

Fungal contamination of hospital mattresses before and following cleaning and disinfection

Contaminação por fungos antes e após limpeza e desinfecção de colchões hospitalares

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Descritores

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Abstract

Objective: To verify the existence of fungal contamination prior to and following the cleaning and disinfection process of hospital mattresses used by patients with Candidemia.

Methods: Cross-sectional study analyzing 25 mattresses used by patients with Candidemia confirmed by blood culture from different hospital wards. The study made use of convenience samples. After growing the samples in an Agar Sabouraud Dextrose environment, isolated yeasts were identified by macroscopic, microscopic and physiologic characteristics.

Results: Analyses showed 15 (60%) mattresses contaminated by *Candida spp.* From these, 10 (66.7%) and five (33.3%) mattresses corresponded respectively to the collection prior to and following disinfection, with *Candida parapsilosis* being the isolated species with the highest frequency.

Conclusion: Considering that half of the mattresses remained contaminated after cleaning and disinfection, there is a risk that these mattresses may act as potential secondary reservoirs in the infection chain.

Resumo

Objetivo: Verificar se existe contaminação por fungos antes e após limpeza e desinfecção terminal de colchões hospitalares utilizados por portadores de candidemia.

Métodos: Estudo transversal que investigou 25 colchões de diferentes unidades hospitalares e utilizados por pacientes com candidemia, confirmados por hemocultura. Utilizou-se amostragem por conveniência. Após crescimento em Ágar Sabouraud Dextrose as leveduras isoladas foram identificadas pelas características macroscópicas, microscópicas e fisiológicas.

Resultados: Totalizou-se 15 (60%) colchões contaminados com *Candida spp.* Desse total, 10 (66,7%) e cinco (33,3%) corresponderam respectivamente à coleta antes e após a desinfecção dos colchões, sendo que a espécie mais frequentemente isolada foi *Candida parapsilosis*.

Conclusão: Considerando que a metade dos colchões permaneceram contaminados após o processo de limpeza e desinfecção, pode-se inferir sobre o risco destes atuarem como reservatórios secundários na cadeia de infecção.

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Introduction

Literature-based evidences show that environmental surfaces contaminated by microorganisms may contribute to the transmission of such pathogenic agents whenever they are associated with health care. Such surfaces play a significant role in cross-transmission occurrences, since they act as steady sources of contamination, including the hands of health-care professionals. Studies indicate that the presence of patients infected or colonized with Vancomycin-resistant *Enterococcus* (VRE), Methicillin-Resistant *Staphylococcus aureus* (MRSA), *Acinetobacter baumannii*, *Pseudomonas aeruginosa*, Norovirus and *Clostridium difficile* stand out as risk factors toward maintaining the colonization or infection of these patients, or the transmission to other patients. As a matter of fact, whenever cleaning and disinfection processes of surfaces have not achieved optimal results, those to be introduced into such environment will be at risk.^(1,2)

It is important to highlight that the so-called final cleaning must be applied to all physical components surrounding patients and which are directly or indirectly used to assist them. Such procedure is recommended whenever a patient is released from a bed as a result of a discharge, death, transfer, hospital stays longer than seven days, and in cases of termination of isolation processes.⁽²⁻⁵⁾

Several physical and chemical procedures may be applied for this purpose. A technical document released by the Brazilian government proposes the use of phenolic active principles, active chlorine-releasing organic/inorganic composts, quaternary ammonium or alcohol principles, or others which comply with specific legislation.⁽⁶⁾ The same document points to potassium monopersulphate as a wide-ranging disinfecting alternative for fixed surfaces, non-corrosive against metals and acting as a bactericide, fungicide and virucide 10 minutes following its application, even in the presence of organic matter. After being diluted, the solution acquires a pink staining pattern, thus indicating that the product is active; therefore, while the solution keeps a pink standard, it can be used for up to seven days.

