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ORIGINAL ARTICLE

Bacterial contamination of the hospital environment during wound dressing change

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KEYWORDS

Bacteria;
Colonized wound;
Hospital environment;
Cross-transmission;
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Summary

Introduction: The hospital environment plays a role in the cross-transmission of multidrug-resistant bacteria. The aim of this study was to evaluate the bacterial contamination of the hospital environment during chronic wound dressing change.

Patients and methods: This study was performed from July 2010 to May 2011. *Staphylococcus aureus*, *Pseudomonas aeruginosa*, *Acinetobacter baumannii* and *Enterobacteriaceae* were counted in environmental samples (air and surfaces) that were obtained in the rooms of patients with wounds colonized (cases, $n=9$) or not (controls, $n=15$) during or not during wound dressing change. Bacterial contamination was compared to that found in the rooms of patients without colonized wounds.

Results: The environment was frequently contaminated during wound dressing change (38% of the sampled series were positive). In comparison, the contamination was less frequent in the environment of patients with colonized wounds when the wounds were not being dressed (14.3%) and in controls (3.8%). *S. aureus* was the most frequent species identified in positive samples.

Discussion: These results suggest that previously recommended measures such as hand hygiene after contact with the environment and wearing a mask are justified. Moreover, other measures should be suggested, in particular cleaning the room before and after dressing change of colonized wounds.

Level of evidence: Level III: case control study.

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Introduction

Healthcare associated infections (HAI) are a major public health problem and 5.38% of the patients who were hospitalized in France in 2010 acquired an HAI [1]. One of the major problems in the fight against HAI is controlling cross-transmission [2].

Patient-healthcare worker-patient hand contamination is an important type of transmission in healthcare organizations (HCO). An estimated 17% of healthcare workers' hands which have been in close contact with an infected or colonized patient carried a bacteria from that patient [2]. Also, 10.6% of the sites colonized by glycopeptide-resistant *enterococci* (GRE) were colonized following a contact with contaminated hands [3]. This risk can be controlled by carefully following hand hygiene protocols before and/or after any contact with a patient [4].

Another type of hand contamination that is often underestimated is environment-healthcare worker-patient hand transmission, which represents a frequent type of patient contamination. The study by Bhalla et al. [5] showed that healthcare workers' hands, which had only been in contact with the environment of colonized/infected patients were often contaminated by bacteria (30% methicillin-resistant *Staphylococcus aureus* (MRSA), 20% GRE and 15% Gram-negative bacteria). Moreover, several studies have shown that the environment of colonized/infected patients was regularly contaminated with their own strains. For example, from 12% to 44% of the rooms of MRSA carriers were contaminated with that bacteria [6,7]. This phenomenon was less important for multi-resistant Gram-negative bacteria since only 4.9% of surfaces were contaminated [8]. The rate of environmental contamination varies according to the microorganism and the site of infection: patients carrying a MRSA in their wound or urine contaminated their room more than patients carrying a MRSA in their lung or blood (36% versus 6%) [9].

The main goal of our study was to determine the rate of environmental contamination during the dressing of chronic wounds in relation to the type of bacteria colonising the wound. The secondary aim was to describe the progression of this contamination over time during wound dressing. The hypothesis of this study was that colonized wounds with tissue loss resulted in greater environmental contamination than non-colonized wounds, in particular during wound dressing.

Patients and methods

Setting and study period

This study was performed between May and July 2011 at the Regional University Hospital (Centre Hospitalier Régional Universitaire [CHRU]) of Besançon (1178 beds) in the general surgery unit, a conventional care unit with 11 single rooms for septic surgical patients (presenting with either a surgical site infection or a wound with significant tissue loss). Wounds were dressed in the patient's room or in certain cases (which were not included in this study) in the operating room.

Included patients

Two groups of patients were included: a "case" group and a "control" group. The patients in each group were included consecutively on admission in the unit.

The case group

The patients included in this group had a discharging wound in the lower limbs (from the foot to the lower third of the thigh) with tissue loss. To determine the infectious agents colonising/infected the wound, a sample was obtained the first time the wound was dressed, and then weekly thereafter. All the patients' wounds were colonized/infected by one or several of the following microorganisms: *Enterobacteriaceae*, *S. aureus* and *Pseudomonas aeruginosa*. Colonisation was not distinguished from infection.

The control group

The patients in this group had non-colonized/infected and non-discharging wound. Localisation of the wound was not limited to the lower limbs.

Microbiology methods

Samples from wounds

Samples were obtained with dry sterile swabs. Seeding of swab cultures, identification of bacteria and antibiograms were performed according to the usual laboratory techniques after 48 h of incubation at 37 °C.

Environmental samples

Fig. 1 shows when samples were obtained for the case and control groups in relation to room cleaning. Two types of samples were obtained during wound dressing according to the sample plan described in Table 1:

- samples of airborne biocontamination;
- surface samples.

