Coaggregation of Oral Candida Isolates with Bacteria from Bone Marrow Transplant Recipients

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In vitro coaggregation between Candida species isolated from immunosuppressed bone marrow transplant recipients and oral bacteria was investigated. Each Candida strain showed a different pattern of coaggregation with the 22 bacterial strains studied. Two strains of Lactobacillus amylovorus isolated from separate bone marrow transplant patients and Fusobacterium nucleatum (VP1 10197) coaggregated with all Candida strains. Ten bacterial strains showed no coaggregation with the Candida strains. A variety of inhibition patterns were observed when coaggregating strains were first incubated with various sugars or subjected to heat treatment. Positive and negative results were generally consistent with all Candida strains. On the basis of the culture characteristics of the oral rinse specimens, relationships between the colonization of bacteria and yeasts and in vitro coaggregation were suggested.

Bone marrow transplant (BMT) recipients frequently experience the proliferation of Candida populations in the oropharynx during the period of neutropenia following myelosuppression (21, 28, 33). Consequences include localized candidiasis and, in some patients, fungemia (20, 21, 33).

Although the oral environment is profoundly altered by medications and antimicrobial agents received by patients during transplantation, it is not known whether candidal succession is primarily a response to these covariates or to other factors, such as a reduction in host immunity, changes in candidal adherence to oral epithelium (18, 19), or bacterium-yeast interactions. The last may involve coaggregation (2), growth stimulation, or inhibition (16).

The aim of the present investigation was to characterize oral fungal and bacterial inhabitants of BMT patients and to examine coaggregation between Candida isolates and oral bacteria. The bacterial strains, chosen to represent common oral inhabitants of immunosuppressed cancer patients (23, 27) and normal subjects (22, 24), were both reference strains and direct isolates from BMT patients.

MATERIALS AND METHODS

Subjects and specimen collection. Eight post-BMT patients at the Johns Hopkins Oncology Center (JHOC) participated. All were diagnosed as having a hematologic malignancy (acute lymphoblastic leukemia, acute myelogenous leukemia, or lymphoma) before receipt of the auto- or allogeneic BMT, and all were neutropenic (<1,000 neutrophils per mm$^3$) at the time of specimen collection. Subjects rinsed with 10 ml of sterilized 0.85% saline solution for 30 s and expectorated into sterile plastic screw-cap containers. The containers were transferred within 1 h to an anaerobic chamber (Coy Lab Products, Inc., Ann Arbor, Mich.) containing a gaseous atmosphere of 5% carbon dioxide–10% hydrogen–85% nitrogen and with an ambient temperature of 37°C. The anaerobic laboratory was located at the University of Maryland Dental School.

Culture procedures. The objectives of the culture procedures were to (i) describe semiquantitatively the total salivary microbiota in the neutropenic subjects, (ii) isolate and characterize salivary bacteria appearing in abnormally high concentrations, and (iii) obtain fungal isolates for the coaggregation experiments. Definition of abnormally high concentrations was based on quantitative studies of salivary microflora from normal subjects conducted previously in our laboratory with similar culture techniques (22–24).

Specimens were dispersed for 10 s by ultrasound (Cell Disruptor; Kontes, Vineland, N.J.), serially diluted in reduced transport fluid (17), and plated on nonselective and selective agar media: MM10 sucrose blood agar (17) was used as the nonselective medium. This medium was incubated anaerobically and aerobically in 10% carbon dioxide at 37°C. Selective media were (i) mitis salivarius-bacitracin-sucrose agar for Streptococcus mutans (10), (ii) actinomyces agar (35), (iii) neisseria agar, (iv) Rogosa SL agar for lactobacilli (Difco, Detroit, Mich.), (v) veillonella agar (Difco), (vi) Sabouraud dextrose agar for yeasts (BBL, Cockeysville, Md.), (vii) mannositol-salt agar for staphylococci (BBL), (viii) deoxycholate agar for enteric bacilli (Difco), (ix) laked sheep blood agar with vancomycin and kanamycin for oral Bacteroides spp. (30), and (x) crystal violet-erythromycin-agar for Fusobacterium spp. (34).

Representative fungal isolates from Sabouraud dextrose agar and isolates of bacteria determined to be present in abnormally high concentrations were purified on nonselective medium and identified with appropriate API (Analytab Products, Plainview, N.Y.) rapid identification systems.

