Survival of Microorganisms on Hospital Fabrics and Methods of Treatments (Review)

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ABSTRACT

Medical fabrics have been used widely in health care units as well as in other sectors such as hotels restaurants and food industries. The hospital fabrics are considered as the host for bacteria and fungi, which they remain surviving on surface of fabrics for several weeks. This paper cites a review of the literature published on survival of microorganisms on hospital fabrics and methods of treatments applied to inhibit the reproduction of the microorganisms. The review shows that the times of persistence of microorganisms on fabrics were depending on type of microorganism, fabric and method of treatment.

INTRODUCTION

Fabrics treated with antibacterial agents gained popularity as field of medical textile and new promising area of researches. These fabrics are used as protective clothing in medical care centers, hotels, restaurants and food industries sectors. The synthetic as well as natural antibacterial agents were used for the fabrics treatment. It has been found that cotton fabrics treated with chitosan and fluoropolyemers exhibit durable antimicrobial activity after laundering (Chung *et al*, 1998). Several other studies

confirmed the effect of chitosan as an antibacterial-finishing agent (Zhou *et al*, 1995, Kim *et al*,1998 and Lee *et al*,1999). Since the beginning of human civilization, people have used plants as medicine. Perhaps as early as Neanderthal man, plants were believed to have healing power. The earliest uses are found in Babylonian circa 1770 BC in the code of Hammurabi and in Egypt circa 1550 BC. (Anna, 1993). Acacia is a large genus comprising more than 1000 species belonging to the family Leguminacae, subfamily Mimosoideae, they are distributed in the warm and drier regions of the world mainly in the tropics and subtropics and are more prevalent in Australia and Africa (Internet,2004).

There are hundreds if not thousands of opportunistic bacteria in our lives on a daily basis. In most we are able to prevent or reduce our exposures to them by several methods, however in a hospital/healthcare setting this is critical. *Legilionella spp*, *Nocardia asteroides*, *Streptococcus pneumonia and Haemophilus influenza* are major concern in the healthcare arena (Burce, 2003). The garments of health care workers are important aspects of the environment that can easy become contaminated. A recent study reported that 65% of nurses who had performed patient care activities on patient with Methicillin Resistant *Staphylococcus aureus* (MRSA) in wound or urine contaminated their nursing uniforms or grows with MRSA. (Alice and Matthew,2000).The fabrics type is an important factor in influencing the duration of bacteria persistence in and on textile. McNeil and Greenstein (1961) pointed out that the physical characteristics of the fibres themselves and, probably, surface electric charges on both the fibre and bacteria cell may be important in influencing the attachments of bacteria to the fabrics surface. (Lee *et al*,1968).

LITERATURE REVIEW

Survival of Bacteria on Fabrics:

Humans are surrounded by a number of microorganisms, most of which are completely harmless and some of which are beneficial and even necessary for our existence. At times, however, our interaction with microbes can lead to an infection. In order for an infection to occur, the microorganism or its products must come in contact with host. Contact can happen in a number of different ways. The microbe might directly contact the host, or it might contact the host via an indirect route involving inanimate objects (Alice and Matthew, 2002).

Few studies have examined the viability of gram –positive bacteria on fabrics and they have tested the survival of staphylococci primary on cotton, however, there are many other garment materials and fabrics, especially synthetics and cotton-synthetic blend, which are used more often than cotton in hospitals today. Also with increasing concerns about Vancomycin-Resistant Enterococci (VRE) survival on fabrics must be considered (Alice and Matthew, 2000). Studies have shown that approximately 25% of the white coats worn by health care workers carry *Staphycoccus aureus*, including methicillin resistant strains of the organism (Treakle *et al*, 2009 and Wong *et al*, 1991). The transfer of gram-positive bacteria, particularly Multi – Resistant - *Staphylococcus aureus* (MRSA) and vancomycin-resistant enterococci (VRE), among patients is a growing concern. One critical aspect of bacterial transfer is the ability of the microorganism to survive on various common hospital surfaces (Alice and Matthew, 2000). The exposure to pathogens on contaminated garments, bed linen and other type of fabrics may occur either by direct contact or indirectly through airbome particles, thus fabrics have been mainly incriminated albeit rarely, in outbreaks of nosocomial -

