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The Epidemiology of Enterococci

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The enterococci are emerging as a significant cause of nosocomial infections, accounting for approximately 10 % of hospital acquired infections. They are found as normal inhabitants of the human gastrointestinal tract, but may also colonize the oropharynx, vagina, perineal region and soft tissue wounds of asymtomatic patients. Until recently, evidence indicated that most enterococcal infections arose from patients' own endogenous flora. Recent studies, however, suggest that exogeneous acquisition may occur and that person-to-person spread, probably on the hands of medical personnel, may be a significant mode of transmission of resistant enterococci within the hospital. The use of broad-spectrum antibiotics, especially cephalosporins, is another major factor in the increasing incidence of enterococcal infections. These findings suggest that barrier precautions, as applied with other resistant nosocomial pathogens, along with more judicial use of antibiotics may be beneficial in preventing nosocomial spread of resistant enterococci.

In recent years, the enterococcus has become recognized as a significant cause of hospital acquired infections (1, 2, 3). In 1984 the Centers for Disease Control listed the enterococcus as the third most commonly isolated pathogen in nosocomial infections in the USA, accounting for 10.4 % of infections (4). Enterococci were reported to be the cause of 14.7 % of cases of nosocomial urinary tract infections (UTI) and 7.1 % of cases of bacteremia. There have also been reports suggesting that the incidence of enterococcal bacteremia has increased in the past 20 years (3,5). Enterococci currently are responsible for 8 % of cases of nosocomial bacteremia at the University of Michigan (Table 1). Whiteside et al. (5) reported that the incidence of bacteremia increased approximately 20 % yearly between 1976 and 1981. Similarly, Maki and Agger (3) noted that the number of cases of nosocomial enterococcal bacteremia increased markedly during the decade 1973–1983, while the number of community-acquired cases of enterococcal bacteremia remained constant. This is supported by the findings of Morrison and Wenzel (6) who showed that the rate of enterococcal nosocomial UTI increased progressively from 12.3 to 32.3 cases per 10,000 patient discharges between 1975 and 1984. These studies clearly emphasize the increasing significance of the enterococci as a nosocomial pathogen.

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Traditionally, the source of enterococcal infections has been thought to be endogenous, arising from the patients own flora (7, 8, 9). Recent evidence, however, has suggested that nosocomial transmission and exogenous acquisition of enterococci may occur (10, 11). The results of these studies indicate that patient-to-patient transfer and inter-hospital spread, well recognized in other bacterial species, can also occur with enterococci.

The Agent: Microbiologic Characterization and Nomenclature

Enterococci have classically belonged to the Lancefield group D streptococci and have been identified in the laboratory by their unique biologic properties (12). Enterococci are gram-positive facultative anaerobic cocci that are able to grow in media containing 6.5 % sodium chloride, 40 % bile or 0.1 % methylene blue. They will usually survive at 60 °C for 30 min and can grow at extremes of pH (up to 9.6) and temperature (range of 10–45 °C). Enterococci also share the ability to hydrolyze esculin with other members of the group D streptococci. Recently, the ability of enterococci to hydrolyze L-pyrrolidonyl β-naphthylamide has been used as part of a method for rapid screening for enterococci in the laboratory (13).

Table 1: Distribution of pathogens for nosocomial bacteremia at University of Michigan Hospital in 1988.

Organism	Percentage
Coagulase negative staphylococci	23.7 %
Staphylococcus aureus	15.7 %
Candida albicans	9.6 %
Escherichia coli	9.1 %
Enterococci	8.2 %
Pseudomonas aeruginosa	5.9 %

