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Artigo Original

VALIDAÇÃO DO PROCESSO DE LIMPEZA HOSPITALAR COM INDUÇÃO ELETROSTÁTICA: UMA EXPERIÊNCIA COM USO DE MICROBIOLOGIA MOLECULAR

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ABSTRACT

Contaminated surfaces in hospitals can contribute to the transmission of microorganisms implicated in healthcare-associated infections (HAIs). However, traditional, manual cleaning and disinfection practices are often less than ideal. This study aims to verify the effectiveness of the process of hospital cleaning and disinfection by no-touch technology, by electrostatic induction. This is a quali-quantitative study, carried out in an inpatient unit of a 410-bed private hospital in the city of São Paulo, Brazil. A comparative evaluation of traditional methods and electrostatic induction technology was performed, with microbiological evaluation to validate the reduction of microbial load by genetic sequencing. A total of 327 microorganisms were identified among the 22 rooms evaluated. Mann-Whitney non-parametric tests indicated no significant difference between the two methods for pre ($p = 0.12$) or post ($p = 0.09$) time points. In general analysis by number of sequences detected, a large percentage of reduction was observed, demonstrating that the terminal cleaning processes both in the manual method and by electrostatic induction allowed a significant decrease in the microbiological load. The knowledge of the microbiome identified in the groups of samples analysed (before and after) in the terminal cleaning process both in the manual technique and in electrostatic induction, presented in this study, gave the access to important information about the effectiveness of the methods, equipment and products used in a cleaning environment.

KEYWORDS

Terminal cleaning and disinfection, No touch, Disinfection, Cleaning, Facilities

INTRODUCTION

Several studies have shown that patients colonized or infected with healthcare-associated microorganisms spread on their skin, clothing, bedding [1] and often contaminate the environment, including porous surfaces (e.g., vinyl curtains) and non-porous surfaces (e.g., siderail and medical equipment) [2,3]. Contaminated surfaces in hospitals may contribute to the transmission of microorganisms implicated in healthcare-associated infections (HAIs). [4,5]

Experts agree that cleaning and disinfection of environmental surfaces are essential elements of effective infection prevention programs [4]. However, traditional manual cleaning and disinfection practices in hospitals are often sub-optimal. This is often due to a variety of staffing issues. Staff turnover between departments is a significant problem [6,7], which can be as high as 30 to 50% in some facilities. As a result, hygiene staff shortages were reported by over 50% of hospitals in a recent survey conducted in the United States [8]. There is often a confusion between hygiene staff and nursing staff, over who is responsible for cleaning various surfaces and equipment [9,10]. Contaminated environmental surfaces are an important source of microorganism transmission. Cleaning of fixed surfaces in rooms is critical to reduce HAIs [11].

While patient rooms are regularly cleaned and disinfected using manual techniques, evidence suggests that the adequacy of cleaning is often suboptimal, especially when the focus is only on high-risk or frequently contacted surfaces (*high-touch*) [4,5].

Inadequate cleaning using manual techniques has led to the development of no-touch systems that can decontaminate surfaces and objects in the patient environment. The technologies found in studies employ the use of ultraviolet (UV) rays or hydrogen peroxide. They complement but do not replace manual cleaning of patient rooms. Surfaces must first be free of dirt and debris before use. Vaporized hydrogen peroxide and UV light systems provide high-level disinfection or decontamination of all fixed surfaces and equipment in patient rooms but are not a stand-alone means of cleaning [12,13,14,15].

Taking this into consideration and the fact that in recent years, several interventions have been shown to be effective in improving surface cleaning and disinfection, the objective of this study is to verify the effectiveness of the hospital surface cleaning process with no-touch technology by electrostatic induction.

METHOD

This is a quali-quantitative study, conducted in inpatient units of a private hospital with 410 beds, in the city of São Paulo, from February 29 to March 1, 2016.

A total of 22 rooms from the inpatient units were randomly chosen, 12 of them as process control and 10 with the electrostatic induction no-touch technology.

In the control rooms it was used the manual terminal cleaning method, standardized in the hospital. The method consists of removing the used bed linen and solid waste. Sanitize and disinfect with a multipurpose sponge and cloth by rubbing the surfaces with a chlorine dioxide-based disinfectant with quaternary ammonia in liquid form.