infection (Sattar *et al*, 2001).The danger of acquiring an infection from contact with contaminated materials in the environment would seem to depend, at least in part, on the length of time that pathogens (or potential pathogens), such as the gram-negative bacteria, remain viable. The study demonstrates that that *Salmonella typhimurium* can remain viable and infectious on different types of fabrics for relatively long periods of time, thus, contaminated fabrics may be a potential environmental source of infection (Lee *et al*, 1968).The fabric type is an important factor influencing the duration of bacterial persistence in and on textile. McNeil and Greenstein (1961) pointed out that the physical characteristics of the fibres themselves and probably, surface electrical charges on both the fibre and bacterial cell may be important in influencing the attachment of bacteria to the fabric surface. In addition, such factors as fabrics construction (type of yarn and tightness of weave), the textile processing of the fabrics and the moisture content of the fabrics influence the viability of bacteria found in and on textile. It is known that polyester and acrylic fibres bind Gram - negative and Gram positive organisms at ratios exceeding 80%, where cotton fibres bind these organisms at ratios less than 10%. Synthetic textiles have been shown to collect more bacterial mass than cellulose based textiles (Teufel *et al*, 2009). It has also been shown that while cellulose based textiles are more colonized by bacteria normally found in human sweat, such as member of propionibacteria, Corynebacteria, Staphylococcus and Streptococcus, while synthetic textiles are frequently colonized by Genera that are not found in human sweat (Teufel *et al*, 2009, Takashima *et al*, 2004 and McNiel and Greenstein, 1961). The methods of exposure used to contaminate the fabric influence the persistence time of *S .typhimurium*. The study conducted by (Lee *et al*, 1968) found that, the persistence time of *S. typhimurium* on fabrics held in 35% relative humidity was substantially longer when the fabrics were contaminated by direct or by exposure to dust containing bacteria

than when contaminated by exposure to aerosolized culture. Thus contaminated fabrics may be a potential environmental source of infection (Lee *et al*, 1968).

Supporting data:

Numerous studies demonstrated that the skin of patients and inanimate surfaces in their environment are contaminated with pathogens (Tables 1, 2, 3).

Table 1**.** Effect of inoculums size on survival of CNS on fabrics and plastic

Isolate	Inoculums (cfu)	Survival (no. of days) on:				
		Cotton	Terry	Blend	Polyester	Polyethylene
1	9×10^2	5	11	9	6	16
1	9×10^4	16	21	6	10	41
2	6×10^2	6	6	<1	9	6
2	1×10^5	21	27	7	16	51

Source: Neely *et al.* (2001).

Table 2**.** Survival of staphylococci and enterococci on fabrics and plastic[a]

Microorganism	No. of isolates tested	Resistance characteristic[b]	Survival (no. of days) of individual isolates on:				
			Cotton	Terry	Blend	Polyester	Polyethylene

CNS	3	MS	8, 16, 21	6, 21, 27	6, 6, 7	7, 10, 16	41, 51, 74
CNS	3	MR	14, 18, 20	14, 15, 16	20, 22, 28	16, 20, 22	47, >90, >90
S. aureus	3	MS	4, 5, 19	9, 9, 24	1, 9, 21	10, 12, 56	22, 48, >90
S. aureus	3	MR	4, 5, 21	2, 6, 14	1, 3, 3	1, 16, 40	40, 48, >51
E. faecalis	2	VS	11, 33	21, 29	19, 29	>90, >90	>90, >90
E. faecalis	2[c]	VR	18, 22	20, 22	18, 22	73, >80	>80, >80
E faecium	2	VS	22, >90	33, >90	29, >90	43, >90	68, >90
E. faecium	2[c]	VR	62, >90	>80, >90	52, >90	>80, >90	>80, >90
E. gallinarum	1[d]	VR	28	34	34	>90	>90
E. casseliflavus	1[d]	VR	15	28	15	>90	>90

[a] Mean inoculum (± standard deviation) of 4.1 (±4.4) × 10^5 CFU.

[b] Abbreviations: MS, methicillin sensitive; MR, methicillin resistant; VS, vancomycin sensitive; VR, vancomycin resistant.