The most clinically important feature of the enterococci which differentiates them from non-enterococcal group D streptococci, is their antibiotic resistance pattern. Most strains of enterococci are inhibited (MIC usually 4 µg/ml) but not killed by benzylpenicillins (14, 15, 16). Ampicillin and the ureidopenicillins are usually active, with MICs of 1–4 µg/ml, but are not reliably bactericidal (17, 18). The MICs of the semisynthetic penicillins, nafcillin, oxacillin and methicillin are much higher, around 8.5 µg/ml (19, 20, 21), while MICs of cephalosporins are even higher (17, 22). Most strains of enterococci are resistant to tetracycline, erythromycin, clindamycin, chloramphenicol and sulfonamides (15, 23). Many strains are reported as sensitive to trimethoprim/sulfamethoxazole but this probably represents an in vitro phenomenon, since enterococci have been shown to escape the action of trimethoprim/sulfamethoxazole on addition of folinic acid (24, 25, 26). Vancomycin and teicoplanin, while highly active against enterococci, are not consistently bactericidal (27, 28). Enterococci are also relatively resistant to aminoglycosides, the average gentamicin and tobramycin MICs being 8–64 µg/ml (15, 29), but high-level aminoglyside resistance is becoming a significant problem in some areas (19, 11, 30, 31, 32).

The current 1984 Bergey's Manual of Systematic Bacteriology lists the enterococci, including *Streptococcus faecalis, Streptococcus faecium, Streptococcus avium* and *Streptococcus gallinarium,* as members of the genus *Streptococcus,* Lancefield group D (33). Shortly after completion of the section on enterococci, however, Schleifer and Kilpper-Balz (34) proposed the formation of a new genus *Enterococcus* based on DNA-DNA and DNA-RNA homology. In 1984 Collins et al. (35) also described two other species that belong to this group, *Enterococcus durans* and *Enterococcus malodoratus.* They further proposed a new species name *Enterococcus casseliflavus* for the previously named *Streptococcus faecium* subspecies *casseliflavus.* Although these names were not incorporated into the official nomenclature of the 1984 Bergey's Manual, the proposals mentioned above were acknowledged and the genus *Enterococcus* has now been accepted by the scientific community. More recently, on the basis of DNA hybridization new species have been proposed including *Enterococcus haire, Enterococcus mundtii, Enterococcus raffinosus, Enterococcus pseudoavium* and *Enterococcus solitarius* (36, 37, 38). Using standard biochemical tests confirmed by DNA hybridization, Facklam and Collins (38) recently identified all of the above species. Each of the strains in their study, except *Enterococcus mundtii,* have been isolated from human blood cultures demonstrating their potential pathogenicity for humans.

Reservoirs of Enterococci

Enterococci are normal inhabitants of the human gastrointestinal tract as described by Andrews and Harder (39), who first applied the name *Streptococcus faecalis.* Rantz and Kirby (40) reported that they found enterococci in nearly all normal human bowels. In a more recent study Noble (41) determined the species of enterococci found in the feces of normal neonates and adults, and hospitalized adults. He found *Enterococcus faecalis* in 48.2 % of adult outpatients and 80 % of adult inpatients. *Enterococcus faecium* was isolated from 41.3 % and 30 % of outpatient and inpatient adults respectively, although viable counts of *Enterococcus faecium* were on average 100-fold lower than those of *Enterococcus faecalis.* Average viable counts of *Enterococcus faecalis* were 10^5–10^7 CFU/g compared to average counts of 10^4–10^5 for *Enterococcus faecium.* Neonates had a similar carriage rate for *Enterococcus faecalis* (48 %), *Enterococcus faecium* or *Enterococcus avium* not being isolated (41).

The incidence of various enterococcal species in human feces has varied with the geographical location and diets of the human subjects. For example, Hill et al. (42) found in 1971 subjects from England, Scotland and the USA eating a mixed Western diet had consistently less enterococci in their feces than individuals from India, Japan and Uganda who ate primarily vegetarian diets. In his study *Enterococcus faecium* predominated in the latter group, while *Enterococcus faecalis* predominated in the group eating the Western diet. These findings were not supported by the study of Finegold et al. (43) in 1974 which compared the fecal flora of individuals of Japanese descent who were living in the USA. In the subjects on a traditional Japanese diet there was a tenfold higher incidence of *Enterococcus faecalis* compared with subjects on a typical US diet. Other