Coaggregation assay. The coaggregation assay of Bagg and Silverwood (2) was used. Aliquots (0.3 ml) of approximately 10$^7$ yeast cells per ml (a McFarland turbidity of 4) and 10$^8$ bacterial cells per ml (a McFarland turbidity of 1) in potassium phosphate buffer (0.25 M, pH 7.4) were combined in sterile 7-ml screw-cap glass vials and incubated for 12 h at...
room temperature on an incubator-shaker (New Brunswick Scientific, Inc., Edison, N.J.) oscillating at 33 rpm. After incubation, 1 drop of the mixture was placed on glass microscope slides, covered with no. 2 coverslips, and examined by dark-field microscopy at ×400. Coaggregation was observed as distinct aggregations of yeast and bacterial particles. Negative control suspensions of either yeasts or bacteria in potassium phosphate buffer were made and examined for coaggregation as described above. Each test or control reaction was conducted in triplicate.

The following yeast strains were used: isolates from the BMT patient salivary specimens, Candida albicans ATCC 18804, a blood isolate of C. albicans from an immunosuppressed patient at JHOC, a blood isolate of C. tropicalis from an immunosuppressed patient at JHOC, and a salivary C. albicans isolate from an immunosuppressed patient at the University of Maryland Cancer Center.

The following reference bacterial strains were used along with salivary isolates from BMT patients (listed in Results): Lactobacillus salivarius ATCC 11741, L. acidophilus ATCC 521, L. casei ATCC 11578, Staphylococcus epidermidis ATCC 12228, S. salivarius ATCC 25975, S. sanguis ATCC 10556, S. sanguis ATCC 10557, S. sanguis ATCC 903, S. mutans Ingbritt ATCC 1600, Klebsiella pneumonia ATCC 13833, Escherichia coli ATCC 25922, Pseudomonas aeruginosa ATCC 27853, Actinomyces viscosus ATCC 15987, Bacteroides gingivalis CS213 isolated from a periodontal pocket of a patient at the University of Maryland Dental School, and Fusobacterium nucleatum VPI 10197. The reference bacterial strains were selected to represent indigenous oral bacteria and species known to inhabit the mouths of immunosuppressed patients.

Inhibition of coaggregation. The objective of these experiments was to identify substances or conditions which inhibited coaggregation reactions. Although the present investigation was not designed to characterize the biochemistry of coaggregation reactions, the inhibition studies were intended to help categorize and partially elucidate the bacterium yeast interactions.

The following substances or conditions were tested for their inhibitory effect: (i) D(+)-glucosamine hydrochloride (Sigma, St. Louis, Mo.), (ii) L-fucose (Sigma), (iii) α-methylmannoside (Sigma), (iv) dextrose (Fisher, Pittsburgh, Pa.), (v) D-mannose (BBL), (vi) α-methyl-glucoside (Mann Research Laboratories, New York, N.Y.), and (vii) heat treatment (85°C for 30 min).

An inhibition assay described by Critchley and Douglas (5) was used. The reagents were prepared in 0.25 M potassium phosphate buffer at a concentration of 200 mg/ml. Samples (50 µl) of the individual stock solutions were added to 0.2-ml bacterial suspensions (10^6 cells per ml) before the addition of 0.2-ml yeast suspensions (10^7 cells per ml). Heat treatments were conducted by exposing individual strains to heat before mixtures were prepared. The culture conditions were the same as those described above for the coaggregation assay.

RESULTS

Culture findings. The distinctive features of the salivary microflora of the BMT patients designated JH01 to JH08 are presented in Table 1.

Gram-negative bacilli (GNB) were predominant in six of the eight specimens and were identified as Pseudomonas species in three specimens. Yeasts either were not detected in specimens in which GNB were predominant or were present in low concentrations. Relatively high levels of yeasts were recovered in specimens from JH05 and JH06, in whom GNB either were not detected (JH06) or were not predominant (JH05). In both of the latter cultures, L. amylovorus was isolated.

The microbial specimens obtained from the BMT patients and used in coaggregation experiments were four strains of C. albicans and one of C. lamberca, L. casei subsp. pseudoplanterum, Pseudomonas stutzeri from two individuals, P. maltophilia, L. amylovorus from two individuals, and S. mitis. Additional candidal and bacterial strains are listed in Materials and Methods.

