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Persistence of Nosocomial Pathogens on Various Fabrics

Nozokomiyal Patojenlerin Değişik Kumaş Türleri Üzerindeki Yaşam Süreleri

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Abstract

Objective: Fabrics can become contaminated with high numbers of microorganisms that may be pathogenic to patients in a hospital setting and can play an important role in the chain of infection. The aim of this study was to investigate the survival of several clinical bacterial and fungal isolates on several fabrics commonly used in hospitals.

Materials and Methods: Bacterial and fungal survival was tested on the following materials, each of which are commonly used in our hospital: 100% smooth cotton, 60% cotton-40% polyester, 100% wool and 100% silk. One isolate each of *Candida albicans, Candida tropicalis, Candida krusei, Candida glabrata, Candida parapsilosis, Geotrichum candidum, Aspergillus fumigatus, Cryptococcus neoformans, vancomycin resistant Enterococcus faecium* (VRE, methicillin-resistant *Staphylococcus aureus* (MRSA), extended-spectrum beta-lactamase (ESBL) positive *Escherichia coli*, inducible beta-lactamase (IBL) positive *Pseudomonas aeruginosa*, IBL-positive *Acinetobacter baumannii* and *Stenotrophomonas maltophilia* were used to contaminate fabrics. The survival of these microorganisms was studied by testing the fabric swatches for microbial growth.

Results: The median survival times for all the tested bacteria and fungi were as follows: 26 days on cotton, 26.5 days on cotton-polyester, 28 days on silk, and 30 days on wool. Among the bacterial species tested, *E. faecium* had the longest survival time on cotton-polyester fabrics. For the fungal isolates, it was observed that *C. tropicalis* and *C. krusei* survived for the shortest amount of time on cotton fabrics in the present study.

Conclusion: This survival data indicate that pathogenic microorganisms can survive from days to months on commonly used hospital fabrics. These findings indicate that current recommendations for the proper disinfection or sterilization of fabrics used in hospitals should be followed to minimize cross-contamination and prevent nosocomial infections.

Key Words: Fabrics, Nosocomial infection, Nosocomial pathogens, Survival time

Özet

Amaç: Kontamine kumaşlar; bakteri, virüs, mantar gibi mikroorganizmaları bol miktarda içerir ve infeksiyon zincirinde önemli bir rol oynarlar. Bu çalışmada; klinik örneklerden izole edilen bazı bakteri ve mantar izolatlarının hastanelerde sıklıkla kullanılan çeşitli kumaş türleri üzerindeki yaşam sürelerinin araştırılması amaçlandı.

Gereç ve Yöntem: Bakteriyal ve fungal yaşam sürelerinin değerlendirilmesi için %100 yün, %100 ipek, %100 pamuk ve %60 pamuk-%40 polyester içeren kumaş türleri kullanıldı. Bu kumaş türleri; *Candida albicans, Candida tropicalis, Candida krusei, Candida glabrata, Candida parapsilosis; Geotrichum candidum, Aspergillus fumigatus, Cryptococcus neoformans,* vankomisine dirençli *Enterococcus faecium* (VRE, metisiline dirençli *S. aureus* (MRSA), genişletilmiş spektrumlu beta-laktamaz (ESBL) pozitif *Escherichia coli*, indüklenebilir beta-laktamaz (IBL) pozitif *Pseudomonas aeruginosa*, IBL-pozitif *Acinetobacter baumannii* ve *Stenotrophomonas maltophilia* suşları ile kontamine edildi. Çalışmaya alınan mikroorganizmaların test edilen kumaş türleri üzerindeki yaşam süreleri bakteriyolojik ve mikolojik kültür yöntemleri ile saptandı.

