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Adherence of *Candida albicans* to Human Vaginal and Buccal Epithelial Cells

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Factors that may influence adherence of *Candida albicans* to exfoliated human vaginal and buccal epithelial cells were studied in vitro. Factors that enhanced germination enhanced adherence. Heat-killed, germinated *Candida* organisms demonstrated poorer adherence than viable *Candida* organisms and no better adherence than nonviable, ungerminated *Candida* organisms. The difference between adherence of *C. albicans* to buccal epithelial cells and that to vaginal epithelial cells was significant, as were differences among volunteers. Preincubation in fucose but not mannose, glucose, or galactose solutions, preincubation of germinated yeast or of epithelial cells in chymotrypsin or trypsin, a culture supernatant of germinated yeast killed by ultraviolet light, or precoating of epithelial cells with lactobacilli each inhibited adherence. These studies indicate that adherence of *C. albicans* is enhanced by a surface component of germinated yeast, probably a surface protein that binds to the epithelial receptor, possibly a glycoprotein.

Adherence of bacteria to epithelial cells is considered a major determinant of colonization and subsequent invasion of tissues [1–3]. There is considerably less information available regarding the adherence of commensal and pathogenic fungi to mucosal surfaces. To date, most studies have been of *Candida albicans* because of the extensive morbidity and occasional mortality associated with this opportunistic yeast [4–6]. Liljemark and Gibbons [4] studied adherence of *C. albicans* to rat tongue and cheek cells and found that *C. albicans* attached in lower numbers to epithelial cells from normal rats than to those from gnotobiotic rats. These findings suggested that indigenous oral flora may interfere with adherence and colonization by *Candida* organisms. The kinetics of *C. albicans* adherence to buccal epithelial cells (BECs) have been investigated by Kimura and Pearsall [5], who reported enhanced adherence to the organisms under conditions promoting yeast germination.

We studied the in vitro adherence of *C. albicans* to both BECs and vaginal epithelial cells (VECs) and evaluated multiple factors influencing fungal adherence to human mucosal cells. This report is the first detailing the interactions between *C. albicans* and VECs.

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Materials and Methods

Epithelial cells. BECs and VECs were obtained from healthy female volunteer medical students, with a mean age of 25 years (range, 22–29 years). All of the volunteers were asymptomatic, were sexually active with regular menses, and had a normal gynecologic examination. The subjects did not use either vaginal douches or topical vaginal medication. None took oral hormonal contraceptives; instead, they used diaphragms and spermicidal cream.

VECs were obtained from the mucosal surface of the midvaginal wall by gently scraping with a spatula. BECs were collected by gently scraping the inside of the cheeks with a tongue blade. The cells were immediately transferred to Williams medium E (Grand Island Biological Co., Grand Island, N.Y.), pH 7.2. Adherence experiments were begun within 30 min of sampling. Unless otherwise specified, each experiment was performed with the cells from one volunteer.

Isolates of C. albicans. Four recent isolates of *C. albicans*, one each from the oral cavity and bronchial secretions obtained at bronchoscopy and two isolates from vaginal secretions, were identified by standard techniques. Each was grown overnight in Sabouraud's glucose broth at 37 C. One-milliliter aliquots were frozen and stored at −20 C. For testing of adherence, a frozen aliquot of each isolate was thawed and incubated on Sabouraud's glucose agar for 24 hr. Isolated colonies were then transferred to Sabou-

raud's glucose broth, incubated overnight at 37 C, and used in the experiment. Unless otherwise specified, one of the vaginal strains was used for all experiments.

Adherence assay. The adherence method of Mårdh and Weström [7] was used with a few modifications. Epithelial cells were washed free of adherent oral or vaginal bacteria by centrifuging three times in 20 ml of Williams solution at 158 *g* for 10 min at 4 C. The final mixture was filtered through a membrane filter with a pore size of 8 μm (Millipore Corp., Bedford, Mass.), which retains epithelial cells but allows free bacteria to pass. The epithelial cells were resuspended in Williams solution or 0.01 M phosphate-buffered saline (PBS), pH 7.2, and were adjusted to a final concentration of 2×10^4 washed epithelial cells/ml, as determined by counting in a hemacytometer.

The fungi were washed twice in PBS by centrifugation at 1,548 *g* for 10 min, resuspended in PBS, and passed through a 25-gauge needle to obtain single yeast organisms, as determined by Gram staining. After initial quantitative cultures had confirmed the fungal density, a spectrophotometer was used to adjust the final suspension of *Candida* in PBS at 37 C to 5×10^5 organisms/ml. This inoculum size of *Candida* was used in all experiments.

