Survival of Some Medically Important Fungi on Hospital Fabrics and Plastics

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Tests of the survival of *Candida* spp., *Aspergillus* spp., a *Fusarium* sp., a *Mucor* sp., and a *Paecilomyces* sp. on hospital fabrics and plastics indicated that viability was variable, with most fungi surviving at least 1 day but many living for weeks. These findings reinforce the need for appropriate disinfection and conscientious contact control precautions.

Fungal infections are an increasing risk, especially for patients who are immunocompromised by diseases or traumas or for patients immunosuppressed because of preparation for organ transplantation, treatment of cancers, or autoimmune diseases (3, 4, 5, 8, 10). As fungi become increasingly more resistant to the limited antifungal agents available, the physician's ability to control these infections with antifungals decreases (1, 4). An alternative or additional means of control is to decrease the exposure of the patient to these microorganisms, thereby preventing an infection from occurring. Limited data are available about the survival of fungi that commonly cause nosocomial infections in compromised patients on typical hospital materials(2, 9). As an initial step in determining if fabrics and plastics might serve as reservoirs or fomites for the transmission of fungi to patients, the ability of some medically important fungi to survive on common hospital materials, such as privacy curtains, towels, scrub suits, plastic splash aprons, and computer keyboard covers, was examined.

The following were tested: two isolates each of *Candida albicans*, *Candida tropicalis*, *Candida krusei*, and *Candida parapsilosis*; three isolates each of *Aspergillus flavus*, *Aspergillus fumigatus*, *Aspergillus niger*, and *Aspergillus terreus*; and one isolate each of a *Fusarium* sp., a *Mucor* sp., and a *Paecilomyces* sp. With the exception of one each of the *Aspergillus* isolates, which were isolated from environmental surfaces in our hospital, all fungal strains used were isolated from burn patients at our hospital.

All *Candida* species were grown overnight at 35°C in yeast extract-peptone-dextrose (1% yeast extract, 2% peptone, 2% dextrose; Difco Laboratories, Detroit, Mich.) broth and adjusted to 10^6 to 10^7 CFU per ml using a Klett-Summerson (New York, N.Y.) colorimeter. Molds were grown on Sabouraud dextrose (Becton Dickinson, Cockeysville, Md.) agar for 3 to 5 days depending upon the time needed for that genus and species to form spores. Spores were harvested by rinsing the plates, their concentration was determined by counting with a hemocytometer, and the spores were refrigerated overnight. The following day, enough spores were added to yeast extract-peptone-dextrose broth to give a concentration of 10^6

to 10^7 CFU/ml and then incubated until filaments began to form, a period of 6 to 17 h depending upon the particular fungi.

Fungal survival was tested on the following materials, each of which are commonly used in our hospital: 100% smooth cotton (clothing), 100% cotton terry (towels, washcloths), 60% cotton–40% polyester blends (scrub suits, lab coats, clothes), 100% polyester (privacy curtains), 25% spandex–75% nylon (pressure garments), 100% polyethylene plastic (splash aprons), and 100% polyurethane (keyboard covers).

A previously described test procedure (6, 7), modified for fungal testing, was used. Briefly, 1-cm^2 swatches of test materials were gas sterilized, aerated, and lined up in rows in a biohazard safety hood. During the entire period of any experiment, the hood fan was left on, the temperature in the hood ranged from 22 to 25°C, and the humidity ranged from 25 to 47%. A 10-μl aliquot (10^4 to 10^5 CFU) of the desired fungal preparation was inoculated onto each swatch. Immediately after inoculation and for every day thereafter, two swatches of each material were picked up with sterile forceps and placed into two separate tubes of thioglycolate medium. The tubes were incubated at 35°C for 48 h and then at room temperature for an additional 12 days; after the incubation period, they were scored for viable (cloudy) or nonviable (clear) fungi. Media from cloudy and clear tubes were plated onto Sabouraud agar to check for viability and nonviability, respectively. The length of survival for each fungus was taken as the last day that at least one of the duplicate samples showed viability. Survival was only checked for 31 days. Therefore, if a fungus was still alive on day 31, its viability was recorded as >30 days. Statistical differences between groups were determined using the Mann-Whitney rank sum test.

