

Persistent bactericidal action by a silver disinfectant on surfaces of hospital furniture

Sonia De Lorenzi¹, Italo Barrai¹, Gianfranco Finzi², Paola Cugini², Germano Salvatorelli¹

¹ Dept. of Life Sciences and Biotechnology – Section of Comparative Anatomy, University of Ferrara, Italy

² Hospital Management, Policlinico S. Orsola Malpighi, Bologna, Ital

Corresponding Author: Germano Salvatorelli

Dipartimento di Scienze della Vita e Biotechnologie – Sez. Anatomia Comparata

Via Luigi Borsari 46

44100 Ferrara Italy

e-mail: svg@unife.it

Phone: 0039532-455709

Fax: 00393532-455715

ABSTRACT

Aims: Recent studies have shown that not only do disinfectants containing silver present an immediate effect, reducing the surface bacterial load, but that this action also appears persistent in time.

This work assesses the bactericidal activity of a long-lasting disinfectant complex composed of silicon oxide, silver ions and a cationic surfactant (BACTERCLINE ENERGY BLAST) applied on the surfaces of two surgery ward rooms and left in place for different amounts of time (15 min and 72 hours).

Study Design: An experimental study

Place and Duration of Study: The investigation was carried out in two rooms of a surgical ward at the Villa Erbosa health care facility in Bologna (Italy) over a period of seven weeks.

Methodology: The samples were taken using contact plates (diameter: 24 cm²) containing an adequate agar culture medium (Tryptic Soy Agar). After incubation at 36±1°C° for 24 and 48h, the number of colonies was counted, the average and standard error calculated and the reduction in bacterial load evaluated as a percentage of initial counting.

Results: The product was able to achieve a high degree of decontamination (around 90%) immediately after application and that, after 72 hours, decontamination remained at about 55%. The results are highly significant.

Conclusion: It may be concluded that the tested product could be profitably used to decontaminate surfaces in hospital wards.

Keywords: Persistent silver disinfectant, surface decontamination, microbicidal effects, hospital infection prevention.

1. INTRODUCTION

In hospitals, surfaces are often colonized by potentially pathogenic microorganisms [1, 2] which can remain on the surfaces for long periods of time [3, 4], thus playing a major role in hospital-acquired infections [5, 6]. Moreover, while direct transmission of nosocomial pathogens — either from one patient to the next or from the operator's hands to the patient — appears to be the most important pathway [7] to such infection. Moreover, indirect transmission — when hands come into contact with contaminated surfaces — has thus far been underestimated, a fact recently brought to light for *Clostridium difficile* [8], *Acinetobacter baumannii* [9] and MRSA [10]. The use of disinfectants provides a temporary reduction in the bacterial load. However, this action does not last in time because, once deposited on the surfaces, common disinfectants cannot withstand environmental aggression such as contact with water and wiping. One way to overcome this drawback could be to use disinfectants with long-term action. Recent studies have shown that not only do disinfectants containing silver present an immediate effect, reducing the surface bacterial load, but that this action also appears persistent in time [11, 12]. The present work seeks to assess the bactericidal activity of a long-lasting disinfectant complex composed of aqueous suspensions of nano particles (average diameter: 150-200 nm) of silicon oxide, silver ions in the form of silver acetate (0.005%), a cationic surfactant,

benzalkonium chloride (0.6%) and 12% ethyl alcohol (BACTERCLINE ENERGY BLAST) applied on the surfaces of two surgery ward rooms and left in place for different amounts of time.

2. MATERIALS AND METHODS

A bi-weekly investigation was carried out in two rooms of a surgical ward at the Villa Erbosa health care facility in Bologna (Italy) over a period of seven weeks. Samples were taken prior to decontamination, as well as 15 minutes and 72 hours after decontamination with the product being tested. After wiping down with tap water and drying, the undiluted product in the dispenser was uniformly sprayed over the surfaces to be tested and then distributed with a cloth, ensuring that a uniform film covered the entire surface. During the 72 hour period running from application of the product to the last sampling, the surfaces only underwent daily wiping with a cloth moistened simply with tap water since a detergent could have interacted with the BACTERCLINE ENERGY BLAST film, voiding its effectiveness. In both rooms, the sampling points, both before and after decontamination, were located in the following critical sites:

- three points on the table;
- two points on the chair;
- six points on the nightstand (3+3);
- three points on the surface of the trolley.

