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The Life and Times of the Enterococcus

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cocci into four divisions: pyogenic, viridans, lactic, and enterococcus. The latter term was used for organisms that (for the most part) grew at 10 and 45°C, in 6.5% NaCl, and at

malodoratus were all distinct; that "*S. faecium* var. *mobilis*" was the same as *S. casseliflavus*; that *S. faecalis* and its former subspecies *liquefaciens* and *zymogenes* were indeed

split esculin was also noted (191). Many of these character-

chickens, designated *S. gallinarum*, were distinct from *S.*

Test	% Positive					
	Enterococci	Lactococci	Aerococci	Pediococci	Leuconostocs	Lactobacilli
Vancomycin resistance[b]	<1	0	0	100	100	90
Reaction with streptococcal group D antiserum	80	0	0	95	35	25
Bile-esculin positive	99	75	60	100	90	50

glycerol, whereas most *E. faecium* but not *E. faecalis* produce acid from melibiose and L-arabinose (43, 65, 66, 187). Several biochemical reactions can be suggestive of the other enterococcal species (42, 43, 66, 69). *E. casseliflavus*, for example, is motile and produces yellow pigment; *E. mundtii* produces yellow pigment and is not motile; *E. gallinarum* is motile but does not produce yellow pigment;

scheme, using both phage and enterococcines, with over 900 enterococci from two hospitals (114). A large percentage (79%) could be typed into one of 25 phage types, although 61% belonged to a single phage type. Seventy-nine percent could also be placed into one of six enterococcine groups which consisted of 85 enterococcinotypes; half belonged to one group. When phage typing was combined with entero-

the patient or with the presence of polymicrobial bacteremia (193). Nine of 14 diabetics, 6 of 10 patients with malignancy or granulocytopenia, 7 of 8 with renal failure, and 3 of 5 alcoholics died (193). In the study by Malone et al., the mortality was 44%; this study did not assess the same factors rapidly or ultimately fatal underlying disease were significantly associated with increased mortality (130). In Maki and

the third most common cause of nosocomial UTIs, causing 14.7% in the 1984 report (36). As will be discussed further below, the hospital setting is complex and a number of factors may contribute to acquisition of enterococcal urinary infection, including frequent instrumentation, prior therapy tated patients, and transmission of resistant organisms.

underlying disorder. In a 1961 review, 12 of 294 cases of meningitis appeared to be caused by enterococci; many of these patients were said to have had a long-term primary

terococci have also caused acute salpingitis, peripartum maternal infection (such as endometritis) with bacteremia, and abscess formation following Cesarean section (83, 122,

The use of antimicrobial agents lacking enterococcal activity has been implicated as an important factor in the development of enterococcal superinfection (16, 46, 74, 98, 137, 176, 207, 230). Moellering reviewed 2,107 patients treated with moxalactam and found that 2.1% developed an enterococcal superinfection during or shortly after moxalactam therapy (137). This infection occurred in 38 (6.6%) of 572 patients who had a UTI; of note, 28 of these 38 had urinary

environment in which antimicrobial agents are heavily used; the hospital setting provides the antibiotics which eliminate or suppress susceptible bacteria, thereby providing a selective advantage for resistant organisms, and the hospital also provides the potential for dissemination of resistant enterococci via the usual routes of nosocomial spread.

Antimicrobial resistance can be divided into two general types, that which is an inherent or intrinsic property and that

ampicillin, and other penicillins in broth macrodilution systems are typically >100 μg/ml (7, 113, 139).

A notable weakness of cephalosporins is that none of these agents routinely inhibits enterococci sufficiently to warrant its clinical use. MICs of cephalothin range from 6.3 higher (72, 113, 158, 209, 218). Although the in vitro activity

agar (91). When enterococcal strains were tested in urine, the mean MIC increased 60-fold; this effect was reversed by methotrexate (235). In addition to the problems with MIC determination, there are also conflicting reports as to whether or not TMP/SMX is bactericidal against enterococci indicate efficacy in vivo. TMP/SMX should not be consid-

because its rate of transposition is increased by exposure to low levels of erythromycin (211).

of enterococci have been resistant to tetracycline (1, 6).

Several different genes have been found, including *tetL* (which is contained in the well-studied plasmid pAMα1) and

tobramycin, but not to streptomycin (100). In 1983, several reports, including two from my laboratory, documented

gentamicin and to all aminoglycosides, including gentamicin

and streptomycin. In these studies, which included strains

from Houston, Tex., Bangkok, Thailand, and Santiago,

abstr. no. 1121, 1989). Working with Jan Patterson, we have and found that, although the restriction endonuclease diges-tion patterns are different, there is extensive homology between most of these plasmids (149; Patterson et al., 28th

of 39.5 kilodaltons (223b). Although it is postulated that this Ala-D-Ala, the mechanism is not yet understood. One of the vancomycin resistance genes has been cloned, and a probe from this strain hybridizes only with enterococci with high-

patients for whom an extracardiac source cannot be identified, particularly when the enterococcus is present in pure culture and was community acquired (129). Whether or not these lengthy regimens are truly necessary or whether shorter courses or single-drug therapy will suffice is not known.

Endocarditis. Therapy of enterococcal endocarditis has patients and animals with enterococcal endocarditis are also cured by penicillin alone, these results are not surprising. Again, however, care must be taken with generalizations, since failures of ampicillin to cure endocarditis in patients infected with a strain of *E. faecalis* resistant to multiple aminoglycosides have been reported (76, 108). It should also be reiterated that, in the absence of HLR, ampicillin plus an

mend testing for beta-lactamase since the organism may

TABLE 2. Zone of inhibition around antibiotic disks

strains and Mueller-Hinton agar plus blood, the lower-content disks gave zones of 6 mm for streptomycin, gentamicin, and kanamycin and 6 to 10 mm for tobramycin; on Mueller-Hinton agar without blood, the zones were 6 to 7 mm for all four agents. On Mueller-Hinton agar plus blood, synergy-susceptible strains had zones of ≥14 mm for streptomycin and ≥20 mm for gentamicin, tobramycin, and kanamycin; on Mueller-Hinton agar without blood, zones

discrepant strains were not reported (198). The disk method and the in-house broth microdilution method also detected three of three streptomycin-resistant *E. faecium* strains; none of seven *E. faecium* strains had HLR to gentamicin.

Recommendations for Screening for HLR to Aminoglycosides

tobramycin, and ≥10 mm for kanamycin (Table 2). The method currently appear highly reliable for detecting *E.*

cocci have displayed resistance to essentially every useful

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