Survival of the 23 different fungal isolates varied, depending somewhat on the particular genus and species tested as well as on the specific material inoculated (Table 1). In general, *Aspergillus* and *Mucor* survived longer (median = 26.0 days) than *Candida*, *Fusarium*, and *Paecilomyces* (median = 5.0 days, $P < 0.001$). Within the *Candida* species, however, *C. parapsilosis* lived longer (median = 30 days) on all materials than did *C. albicans*, *C. tropicalis*, or *C. krusei* (median = 4.0 days, $P < 0.001$). There was also a tendency for the fungi to be viable longer on 100% synthetic materials (polyester, spandex, polyethylene, and polyurethane) (median = 19.5 days) than on

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TABLE 1. Survival of fungal isolates[a] on various fabrics and plastics

Microorganism	No. of isolates tested	Length of survival (no. of days) of individual isolates on:						
		Cotton	Terry	Blend	Polyester	Spandex	Polyethylene	Polyurethane
C. albicans	2	1, 3	1, 1	1, 3	1, 1	3, 4	5, 6	4, 5
C. tropicalis	2	1, 2	1, 1	3, 5	1, 8	7, 10	7, 18	6, 12
C. krusei	2	1, 1	<1, <1	2, 4	8, 8	10, 11	3, 7	4, 4
C. parapsilosis	2	9, 27	2, 9	>30, >30	27, >30	>30, >30	>30, >30	>30, >30
A. flavus	3	2, 8, >30	7, 18, 19	5, 10, >30	2, 6, 20	19, 26, >30	>30, >30, >30	8, 22, >30
A. fumigatus	3	1, 10, >30	4, 5, >30	3, 3, >30	1, 7, >30	5, >30, >30	>30, >30, >30	5, >30, >30
A. niger	3	3, 8, >30	1, 1, >30	4, 7, >30	2, 8, >30	>30, >30, >30	>30, >30, >30	2, 6, >30
A. terreus	3	2, >30, >30	1, >30, >30	2, >30, >30	2, >30, >30	18, >30, >30	>30, >30, >30	12, >30, >30
Fusarium sp.	1	10	4	10	10	10	>30	6
Mucor sp.	1	21	16	20	24	>30	21	20
Paecilomyces sp.	1	<1	<1	<1	5	11	4	11

[a] Inoculum of 10^4 to 10^5 CFU/swatch.

fabrics with some natural fiber content (cotton, terry, and blends) (median = 5.0 days, $P < 0.001$).

These data indicate that many of the fungi (*Candida*, *Aspergillus*, *Mucor*, and *Fusarium*) which are associated with nosocomial infections in patients survived for at least a day and often longer on fabrics and plastics routinely used in hospitals. While a couple of studies have presented the survival of yeasts on various surfaces, such as petri dishes (2, 9), to our knowledge this is the first survival study of *Aspergillus*, *Mucor*, *Fusarium*, and *Paecilomyces* on a variety of common hospital fabrics and plastics. Where comparisons are possible for the yeast data, our results agree with and extend what is in the literature. For example, in one study (2), an isolate of *C. parapsilosis* lived nine times longer on a petri dish than did an isolate of *C. albicans*. Essentially, on all surfaces utilized in the present study, the two isolates of *C. parapsilosis* survived longer than did the two isolates of *C. albicans*.

The length of survival of the fungi was dependent upon both the particular genus and species tested and on the specific surface upon which the fungi were inoculated. For any of the four *Candida* spp. examined, survival of the two isolates tested varied from surface to surface but was quite consistent on any one surface. However, for the *Aspergillus* spp., there was marked variation in survival from one strain to another within the same species. Blaschke-Hellmessen et al. (2), in a study of yeast resistance to dryness, found that those species of yeast that are more common in the environment, such as *Rhodotorula* spp., were more resistant to drying than yeast species that were more common on mucous membranes, such as *C. albicans*. Therefore, we examined whether the variation in survival among the *Aspergillus* fungal isolates was related to whether a particular strain was cultured from an environmental surface or from a patient. For the *Aspergillus* spp. in this study, one strain of each species tested was an environmental isolate, while the other two strains of each species were patient isolates. For each of the four *Aspergillus* species tested, the longest-lived isolate was not the environmental one but one of the patient isolates. Therefore, for these limited data (four environmental isolates and eight patient isolates of various *Aspergillus* spp.), the site of isolation did not necessarily dictate viability.

These survival results indicate the potential for various fabrics and plastics to serve as reservoirs or vectors for fungi because the fungi tested generally remained viable on these surfaces for at least a day and often for weeks. Rangel-Frausto et al. (9), in studying *C. albicans* dried onto plastic, showed that 90% of the time (in 18 of 20 tests) *C. albicans* was transferred to the hands of test volunteers, and conversely, 90% of the time *C. albicans*-contaminated hands transferred the fungi to sterile plastic lids. While similar data do not exist for other fungi, the findings that other fungi can exist for extended periods on common hospital fabrics and plastics suggest that similar transfers from contaminated materials to hands, and vice versa, are likely. These survival data indicate that in this age of increasing antifungal resistance, when treatments for patients are becoming more limited, appropriate disinfection of the environment and conscientious contact control procedures are essential for optimal control of infections in hospitals.

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