Coaggregation assay. The results of the coaggregation assays are shown in Table 2 and Fig. 1. None of the Candida strains autoagglutinated. The three strains of S. sanguis were the only bacteria which autoagglutinated. Three strains of bacteria coaggregated with all of the yeast strains. These were L. amylovorus isolated from two BMT patients and F. nucleatum ATCC 10197. Another Lactobacillus species, L. casei subsp. pseudoplantorum, isolated from a BMT patient showed no coaggregation with Candida strains, nor did reference strain L. casei ATCC 11578 or L. acidophilus ATCC 512. L. salivarius ATCC 11741 coaggregated with two of the nine yeast strains. S. mitis isolated from a BMT patient coaggregated with five yeast strains, including a yeast strain from the same patient. S. epidemidis ATCC 12228 coaggregated with two yeast strains. S. salivarius ATCC 25975 only coaggregated with C. albicans and C. tropicalis isolated from a blood specimen of a BMT patient. S. sanguis ATCC 10556 coaggregated with six yeast strains, and S. sanguis ATCC 10557 coaggregated with seven. Although some autoagglutination was seen with S. sanguis, positive and negative interactions with yeast strains could be detected by examining the cellular morphology of the strains. A. viscosus ATCC 15987 and B. gingivalis CS213

<table>
<thead>
<tr>
<th>Patient</th>
<th>Predominant bacteria</th>
<th>Yeasts</th>
</tr>
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<tbody>
<tr>
<td>JH01</td>
<td>P. stutzeri (55)b, L. casei subsp. pseudoplanterum (18)b</td>
<td>C. albicans (0.03)</td>
</tr>
<tr>
<td>JH02</td>
<td>GNB (78)</td>
<td>C. lamberca (0.001)b</td>
</tr>
<tr>
<td>JH03</td>
<td>GNB (92)</td>
<td>ND*</td>
</tr>
<tr>
<td>JH04</td>
<td>GNB (60), alpha-hemolytic streptococci (40)</td>
<td>ND</td>
</tr>
<tr>
<td>JH05</td>
<td>S. mitis (67)b, P. maltophilia (16)b, L. amylovorus (16.0)b</td>
<td>C. albicans (0.7)b</td>
</tr>
<tr>
<td>JH06</td>
<td>Alpha-hemolytic streptococci (48), L. amylovorus (8.0)b, Veillonella species (36)</td>
<td>C. albicans (1.0)b</td>
</tr>
<tr>
<td>JH07</td>
<td>GNB (80), S. sanguis (20)</td>
<td>ND</td>
</tr>
<tr>
<td>JH08</td>
<td>P. stutzeri (99)b</td>
<td>C. albicans (0.01)b</td>
</tr>
</tbody>
</table>

* Determined on MM10 sucrose blood agar incubated anaerobically at 37°C.
* Used in coaggregation experiments.
* ND, Not detected.

**Inhibition of coaggregation.** Yeast-bacterium mixtures which exhibited coaggregation were incubated with a variety of sugars and subjected to heat prior to mixing (85°C for 30 min) in an effort to examine the specificities of the coaggregation reactions (Table 3).

All *Candida* strains which coaggregated with a particular bacterial strain reacted similarly in the inhibition experiments when combined with the same bacterial strain. Reactions involving all *S. sanguis* strains, *S. epidermidis*, and *A. viscosus* were not inhibited by the sugars tested. Reactions involving *S. mitis*, *L. salivarius*, *S. salivarius*, and *B. gingivalis* were inhibited by only one sugar each. These were, in respective order, α-methyl-glucoside, α-methyl-mannoside, D-(+)-glucosamine, and dextrose. Coaggregation reactions between *Candida* strains and *F. nucleatum* were inhibited by α-methyl-mannoside and d-mannose. Those between *Candida* strains and both *L. amylovorus* strains were inhibited by α-methyl-mannoside, d-mannose, dextrose, and α-methyl-glucoside.

After heat treatment, *S. salivarius*, *S. epidermidis*, *B. gingivalis*, and *F. nucleatum* still coaggregated with yeast strains. However, this activity was lost in reactions involving *L. amylovorus*, *S. mitis*, *L. salivarius*, all *S. sanguis* strains, and *A. viscosus*.