[c] One *vanA* isolate and one *vanB* isolate.

[d] One *vanC* isolate.

Source: Neely *et al.* (2001).

Table 3: Contamination of healthcare worker clothing with various pathogens

Source	clothing	Microorganism	Number tested	% Positive

Ditchburn(2006)	Ties	S.aureus	40	20
Nurkin (2005)	Ties	S.aureus Gram-negative rod Aspergillus	42 42 42	29 12 2
Perry (2001)	Nurse uniform	MRSA VRE	57 57	14 38
Wong (1991)	White coats	S.aureus	100	29
Loh (2000)	White coats	S.aureus Acinetobacter	100 100	5 7
Osawa (2003)	White coats	MRSA	14	79
Treakle (2008)	White coats	S.aureus	149	23

Source: Neely *et al.* (2001).

Fabrics Treated with Antimicrobial Agents:

Textile and fibrous material are subjected to various finishing techniques to afford protection for the user of textile materials against bacteria, yeasts, fungi and other related micro-organisms for aesthetic, hygienic or medical purposes. Also they afford protection of textile itself from bio-deterioration due to mould, and mildew (Lee *et al*, 1968).

The term antimicrobial refers to a broad range of technologies that can provide varying degrees of protection for textile products against microorganisms'. Antimicrobials are very different in their chemical nature, mode of action, impact on people and the environment. Generally speaking microbes fall into three categories, bacteria, fungi and algae, although only the first two are generally applicable to textiles. Table (4) outlines the main differences of these microbes and the problems they can causes in textile.

Table 4: Effects of different microbes on textiles

Microbe Type	Description	Causes	Treated With
Bacteria	Simple structure/ fast Growing in warm and Wet condition	Unpleasant colours (e.g.E.coli)	Antibacterial agent
Fungal (moulds & mildews	Complex structure/slow growing	Staining and loss of performance skin infections(e.g.Candida,Athlete's Foot)	Antimycotic agent

Source: Internet (2004).

Bacteria and fungi can cause deterioration in a range of textiles including sports textiles, leading loss of performance and ageing, as well as unsightly staining, unpleasant odors and potential skin infections causes by fungal growth.

A recent results of News poll showed that three out of four Americans are conscious of germs in their daily lives. This poll indicates that 61 percent of the women surveyed make an extra effort to buy antibacterial or antimicrobial products (Internet, 2004). Understanding microorganism, what they are, where they come from and why they grow on certain materials provides us a basis for controlling them and their negative effects. This control capability with the right technology can provide for a valuable feature on a wide range of textile. There are hundreds and may be thousands of chemistries on the earth that kill microorganisms. Many of these ,like arsenic, lead, tin, mercury, silver, plant extracts, and animals extracts are natural but can also be highly toxic to people and the environment in most uses. An effective antimicrobial for textile industry can't just kill

or repel microorganisms. It must do so safely, over the life of the treated products and without negatively affecting the other important characteristics of the textile (Curtis, 2005). The bound unconventional antimicrobial technology, an organ functional silane, has a mode of action that relies on the technology remaining affixed to the substrate – killing microorganisms as they contact the surface to which it is applied. Effective levels of this technology do not leach or diminish over time. The technology actually polymerizes with the substrate making the surface antimicrobial. This type of antimicrobial technology is used in textiles that are likely to have human contact or where durability is of value. Bacterial reduction is evaluated using the modified Quinn method. *Escherichia coli* is effectively inhibited at 0.3g/l chitosan solution and the hay bacillus at 0.5g/l. Glutaric dialdeyhyed used to bond chitosan to fabrics chemically, cotton fabrics treated with glutaric dialdehyed and chitosan show a good ability to inhibit bacteria reproduction (Zhang *et al,* 2003). The North Carolina State University joined forces with textile scientist from Egypt to create textile that have permanent antimicrobial properties. Using atmospheric plasma and glycidyl methacrylate (GMA), a chemical catalyst, to open the molecular bonds of fibres the research team has been able successfully attach antimicrobial agents to the molecular structure of fibres creating a permanent bond between the fibres and the agent so that washing and wearing do not reduce the efficiency.Theantimicrobial compound of (3-trime thoxy -silypropyld- imethyloctadecyl ammonium chloride) imparts a durable antimicrobial finish to textiles. This finish protects the fabric against bacteria and fungi, which cause textile deterioration (Lamama and Mallette, 1965). A recent study investigated the effect of the extracts of Mesquite leaves on cotton fabrics, showed that the number of cells of the Gram positive bacterium, *Staph aureus* decreased continuously with the incubation time (Fig.1) and they persisted for only 12days in the cotton fabrics impregnated with Mesquite leaf extracts (Fig.1). On