early studies have emphasized the importance of geographic location for the incidence of enterococcal species in human feces. Studies performed in the USA, UK and Egypt have shown a predominance of *Enterococcus faecalis* species, *Enterococcus faecium* being found less frequently or at lower levels (43, 44). At the same time, studies performed on individuals living in Europe, India, Japan and Uganda showed a predominance of *Enterococcus faecium* in fecal samples (44). It was presumed that dietary and environmental factors accounted for the variation in incidence of the different enterococcal species. More recent studies from a wide variety of geographic locations including Japan, Canada, Germany and Scandinavia, however, have shown a predominance of *Enterococcus faecalis,* only a minority of subjects harboring *Enterococcus faecium* (45, 46, 47). It may be concluded that in most geographic locations *Enterococus faecalis* is found in the feces of most normal adults at a greater frequency and in greater quantities than *Enterococcus faecium* or other enterococcal species, but that diet and other factors may alter the proportions of the enterococcal species.

Other human reservoirs of the enterococci include the oral cavity, hepatobiliary tract and vagina of asymptomatic women, as well as soft tissue lesions and chronic decubital ulcers. Enterococci are found in low numbers in the oral cavity (48). In a study of patients with acute leukemia enterococci were found in 24 % of oral washings and/or sputum cultures upon admission to hospital. This percentage decreased with antibiotic treatment however (49). Another study revealed enterococci in approximately 10 % of cultures of dental plaque of various groups, including healthy hospital personnel and hemodialysis patients (50). The carriage rate in the vagina of asymptomatic women is slightly higher, ranging from 24–34 % with mean concentrations of 10^7 CFU/g (51, 52). Similarly, Gross et al. (7) found that more than 60 % of men in a Veterans Administration hospital had perineal and meatal cultures positive for enterococci. Enterococci have also been isolated in 5 % of 501 selected cholecystectomy specimens (53). The major site of colonization in hospitalized patients, however, is soft tissue wounds and ulcers. Horvitz and von Graevenitz (54) found that enterococci occurred in mixed cultures in many wounds but also in pure culture. Seventy-one percent of the pure culture came from wounds with no clinical evidence of infection. Although the gastrointestinal tract is the primary reservoir for enterococcus, the above studies emphasize the ability of the enterococci to colonize diverse sites, all of which may act as a portal of entry for the organism in infection.

Modes of Transmission of Enterococci

Traditionally, the source of enterococcal infections has been thought to be the endogenous flora of the host (7, 8, 9, 40, 55, 56). One early study which gave credibility to this belief was done by Gross et al. (7) in a Veterans Administration hospital during 1972–1973. The enterococcus was the most common isolate from infected urines in this select population. All but one patient was male and the mean age was 63 years. Also of note is the fact that urinary tract instrumentation had occurred in 30 of 34 patients (88 %). Using antibiograms to identify strains of enterococci, Gross et al. (7) found no clustering when reviewing the positive isolates by location in the hospital. They then studied the environment of nine patients with indwelling -foley catheters and found that four had positive urine cultures ($> 10^5$ organisms/ml) and seven had positive rectal cultures. There was heavy contamination of the perineum, meatus and components of the Foley catheter as well as bed sheets in all the patients with positive rectal cultures. Cultures of hands of nursing personnel and physicians revealed that only 10 % were positive for enterococci and all but one strain had antibiograms different from those of the strains found in patients in that location. The authors then prospectively studied perineal and urine cultures of patients once the Foley catheter was inserted. Two patients found to harbor enterococci in their rectum went on to develop positive urine cultures with enterococci which had antibiograms identical to that of the original rectal and meatal isolates. The authors concluded that nosocomial enterococcal bacteremia was usually caused by the patient's own endogenous fecal flora introduced into the bladder with instrumentation of the urinary tract and that there was no evidence of person-to-person spread within the hospital (7).