The environment and all objects surrounding the patient get contaminated with microorganisms, including multiresistant ones.⁽⁷⁾ Among the objects surrounding the patient, the mattress is the closest to the patient's body; as such, it may become a deposit and/or source of organic dirt, as well as of microorganisms – including fungi – responsible for infections.^(4,5) Nevertheless, the studies analyzed by the present research skipped fungi-based microbiota and focused only on the identification of bacterial groups^(4-6,8-11) present on hospital mattresses, representing equally serious healthcare threats.⁽⁵⁻¹²⁾

It must be highlighted that the number of fungi-based diseases has increased in past years. In this sense, fungi-based bloodstream infections (candidemia) have been deemed to be the fourth major cause of sepsis, according to data from the Nosocomial Infection Surveillance System. The majority of these infections is said to be caused by yeast species of the *Candida* gender, thus resulting in a substantial increase in morbidity and mortality rates.⁽¹²⁾

The incidence of candidemia has enhanced throughout the last two decades in several parts of the world and in distinct healthcare environments, mainly due to an expansion in the use of aggressive therapeutic practices, such as the use of intensive chemotherapies toward treating hematologic malignancies, transplants and admittance to intensive care units (ICU); in lesser extent, there is also the application of immunosuppressors toward treating autoimmune diseases, among others, and even toward the lengthening of life, thus generating a previously nonexistent population of immunocompromised individuals.⁽¹²⁾

The high turnover of hospital beds may sometimes compromise the efficient execution of standard disinfection protocols. In this sense, a frequent microbiologic investigation process must become an assessment practice of the quality of services, aiming to detect nonconformities and enabling the correction of processes that can minimize the occurrence of hospital-based infections.

In this context, the objective of this study was to verify the existence of fungal contamination before and following the final cleaning and

disinfection of hospital mattresses used by patients with candidemia.

Methods

The present descriptive study was carried out in a general high-complexity tertiary private hospital located in the interior of São Paulo State, Southeast Brazil, following the approval of the hospital administration. Beds from different wards of the hospital, such as the General, Pediatric and Nursing Intensive Care Units, were considered as sample sources.

A convenience sample was used, including mattresses that complied with the following criteria: being used by patients with candidemia between August 2007 and October 2009; being assessed by the Hospital Infection Committee and confirmed by blood samples in an automatized system (Becton Dickinson BACTEC™ 9240); waterproof mattresses manufactured in polyurethane foam and covered with sheepskin (leather) under the following dimensions, 188x88x12 cm; and mattresses whose cleaning and disinfection had been carried out by the same hospital sanitization and cleaning team hired by the institution. From August 2007 to October 2009, 25 mattresses were part of the sample and microbiologic cultures were collected prior to and after the final cleaning/disinfection process.

Following the release of the beds, the samples were collected with the application of sterile swabs moisturized in a sterilized 0.85% saline solution. The swabs were rolled down in three areas (upper, middle, lower) in five quadrants of the surfaces in contact with patients; immediately after this process, the swabs were introduced in a flask containing a Sabouraud Dextrose solution (DIFCO™).

The beds were cleaned and disinfected using a potassium monopersulphate solution applied with a 40x30cm piece of microfiber cloth composed of 80% polyester and 20% nylon (polyamide). It is important to highlight that this microfiber may be processed and reused several times, according to the manufacturer's norms. The cleaning/disinfection

routine of the mattresses carried out by the studied hospital established that the process should be performed in a unidirectional manner, that is, from the upper part toward the lower part, including the natural drying of the pieces.

All collected materials were immediately processed in the laboratory by means of a seeding process into Agar Sabouraud Dextrose (DIFCO™) and CHROMagar™ Candida (CHROMagar, Paris, France) plates, both kept in an oven at 30° C for 96 hours. The yeasts were isolated and identified by their macroscopic, microscopic and physiologic characteristics.

Collected data were submitted to a descriptive statistical analysis by means of absolute and relative frequency calculations carried out using the Microsoft Excel® 2007 software.