**DISCUSSION**

The experimental results confirmed the report of Bagg and Silverwood (2) that certain strains of indigenous oral bacteria bound to *C. albicans* and formed visible aggregates. In their study, strains of *S. sanguis* NCTC 10558, *S. salivarius* NCTC 8606, *S. mutans* D282 (NCTC 10832), *S. mitis* 3 (NCTC 10712), *F. nucleatum* NGB 15-73, and *A. viscosus* ATCC 15987 coaggregated with *C. albicans* NCPF 3281 (2). The results of the present study are consistent with the findings of Bagg and Silverwood (2), with the exception that

**TABLE 2. Coaggregation of Candida species with oral bacteria**

| Oral bacterium                  | C. albicans (JH01) | C. lambergeri (JH02) | C. albicans (UMCC) | C. albicans (JH05) | C. albicans (JH06) | C. albicans (JH08) | C. albicans (JH, blood) | C. albicans (JH, blood) | C. albicans (ATCC 27853) | C. albicans (ATCC 13883) | C. albicans (ATCC 27853) |
|--------------------------------|--------------------|----------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|-------------------|-------------------|-------------------|
| L. casei subsp. pseudo-planterum (JH01) | -                   | -                    | -                   | -                   | -                   | -                   | -                   | -                   | -                  | -                  | -                  |
| P. stutzeri (JH01)             | -                   | -                    | -                   | -                   | -                   | -                   | -                   | -                   | -                  | -                  | -                  |
| L. amylovorus (JH05)           | +                   | +                    | +                   | +                   | +                   | +                   | -                   | -                   | -                  | -                  | -                  |
| S. mitis (JH05)               | +                   | +                    | +                   | +                   | +                   | +                   | -                   | -                   | -                  | -                  | -                  |
| P. maltophilia (JH05)         | -                   | -                    | -                   | -                   | -                   | -                   | -                   | -                   | -                  | -                  | -                  |
| L. amylovorus (JH06)           | +                   | +                    | +                   | +                   | +                   | +                   | -                   | -                   | -                  | -                  | -                  |
| P. stutzeri (JH08)             | -                   | -                    | -                   | -                   | -                   | -                   | -                   | -                   | -                  | -                  | -                  |
| L. salivarius (ATCC 11741)     | -                   | -                    | -                   | -                   | -                   | -                   | -                   | -                   | -                  | -                  | -                  |
| L. acidophilus (ATCC 521)      | -                   | -                    | -                   | -                   | -                   | -                   | -                   | -                   | -                  | -                  | -                  |
| L. casei (ATCC 11578)          | -                   | -                    | -                   | -                   | -                   | -                   | -                   | -                   | -                  | -                  | -                  |
| S. epidermidis (ATCC 12228)    | -                   | -                    | -                   | -                   | -                   | -                   | -                   | -                   | -                  | -                  | -                  |
| S. salivarius (ATCC 25975)     | -                   | -                    | -                   | -                   | -                   | -                   | -                   | -                   | -                  | -                  | -                  |
| S. sanguis (ATCC 10557)        | +                   | +                    | +                   | +                   | +                   | +                   | -                   | -                   | -                  | -                  | -                  |
| S. sanguis (ATCC 903)          | +                   | +                    | +                   | +                   | +                   | +                   | -                   | -                   | -                  | -                  | -                  |
| S. mutans Ingbrit (ATCC 1600)  | -                   | -                    | -                   | -                   | -                   | -                   | -                   | -                   | -                  | -                  | -                  |
| K. pneumoniae (ATCC 13883)     | -                   | -                    | -                   | -                   | -                   | -                   | -                   | -                   | -                  | -                  | -                  |
| E. coli (ATCC 25922)           | -                   | -                    | -                   | -                   | -                   | -                   | -                   | -                   | -                  | -                  | -                  |
| P. aeruginosa (ATCC 27853)     | -                   | -                    | -                   | -                   | -                   | -                   | -                   | -                   | -                  | -                  | -                  |
| A. viscosus (ATCC 15987)       | +                   | +                    | +                   | +                   | +                   | +                   | -                   | -                   | -                  | -                  | -                  |
| B. gingivalis (CS213)          | -                   | -                    | -                   | -                   | -                   | -                   | -                   | -                   | -                  | -                  | -                  |
| F. nucleatum (VI 10197)        | +                   | +                    | +                   | +                   | +                   | +                   | -                   | -                   | -                  | -                  | -                  |

* Designations in parentheses indicate strain designation, BMT patient, or other source. UMCC, University of Maryland Cancer Center.

* There was no autoagglutination of yeasts.