One milliliter of the yeast suspension was mixed with 1 ml of the epithelial cell suspension, which resulted in a ratio of 25 *Candida* organisms to one epithelial cell, and the mixture (pH 7.2) was incubated aerobically on a rocker at 37 C for 2 hr. Epithelial cells were then washed free of nonadherent yeast by centrifugation at 158 *g* in PBS and filtration through a membrane filter with 8-μm pores. To transfer the cells to slides, the membranes were gently pressed against glass slides that had previously been coated with a thin layer of albumin. Cells attached to the slide were fixed in 95% ethanol for 10 min, air-dried, and Gram-stained. The number of yeast adherent to epithelial cells was counted under a light microscope at ×1,000. Experiments were done in duplicate. In each experiment, at least 50 epithelial cells were counted. All slides were coded and read in a blind fashion. The presence of germ tubes was assessed quantitatively.

In all experiments, controls were included that contained epithelial cells alone, without *Candida* organisms. In addition, quantitation of *Candida* was performed at the start and at the end of the incubation in tubes that contained mixtures of epithelial cells and *Candida* organisms in either PBS or Williams solution. As no significant increase in cfu of *Candida* occurred during the first 2 hr of incubation but did thereafter, experiments were terminated at 2 hr.

In some experiments, the yeast organisms were first killed either by heating at 63 C for 90–120 min or by incubating overnight at 4 C in 0.5% formaldehyde in 0.85% NaCl. These fungi were then washed twice in PBS before being tested.

In some studies, potential inhibitors of adherence between *Candida* organisms and epithelial cells were added to the incubation mixtures. The compounds studied included α-D(+)-fucose, α-L(−)-fucose, D(+)-galactose, β-D(+)-glucose, D(+)-mannose, L(−)-mannose, and α-methyl-D-mannoside (Sigma Chemical Co., St. Louis, Mo.), at concentrations of 25 mg/ml. In these experiments, *Candida* organisms were preincubated for 2 hr at 37 C in Williams solution to enhance germination and washed and suspended in PBS. Next, *Candida* organisms were incubated with an inhibitor for 60 min at 37 C in PBS. Then, epithelial cells were added to the *Candida* organisms in PBS for 2 hr.

In other experiments, the effect of trypsin or chymotrypsin on adherence was studied. *Candida* organisms were preincubated in Williams solution for 2 hr at 37 C to enhance germination and were then washed and resuspended in PBS. Either *Candida* organisms or epithelial cells were incubated with trypsin (2.5–7.5 mg/ml) or chymotrypsin (2.5–7.5 mg/ml) (Sigma) in PBS for 60 min at 37 C and then washed free of enzyme with PBS. Finally, the yeast and epithelial cells were incubated together in PBS for 2 hr. These experiments were performed in PBS because Williams solution provided substrate for the proteolytic activity of the enzymes tested.

Cultures of germinating yeast preincubated in Williams solution for 2 hr at 37 C were suspended in PBS, placed in flat petri dishes, and killed by exposure to ultraviolet light. *Candida* organisms were then removed by centrifugation, and the supernatant was collected and used for incubation of *Candida* organisms and epithelial cells in the adherence assay.

In further studies, species of *Lactobacillus* obtained as fresh vaginal isolates were grown over-

Table 1. Adherence of *Candida albicans* to vaginal epithelial cells incubated in Williams solution or in phosphate-buffered saline (PBS) for various intervals.

Medium	Incubation time (hr)					
	0.5	1	1.5	2	2.5	3
Williams solution	12.9 ± 1.0 (318)	14.4 ± 1.3 (344)	19.4 ± 1.2 (349)	21.6 ± 0.7 (326)	22.6 ± 1.4 (149)	23.9 ± 1.0 (183)
PBS	8.1 ± 1.0 (182)	13.0 ± 0.9 (161)	10.4 ± 0.6 (175)	10.1 ± 0.7 (157)	. . .	. . .

NOTE. Data are mean ± SE (no. of vaginal epithelial cells counted).

night on Rogosa agar (Difco Laboratories, Detroit, Mich.) at 37 C, and 10^8 cfu/ml were incubated with washed VECs for 30 min in PBS. Nonadherent lactobacilli were removed by washing with centrifugation. Epithelial cells coated with adherent lactobacilli were incubated with a vaginal isolate of *C. albicans* for 2 hr at 37 C in Williams solution, and yeast adherence was measured.