Table 1 Kinetics of positive air and surface samples during wound dressing.

| Time of sampling | Number of positive samples (%) |
|---|--------------------------------|
| <i>Air</i> | |
| T0 immediately before dressing removal ^a | 2 (9.5) |
| T1 at removal ^a | 5 (23.8) |
| T10 10 min after removal ^a | 2 (9.5) |
| T20 20 min after removal ^a | 3 (14.3) |
| T30 30 min after removal ^a | 3 (14.3) |
| <i>Surfaces</i> | |
| T0 immediately before dressing removal ^a | 1 (4.8) |
| T30 30 min after removal ^a | 4 (19.0) |
| T60 60 min after removal ^a | 4 (19.0) |

^a Removal of the old bandage corresponding to the beginning of wound care.

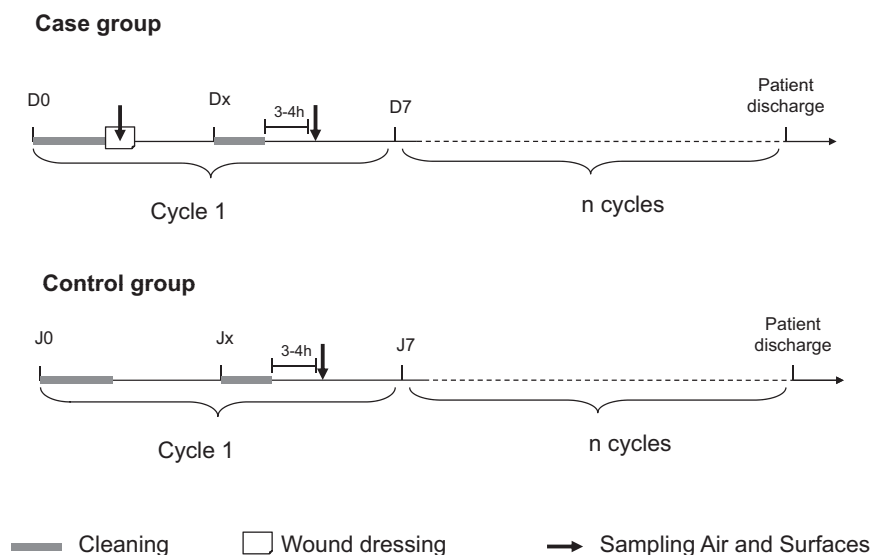


Figure 1 Cleaning of the rooms; time of samples for cases and controls.

A sample series was defined as all the samples obtained on a certain day for a particular patient. A sample series was considered positive if any of the samples of the series was positive. Sample series for the "case" group were obtained during both wound dressing and not during wound dressing. Samples obtained not during wound dressing were collected once a week in the patient's rooms in the "case" and "control" groups until the patient was discharged. A sample series included one airborne biocontamination sample obtained by the impaction and sedimentation methods respectively and 5 surface samples (overbed tables, bedside table, blanket, bed rails, lifting pole).

Samples of airborne biocontamination

Airborne biocontamination was determined by two methods, first by an impaction method with a bioimpactor (Sampl'air®, AES Chemunex, Bruz, France) placed 1 m from the wound, at a height of 1.20 m which sampled 250 L of air and by a sedimentation method with agar plates placed on the ground at the head of the bed and left open for 2 h. Mueller-Hinton growth media was used for these samples and they were incubated at 37 °C for 48 h. If results were positive, the colonies were identified and an antibiogram was performed according to the usual laboratory techniques.

Surface samples

These samples were obtained by wiping dry sterile swabs on a 25 cm² surface for each sample. The swabs were used to inoculate agar plates chosen according to the strains that had been identified in the wound (Drigalski agar to identify Gram-negative bacteria, Chapman medium to identify *S. aureus* and Mueller-Hinton agar for other microorganisms).

Statistical analyses

The statistical units used in the analyses are represented by a series of samples such as those defined in the paragraph "Environmental samples". The percentages were compared

with Epi-info version 2002 software with the Chi² or Fisher exact test. A *p*-value of less than 0.05 was considered to be statistically significant.

Results

Inclusions

Nine patients were included in the "case" group with 21 sample series during wound dressing and 14 sample series not during wound dressing, and 15 patients were included in the "control" group with 26 sample series. The wounds of seven patients and 13 sample series in the "case" group were positive with *S. aureus* (methicillin resistant in three patients and six sample series). A co-colonisation was identified in three out of seven patients: *S. aureus* + *P. aeruginosa* in one patient and one sample series, *S. aureus* + *A. baumannii* in one patient and one sample series and *S. aureus* + *Enterobacter cloacae* in one patient in two sample series. The wound was positive with *P. aeruginosa* in the two final patients with two sample series.