Bulgular: Test edilen tüm mikroorganizmaların ortalama yaşam süreleri; pamuk kumaşlar üzerinde 26, pamuk-polyester türü kumaşlarda 26.5, ipeklerde 28, yün kumaşlarda ise 30 gün olarak tespit edildi. Test edilen bakteriler arasında, *E. faecium* en uzun yaşam süresine sahip olup, pamuk-polyester türü kumaş üzerinde üredi. Mantarlar arasında ise; *C. tropicalis* ve *C. krusei* en kısa yaşam süresine sahipti ve pamuk türü kumaşlar üzerinde yaşadığı gözlendi.

Sonuç: Bu sonuçlar, patojen mikroorganizmaların hastanelerde sıklıkla kullanılan kumaş türleri üzerinde günler, aylar gibi uzun süreler boyunca canlılıklarını devam ettirdiklerini göstermektedir. Dolayısıyla bu çalışma; çapraz kontaminasyonu en aza indirmek ve hastane infeksiyonlarını önlemek için, hastanelerde kullanılan kumaş malzemelerin temizliği, dezenfeksiyonu veya sterilizasyonu için güncel önerilerin uygulanması gerekliliğini vurgulamaktadır.

Anahtar Kelimeler: Kumaş türleri, Hastane infeksiyonu, Nozokomiyal patojenler, Yaşam süresi

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Introduction

The most common nosocomial pathogens may be well equipped to survive or persist on surfaces; thus, the environment can play a marked role in nosocomial transmission of microorganisms. Contaminated textiles and fabrics are an excellent substrate for bacterial and fungal growth under the appropriate moisture and temperature conditions [1, 2]. When fabrics are heavily contaminated with potentially infectious agents, they can contain bacterial loads of 10^6-10^8 Colony Forming Unit (CFU)/100 cm^2. In a clinical setting, these pathogens can contaminate patients and personnel as well as the direct and indirect environment [3, 4].

The environment and the fabrics play a key role in the nosocomial transmission of Gram-positive pathogens, such as methicillin-resistant *Staphylococcus aureus* (MRSA) or vancomycin-resistant enterococci (VRE, that cause serious and potentially life threatening infections [5, 6]. Multidrug-resistant (MDR) *Acinetobacter baumannii*, *Pseudomonas aeruginosa* and *Escherichia coli* have become progressively more common in hospitalized patients, resulting in significant morbidity and mortality. These pathogens can even survive in containers that store the disinfectants used to prevent bacterial growth [7]. Fungal infections are an increasing risk, especially for immunocompromised patients. Endogenous infections of fungi can occur, but transmission through hands and other vehicles is also common [8].

The hospital environment harbors many pathogens that are capable of causing nosocomial infections in patients, and the fabrics utilized in this setting play an undeniable role in the chain of infection. Therefore, the purpose of this study was to analyze the persistence of pathogens on fabrics that are commonly used in hospitals.

Materials and Methods

Bacterial and fungal strains

All bacterial and fungal strains used in this study were isolated from patients at our hospital. One isolate each of *Candida albicans*, *Candida tropicalis*, *Candida krusei*, *Candida glabrata* and *Candida parapsilosis*; *Geotrichum candidum*, *Aspergillus fumigatus* and *Cryptococcus neoformans* was used for analyzing the survival times of fungi on the fabrics. The bacterial isolates included: VRE, MRSA, extended-spectrum beta-lactamase (ESBL) positive *E. coli*, inducible beta-lactamase (IBL) positive *Pseudomonas aeruginosa*, IBL-positive *Acinetobacter baumannii* and *Stenotrophomonas maltophilia*. Antimicrobial susceptibility tests were performed using the Kirby-Bauer disk-diffusion method according to CLSI recommendations [9].

Test materials

Bacterial and fungal survival were tested on the following materials, each of which are commonly used in our hospital: 100% smooth cotton, 60% cotton-40% polyester, 100% wool and 100% silk. Test fabrics were washed at 90°C with pure water and dried. One hundred and eighty swatches (≈ 1 cm^2) for each of the four different fabrics were prepared. Swatches of fabric were gas sterilized, properly aerated and lined in rows in a biohazard safety hood [5, 6, 8].