These conclusions were supported by other studies on UTI and bacteremia which have not shown evidence of person-to-person spread (9, 57). Stamm et al. (57) reviewed 265 consecutive epidemics of UTI reported by the Centers for Disease Control (CDC) between 1956 and 1979. They found that enterococci accounted for less than 1 % of epidemic UTIs compared to approximately 10 % of endemic UTIs. Similarly, Maki (9) reviewed the epidemiology of nosocomial bacteremia and found that enterococcal bacteremia was most often secondary to UTI or post-surgical abdominal infection. He identified no epidemics of enterococcal bacteremia.

Until recently there has been very little evidence to dispute the assumption that endogenous flora is the primary source of enterococcal infections. One notable exception has

been the report of enterococcal endocarditis in husband and wife heroin addicts who shared needles and syringes. The pair developed endocarditis with *Enterococcus faecalis* strains exhibiting identical antibiotic susceptibility patterns and biochemical profiles which strongly suggested transmission of enterococci from one spouse to the other (58). Another report of an exogenous source of enterococcal colonization came from Smith and Dayton (59) who noted an increased incidence of *Enterococcus faecalis* in cultures of burn wounds. The increase was traced to porcine xenografts contaminated with *Enterococcus faecalis* (59).

Previously, it has been difficult to perform epidemiologic studies on enterococcal transmission since antibiotic sensitivity patterns and biochemical profiles do not reliably show enough variation to distinguish different strains of *Enterococcus faecalis* among isolates (10, 11, 60, 61). Analysis of the plasmid content of bacteria is often more effective in differentiating strains. This method has been used successfully in epidemiologic studies of other nosocomial outbreaks (62). Using this method, Zervos et al. (10, 11) obtained results which strongly support exogenous acquisition and transmission of enterococci. In their first study they retrospectively compared patients at the University of Michigan Hospitals with high level gentamicin resistant enterococci (MIC > 2000 μg/ml) with a control group of patients with gentamicin sensitive enterococci (MIC < 64 μg/ml) (11). They reported a marked increase in gentamicin resistant organisms between 1981 and 1984 in their hospital. This increase continues, over 15 % of clinical isolates being resistant to gentamicin in 1988 (Table 2). Other important findings were that highly gentamicin resistant *Enterococcus faecalis* infections were significantly associated with prior antibiotic therapy, including preoperative antibiotic prophylaxis, previous surgical procedures and longer hospitalization. All patients with high level gentamicin resistant *Enterococcus faecalis* had received antibiotics in the preceding three months (94 % received cephalosporins, 73 % received aminoglycosides). The mean number of days of hospitalization prior to isolation of enterococci was much longer for patients with high level gentamicin resistant organisms (mean 25.7 days) compared to gentamicin sensitive strains (mean 15.2 days). Also, strains isolated from ten patients in a surgical intermediate care ward within a two-month period had identical plasmid content, transfer properties, and donor and transconjugant resistance patterns. Moreover, high level gentamicin resistant *Enterococcus faecalis* with the same plasmid profile as the outbreak strain was cultured from a door handle in the surgical intensive care unit suggesting at least transient carriage on the hands of medical personnel (11).

This study, which suggests that nosocomial transmission of enterococci may occur, was supported by a second prospective study of gentamicin resistant enterococci by the same authors (10). At the Ann Arbor Veterans Administration Medical Center all patients admitted to an index general medicine ward or surgical intensive care unit (SICU) over a two-month period were followed up with cultures. Initial cultures in 33 % of patients were positive for gentamicin resistant enterococci. All of these patients had been hospitalized for more than 72 hours before entry to the study. Another 10 % of patients acquired high level gentamicin resistant enterococci, six after admission to the SICU and four on the medical ward. The six patients who acquired their resistant enterococci in the SICU were clustered by location and by the time of hospitalization. Three plasmid types were found in the isolates of these six patients, however isolates from patients in adjacent beds of the SICU as well as an isolate from the hands of a nurse working in that unit were identical in plasmid content. Another patient acquired a high level gentamicin resistant *Enterococcus faecalis* strain which was identical to a strain of enterococcus causing an outbreak of infection in patients on the surgical ward at the University of Michigan Hospital. Another important finding was that patients initially colonized with high level gentamicin resistant enterococci in their perineal or rectal areas later de-

Table 2: Frequency of isolation of high-level gentamicin resistant enterococci at University of Michigan Hospital, 1982–1988.