Results

The distribution of clinical isolates showed that the *Candida albicans* was the prevalent species, with 12 cases (46%), followed by six (27%) *Candida parapsilosis*, four (15%) *Candida tropicalis*, two (8%) *Candida orthopsilosis* and one (4%) *Candida glabrata*.

In addition, out of the 25 analyzed mattresses, the *Candida* species grew in 15 (60.0%) of them, being 10 (66.7%) prior to and five (33.3%) following the cleaning/disinfection process. Table 1 shows that after the completion of the process, fungi were still found in mattresses from all assessed units, except for the Pediatric Intensive Care Unit.

Out of the 25 mattresses assessed before the cleaning/disinfection process, Nursing wards had the highest numbers of mattresses with fungal contamination. After the completion of the cleaning/disinfection process, a reduction in the contamination levels was observed in mattresses from all units, with a special highlight to the Pediatric Intensive Care Unit, which did not have records of any trace of fungi. Moreover, taking all units into account, it was verified that prior to the cleaning/disinfection process, 15 (60%) of the mattresses did not display any trace of *Candida non-albicans* species.

Table 1. Research per type of fungi, according to the origin of the mattresses

Wards	Positive		Negative		Total	
	Before n(%)	After n(%)	Before n(%)	After n(%)	Before n(%)	After n(%)
Nursing	7(28)	4(16)	6(24)	9(36)	13(52)	13(52)
General ICU	2(8)	1(4)	9(36)	10(40)	11(44)	11(44)
Pediatric ICU	1(4)	0(0)	0(0)	1(4)	1(4)	1(4)
Total	10(40)	5(20)	15(60)	20(80)	25(100)	25(100)

Legend: General ICU – General Intensive Care Unit; Pediatric ICU – Pediatric Intensive Care Unit

After the cleaning/disinfection process, only two mattresses showed negativity, being one from the Nursing ward (*Candida glabrata*) and one from the Pediatric Intensive Care Unit (*Candida parapsilosis*). For the mattresses originated from the other wards, the contamination status either decreased or remained the same, showing a prevalence of the *Candida parapsilosis* and *Candida guilliermondii* species, respectively.

Discussion

The limitations of the results of the present study are related to a series of factors worth being mentioned. The cross-sectional design does not allow for the establishment of causal correlations, in other words, it is not possible to affirm that the fungi observed in the mattresses are the same identified in the patients, and vice-versa; a convenience sample was considered as a model that brought about consequences to the generalization of results; the type of mattress used by patients with candidemia may have had an influence on the small sample; cleaning professionals were aware of the objective of the study, and this previous knowledge may have contributed toward a positive effect in their work behavior, causing them to be more careful in the disinfection process (Hawthorne effect); and last, it is not possible to state that all mattresses were equally disinfected, thus complying with the established routine of the assessed service, especially because more than one professional carried out such proceeding in different wards.

The results obtained in this study reflect the need for a meticulous reassessment of the disinfection process carried out in the analyzed institution. In this sense, some studies brought expressive contributions toward understanding the effectiveness of cleaning/disinfection processes of hospital mattresses, as well as their potentials as secondary deposits for epidemiologically significant microorganisms.^(5,8-10) It must be emphasized that, at times, the techniques applied to clean and disinfect mattresses are not clearly presented, or considerably veer from one another. Hence, the results of these studies, as well as those obtained in this research, point out that the procedure was not at all effective. Although not merited in the present study, the microbial quantification and maintenance of the yeast before and after cleaning/disinfection suggest that the current method is not satisfactory.

It is worth highlighting that the studies related to this issue present biases, such as the lack of descriptions of some cleaning/disinfection aspects concerning the types of cloths used; the replacement frequency for such cloths; the application method; intensity of friction and length of time products were in contact with the mattresses; dilutions of employed detergents and/or soaps, as well as their replacement; microbiological sampling protocols; sample processing; and means of used cultures.