Survival tests

The bacterial isolates were grown on nutrient agar, and colonies were emulsified in sterile saline to match a 1.0 McFarland standard. The four materials were placed in a quadrant of a petri dish and tested with a single microorganism. Forty-five series were prepared for every bacterium in this manner. All experiments were prepared and left in a biohazard safety hood. During the three-month study period, the hood fan was left on, the temperature ranged from 21 to 24°C, and the humidity ranged from 30 to 49%. Using a micropipette, swatches were inoculated with 10-µl aliquots of a desired concentration of each microorganism. Every other day after the inoculation, a single swatch of each material was picked up with sterile forceps and placed onto trypticase soy agar with 5% sheep blood (TSA II) plates and incubated at 37°C for 48 h, and then scored for the presence or absence of viable bacteria. Typically, once one swatch showed no viable bacteria, the next swatch for that sample also showed no growth. However, there were occasions when a swatch taken on one day showed no growth, but the next swatch taken showed viable bacteria. Therefore, we required that two consecutive swatches be negative before we considered the bacteria to be no longer viable [5, 6].

For fungal testing, ten swatches of each fabric were prepared per isolate. The temperature in the biohazard safety hood ranged from 22 to 25°C, and the humidity ranged from 25 to 47%. After fungal inoculation of swatches, one of each material was picked up with sterile forceps and placed onto Sabouraud agar every third day. The plates were first incubated at 35°C for 48 h and then at room temperature. After the incubation period, the plates were scored for viable fungi. Survival was monitored for 31 days. Therefore, if a fungus was still alive on day 31, its viability was recorded as >30 days [8].

Results

Among the bacteria tested, *E. faecium* had the longest survival time on cotton-polyester fabrics. *S. maltophilia* had the shortest survival time on all of the tested fabrics. Among the fungal isolates tested, it was observed that *C. tropicalis* and *C. krusei* had the shortest survival time on cotton fabrics.

bacteria and fungus able to survive for long time on surfaces/ fabrics- which fabric works best and why>

even though technically article for humans- similar type of pathogens

fungus and bacteria- taken from current hospital patients- allows better application

is it possible that similar strains of bacteria and fungus are prevalent in both human and horse/ animal?

The survival periods of bacteria and fungi on the tested fabrics are displayed in Table 1. The median survival periods for all of the tested bacteria and fungi were 26 days on cotton, 26.5 days on cotton-polyester, 28 days on silk and 30 days on wool.

Discussion

The survival of pathogenic microorganisms on fabrics found in the healthcare environment is becoming an important issue in the fight against healthcare-acquired infections. A critical factor for the transmission of microorganisms from person to person or from the environment to a healthcare provider or patient is the ability of the pathogen to survive on environmental surfaces [10]. Treakle et al. [11] determined that a large proportion of healthcare workers' coats were contaminated with *S. aureus,* including MRSA. Boyce et al. [12] demonstrated that 42% of nurses contaminated their gloves with MRSA while performing activities that required no direct patient contact but involved touching objects in the rooms of MRSA patients.

VRE remains an important cause of nosocomial infections. VRE is associated with high morbidity and mortality and increases in the cost and length of hospitalization. These pathogens are also capable of surviving on contaminated environmental surfaces for prolonged time periods. They have been cultured from various hospital environments, including fingertip cultures, gloved hands, stethoscopes, bedrails, telephones, thermometers, laboratory bench tops and upholstery [13]. Malnick et al. [14] sampled pajamas and bed sheets before and after overnight usage by 18 patients in an Israeli hospital. In their study, the area swabbed corresponded to the surfaces in contact with the patient's back, and *E. faecalis* was isolated from the pajamas and bed sheets of 9 patients. A number of studies have documented that these pathogens can persist for longer than seven days on fabric chairs and from a few days to more than three months on cloth and plastic surfaces [1, 5, 15, 16]. Likewise, we found that the survival VR *E. faecium* varied from 49 to 51 days on several fabrics.

