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Automatic environmental disinfection with hydrogen peroxide and silver ions versus manual environmental disinfection with sodium hypochlorite: a multicentre randomized before-and-after trial

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SUMMARY

Background: New technologies for automated disinfection have been developed, including the use of hydrogen peroxide atomized by specific equipment, with associated silver compounds.

Aims: To compare the effectiveness of an automated disinfection system with hydrogen peroxide <8% and silver ion versus a manual method with 0.5% sodium hypochlorite solution when evaluating the reduction of microbial mesophilic contamination and *Clostridium difficile* presence; and to evaluate the time required for both of these processes.

Methods: This was a randomized multicentre trial performed in different hospital wards that had been occupied previously by patients with *Clostridium difficile* infection. When patients were discharged their rooms were randomized to one of two decontamination arms. The surfaces where sampled using swabs, before and after disinfection. Swab samples were cultured for quantitative detection of microbial mesophilic contamination and qualitative detection of *C. difficile*.

Findings: Before disinfection, 13% of surfaces decontaminated with hydrogen peroxide and silver ions and 20% of surfaces decontaminated with sodium hypochlorite showed presence of *C. difficile* spores. After disinfection, the samples containing *C. difficile* were 0% ($P < 0.001$) in the group decontaminated with hydrogen peroxide and silver ions, and were 3% ($P < 0.001$) in the group decontaminated with sodium hypochlorite. This difference was not statistically significant; nor was the difference in the reduction of the microbial mesophilic contamination.

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Conclusion: The differences between the groups were not statistically significant; however, the disinfection with hydrogen peroxide and silver ions is preferable due to less dependence on operators.

Introduction

Healthcare-associated infections are infections acquired during hospitalization, including those that arise in the first few days after discharge; *Clostridium difficile* is particularly important [1]. *C. difficile* has epidemiological characteristics comparable to other Gram-positive micro-organisms resistant to antibiotics. It spreads from patients to the environment and may survive up to five months in the form of spores [2]. Furthermore, it is transmitted to other patients through hands of healthcare workers and via inanimate surfaces [3—5]. Several studies have shown that cleaning at the end of the hospitalization of infected patient rooms may reduce the risk of acquiring pathogens from contaminated surfaces [5].

International guidelines recommend the use of active sporicidal agents on *C. difficile*, preferably chlorine derivatives with a concentration $\geq$1000 ppm [6]. The cleaning procedures for contact disinfectants often do not reach the expected results. The complexity of environmental surfaces in healthcare facilities has increased and cleaning is highly operator-dependent.

In the last decade, new technologies for automated disinfection have been developed which have benefits of efficacy, reliability and safety, but with some negative aspects. For example, these technologies can be used only in vacated rooms without people [3]. One of these technologies is the use of hydrogen peroxide atomized by specific equipment, with associated silver compounds; especially after the recent emergence of nanotechnologies, which have allowed the production of disinfectant compound agents [4,7].

This study aims to compare the effectiveness of an automated room disinfection system with hydrogen peroxide solution and silver ion vapour with the conventional practice of a chlorine-based disinfectant solution. Evaluation of the proposed study was carried out to calculate the reduction of *C. difficile* and total bacterial contamination.

Methods

A randomized multicentre trial was performed in four public and private health facilities in the Emilia-Romagna Region identified as A, B, C, D (to maintain anonymity). In all the public health facilities cleaning is outsourced to a service company, whereas the private health facilities use in-house cleaning services. All the staff employed were aware of the study being conducted.

Between December 2014 and September 2015, 28 hospital rooms (medicine, orthopaedics, long-term care, recovery and functional rehabilitation) were included. These were all single rooms with similar dimensions and discharge times. The mean age of patients who occupied the 28 rooms was 84 years (range: 62—99) and 85% were not independent during hospitalization. To be included in the study the rooms needed to have: (i) accommodated patients infected with *C. difficile* for at least 48 h; (ii) be available for decontamination at the time of discharge.

Clostridium difficile-infected patients were defined as those with diarrhoea or toxic megacolon, and with a positive laboratory test for toxin A and/or B or a toxogenic *C. difficile* strain as well as patients who had pseudomembranous colitis diagnosed in the course of endoscopy, surgery, or histopathological examination. At the moment of discharge of patients with *Clostridium difficile* infection, the availability of the room was ascertained through an e-mail system.

After being included in the study, the rooms were randomly assigned to disinfection with hydrogen peroxide and silver ion 99MS system or to the terminal disinfection with a disinfectant solution using 0.5% sodium hypochlorite. The randomization list was generated by www.randomization.com, and 14 rooms were assigned to each disinfection group.

Before disinfection, rooms underwent a standard cleaning procedure involving removal of visible dirt (emptying the rubbish, electrostatic sweeping, etc.) and a cleaning phase (furniture, walls, floor and bathroom). Following this, a disinfection phase took place. For the rooms assigned to decontamination with hydrogen peroxide and silver ions, the 99S solution was atomized into microparticles of submicron size, by setting the modulator 99M at a speed of 1.5 mL/m^3, in order to uniformly distribute solution into the environment. After waiting for the discharge period (20 min) and the decrease of hydrogen peroxide (35 min), the room was ready to be used. In the rooms assigned to sodium hypochlorite decontamination, the housekeeping staff proceeded to the manual preparation of the solution and to the disinfection of furniture and surfaces using disposable cloths, and floor mops.

Collection of viable bacteria was achieved using a specific swabbing technique. The use of moistened swabs is convenient for sampling large, non-absorbent, irregular or recessed surfaces not accessible to contact devices. They were used to determine the presence and/or number of viable microbes on the surfaces, in order to estimate the level of contamination or the effectiveness of cleaning and disinfecting protocols [8,9]. Samples were collected before and after disinfection. The sampling protocol was defined according to UNI EN ISO 14698-1:2004 annex C [8].

In each room, the following environmental surface areas were sampled: 100 cm^2 plain surface areas of bedside table and washbasin (identified as flat surfaces), handle or inlet of the nightstand drawer, light and nursing-call devices, drip stand, foot bed tubular, inner door-handle of the room, inner bathroom door handle (identified as irregular surfaces). The sampling locations were defined according to the Centers for Disease Control and Prevention checklist for the evaluation of environmental contamination [10]. Table I illustrates the numbers of samples collected for each room.