In the rooms selected for evaluation of the new method of cleaning and disinfection by electrostatic induction, the following steps were performed: removal of used bedding and solid waste, manual cleaning of the bed, dining table, hand hygiene sink, floor, and bathroom. Afterwards, the same disinfectant product, based on chlorine dioxide with quaternary ammonium, was applied with electrostatic induction equipment. When applying the product by electrostatic induction no sponge, multipurpose cloth, or similar were used for cleaning. The equipment was directed from top to bottom and around the entire room.

The hospital standardized time to perform manual terminal cleaning was 60 minutes. The time used to perform the cleaning with electrostatic induction technology was divided into the following steps: time spent for the manual steps (bed, dining table, hand hygiene sink, floor, and bathroom), 1 minute applying the product with the equipment, 10 minutes for product action, bed making, and after this period the room was cleared for use.

In order to validate the terminal cleaning both in the manual technique and by electrostatic induction it was used the molecular biology method, with large-scale DNA sequencing technique, allowing the identification of all microorganisms present in a sample, together with its great capacity for analysis. The sample was collected using a sterile dry cotton swab moistened with saline solution to be swabbed on the selected surfaces and then sent to Neoprospecta Microbiome Technologies for analysis. In this study it was adopted the digital microbiological diagnosis method (DMD).

The DMD aims to provide a diagnosis to detect microorganisms from different types of samples with sensitivity and specificity. This tool provides information about the microbiota of the hospital environment, accurately and with scalability, indicating environments that pose a risk to patient health [16].

The analysis was performed from 8 surface points, pre-selected by the hospital infection control service and the hygiene service of the hospital under study. Points collected: room entrance door handle, room entrance light switch, television remote control, siderail, telephone, dining table (upper part), gas ruler valves and alcohol gel dispenser activation lever. These points were chosen because they are places of greater hand contact during patient care, thus being a greater means of dissemination of microorganisms once poorly sanitized.

The study began with the release of the room for terminal cleaning, soon after the patient's departure. At this moment, samples were collected from the 8 points (pre-cleaning), later the terminal cleaning was performed (manual or by electrostatic induction) and afterwards new samples were collected from the 8 points (post-cleaning). The collections were always performed by the same person, to avoid bias of samples from different sites and/or collection technique.

RESULT

The visualization of the results was made through the Neobiome Platform that monitors quality, identify, analysis and manage microorganism control. It can be accessed by login and password provided by the commercial sector of the company Neoprospecta microbiome technologies.

HAIs -associated bacteria with the highest number of 16S rDNA sequences identified in the analyses were listed, separated in the groups of pre- and post- terminal room cleaning process samples, both in the manual method and in the electrostatic induction no-touch technology.

Analysis of the manual terminal cleaning process

Considering the samples collected before the manual terminal cleaning, the sequencing analyses allowed the identification of 49 species associated with HAIs from a total of 1,237,163 16S rDNA sequences obtained. And for the samples collected after the cleaning procedure, it was possible to obtain a total of 154,047 16S rDNA sequences, with 45 species associated with HAIs, representing a reduction of 87.55% in the number of 16S rDNA sequences.

The samples with the highest amounts of (16S rDNA) bacterial sequences in the pre-cleaning were: siderail (N= 519,793), meal table (N= 233,306), telephone (N= 165,248) and remote control (N= 128,519).

It was possible to observe a significant decrease in the sequences of bacteria associated with HAIs in the corresponding post-cleaning samples, except for the alcohol gel dispenser surface, in which there was a post-cleaning increase, which may denote a contamination of the sampled surfaces during the manual terminal cleaning process, in which fibres and/or nonwovens are used, for example, to perform the technique.

Table-I. Analysis of manual terminal cleaning by surface

	Nº of 16S rDNA sequences		% reduction (-)
	Pre-cleaning	Post-cleaning	
Door handle	72905	5918	-91,88
Interrupter	32789	11551	-64,77
Remote Control	128519	41679	-67,57
Siderail	519793	11245	-97,84
Telephone	165248	7445	-95,49
Dining Table	233306	30799	-86,80
Gas valve	83370	43799	-47,46
Alcohol Gel Dispenser	1228	1657	34,93

Regarding bacteria associated with HAIs, in the pre-cleaning samples group, bacteria of the genera *Acinetobacter* spp. *Pseudomonas* spp. and *Staphylococcus* spp. stand out as common colonizers of abiotic surfaces.