Although the cleaning/disinfection procedure is adopted after a standardized training program, it does not seem to be clear whether the hospital sanitization and cleaning professionals' personal performance, the used product or the disinfection procedure exerted direct influence on the results,⁽¹³⁾ as the

negativity of cultures for the majority of assessed mattresses was expected following the completion of the disinfection process.

In that sense, the present research analyzed mattresses originated from distinct units, which somehow represented a heterogeneous sample of all the mattresses in the hospital. Despite not being the objective of this study, it is also relevant to understand that investments in the improvement of new techniques, as well as permanent educational investments for hospital sanitization and cleaning personnel, should be taken into account.

Moreover, before the cleaning/disinfection process, the majority of mattresses, 15 (60%), did not show any trace of *Candida non-albicans* species, which allows to infer that the cleaning/disinfection process may vary according to the environment, even when performed by trained professionals.

In this study, the cleaning process carried out in a unidirectional manner, a standard proceeding in the institution, that is, from the head toward the bottom of the bed, aimed to eliminate a larger amount of microorganisms; such event, however, was not satisfactorily observed. Conversely, one study showed that this type of protocol aimed at disinfecting mattresses showed to be less efficient in reducing the microbial count when compared with a circular motion protocol, regardless the contamination degree.⁽¹⁰⁾ In any case, it should be taken into account that contaminated hands and microfibers might favor the dispersion of fungi throughout the mattresses.

As per the etiology of the infections in the bloodstream, resulting data are consistent with those of epidemiologic studies, which point out the prevalence of *Candida albicans*, followed by *Candida non-albicans*, such as *Candida parapsilosis* and *Candida tropicalis*.⁽¹⁴⁻¹⁸⁾ Such results are similar to those found in this study, in which contamination with *Candida parapsilosis* following the cleaning/disinfection process persisted in three hospital mattresses.

In general, although the *Candida albicans* species is prevalent in candidemia cases, the hospital environment may present a broad variety of fungal species. As a matter of fact, taking all the assessed mattresses into account, *Candida parapsilosis* was

found in two mattresses both before and following cleaning/disinfection, and *Candida guilliermondii* was identified in seven and three mattresses, respectively. These data differ from those resulting from another study,⁽¹⁹⁾ in which *Trichosporon* spp. was found to be the most common species. Therefore, *Candida parapsilosis* is usually spotted in the pediatric population, whereas the incidence of the *Candida glabrata* increases as age advances.^(12,14-15,20)

The *Candida parapsilosis* species is often found on the skin, and its transmission is predominantly exogenous, mainly by the hands of healthcare professionals. Its occurrence is also highly prevalent in children and premature newborns admitted in intensive care units.^(15,21)

Several countries have reported resistance problems of yeast species originated from the previous use of wide-range antimicrobials, such as the fluconazole.^(12,20) Indeed, the extensive use of this drug has levered the rise of non-*albicans* species, an event registered here in the samples collected from the mattresses.

It is worth highlighting that the cleaning/disinfection routine of the mattresses at the referred medical institution complied with the disinfecting product manufacturer's recommendations, as follows: to sprinkle the solution over the surface or to apply a moisturized cloth on the surface of the mattress, wait for 10 minutes and dry it up, using a humid or dry cloth, or a paper towel if necessary. There is a clear and direct correlation between the adequate distribution and length of time the detergents/disinfectants were in contact to the surface, and the professional who applies the solution, toward a satisfactory result.⁽¹⁾ Hence, it is not possible to state that the permanence of the *Candida* spp. on the mattresses occurred due to the inefficacy of the disinfecting product on a soft surface.⁽⁴⁾ Therefore, despite the type of protocol used to disinfect the mattresses in the referred hospital, the real length of time of contact versus the time advocated by the manufacturer may not have been respected in each and every case.