The examined surfaces were smooth, undamaged and made of plastic laminate.

The samples were taken using contact plates (diameter: 24 cm²) containing an adequate agar culture medium (Tryptic Soy Agar) and a neutralizer (lecithin 3 g/l; polysorbate 80 30 g/l V/V; sodium thiosulfate 5 g/l; L-histidine 1 g/l; saponine 30 g/l in diluents at 1% V/V). After incubation at 36±1°C for 24 and 48h, the number of colonies was counted, the average and standard error calculated and the reduction in bacterial load evaluated as a percentage of initial counting. In addition, statistical analysis of the results was performed using the Student t-test to determine significance and, finally, probability was calculated.

Samplings were performed by the same operator using a Rodac-Weight (International pbi S.p.a. – Novara, Milano, Italy), which applies the same pressure — equivalent to a standard weight of 500 gr — on the contact plate. The time of application was 10".

During the first 4 weeks, the cleaning contractor personnel were supplied with non-woven fabric cloths (LBK 45 g/m²) composed of wood pulp, viscose and PEP (Magris S.p.a Seriate, Bergamo, Italy) and these were used for cleaning operations. In the following 3 weeks, the manufacturer of the disinfectant supplied the contractor with 80% polyester-20% polyamide non-woven cloths (Falpi S.r.l. Trivero Ponzzone, Belluno, Italy), again used to wipe down the surfaces after being moistened with tap water.

The use of two different cloths is justified by the fact that not all materials are compatible with the disinfectant. For example, cotton deactivates the silver ions while, given their abrasiveness, microfiber cloths could quickly damage the silver-containing film on the surfaces treated.

3. RESULTS AND DISCUSSION

The results obtained at a series of points analyzed in the two ward rooms — for the first four weeks of the investigation — and those obtained on the surfaces of the room furnishings — over the entire duration of the study — are summarized in table 1. The average CFU/24cm² before disinfection was 72.74±16.17 (from 1 to 1100 CFU/24cm²) and after decontamination it was 3.88±0.90, (from 0 to 78 CFU/24cm²) hence the immediate reduction was 94.67%. The results obtained appear to be highly significant ($t_{112}=4.252$, $p\rightarrow 0$). 72 hours after application of the disinfectant, the average CFU was 31.31±3.57 (from 1 to 270 CFU/24cm²) which is still a 56.97% reduction from the initial load and this result, too, is quite significant ($t_{112}=2.502$, $p=0.013$).

The results of decontamination during the following three weeks are summarized in table 2. Just 15 minutes after use of the disinfectant, the average initial CFU/24cm² of 31.18±7.96, (from 0 to 516 CFU/24cm²) had dropped to 3.23±0.48 CFU/24cm², (from 0 to 30 CFU/24cm²). Therefore, again in this case, the microbial load was markedly lower with an 89.65% reduction. This result is highly significant ($t_{84}=3.505$, $p\rightarrow 0$). Moreover, 72 hours after application of the disinfectant, the microbial load was 12.56±3.29, (from 0 to 232 CFU/24cm² with a 59.72% reduction). The results obtained are significant ($t_{84}=2.161$, $p=0.032$).

Tab. 1. Statistical analysis of the data: averages and standard errors, pre- and post-disinfection, Student t value, degrees of freedom (d.f.), p value and percentage reduction for the data acquired during the first four weeks.

	Initial average CFU/24cm ² prior to disinfection	Average CFU/24cm ² after disinfection	Student t	d.f.	P	Significance	R%
After 15 minuts	72.74 ± 16.17	3.88 ± 0.90	4.252	112	→ 0	Highly significant	94.67
After 72 hours	72.74 ± 16.17	31.31 ± 3.57	2.502	112	0.013	Highly significant	56.97

Tab. 2. Statistical analysis of the data: averages and standard errors, pre- and post-disinfection, Student t value, degrees of freedom (d.f.), p value and percentage reduction for the data acquired during the following three weeks.