Results

Factors influencing adherence of C. albicans to VECs. Table 1 shows the results of adherence of *C. albicans* to VECs using a vaginal strain at a concentration of 5×10^5 organisms/ml and VECs at 10^5/ml with incubation for 0.5–3 hr at 37 C. Maximal adherence in Williams solution occurred at 2 hr after the start of incubation, and further exposure of epithelial cells to *Candida* organisms did not result in any significant additional adherence ($P > 0.05$). Accordingly, a 2-hr period of epithelial cell-*Candida* admixture was used in all experiments comparing adherence of isolates of *C. albicans* to epithelial cells. Adherence was significantly greater in Williams solution than in PBS for comparisons at 0.5, 1.5, and 2 hr ($P < 0.01$ for each comparison).

When we compared the microscopic characteristics of the fungal adherence to VECs in the two incubation conditions, it was apparent that the *Candida* organisms in Williams solution had many more germ tubes than those in PBS. Germination kinetics were studied in PBS and Williams solution (figure 1). Virtually no germ tube formation occurred in PBS, whereas 75% of the yeast formed germ tubes after incubation for 90 min in Williams solution.

Effect of viability on adherence of C. albicans. *Candida* organisms killed by treatment with either formalin or heat did not adhere as well to VECs as did viable *Candida* organisms incubated in Williams solution at 37 C for 1 or 2 hr ($P < 0.01$ for each comparison) (table 2).

Preincubation in Williams solution to enhance germination did not increase adherence if the *Candida* organisms were heat-killed (table 3). When viable *Candida* organisms were preincubated in Williams solution for 60 min at 37 C, washed twice with PBS, and incubated with VECs in PBS for 2 hr, the adherence was greater than that obtained when viable *Candida* organisms were preincubated with PBS, which suppressed germination ($P < 0.01$). However, adherence to VECs was poor for *Candida* organisms that had been heat-killed after preincubation in either Williams solution (which enhanced germ tube formation) or PBS (which suppressed germ tube formation) in comparison to adherence of viable *Candida* organisms preincubated in PBS ($P < 0.01$) or Williams solution ($P < 0.01$).

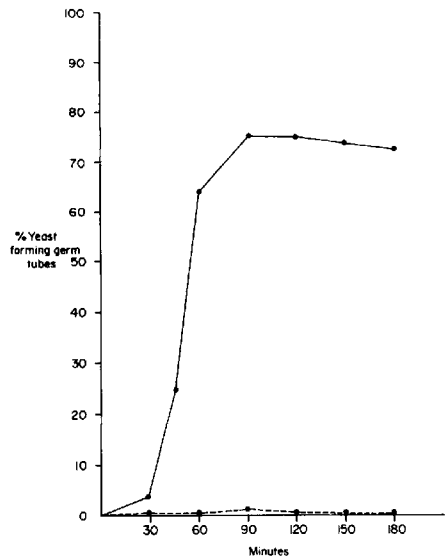

Figure 1. Percentage of *Candida albicans* yeast forming germ tubes in phosphate-buffered saline (●- - ●) and in a 1:2 dilution of Williams solution (●——●) with incubation for 3 hr at 37 C.

Table 2. Adherence of viable *Candida albicans* or *C. albicans* killed by formalin or heat to vaginal epithelial cells incubated in Williams solution for various intervals.

C. albicans	Incubation time (hr) 1	2
Viable	9.1 ± 0.4 (291)	20.0 ± 0.7 (251)
Formalin-killed	6.5 ± 0.3 (200)	5.6 ± 0.3 (200)
Heat-killed	5.4 ± 0.2 (300)	5.3 ± 0.3 (300)

NOTE. Data are mean ± SE (no. of vaginal epithelial cells counted).

Effect of pH on C. albicans adherence. Candida organisms and VECs were mixed in Williams solution at different pHs, achieved by adding concentrated HCl or NaOH. During the 1-hr experiment, pH values remained stable. The mean (± SE) adherence was 11.5 ± 0.7 at pH 3, 12.0 ± 1.0 at pH 4, 15.8 ± 1.0 at pH 5, 18.4 ± 0.7 at pH 6, 14.3 ± 0.7 at pH 7, and 14.2 ± 1.1 at pH 8. The adherence at pH 6 was significantly greater at the $P < 0.01$ level than that at pH 3, 4, 7, or 8 and at the $P < 0.05$ level than that at pH 5. Evaluation of the increased adherence at pH 6 when compared with that at pH 3 and 4 revealed that 88% of the adherent yeast had formed germ tubes at pH 6, compared with only 8% at pH 4 and 2% at pH 3 ($P < 0.01$ for both comparisons). The enhanced adherence at pH 6 was unrelated to differences in the number of viable yeast cells at the various pHs studied, since quantitative cultures performed simultaneously revealed similar numbers of cfu at pH 3, 4, and 6 ($P > 0.05$ for each comparison).