**FIG. 1.** Coaggregation between *C. albicans* and *A. viscosus.*
S. mutans Ingbrit and E. coli ATCC 25922 did not coaggregate with any Candida strain. As wide differences in coaggregation occurred with Candida strains in the present study, selected bacterial strains may also react differently. The L. amylovorus strain used by Bagg and Silverwood (2) was a fimbriated strain which coaggregated consistently with their Candida strain. The type of fimbriae present on the E. coli strain used in the present study or their absence may explain our negative findings. Other possible explanations for differences in coaggregation between various investigations are differences in the surface properties of Candida strains induced by various growth media (4, 19) or growth conditions (4, 14). A recent study by Brawner and Cutler (3) found that C. albicans strains isolated from immunosuppressed individuals differed serologically from strains isolated from immunocompetent individuals.

Attachment of microorganisms to epithelial cells is recognized as a crucial step in the colonization and infection of the host. Although it was suggested that certain bacteria possess ligands that could bind to both candidal and epithelial cells and thereby mediate adherence of the yeasts by a “bridging” action, the possible role of this type of attachment in relation to oral colonization by yeasts has been studied in detail. Gibbons and van Houte (9) reported that S. salivarius and S. sanguis were recovered in high proportions from cheek and tongue surfaces, which are often colonized by C. albicans, whereas S. mutans was present only in low proportions, if at all, on these surfaces. The coaggregation found in the present study between candidal strains and S. sanguis and S. salivarius but not S. mutans supports the possibility that certain streptococci may act as mediators of candidal attachment to oral mucosal surfaces.

Previous investigations have not examined the coaggregation of Lactobacillus species with yeast cells. We observed that two strains of L. amylovorus isolated from BMT patients coaggregated with all nine yeast strains. It is possible that L. amylovorus, previously reported to be isolated from waste corn fermentation (29), plays an important role in candidal colonization. Our results showing that L. salivarius ATCC 11741 coaggregated with yeast strains while L. acidophilus ATCC 521, L. casei ATCC 11578, and L. casei subsp. pseudoplan tarum did not suggest that L. salivarius may aid candidal cells in mucosal colonization of the oral cavity surfaces which are in contact with saliva, while L. salivarius is commonly isolated from the saliva and tongue. L. acidophilus is usually found in dental plaque, and L. casei is usually found in carious dentin (11).

A. viscosus, a predominant Actinomyces species isolated from dental plaque, is recognized as being indigenous to the human oral cavity (12). A. viscosus ATCC 15987 coaggregated with C. lambica, C. tropicalis, and two strains of C. albicans in the present study. Bagg and Silverwood (2) also reported coaggregation between Actinomyces and Candida strains.

F. nucleatum VPI 10197, isolated from the gingival crevice, has shown a characteristic hemagglutination pattern with a variety of erythrocytes of human and animal origin (8). It was suggested that this bacterial species possesses lectins that recognize galactoselike residues on human cell surfaces and possibly allow attachment of the bacteria to cell surfaces. Since coaggregation was found in the present study between F. nucleatum VPI 10197 and all the yeast strains tested, a potential for mediation by this bacterium of oral colonization by yeasts exists.

Bacteroides species have been recognized as prominent members of maturing dental plaque (31). B. gingivalis was reported to be the only member of the black-pigmented Bacteroides group that coaggregated with several oral species, including Veillonella, Capnocytophaga, Actinomyces, and Rothia species (6). In the present study, B. gingivalis CS213 coaggregated with three yeast strains. B. gingivalis was reported to be present on the dorsum of the tongue and oral mucosa but only in very small numbers (15). Bagg and Silverwood (2) proposed that, because of the scarcity of B. gingivalis, its cooperation in the colonization of the oral mucosa by yeast strains in vivo is unlikely.

Previous investigations have suggested that differences in enzyme production or the ability to adhere to epithelial cells exist among various strains of C. albicans (1). Our findings of differences in coaggregation among seven strains of C. albicans strongly suggest that specificities of coaggregating pairs existed at the strain level. Differences also existed at the species level. C. lambica, for example, showed less coaggregation with bacterial strains than did C. albicans or C. tropicalis.

