolates of *E. faecalis,* 796 were susceptible and 64 were resistant to penicillin. Penicliin resistance is found higher in *E. faecium.* Enterococci susceptible to penicillin are predictably susceptible to ampicillin, amoxicillin, ampicillin-sulbactam, amoxicillin-clavulanate, and piperacillin-tazobactam for non β lactamase-producing enterococci.

DISCUSSION

Enterococcus species live normally in human intestines and animals. All of us carry one or two types of them. Because they can tolerate drying, high concentration of salt (up to 10%), enterococci are also often found in the environment including sea water. They can sometimes cause infections, but generally only in people who are having underlying medical illness and undergone interventions. The two types of enterococci which usually cause infections are *Enterococcus faecalis* and *Enterococcus faecium*. Enterococci are one of the common causes of Nosocomial urinary tract infection (Catheter associated urinary tract infection) worldwide[15]. *Enterococcus faecalis* is the most prevalent isolate being associated with 80-90% of human Enterococcal infection, *Enterococcus faecium* ranks second and is isolated from 10-15% of infections. Other species are infrequently isolated from clinical specimens are *E. gallinarum, E. avium, E. casseliflavus*, *E. flavescens,* and *E. hirae*[16]. Enterococci are highly notorious for their drug resistance pattern. In vitro, Enterococci have penicillin MICs 10 to 100 fold higher than that of Streptococci which are uniformly sensitive to penicillin and β lactam group of drugs[17]. In the United States of America, more than 90% of isolated *Enterococcus faecium* are resistant to Ampicillin whereas resistance to Ampicillin is much less common in *Enterococcus faecalis* (4%) [18, 19]. Undiagnosed and untreated Enterococcal UTI is a well-known source of fatal complications such as Enterococcal bacteraemia & endocarditis especially in immunocompromised patients especially in nosocomial set up[20, 21, 22]. Resistance to the antibiotics such as vancomycin is a particular concern, as it is an important treatment for serious life threatening infections. The overall incidence of Enterococcal infection varies across continents, countries and also within hospitals. In India, the occurrence varies from 1% to 36%. Karmakar *et al* carried out a study in Mumbai in which the isolation rate of Enterococci from urine samples was 10.28%[23]. Kaur *et al* in March 2006, reported an Enterococcal isolation rate of 33% from urine samples in Haryana, North India[24]. Agarwal *et al* in Lucknow, Uttar Pradesh, India, showed an isolation rate of 1.46% in diverse clinical samples[25]. Similar to the studies of some other workers such as Duo *et al* (Kuwait, 2002) & Ford *et al* (UK, 1994), *Enterococcus faecalis* was the most prevalent isolate[26]. Of the total 1113 isolates of Enterococcus species from urinary tract, *Enterococcus faecalis* (77%) was found to be the most common species followed by *Enterococcus faecium* (21%). In general *Enterococcus faecium* was found to be more resistant to antimicrobials with higher MIC values. Antimicrobial susceptibility pattern revealed the fact that *Enterococcus faecalis* and *Enterococcus gallinarum,* and *Enterococcus hirae* (3 isolates) isolates were sensitive to β- lactam antimicrobials (Benzyl penicillin and Ampicillin). *E. faecium* found to be more resistant to β- lactam antimicrobials (Benzyl penicillin and Ampicillin) of which only 25 strains out of 230 were susceptible to penicillin. In our study we found high incidence of Fluoroquinolone resistance with drugs like ciprofloxacin and levofloxacin. Ciprofloxacin and levofloxacin used for treatment of urinary tract infections by Enterococcus species are found have higher MIC values. Of the 860 isolates of *E. faecalis,* 542 (63.02%) were resistant to ciprofloxacin and 527(61.27%) were resistant to levofloxacin. All the three isolates of *E. hirae* were sensitive to both ciprofloxacin and levofloxacin. Gatifloxacin and moxifloxacin can be tested only from urinary isolates of Enterococcus species as per CLSI. Daptomycin has been tested only for 90 isolates of *Enterococcus faecalis* in which all the strains were susceptible. Daptomycin should not be reported for isolates from the respiratory tract. Macrolides such as Erythromycin should not be used empirically for treatment of urinary isolates of Enterococci[27]. Of the 860 strains of *Enterococcus faecalis,* 30 (3.48%) strains were found to have intermediate susceptibility and 30 (3.48%) were resistant to vancomycin with MIC values more than 32 µg/ml. Of the 230 isolates of *Enterococcus faecium* thirty two strains were resistant to vancomycin. This suggest high incidence of VRE (13.91%) in *Enterococcus faecium* infections. Note that *Enterococcus gallinarum* is intrinsically resistant to vancomycin with very high MIC values in which teicoplanin and linezolid remains the drugs of