Table 1. Survival of bacterial and fungal isolates on various fabrics

Microorganism	Length of survival (no. of days) of individual isolates on			
	Cotton	Cotton-Polyester	Wool	Silk
E. faecium	49	51	49	49
S. aureus	37	37	41	37
E. coli	45	37	45	45
P. aeruginosa	13	23	33	33
A. baumannii	19	19	7	19
S. maltophilia	7	7	7	7
C. albicans	6	6	12	12
C. tropicalis	3	9	>30	24
C. krusei	3	6	>30	21
C. glabrata	>30	>30	>30	>30
C. parapsilosis	>30	>30	>30	>30
G. candidum	21	6	12	6
A. fumigatus	>30	>30	>30	27
C. neoformans	>30	>30	>30	>30

The frequency of MRSA infections continues to increase in hospital-associated settings, and more recently, in community settings globally. Inanimate surfaces near affected patients including stethoscopes, floors, linens, air vents, charts, tourniquets, furniture, hydrotherapy tubs, bed sheets, and dry mops commonly become contaminated with MRSA, and these are important paths of transmission [4, 13]. Numerous studies have demonstrated that white coats and uniforms worn by healthcare providers were frequently contaminated with bacteria, including both methicillin-sensitive and -resistant *S. aureus* and other pathogens [17-19]. For example, Wong et al. [20] noted that MRSA strains were isolated in 29 of 100 white coats worn by doctors. Neely et al. [5] demonstrated that methicillin-sensitive and -resistant staphylococci could survive for up to 90 days on various types of scrub suits. Takashima et al. [21] suggested that polyester, acrylic, or wool clothes could be good carriers of *S. aureus*. Similarly, in our study, MRSA survived on wool longer than on other fabrics.

E. coli, P. aeruginosa, A. baumannii and *S. maltophilia* are commonly observed in hospitalized patients [22]. Neely et al. [6] investigated the survival periods of several Gram-negative bacteria on the surfaces of various textiles and plastics and found that bacteria survived from less than 1 hour to 8 days when an inoculum of 10^2 was utilized. At 10^4 to 10^5 bacteria, survival ranged from 2 hours to more than 60 days. In our study, using inocula of 10^4-10^5 colony-forming units, the longest median survival time was found for *E. coli* among the Gram-negative bacteria tested.

Invasive fungal infections are increasing in healthcare settings, especially for immunocompromised patients. The predominant nosocomial fungal pathogens include: *Candida* sp., *Aspergillus* sp., *Mucorales*, *Fusarium sp*., and other molds, including *Scedosporium* sp. *C. neoformans* is a systemic mycosis and is predominantly an opportunistic infection observed in cellular immunodeficiency conditions [23]. In their study, Traoré et al. [24] demonstrated that *C. albicans* and *C. parapsilosis* could survive for at least 14 days on 100% cotton and a blend of 50% cotton-50% polyester. However, we found that

some kind of cotton- best way to go for antibacterial

if can spread this easily in hospital- how easy can spread in non sterile environment like barn

is VRE faecium more of a human bacteria or could it also be in horses

wool= longest definitely not want to make out of wool

some type of cotton is definitely important component- does it have something to do with structure of fibers?

the survival time for *C. albicans* was 7 days on both types of fabric, and *C. parapsilosis* survived > 30 days. The study results of Neely et al. [8] were similar to those of our study: *Candida* species lived for a shorter period of time on the fabrics than did *Aspergillus* species.

which kind of fungus is more prevalent in horses?

These survival data indicate that pathogenic microorganisms can survive for days to months on commonly used hospital fabrics. This extended survival emphasizes the need for meticulous control procedures for fabrics used in hospital environments and careful disinfection to limit the spread of these pathogens.

would more sterile treatment of saddle pads help with fungus and bacterial growth?

Conflict of interest statement: The authors declare that they have no conflict of interest to the publication of this article.

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