It has been reported that the 10-minute action time may not always be feasible in the care process, particularly in intensive care units and other

units with high turnover.⁽²²⁾ Thus, a highly effective germicide that is supposed to act after 10 minutes often does not remain in the surface for over one minute due to the pressing urgency toward being used again for another care procedure.⁽²²⁾

Given such possibility, other factors contributing toward the inadequate reduction of the presence of *Candida* spp. following the mattresses' final disinfection process should not be disregarded.^(5,22) In this sense, the following characteristics should be taken into account: quality and correct use of the microfiber, according to the manufacturer's recommendation; washing and reutilization frequency of the cloths; the microfiber's folding pattern during the cleaning process, so that all clean sides of the cloth are exposed, despite the capillarity phenomenon; amount of sanitizing product used to moisturize the microfiber; intensity of strength applied to remove disinfecting product excesses, and friction strength applied on the mattress surface to disinfect it; range of the whole area to be disinfected, as well as the rinsing process of the microfiber during the cleaning and disinfection process of the surface.⁽²³⁾

In order for the microfibers to have an effective action they must be moisturized,⁽²³⁾ a fact observed by this study. Nevertheless, when taking this specific material into account, other factors may have influenced the results, as previously described.

Practices related to the rinsing, cleaning, drying and replacement processes of the cloths used to sanitize surfaces are crucial; nevertheless, evidences show that these cloths are not frequently replaced as they should be.⁽²³⁾ Such feature, without a doubt, may contribute toward the inefficacy of the cleaning and disinfection process of surfaces and may also cause cross-contamination of microorganisms.

Previous studies^(5,8-11) undertaken to assess the microbiological condition of mattresses agree with the results found in this study, as it has observed the permanence of microorganisms after the completion of the disinfection process. The persistence of the contamination levels following disinfection on the analyzed mattresses may have taken place due to the displacement of *Candida* spp. in the moment of the disinfection practice – from the upper toward the lower portion of

the mattress – in addition to other intervening factors already outlined.

The permanence of some types of *Candida* spp. in five (50%) mattresses following cleaning/disinfection should be a concern in the final cleaning process, as it is known that other patients will use the bed. The odds for the existence of some areas colonized and/or infected by fungal microorganisms on the mattresses are very high, especially when they are expected to have a prolonged survival on these surfaces.⁽²⁴⁾

Although the vast majority of *Candida* infections are likely to be originated from endogenous sources, molecular typing studies of yeasts recovered from patients, from the hands of healthcare professionals, and from environmental surfaces suggest that the latter may play a critical role in the dissemination of *Candida albicans*, *Candida glabrata* and *Candida parapsilosis*. These species acquired by patients are proven to be identical to those found on hospital room surfaces where they were originally lodged, prior to the acquisition of the infection.⁽²⁵⁾

This discussion should not disregard the insufficient attention given to the qualification of the team of sanitization and cleaning of surfaces in healthcare services, a damaging element in this process. The hospital infection control commissions should be proactively involved in the cleaning and nursing services, so that conjoint activities could be developed concerning environmental sanitization, training and team supervision protocols.⁽²²⁾

In a general perspective, the analysis of the studies related to the cleaning/disinfection processes of mattresses performed in this present study, without excluding these findings, evidences the need for carrying out new studies considering representative samples of mattresses originated from different wards, as well as the need for dealing with the previously discussed variables.

Conclusion

The present study showed the occurrence of *Candida* spp. before and following the final cleaning process of mattresses from different hospital wards used

by patients with candidemia. *Candida parapsilosis* was the most prevalent species.

The persistence of the *Candida* spp. in five (50%) mattresses after disinfection indicates that the process is flawed. It also shows that these mattresses represent cross-transmission risks of such agents toward patients and professionals, as well as the contamination of environmental surfaces.

Collaborations

Fernando FSL; Ferreira AM; Colombo TE; Rubio FG and Almeida MTG contributed to the conception of the project, data analysis and interpretation, writing of the article, relevant critical review of the intellectual content, and final approval of the version to be published.

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