choice. All the thirteen isolates of *Enterococcus avium* and 3 isolates of *Enterococcus hirae* were susceptible to vancomycin and teicoplanin. Karmakar *et al* (Mumbai, 2003) found more than 20% of Enterococcal isolates were VRE, whereas Agarwal *et al* (Lucknow, 2008) found nearly 2% of isolates to be VRE. Similar to other studies, in our study also, VRE isolates were susceptible to teicoplanin and linezolid, but it was resistant to Fluoroquinolones, and Tetracyclines. Susceptibility to Tetracyclines was minimal in both *E. faecalis* and *E. faecium.* Glycopeptide resistance in enterococci involves a two component system where the cell wall composition is altered from the peptidoglycan precurser D-Ala-D-Ala (vancomycin-susceptible) to D-Ala-D-lactate (D-Lac). The latter has 1000 times less affinity for vancomycin, while DAla- D-Ser has a sevenfold decrease in affinity for vancomycin, thus removing the susceptible target[28]. The genes involved in this two-component system are vanS/vanR. The VanS sensor kinase is activated in response to vancomycin, resulting in the activation of DLac or D-Ser peptidoglycan precursor and the repression of D-Ala-D-Ala (Stephenson & Hoch, 2002). To date six gene clusters associated with glycopeptide resistance have been identified in Enterococcus species: vanA to vanG. The three main types of resistance are those encoded by the vanC, vanA and vanB clusters. Intrinsic vanC resistance is specific to E. gallinarum, E. casseliflavus and E. flavescens, and the vanC operon is chromosomally located and is not transferable. The vanA resistance operon comprises seven genes (vanH, vanA, vanX, vanR, vanS, vanY and vanZ) and is acquired through the Tn1546 transposon.

Table 3 Vancomycin resistance genotypes adapted from Gilmore, M. (2002). The Enterococci: Pathogenesis, Molecular Biology and Antibiotic Resistance. Washington, DC: American Society for Microbiology.

Genotype	Vancomycin MIC (*m*g ml"1)	Location	Expression	Precursor
vanA	64-1000	Plasmid or chromosome	Inducible	D-Ala-D-Lac
vanB	4-1000	Plasmid or chromosome	Inducible	D-Ala-D-Lac
vanC	2-32	Chromosome	Constitutive or inducible	D-Ala-D-Ser
vanD	64-168	Chromosome	Constitutive	D-Ala-D-Lac
vane	16	Unknown	Inducible	D-Ala-D-Ser
vanG	<16	Unknown	Unknown	Unknown