Organisms with the ability to coaggregate with epithelial surfaces or plaque bacteria may have an advantage over noncoaggregating organisms, which could be more easily removed from the oral environment by salivary flow. Bagg and Silverwood (2), however, proposed that large aggregates of bacteria and yeasts may be more readily cleared from the oral cavity than are individual cells. In vivo studies involving germ-free animals may be necessary to elucidate the biological significance of in vitro coaggregation.
There appeared to be consistent correlations between some of the culture findings and coaggregation reactions. Specimens which yielded GNB, usually Pseudomonas species, as predominant isolates harbored only low levels of Candida organisms or no Candida organisms (JH01, 0.03%; JH02, 0.01%; JH03, 0.0%; JH04, 0.0%; JH07, 0.06%; and JH08, 0.01%). As none of the Candida strains coaggregated with the Pseudomonas strains from the BMT patients or some of the culture findings and coaggregation monas species actively inhibit Candida species, should be investigated.

Specimens showing relatively high levels of Candida organisms contained bacterial strains with which the same candidal strains coaggregated in vitro. JH05, with 0.7% C. albicans, harbored a high concentration of L. amylovorus. JH06, with 1.0% C. albicans, harbored L. amylovorus and very high concentrations of a catalase-positive Actinomyces species. Previous studies have demonstrated that many bacteria have the ability to bind to mannose-containing receptors such as yeast mannans, which are the major polymers of the yeast cell wall. Strains of L. amylovorus, S. mitis, and F. nucleatum were inhibited from coaggregation with yeast strains by mannose in the present study. This result suggests that the above-listed bacteria have mannose-binding properties. S. sanguis, A. viscosus, S. salivarius, B. gingivalis, and L. salivarius were considered negative with respect to mannose-binding capacity. α-Methyl-mannoside, a polymer of α-methyl-mannose which differs from D-mannose in that the OH group at carbon 1 in D-mannose is replaced by a CH3 group, displayed the same inhibitory effect as D-mannose.

D-(+)-Glucosamine, a component of chitin, did not show an inhibitory effect, except with S. salivarius. This result was expected, since chitin is thought to be concentrated in the inner layers of the yeast cell wall and thus to be unavailable for surface interactions (32). The exception of S. salivarius cannot be explained.

L-Fucose, which has been shown to have no inhibitory effect on F. nucleatum hemagglutination activity (26), displayed no inhibition of candidal coaggregation with F. nucleatum or other bacteria tested in this study. This result suggests the absence of l-fucose-like groups at the termini of attachment sites.

Dextrose and α-methyl-glucoside were equally capable of inhibiting L. amylovorus coaggregation with yeast cells. Neither of them inhibited yeast coaggregation with S. epidermidis, S. salivarius, S. sanguis, or F. nucleatum. These two sugars had different effects on the coaggregation activity of S. mitis, B. gingivalis, and L. salivarius in that dextrose inhibited B. gingivalis and α-methyl-glucose inhibited S. mitis and L. salivarius from coaggregation with yeast cells. Eshdat et al. (7) isolated a mannose-binding lectin (carbohydrate-binding protein) from E. coli. This bacterial protein was proposed to play a role in the agglutination of yeast cells by E. coli, a process which could be reversed by heat treatment. As our results showed that heat treatment abolished the coaggregation activities of L. amylovorus, L. salivarius, S. sanguis, S. mitis, and A. viscosus, it is suggested that a certain bacterial or yeast protein(s) participated in the coaggregation mechanism. A role of bacterial or yeast protein in mediating yeast coaggregation is evident only when heat treatment inhibits coaggregation. This was the case with S. sanguis and A. viscosus. A recent study by Jenkinson et al. supported the presence of a protein mediator in coaggregation reactions between Candida species and certain Streptococcus species (14).

Previous investigations showed that bacterial adhesion to mammalian cells occurs by various means, including lectin-like interactions, cell surface adhesins, hydrophobicity, and fibronectin (18). Although the tests in the present study were not performed to determine the exact mechanism(s) of coaggregation, the results indicated that lectin-like interactions and nonmannoprotein adhesins contribute to the coaggregation of yeast cells with bacterial cells.

As previous coaggregation studies did not address the quantities of yeasts and bacteria in natural specimens, the results cannot be compared with those of other research. It is recognized that the BMT subjects presented many complex variables, such as antifungal, antibiotic, and immunosuppressive treatment regimens, as well as differences in the immunocompetence status. These, of course, make the establishment of definitive conclusions difficult. The data do, however, indicate that oral bacteria should be regarded as factors which may contribute to Candida colonization and proliferation in the oral cavities of BMT subjects.

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LITERATURE CITED