Stratifying the most important bacteria, it found a significant reduction in the species *Acinetobacter* spp, *Acinetobacter. baumannii, Enterococcus faecium*, and *Pseudomonas aeruginosa.*

Table-II. Analysis of manual terminal cleaning by identified microorganism

	Nº of 16S rDNA sequences		% reduction (-)
	Pre-cleaning	Post-cleaning	

Acinetobacter spp	487127	1967	-99,60
Acinetobacter baumannii	46751	131	-99,72
Enterococcus spp	9	5	-44,44
Enterococcus faecalis	54	35	-35,19
Enterococcus faecium	210	46	-78,10
Escherichia coli	284	514	80,99
Klebsiella spp	22	89	304,55
Klebsiella pneumoniae	21	20	-4,76
Pseudomonas spp	2876	5410	88,11
Pseudomonas aeruginosa	224	13	-94,20
Staphylococcus aureus	83	76	-8,43
Staphylococcus coagulase negative	3319	2645	-20,31

The species that showed an increase in the number of sequences in the post-cleaning (*E. coli, Klebsiella* spp, and *Pseudomonas* spp,) were found in the alcohol gel dispenser and siderail, inferring possible contamination related to the cleaning technique.

Analysis of the electrostatic induction cleaning process

Considering the samples collected prior to terminal cleaning by electrostatic induction, the sequencing analyses allowed the identification of 61 species associated with HAIs from a total of 3,286,909 16S rDNA sequences obtained. For the samples collected after the cleaning procedure, it was possible to obtain a total of 264,030 16S rDNA sequences, with 42 species associated with HAIs, representing a reduction of 91.97% in the number of 16S rDNA sequences.

The samples with the highest amounts of (16S rDNA) bacterial sequences in the pre-clean-up were: meal table (N= 678,134), siderail (N=665,381), telephone (N= 544,913) and remote control (N= 544,440).

Table-III. Analysis of terminal cleaning with electrostatic surface induction

	Nº of 16S rDNA sequences		% reduction (-)
	Pre-cleaning	Post-cleaning	
Door handle	239506	18498	-92,28
Interrupter	54011	8239	-84,75
Remote Control	544440	32634	-94,01
Siderail	665381	35183	-94,71
Telephone	544913	43833	-91,96
Dining Table	678134	105055	-84,51
Gas valve	469736	12142	-97,42
Alcohol Gel Dispenser	90788	8446	-90,70

Regarding bacteria associated with HAIs, bacteria of the genera *Acinetobacter* spp., *Pseudomonas* spp. and *Klebsiella s*pp., common colonizers of abiotic surfaces, stood out in the group of pre-cleaning samples.

Stratifying the most important bacteria, there was a significant reduction in the *Acinetobacter* spp, *Acinetobacter. baumannii, Klebsiella* spp, *Pseudomonas* spp and *Pseudomonas aeruginosa* species.

Table-IV. Analysis of the main microorganisms identified in terminal cleaning by electrostatic induction

	Nº of 16S rDNA sequences		% reduction (-)
	Pre-cleaning	Post-cleaning	
Acinetobacter spp	551321	8071	-98,54
Acinetobacter baumannii	61289	1421	-97,68
Enterococcus spp	83	61	-26,51
Enterococcus faecalis	1184	700	-40,88
Enterococcus faecium	229	130	-43,23
Escherichia coli	12923	5871	-54,57
Klebsiella spp	104592	1718	-98,36
Klebsiella pneumoniae	364	569	56,32
Pseudomonas spp	411584	7613	-98,15
Pseudomonas aeruginosa	72496	1058	-98,54
Staphylococcus aureus	201	388	93,03
Staphylococcus coagulase negative	27220	16738	-38,51

The species that showed an increase in the number of sequences in the post-cleaning (K. pneumoniae and S. aureus) were found on the dining table and remote control. Those items were excluded from electrostatic induction cleaning because of this evaluation.

Statistical Analysis

A total of 327 microorganisms were identified among the 22 rooms evaluated. Two statistical analyses were performed, the first aiming to compare the efficiency in reducing the gross number of microorganisms between the manual and electrostatic methods. For this statistical analysis of the two methods, the sum of the microorganisms identified at the 8 locations evaluated (TV remote control, alcohol gel bottle, siderail, light switch, dining table, door handle, telephone, and gas damper) was obtained for each room. Comparisons were made for each of the two methods (manual and electrostatic) in the number of microorganisms between the pre- and post-cleaning periods. A comparison was also made of the pre and post periods between the two methods, which would allow an indication of comparison in the effectiveness between the techniques. Since the data present asymmetric distribution, it was chosen to perform non-parametric tests, with a significance level (α) of 5%.