Year	Total no. of enterococci	No. with high level resistance	Percent
1982	954	5	0.5
1983	971	14	1.4
1984	1121	58	5.2
1985	1044	107	10.3
1986	639	68	10.6
1987	833	91	10.9
1988	672	103	15.3

veloped clinical infections with resistant strains; six developed UTI and one a wound infection (10). Again, acquisition of gentamicin resistant strains was significantly associated with prior systematic antibiotic therapy.

This study documents nosocomial acquisition of gentamicin resistant *Enterococcus faecalis* and strongly suggests that transmission occurs from person to person within the hospital via transient carriage on the hands of medical personnel (10). This agrees well with what is known about the epidemiology of resistant staphylococci (63, 64, 65). Carriage on the hands of hospital personnel appears to be the most important mode of transmission of these organisms within the hospital. Inter-hospital transmission was also suggested in this study by the finding of a resistant strain of *Enterococcus faecalis* isolated in the SICU of the Ann Arbor Veterans Administration Hospital which was identical to a strain isolated from a patient cluster in the surgical units of the University of Michigan Hospital (10). Spread between the two hospitals may have occured by carriage on the hands of rotating medical students and house officers or by transfer of colonized patient from one hospital to the other . This method of inter-hospital spread has been suggested for other nosocomial pathogens, such as resistant gram-negative rods and methicillin resistant *Staphylococcus aureus* (66, 67).

These conclusions are supported by recent studies on enterococcal infection in neonatal intensive care units (68, 69) Coudron et al. (68) first reported an outbreak of *Enterococcus faecium* bacteremia and meningitis among low birth weight babies in their neonatal intensive care unit. On the basis of biochemical reactions in rapid identification systems, the authors were able to identify isolates from outbreak patients and hands of hospital personnel (68). Luginbuhl et al. (69) described a similar epidemic of *Enterococcus faecalis* bacteremia in a neonatal intensive care unit. Two biochemical assays and plasmid profiles were used to identify epidemic strains from background nursery strains of enterococci. When compared to controls matched for date of admission and weight, cases were significantly more likely to have had a non-umbilical central line, a longer duration of the central line in situ, and a bowel resection (69). Another nosocomial outbreak of gentamicin resistant beta-lactamase producing *Enterococcus faecalis* in an infant/toddler surgical ward was described recently E. Rhinehart et al., 28th Interscience Conference on Antimicrobial Agents and Chemotherapy, Los Angeles, 1988, Abstract no. 1073). At the time of reporting, 23 % of patients and 25 % of personnel exhibited stool colonization. Case-control data suggested that patient colonization was associated with exposure to a chronically colonized nurse.

These reports of exogenous acquisition and nosocomial transmission of enterococci resistant to gentamicin and producing or not producing β-lactamase raise the question as to whether in patients known to harbor these organisms barrier precautions should be applied (2, 3, 10, 11). These techniques have been recommended and used for patients known to be colonized with multi-resistant gram-negative bacilli (67). The importance of the increased use of broad-spectrum antibiotics, particularly cephalosporins and aminoglycosides, in selecting for resistant enterococci in the hospital is also emphasized.

Epidemiologic Aspects of Enterococcal Infection

Urinary Tract Infection In the 1984 US National Nosocomial Infection Survey (NNIS), enterococci accounted for 14.7 % of nosocomial UTIs (4). The UK national survey of infection in hospitals in 1980 reported enterococci in 7.2 % of UTIs (70). The number and proportion of UTIs caused by enterococci appear to be increasing (6, 71). Lemoine and Hunter (71) noted an increase from 11 % to 20 % in catheterized patients' urine specimens with more than 10^5 organisms over the six years of their study. As mentioned earlier, Morrison and Wenzel (6) found a similar increase in UTIs caused by enterococci.