Of the total 860 isolates of *Enterococcus faecalis,* only 118 strains have been tested against fosfomycin. As per CLSI guidelines, fosfomycin is reported for *E. faecalis* from urinary tract isolates only. The approved MIC testing method is agar dilution. Agar media should be supplemented with 25 µg/mL of glucose-6-phosphate. Broth dilution testing should not be performed. The 200-µg fosfomycin disk contains 50 µg of glucose-6-phosphate. Of 118 strains tested with disk diffusion method, 113 were susceptible to fosfomycin and only two strains were resistant with zone diameter more than <=12 mm. Fosfomycin may be used as an alternative drug for treatment of VRE by *E. faecalis* isolated from urinary tract. Of the total 860 isolates of *Enterococcus faecalis,* 411 (47%) were resistant to High Level Gentamicin (HLG) and 449 (52.20%) were susceptible. Interpretation of HLG with other antimicrobial agents acting on the cell wall is critical particularly in cases with bacterial endocarditis caused by Enterococcus species. Combination therapy with ampicillin, penicillin, or vancomycin (for susceptible strains only), plus an aminoglycoside, is usually indicated for serious enterococcal infections, such as endocarditis, unless high-level resistance to both gentamicin and streptomycin is documented; such combinations are predicted to result in synergistic killing of the *Enterococcus.* If HLG is resistant, it is not synergistic with cell wall-active agent (eg, ampicillin, penicillin, and vancomycin). If susceptible, it is synergistic with cell wall-active agent (eg, ampicillin, penicillin, and vancomycin). If disk diffusion result is inconclusive, perform an agar dilution or broth dilution MIC test to confirm. Strains of enterococci with ampicillin and penicillin MICs >=16 µg/mL are categorized as resistant. However, enterococci with low levels of penicillin (MICs 16-64 µg/mL) or ampicillin (MICs 16-32 µg/mL) resistance may be susceptible to synergistic killing by these penicillins in combination with gentamicin or streptomycin (in the absence of high-level resistance to gentamicin or streptomycin, if high doses of penicillin or ampicillin are used. Enterococci possessing higher levels of penicillin (MICs >=128 µg/mL) or ampicillin (MICs >=64 µg/mL) resistance may not be susceptible to the synergistic effect. To determine the actual MIC of penicillin or ampicillin for blood and CSF isolates of enterococci should be considered. Other aminoglycosides need not be tested, because their activities against enterococci are not superior to gentamicin and streptomycin. Of the 860 isolates of *E. faecalis,* 796 were susceptible and 64 were resistant to penicillin. Penicliin resistance is found higher in *E. faecium.* Enterococci susceptible to penicillin are predictably susceptible to ampicillin, amoxicillin, ampicillin-sulbactam, amoxicillin-clavulanate, and piperacillin-tazobactam for non β lactamase-producing enterococci. However, enterococci susceptible to ampicillin cannot be assumed to be susceptible to penicillin. If penicillin results are needed, testing of penicillin is required. The results of ampicillin susceptibility tests should be used to predict the activity of amoxicillin. Ampicillin results may be used to predict susceptibility to amoxicillin-clavulanate, ampicillin-sulbactam, and piperacillin-tazobactam among non β lactamase producing enterococci. Ampicillin susceptibility can be used to predict imipenem susceptibility, providing the species is confirmed to be *E. faecalis.* Penicillin or ampicillin resistance among enterococci due to β lactamase production has been reported very rarely. Penicillin or ampicillin resistance due to β lactamase production is not reliably detected with routine disk or dilution methods, but is detected using a direct, nitrocefin based β lactamase test. Because of the rarity of β lactamase-positive enterococci, this test need not be performed routinely, but can be used in selected cases. A positive β lactamase test predicts resistance to penicillin, as well as amino and ureidopenicillins. In our study, we did not test susceptibility to Nitrofurantoin. Enterococcal susceptibility pattern to Nitrofurantoin is inconsistently reported by many workers. Increased level of antimicrobial resistance by different isolates of Enterococcus possesses a threat to nosocomial set up as it tends to limit treatment options. This fact demands the study of the epidemiology & antibiogram of Enterococcal urinary tract infections vividly so as to set up an empirical therapy in health care setup for reduction of morbidity & mortality.

CONCLUSION

The identification of and speciation of Enterococcus is of utmost importance because for many years enterococci were believed to be harmless to humans and considered unimportant

medically. They were thought mainly to be part of the human endogenous non-pathogenic microflora. Recently, enterococci have become one of the most common nosocomial pathogens, giving a high mortality and morbidity. The ability of Enterococcus species to survive a range of adverse environments allows multiple routes of cross-contamination of enterococci in causing human disease, including those from food, environmental and hospital sources. Overall, greater understanding of the ability of Enterococcus species to survive stresses and especially of increasing antibiotic resistance, is needed in order to fully appreciate the complexity of Enterococcus species in causing human disease.

Acknowledgements

We are thankful to the Department of Microbiology, Metropolis Healthcare Ltd, Mumbai, India.

Conflict of Interest

Author declares no conflicts of interest

Funding

No source of funding has been received

Ethical Approval

Not applicable

Guarantor

First (corresponding) and Second author

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How to cite this article:

Prashant Mule., Niranjan Patil and Seema Gaikwad (2018) 'Medically Important Enterococcus Species From Isolates of Urinary Tract Infection with their Antimicrobial Susceptibility', *International Journal of Current Advanced Research,* 07(5), pp. 12506-12512. DOI: http://dx.doi.org/10.24327/ijcar.2018.12512.2200

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