Silver Embedded Textiles A Novel Barrier to Infectious Diseases

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Author:
Andrew Duong
andrew@infectintips.org

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Abstract

Silver is regularly employed as an antimicrobial agent in a number of materials. In hospitals, fabric surfaces can be reservoirs for dangerous pathogens. Although regularly cleaning these fabrics would be ideal, it is often not feasible for the already overworked staff. Silver coatings were introduced to assist in reducing the presence of pathogens. In this evaluation, a novel silver-embedded fabric was tested for its bactericidal activity. It was found that the silver-embedded fabric sample decreased the microbial load by over 99.9% following a 24-hour exposure. The use of silver embedded fabrics provides a distinct advantage over untreated textiles.

Introduction

In a hospital, textiles represent a consistent, but unavoidable reservoir of microorganisms. Used in bedding, clothing, and as protective covers (among others), patients and healthcare workers are in constant contact with these fabrics. Fabrics are typically used for draping between patient areas and on furniture in hospitals. These areas are especially prone to harbouring dangerous pathogens (Noskin et al, 2000). Increasingly, antimicrobial resistant microorganisms are being identified in these fabrics.

Silver has been in use in fabrics for nearly 30 years (Deitch et al, 1987). The antimicrobial properties of silver are well known, and are lauded for their relative non-toxicity. Typically, silver coatings are applied to fabrics to reduce to eliminate the presence of harmful pathogens (Kleuh et al, 2000). Like many antimicrobial coatings, their antimicrobial effectiveness is optimized with regular cleaning. For most fabrics, this requires laundering at high temperatures. One potential negative outcome of this is that the coating may be worn away with repeated cleaning (Perera et al, 2013).

An alternative to silver coated fabrics is the use of fabrics where silver is embedded to form a polymer with each of the fibres making up the fabric (BioShield, Clinical Fabric Solutions). The fibres are embedded with silver during the manufacturing process, increasing retention of silver, even after repeated laundering. In this evaluation, the antimicrobial properties of a silver-embedded fabric are examined.

Methods

To evaluate the antimicrobial activity of the fabric, small samples squares (weighing 0.4g ± 0.05g) of both normal denim and silver-embedded denim (BioShield, Clinical Fabric Solutions) were inoculated with 4.43×105 colony forming units (CFU) of Escherichia coli (ATCC 25922) suspended in 10 ml of 0.2% TSB +0.05% Triton X-100. After 24 hours incubation at 37˚C, the samples were neutralized by adding 10 ml of Dey/Engley Neutralizing Broth (1x) directly to the sample. Samples are vortexed vigorously for one minute to effectively dislodge all microorganisms. Samples are serially diluted in 1:10 intervals, and plated on tryptic soy agar to isolate between 25-250 colonies per plate. Tryptic soy agar plates were incubated overnight at 37˚C, and plated. As an additional control, a sample of the inoculum was incubated and treated in parallel without the fabric samples to control for any effect that the normal denim may have on the assay.

Results

Following 24h incubation of the culture without any additional fabric added, the sample continued to grow, reaching a total microbial load of 1.95×106 CFU. In the non-treated sample, there was a modest increase in the microbial load, increasing from 4.43×105 CFU to 6.35×105 CFU (Table 1). In the treated samples, the average microbial load was reduced to 2.49×102 CFU (~3.48 log reduction).

Table 1: Microbial load following 24 h incubation with fabric sample

Sample	Starting Inoculum	Number of Microorganisms Recovered	Logarithmic Reduction
Control	4.43×10^5 CFU	1.95×10^6 CFU	N/A
Untreated Denim	4.43×10^5 CFU	6.35×10^5 CFU	N/A
Ag^{2+} Denim (#1)	4.43×10^5 CFU	4.90×10^1 CFU	3.96
Ag^{2+} Denim (#2)	4.43×10^5 CFU	4.50×10^2 CFU	2.99

Discussion

Fabric and other textiles are employed in a variety of environments and can harbour pathogens. Especially prevalent in healthcare environments such as hospitals and nursing homes, cleaning of these textiles is critical for limiting the spread of pathogens. In this evaluation, the use of silver-embedded denim resulted in a 99.95% reduction in bacterial load (3.48-fold log reduction) following a 24 hour incubation in nutrient broth. In contrast, there was no reduction in CFU with using traditional denim. This suggests that silver-embedded textiles can be a beneficial alternative to traditional textiles in hospitals and other public areas prone to transfer of infectious diseases.

Both control samples (without added fabric and with untreated denim) demonstrated an increase in the number of CFU. Within the 24-h period, there was a 4.4-fold increase the number of E. coli, whereas the untreated denim showed a 1.4-fold increase. Although the presence of denim did not have any antimicrobial effect, it is possible that the untreated denim may have limited bacteriostatic antimicrobial activity. Denim has not been previously identified as a material with antimicrobial properties (Chun et al., 2009).

The silver-embedded textiles showed a remarkable reduction in microbial load following a 24-h incubation. The nearly 3.5-fold log reduction represents >99.9% reduction of E. coli in the sample. This suggests that similar to other silver-based technologies, silver in the denim has bactericidal effects (Agnihotri et al., 2013; Schwartz et al., 2014). However, further testing to evaluate its effectiveness in a clinical environment should be performed to determine if these results can be directly translated.

There is a unique advantage in the use of silver-embedded textiles compared to silver-coated textiles. After repeated washes, silver nanoparticles and the coating are released in miniscule amounts (Perera et al., 2013; Lombi et al., 2014). The antimicrobial efficacy of these fabrics following repeated washes has not been evaluated based on our literature search. It has been hypothesized that repeated washes will reduce its antimicrobial properties. However, this hypothesis is currently not substantiated.

One limitation of this experiment is the lack of silver-coated fabrics as a control. Evaluation of silver-embedded fabrics in parallel with silver-coated fabrics would show if one is more appropriate for use in healthcare systems than the other. In addition, testing of the materials after repeated washes could provide insight into the cost-effectiveness of one textile over another.

Conclusion

Silver-embedded denim is highly effective in reducing the number of bacteria after a 24-h period. The bactericidal properties of the silver eliminated over 99.9% of the bacteria, suggesting a potential clinical use of silver-embedded denim. Additional testing is required to evaluate if these findings can be translated to clinical use. These preliminary results suggest that this technology has the potential to greatly reduce bioburden populations in textiles and improve patient outcomes following hospital stays.

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