Comparison of adherence of four isolates of C. albicans to VECs and BECs. A three-way analysis of variance with two observations per cell was used to compare the adherence of the four isolates of *C. albicans* to VECs and BECs from 10 healthy female volunteers on two separate occasions. The only significant variations were in the adherence among the 10 volunteers ($P < 0.01$), the adherence to BECs as compared with that to VECs ($P < 0.05$), and the interaction of adherence to BECs with that to VECs among the 10 women ($P < 0.05$) (table 4). Adherence to BECs was slightly greater than that to VECs: mean adherence was 16.4 and 14.7, respectively.

Table 3. Adherence to vaginal epithelial cells (VECs) of viable and nonviable *Candida albicans* preincubated for 1 hr in Williams solution or phosphate-buffered saline (PBS) and then incubated with VECs for 2 hr in PBS.

C. albicans	Pre-incubation medium	Germ tubes	No. of adherent *C. albicans*/VEC*
Viable	PBS	Absent	12.7 ± 1.0 (181)
	Williams	Present	28.1 ± 1.4 (88)
Heat-killed (after pre-incubation)	PBS	Absent	5.4 ± 0.2 (200)
	Williams	Present	3.7 ± 0.4 (100)

* Data are mean ± SE (no. of VECs counted).

Inhibition of adherence of C. albicans to VECs. Neither mannose, galactose, nor α-methyl-D-mannoside inhibited adherence of *Candida* organisms to VECs ($P > 0.05$ for each comparison) (table 5). However, both α-D(+)- and α-L(−)-fucose decreased adherence by about 25% ($P < 0.01$ for each comparison), and glucose increased adherence by about 25% ($P < 0.01$).

Enzymes were then tested for their effects on the surfaces of *Candida* organisms and VECs

Table 4. Analysis of variance of number of adherent *Candida albicans* per epithelial cell.

Source of variation	*df*	Sum of squares	Mean square	*F*	*P*
Among women	9	621.82	69.09	4.08	<0.01
Between two epithelial cell types	1	113.38	113.38	6.70	<0.05
Among four *C. albicans* strains	3	75.94	25.31	1.50	>0.05
Two-way interactions					
Women × epithelial cell type	9	350.63	38.96	2.30	<0.05
Women × *C. albicans* strain	27	256.38	9.50	. . .	>0.05
Epithelial cell type × *C. albicans* strain	3	37.89	12.63	. . .	>0.05
Three-way interactions					
Women × epithelial cell type × *C. albicans* strain	27	89.25	3.31	. . .	>0.05
Residual	80	1,354.28	16.93	. . .	. . .

Table 5. Adherence of germinated *Candida albicans* to vaginal epithelial cells after incubation with various carbohydrates.

Carbohydrate	Adherence*
None (control)	21.5 ± 0.92 (200)
α-D(+)-fucose	16.2 ± 0.8 (200)†
α-L(−)-fucose	15.7 ± 0.9 (166)†
D(+)-galactose	23.7 ± 0.9 (174)
β-D(+)-glucose	27.0 ± 0.9 (200)†
D(+)-mannose	19.6 ± 0.7 (200)
L(−)-mannose	22.6 ± 1.2 (172)
α-Methyl-D-mannoside	22.7 ± 1.2 (185)

* Data are mean ± SE (no. of vaginal epithelial cells counted).

† $P < 0.01$ in comparison to control.

Table 6. Effect of preincubation of germinated *Candida albicans* or vaginal epithelial cells (VECs) with potential inhibitors of adherence.