A second statistical test was based on the indicative risk of contamination. In this case, when the number of microorganisms detected at one of the eight sites evaluated in a room exceeded 1000 16S rDNA sequences, it was coded as 1 (i.e., microorganism with risk of contamination) or 0 (no risk). Thus, each room could assume a value from 0 to 184 (23 microorganisms and 8 possible sites). Based on this data, quantitative analysis was performed by Chi-square test for adherence analysis to assess the existence of risk of contamination by indicator microorganisms in the environment before and after the cleaning of each of the methods.

Gross number of microorganisms

Considering as for the difference between the pre and post periods for the manual cleaning method, the non-parametric Wilcoxon test showed no significant difference between the two periods for microorganisms ($p = 0.18$). For the electrostatic method, the same test indicated that there was a significant difference ($p = 0.007$).

The Mann-Whitney non-parametric tests indicated that there was no significant difference between the two methods at the pre ($p = 0.12$) or post ($p = 0.09$) times.

Contamination risk

Chi-square tests for adherence were performed for the pre and post times to assess the possible difference in the number of observed cases of contamination risk in each cleaning method with a hypothetical model where there would be no difference in expected frequency. The adherence test showed no difference in the number of risk cases in the pre moment ($p = 0.89$) with an expected frequency, while the significant difference detected in the post moment ($p = 0.004$) suggests an association between the number of observed cases of contamination risk with the cleaning method adopted.

In a qualitative analysis it is possible to identify that great majority of the rooms, except one, were free of contamination risk points after electrostatic cleaning, while in manual cleaning only two rooms had no cases of contaminated sites.

DISCUSSION

It was found that the most commonly used methods for monitoring the cleaning process in the studies were: fluorescent surface/ Ultraviolet (UV) and adenosine triphosphate (ATP) markers [11]. These methods provide a means of evaluating the techniques and validating the products used for cleaning the surfaces.

The use of electrostatic induction equipment has been questioned for in-hospital use. Some hospitals in the United States use this system of dispersing disinfectant product after manual cleaning, thus ensuring that all surfaces are disinfected.

In a general analysis by number of sequences detected was observed a large percentage of reduction, demonstrating that the terminal cleaning processes both in the manual method and by electrostatic induction allowed a significant reduction in the microbiological load.

During the evaluation it wasn't observed any reduction, in all points considering the number of sequences obtained when stratified by bacteria. This can be explained by occasional failures in the cleaning process, which culminated in contamination of the surfaces after the process.

Regarding the tests for differences in the raw number of microorganisms between pre and post times, they indicated that only the electrostatic method led to a significant reduction in the number of indicator bacteria. However, no difference was detected between pre or post times for indicator organisms between the two methods. The difference identified for the electrostatic method may be due to a slightly higher number of indicator organisms in the samples pre for this method, this divergence being of small effect for a test of difference between independent samples, but of greater effect for a more sensitive test such as the paired sample test. A second statistical test sought to assess the adherence between the observed distribution of cases at risk of contamination for each cleaning method. The test showed that while no significant difference was detected in the number of cases for the pre moment, it was possible to observe a significant difference between cases observed with expected frequency for the post moment, suggesting that compared to the manual method, the electrostatic cleaning method is associated with a lower number of risk cases after cleaning. Thus, the data presented here suggest superiority in the electrostatic cleaning method.

It is important to present some restrictions for the present study. First, a small number of rooms was selected for the experiment, mainly due to the complexity for the collection and sampling of the investigated microorganisms. It would be interesting for future studies to comparatively evaluate the two techniques on a larger sample, thus allowing a more accurate comparison between the two techniques.

CONCLUSION

The knowledge of the microbiome identified in the groups of samples analysed (before and after) in the process of terminal cleaning in both the manual technique and the electrostatic induction, presented in this study, provided us access to important information about the effectiveness of the methods, equipment and products used in a cleaning environment.

The monitoring of the cleaning technique performed daily in the inpatient rooms is essential for the cleaning process by electrostatic induction to be effective. Is necessary a periodic evaluation of the rooms to ensure the effectiveness of the cleaning process.

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