Risk factors for enterococcal UTI have been identified as urinary tract instrumentation or catheterization (6, 7, 71, 72), other genitourinary tract pathology (6, 7), and previous use of antibiotics especially cephalosporin (6). One study noted previously showed that an increase in enterococcal UTI paralleled an increase in cephalosporin use in the hospital (6).

The source of the enterococci, as previously discussed, was originally thought to be the patients' own endogenous fecal flora, based on the study of Gross et al. (7). Using biochemical tests and antibiograms they showed that patients colonized with enterococci developed positive urine cultures with identical enterococci after urinary catheterization (7). This assumption must be reevaluted now in the light of the recent study of Zervos et al. (10). These authors identified several patients with rectal or perineal enterococcal colonization who later developed UTI or wound infections with enterococci.

Using antibiotic sensitivity patterns and plasmid profiles, however, they showed that the urinary tract isolate differed from the rectal or perineal isolate in two out of three cases, suggesting that colonization during catheter insertion, and not rectal or perineal colonization, predisposes to UTI (10).

Bacteremia. Enterococci were reported in the 1984 NNIS (4) to cause 7.1 % of cases of nosocomial bacteremia. Again, based on a number of recent studies the incidence of enterococcal bacteremia appears to be increasing (3, 5, 73). Maki and Agger (3) showed that the increase in enterococcal bacteremia in their hospital was entirely due to nosocomial bacteremia since the incidence of community-acquired enterococcal bacteremia did not change during the study period. In two separate studies 77–78 % of cases of enterococcal bacteremia were hospital acquired (3, 56).

The possible sources of enterococcal bacteremia include infection or colonization of the genitourinary, gastrointestinal and hepatobiliary tracts. The most common source of enterococcal bacteremia in several studies has been the urinary tract, accounting for 19–24 % of cases of enterococcemia (1, 74, 75). Ledger et al. (76) have reported enterococcus as a frequent cause of secondary bacteremia in patients in an obstetric and gynecologic ward with endometritis, postoperative wound infections, pyelonephritis and other gynecologic infections. Other major sources of enterococcal bacteremia include the hepatobiliary tract and intra-abdominal infections (1, 3, 74, 74, 77, 78, 79). Intravascular catheters were a significant source of enterococcal bacteremia in Maki and Agger's recent study (3). Finally, soft tissue infections account for another major source of enterococcal bacteremia (3, 74, 75). Given the nature of the most common sources listed above, it is not surprising that enterococcal bacteremia is frequently polymicrobial (up to 42 % in some cases) (1, 3, 74, 75, 77, 78).

Several recent reviews of enterococcal bacteremia have listed burn wounds as a significant source of enterococcemia (1, 3). Another study has reported a large increase in cases of enterococcal burn bacteremia associated with a high mortality rate (80). Maki and Agger (3) reported that 11 of their 25 patients with enterococcal burn wound bacteremia had received an oral prophylactic antibiotic regimen consisting of erythromycin and neomycin. Ninety percent of isolates from these patients were resistant to erythromycin, again emphasizing the selective pressure of antibiotics in the increasing incidence of enterococcal bacteremia.

Neonatal bacteremia and sepsis have also recently been reported to be increasing in incidence and clinical significance. Siegel and McCracken (81) reported an incidence rate of 0.6 cases per 1,000 live births at their institute between 1974 and 1977. A retrospective review of neonatal infections performed by Buchino et al. (82) identified nine cases of enterococcal sepsis between 1970 and 1976. The epidemiology of endemic enterococcal bacteremia in neonates has not been fully investigated. In two recent outbreaks of neonatal enterococcal sepsis caused by a single organism, however, there was evidence of exogenous acquisition and nosocomial transmission of the enterococcal strain (68, 69).