Preincubation inhibitor, concentration	Cell preincubated	Mean ± SE *C. albicans*/ VEC*	P†
None	Control	21.5 ± 1.0	. . .
Trypsin			
0.25%	*C. albicans*	10.7 ± 1.1	<0.01
0.50%	*C. albicans*	12.4 ± 0.7	<0.01
0.75%	*C. albicans*	12.4 ± 1.0	<0.01
Trypsin			
0.25%	VECs	6.3 ± 0.7	<0.01
0.50%	VECs	5.5 ± 0.4	<0.01
0.75%	VECs	7.0 ± 0.5	<0.01
None	Control	26.1 ± 0.9	. . .
Chymotrypsin			
0.25%	*C. albicans*	23.2 ± 1.0	<0.05
0.50%	*C. albicans*	20.4 ± 1.0	<0.01
0.75%	*C. albicans*	17.2 ± 1.0	<0.01
Chymotrypsin			
0.25%	VECs	14.9 ± 0.9	<0.01
0.50%	VECs	12.3 ± 1.0	<0.01
0.75%	VECs	12.6 ± 0.9	<0.01

* Calculated by direct microscopic counting of 100–200 VECs.

† By *t*-test.

(table 6). Chymotrypsin and trypsin significantly inhibited adherence between the epithelial cells and *Candida* when either VECs or *Candida* organisms were preincubated with these enzymes. Inhibition was greater after preincubation of VECs with enzyme than after preincubation of *C. albicans*. Inhibition of adherence of enzyme-treated *Candida* organisms was not due to loss of viability, as the number of viable *Candida* organisms remained constant after exposure to enzymes. Similarly, the enzymes did not affect viability of the VECs as determined by exclusion of trypan blue.

Cultures of germinated *C. albicans* were killed with ultraviolet light, and the supernatants were studied for their effect on inhibition of adherence of yeasts to epithelial cells in Williams solution. The supernatants inhibited adherence of *Candida* yeast to both BECs and VECs: after 2 hr of incubation, the mean (± SE) number of *Candida* organisms per VEC was reduced from 15.7 ± 0.7 to 11.7 ± 0.7 ($P < 0.05$), and the number of *Candida* organisms per BEC was reduced from 17.2 ± 0.9 to 12.4 ± 0.8 ($P < 0.05$).

In duplicate experiments, vaginal cells were preincubated with two vaginal isolates of *Lactobacillus* for 30 min and washed free of nonadherent bacteria. Mean (± SE) numbers of adherent lactobacilli per VEC for each of the two strains were 26.7 ± 4.4 and 22.8 ± 2.8, respectively. Coated VECs were then immediately incubated with *C. albicans* for 2 hr in Williams solution. A significant reduction in *Candida* organisms that adhered to *Lactobacillus*-coated VECs occurred with both strains of lactobacilli studied. The mean (± SE) number of *Candida* organisms adhering to uncoated VECs was 20.8 ± 1.4, whereas numbers of *Candida* organisms adhering to *Lactobacillus*-coated VECs were 14.7 ± 0.8 and 12.4 ± 0.5, respectively ($P < 0.01$ for each comparison).

Discussion

Adherence of microorganisms to epithelial cells is a critical step in colonization of mucosal surfaces and the subsequent capacity to cause disease [1–3, 8]. Studies of numerous bacterial species have revealed that pathogens that adhere to mucosal cells are better able to colonize the tissue surface and produce disease than are those that do not adhere [3, 9–12]. Results of recent in vitro studies suggest that factors inhibiting bacterial adherence might be used in vivo to prevent colonization of mucosal surfaces by pathogenic bacteria [13].

With findings similar to those of the present study with VECs, Kimura and Pearsall demonstrated the adherence of *Candida* organisms to BECs and stressed the importance of germ tubes for adherence [5]. In the present study, although adherence of *C. albicans* in the yeast form to epithelial cells occurred, conditions conducive to germ tube formation resulted in significantly

greater adherence. Thus, viability, time sufficient for germination to occur, and an incubation medium and pH conducive to germ tube formation increased the extent of adherence. Heat-killed, germinated yeast demonstrated no better adherence than heat-killed, ungerminated yeast and poorer adherence than viable, ungerminated yeast. Heating may have destroyed a surface component of the yeast cell necessary for optimal adherence. The present findings are similar to those of Diamond and Krzesicki [14] and Diamond et al. [15], who showed that killing of *C. albicans* pseudohyphae eliminated their ability to attach to neutrophils.