	Initial average CFU/24cm ² prior to disinfection	Average CFU/24cm ² after disinfection	Student t	d.f.	P	Significance	R%
After 15 minuts	31.18 ± 7.96	3.23 ± 0.48	3.505	84	→ 0	Highly significant	89.65%
After 72 hours	31.18 ± 7.96	12.56 ± 3.29	2.161	84	0.032	Significant	59.72%

4. CONCLUSIONS

The product tested (BACTERCLINE ENERGY BLAST) achieved high decontamination immediately after application. This is due to the fact that application creates a continuous film of product on the surfaces and that the nano particles of SiO₂ bond with the silver ions and cationic surfactant molecules. The positively charged nano particles trap the bacteria on the surface of the film. Indeed the negative charge in the bacterial outer membrane facilitates transfer of the silver ions to the microorganisms where they bond with the membrane's sulphhydryl groups. The silver then penetrates into the cell, accumulating until a toxic threshold is reached, killing the microorganism. Such decontamination was maintained in time although it did decline somewhat, most likely because, during the 72 hours that had elapsed since application of the product, the surfaces were wiped down with cloths dampened with tap water and this rubbing may have altered the disinfectant film adhering to the surfaces.

After ascertaining the fact that the components of the disinfectant tested do indeed have microbicide properties, we feel that its effectiveness can above all be ascribed to the silver ions while the surfactants only act as coadjuvant. In reality, there do not appear to be any publications indicating that the product as a whole is able to reduce (as per UNI EN 13697) initial bioburdens in the 1.5-5x10⁸ range for *Pseudomonas aeruginosa* ATCC 15442, *Escherichia coli* ATCC 10536, *Staphylococcus aureus* ATCC 6538 e di *Enterococcus hirae* ATCC 10563 on the surfaces by more than a logarithm of 4. At the same concentration present in the product (0.06%) the surfactant (benzalkonium chloride) lead to a reduction of less than a logarithm of 1. Obviously, in our test field, the reduction is less evident because the initial surface bioburden

was generally quite low, as would necessarily be the case in a hospital ward when routine cleaning of the surfaces is performed correctly.

The residual decontamination on the surfaces treated with the silver-containing disinfectant has proved effective against numerous pathogenic microorganisms, even after repeated environmental stress induced by washing and wiping [11]. Likewise a pilot study — performed in two wards where the surfaces contained silver and two others where this element was absent — showed that the bacterial loads were 62% and 98% lower on the surfaces with the silver vs. similar ward surfaces treated with materials not containing silver.

Moreover, some of the surfaces left untreated but located in the vicinity of those treated with the silver also showed lower bacterial loads than those found in environments with untreated surfaces. This would indicate that the decontamination with silver-containing products was not limited solely to the materials treated, but even extended to the broader environment [12], thus decreasing the likelihood of hospital-acquired infections in the entire ward. In light of these and other results in the literature, we can conclude that disinfectants containing silver offer very high decontamination immediately upon application and that this effect is maintained in time despite the aggression of damp wiping with tap water. Between one application and the next this treatment appears to offer a two-fold advantage: i) economic savings on the products previously used for daily damp wiping and ii) reduced environmental pollution from residues of the chemicals in the cleansers used instead of tap water.

Finally, allergies to silver are quite rare and thus disinfectants containing this element offer lower risk for operators and patients than other products used for surface decontamination.

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COMPETING INTERESTS

All authors declare that no competing interests exist.

AUTHORS' CONTRIBUTIONS

This work was carried out in collaboration between all authors. S. De Lorenzi managed the analyses of the study. I. Barrai performed the statistical analysis. G. Salvatorelli the first and the final draft of the manuscript. G. Finzi designed the study and wrote the protocol. P. Cugini managed the literature searches. All authors read and approved the final manuscript.

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212
213
214

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