Endocarditis. Enterococcal endocarditis occurs much less frequently than bacteremia caused by the same organism. Recent reviews have reported the percentage of patients with enterococcal endocarditis identified among patients with enterococcal bacteremia to be 8–32 % (1, 3, 75). It has been estimated that enterococci cause 5–15 % of cases of endocarditis (8, 83). Enterococcal endocarditis is uncommon in infancy and early childhood (84, 85). Patients with enterococcal endocarditis are predominantly male, with an average of 56–59 years, although one recent study reported an average age of 65 years (86–88}. Women with endocardidits tend to be much younger, with an average age of 35–37 years (86, 87).

Although a source of enterococci is not found in most cases, the genitourinary tract is implicated in those patients where a source is suggested. Mandell et al. (87) found that 50 % of men had a history of preceding enterococcal UTI or genitourinary tract instrumentation and that 43 % of women had a history of childbirth or abortion in the preceding three months. Patients with underlying valvular heart disease are at greatest risk of acquiring enterococcal endocarditis (3, 87, 89, 90), although 42 % of patients in Mandell's series had no underlying heart disease (87). Other risk factors for endocarditis identified by Maki and Agger (3) in their series on enterococcal bacteremia include community acquired enterococcemia and lack of an extracardiac source of infection. Bacteremia with enterococci as sole isolate also significantly correlated with endocarditis, while no patients with polymicrobial sepsis had endocarditis.

Intravenous drug users are the final group of patients at risk for enterococcal endocarditis (58, 91). In one series enterococci caused 55 % of cases of narcotic-associated endocarditis during the 54-month study period. Patients in this study were younger and less often had a history of underlying heart disease or genitourinary tract abnormalities than non-addict patients reported in earlier series (91).

Intra-Abdominal Infection. Although enterococci can be isolated in a significant number of intra-abdominal infections, their role in these infections is controversial (92). In the experimental intra-abdominal abscess model of Onderdonk et al. (93) enterococci alone caused no abscess formation or mortality. When given with anaerobes such as *Bacteroides fragilis* or *Fusobacterium varium*, however, the combination caused abscesses in 89–95 % of cases. These authors suggest that enterococci are pathogenic in these infections only synergistically with anaerobes. Furthermore, antibiotic regimens with no activity against enterococci have been shown to be effective in treating intra-abdominal infections, even when enterococci are grown (94, 95). Despite such evidence several reviews on bacteremia have revealed that the source of enterococcal bacteremia is intra-abdominal infection in a significant number of cases (1, 3, 80). There are also several clinical reports of enterococci occurring as sole isolates in intra-abdominal infections (79, 96, 97). The presence of foreign bodies, such as dialysis catheters, and the use of prior antibiotics appear to be predisposing factors for enterococcal intra-abdominal infections (96, 98).

Other Miscellaneous Enterococcal Infections. Enterococci are a rare cause of meningitis in healthy individuals. As discussed earlier, neonates are at risk for enterococcal sepsis and meningitis (68, 69, 81, 82). Risk factors for meningitis have been identified as anatomical central nervous system defects or prior neurosurgical procedures such as shunt placement, especially if the shunt drains into the peritoneum (99, 100). Other risk factors include enterococcal UTI or endocarditis (99), however one recent case report described enterococcal meningitis in a man whose only predisposing factor was steroid therapy for chronic obstructive pulmonary disease (101).

Enterococci are rarely implicated as the cause of lower respiratory tract infections. The exceptions are a few cases of enterococcal pneumonia reported in patients being treated with broad-spectrum antibiotics. These reports suggest that more cases of enterococcal pneumonia may arise in the future with widespread cephalosporin use (102).

Conclusion

The enterococci produce disease in a number of sites but are especially common as causes of deep soft-tissue infection, bacteremia and urinary tract infection. The majority of infections appear to be endogenous but cross-infection has been documented in the hospital, especially with resistant strains. The enterococci seem to be readly selected for the use of broad-spectrum antimicrobial agents, especially the newer cephalosporins. As a consequence of this selection coupled with the emergence of strains highly resistant to aminoglycosides and more recently vancomycin, the enterococci are emerging as problem pathogens within hospitals.

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