It is not clear why viable germ tubes enhance adherence. It has been suggested that during the transition from yeast form to filamentous forms, changes in surface components occur that could account for the increased adherence [5]. There is evidence of specific antigens present on germ tubes that are not found on yeast forms [16]. Clinical observations have correlated the presence of filamentous forms with tissue invasion, and specific germ tube-associated antigens have been exploited in the serodiagnosis of invasive candidiasis [16]. Diamond and Krzesicki [14] have suggested the presence of receptors on the neutrophil which directly recognize pseudohyphae of *Candida* but not the yeast phase. It is conceivable, but as yet speculative, that epithelial cell membranes have specific receptors for surface components of germ tubes. Observations by light microscopy in our laboratory suggest that physical factors may also be important, since the germ tubes promote clumping of yeast cells and binding of adjacent filaments, thus bringing a larger number of *Candida* organisms into contact with epithelial cells. However, the fact that adherence is poor when the germinated *Candida* organisms have subsequently been killed is evidence against the importance of physical factors.

It is of interest that *C. albicans* adherence to vaginal cells at pH 6 was considerably greater than that at pH 3–4, a range that closely corresponds to normal vaginal pH [17]. It has been a clinical observation that candida vaginitis tends to become clinically apparent during or shortly after menses, corresponding to the increase in vaginal pH that normally accompanies menstruation [18].

Regardless of the mucosal site of origin (buccal or vaginal), all of the four isolates of *C. albicans* adhered equally well to BECs or VECs. In contrast, it is of interest that Alkan et al. showed that streptococci isolated from the skin and the pharynx adhered better to the epithelial cells corresponding to their site of isolation [19].

Small but statistically significant differences were detected among the 10 healthy volunteers with regard to *C. albicans* adherence to their BECs and VECs; however, the relevance of this observation to in vivo conditions is unclear. There exists a large group of women with recurrent vaginal candida infections, the risk factors of which are not always apparent or understood; diabetes mellitus and hormonal therapy account for only a small minority. Studies of yeast adherence in this predisposed group might be useful.

Adherence is presumed to be caused by the specific interaction of fungal components with receptor substances located on the VEC surface. With use of inhibitors, some factors that affect attachment of *Candida* organisms to epithelial cells were defined. As in certain enteropathogenic bacteria [20], an adhesive substance on *C. albicans* appears to be a surface protein, sensitive to degradation by trypsin or chymotrypsin. Bacteria probably adhere to sugar residues of the glycocalyx, a group of glycoproteins formed on the epithelial cell surface. Adhesion of *Vibrio cholerae* to the epithelial cell brush border of rabbit gut is partially inhibited by either L-fucose or D-mannose but not by other sugars [20]. It is possible that the receptor on the epithelial cell for *C. albicans* is similarly a glycoprotein, being partially inhibited by the carbohydrates L-fucose and D-fucose and proteolytic enzymes. These findings are similar, although not identical, to those of Diamond and Krzesicki [14], who studied mechanisms of contact of pseudohyphae of *Candida* to neutrophils. These authors reported and characterized a protein component of killed pseudohyphae culture supernatant (mol wt, 10,000) that reduced the affinity of pseudohyphae for neutrophils, and they hypothesized as to the role of this material in the pathogenicity of fungal elements in systemic candidiasis. The supernatants of killed, germinated *Candida* organisms in the present study inhibited the attachment of viable *Candida* organisms to epithelial cells, possibly by blocking the interaction of *C. albicans* and receptors sites on the epithelial membrane. Further characterization of this material, which may be the same as that reported by Diamond and Krzesicki [14], might be useful for in vivo prevention of fungal colonization of mucosal surfaces.

The interaction of bacteria and fungi on epithelial surfaces has aroused clinical interest for some time. It has been observed that the normal resident bacterial flora suppresses fungal colonization, whereas alteration and reduction in surface bacteria, such as occur after antibiotic therapy, are associated with fungal colonization and often symptomatic disease. Saigh et al. [21], in longitudinal studies of vaginal flora, noted reduced counts of lactobacilli during and immediately after menses, during which periods vaginal candidiasis occurs with peak frequency. Savage [22], using an in vivo model, showed strong microbial interference between indigenous yeasts and lactobacilli. Lactobacilli normally are layered on the surface of the keratinized gastric epithelium, and yeasts are layered on the nonkeratinized portion of gastric epithelium. When mice are given a penicillin solution in place of drinking water, the lactobacilli disappear and are replaced by yeasts. When penicillin is discontinued, the lactobacilli displace the yeasts from the keratinized epithelium. The yeast organisms never populate the keratinized epithelium when lactobacilli are present. The results of the present studies demonstrate that when epithelial cells are coated with lactobacilli, there is significantly decreased *C. albicans* adherence. This coating effect may in part explain the protective effect of normal host flora in preventing colonization and infection with *C. albicans*.

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