the other hand cells of the Gram negative bacterium *E . coli* (Fig. 2) were more affected and able to persist for 10 days on fabrics impregnated with Mesquite extracts (Idris and Abdelrahim, 2007).The pure cotton fabric treated with the solution containing 5gpl aloe gel showed excellent antimicrobial activity. The treated sample showed high reduction rate in the number of colonies grown and a clear zone of bacteria inhibition (Jothi, 2009). A recent study examines techniques that might improve cotton textiles by impregnating them with potentially antimicrobial chemical such as chitosans and chit oligosaccharides (Fernandes *et al*, 2010). Studies in Japan have shown the use of garments impregnated with the existing antimicrobial, degenite, by health care workers significantly reduced the number of febrile days experienced by their patients (Sato *et al*, 1993).

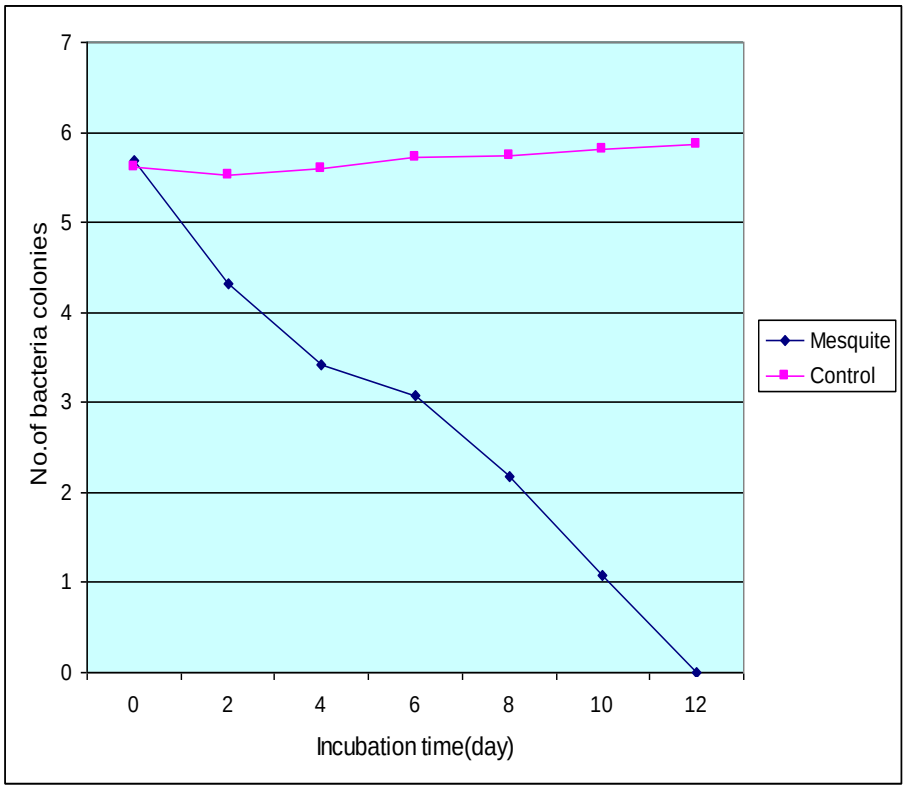

Fig.1: Survival of Staph. Aureus on cotton fabrics treated with Mesquite extract

Source: Idris and Abdel-Rahim (2010).

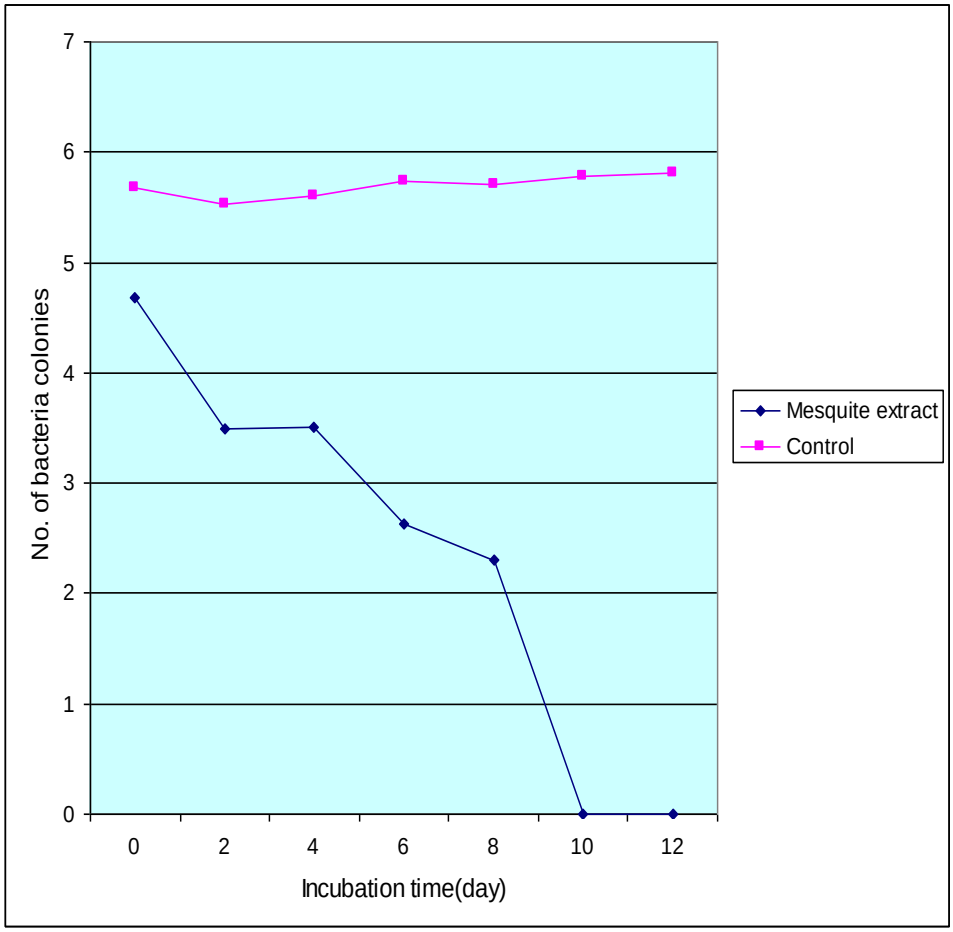

Fig.2: Survival of *E.coli* on cotton fabrics treated with Mesquite extract

Source: Idris and Abdel-Rahim (2010).

CONCLUSION

Fabrics used in hospitals were considered as source of infection. Some of the microorganisms can remain active on the surface of these fabrics for several weeks. These

fabrics were subjected to finish treatment in order to reduce inhibition of bacteria and fungi. Both natural and synthetic agents were applied. The recent studies showed that, the treated fabrics showed a reduction in the rate of colonies growth and persistence time of microorganisms was also decreased. For further improvement intensive research is required for minimizing the time of persistence and to reduce the transmission of infection from fabrics to patient and vice versa.

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الملخص

تستخدم المنسوجات الطبية في وحدات العناية الطبية علاوة علي استخدامها في الفنادق والمطاعم والصناعات الغذائية. تعتبر المنسوجات الطبية عائل للبكتيريا والفطريات و تستطيع هذه الاحياء الدقيقة ان تعيش علي سطح المنسوجات ولعدة اسابيع. الغرض من هذه الورقة استعراض نتائج الابحاث التي تحدثت عن فترة حياة الكائنات الدقيقة في المنسوجات وطرق محاربتها للتقليل من تكاثرها. واظهر الاستعراض ان الزمن الذي تستغرقه تلك الكائنات الدقيقة علي المنسوجات يعتمد علي نوع الكائنات والمنسوجات وطريقة المعالجة.