Contamination of the environment

In the "case" group, eight out of 21 of the sample series were positive (38%) during wound dressing and 2/14 series (14.3%) not during wound dressing. In the "control" group, one out of 26 of the sample series was positive (3.8%). Table 2 reports the frequency of contamination by each type of microorganism colonising the wounds in the "case" group during and not during wound dressing. Table 3 reports the frequency of contamination of the environment by the "case" and "control" groups during wound dressing. There was no difference in the frequency of air or surface contamination between methicillin-sensitive and resistant *S. aureus*. The only significant difference between the "case" and "control" groups during wound dressing were surface

Table 2 Frequency of contaminated samples according to bacteria colonising the wounds during dressing ("case" group).

| | <i>S. aureus</i> | | <i>P. aeruginosa</i> | | <i>Enterobacteriaceae/A. baumannii</i> | |
|----------|------------------|-----------|----------------------|---------|--|-------|
| | N | n (%) | N | n (%) | N | n (%) |
| Air | 95 | 14 (14.7) | 20 | 1 (5) | 45 | 0 (0) |
| Surfaces | 171 | 8 (4.7) | 36 | 1 (2.8) | 81 | 0 (0) |

N: total number of samples; n: number of positive samples with bacteria colonising/infecting the wound.

Table 3 Contamination of the environment during wound dressing.

| | "Case" group ^a | | "control" group ^a | | RR (CI95%) p |
|---------------|---------------------------|----------|------------------------------|----------|-------------------|
| | N | n (%) | N | n (%) | |
| Air | 28 | 3 (10.1) | 52 | 1 (1.92) | 5.57 (0.61–51.10) |
| NS | | | | | |
| Impaction | 14 | 2 (14.3) | 26 | 1 (3.85) | NS |
| Sedimentation | 14 | 1 (7.1) | 26 | 0 | NS |
| Surfaces | 70 | 5 (7.1) | 130 | 0 | 0.0047 |

N: total number of samples; n: number of positive samples with strains colonising/infecting the wound; RR: relative risk; CI 95%: confidence interval at 95%.

^a All strains were *S. aureus*.

sample results ($p=0.0047$). Table 1 shows the number of positive samples according to when air and surface samples were obtained. This table shows that environmental contamination was the highest immediately after the bandage was removed and decreased thereafter but persisted over time (for at least 60 min).

Discussion

The results of this study suggest that contamination in the hospital environment is frequent during the dressing of colonized wounds with tissue loss. These results support previous studies, which have shown that more than 50% of surface samples and nearly 40% of airborne samples were positive [6,7,10,11]. They also confirm the frequency of different strains of bacteria that contaminate the environment. Thus Lemmen et al. [8] reported a 24.7% frequency for contamination with Gram-positive bacteria, in particular *S. aureus* and only 4.9% for Gram-negative bacteria (versus 4.7% for *S. aureus* alone on surfaces and 0% for *Enterobacteriaceae* in our study) [6,8,11].

In our study, airborne and surface samples were obtained using two techniques with different sensitivities. Indeed the sensitivity for airborne samples obtained by the impaction technique is similar to that using contact agar plates, while the swab technique, which is considered to be less sensitive than agar contact sheets, was used for surface samples [12]. Moreover, surface samples during wound dressing were obtained at least 30 minutes after the bandage had been removed. The delay between bacterial sedimentation on the surface and sampling could reduce the sensitivity of the sample due to adsorption of the bacteria on the inert surface [12]. Thus, given the techniques used, the frequency

of environmental contamination observed in our study may have been underestimated especially on surfaces.

Our study has an advantage compared to others: the baseline of environmental contamination in the rooms was based on samples obtained outside the period of wound dressing as well as from the rooms of patients whose wounds were not colonized. When these samples were obtained, residual contamination was frequently found in the rooms of patients with colonized wounds. What was the source of this biocontamination? Residual contamination due to poorly applied daily cleaning procedures (there was no audit of cleaning practices during this study)? Rapid recontamination that might be linked to patients and continuous discharge of bacteria into the environment or linked to renewed suspension of bacteria charged particles when beds are made? None of these hypotheses can be ruled out [6,13]. Since we did not compare (i.e. genotyping methods) the strains that colonize the wounds and those from the environment, we cannot confirm that the wound played a "contaminating" role. However, the nearly total absence of bacteria in the environment of patients with non-infected wounds provides evidence of the role of the colonized wound as "contaminator". It is difficult to interpret these kinetic results in particular because of the small number of sample series obtained during wound dressing. Nevertheless, they do confirm our idea of the contamination process: removal of the bandage could result in a particular aerosol containing numerous bacterial particles that have colonized the wound; sedimentation of this bacterial aerosol then occurs on the surfaces in the environment at a speed that is dependent upon the size of the particles. These results support measures that have already been widely recommended such as having healthcare workers wear masks when treating wounds, or disinfecting the hands following contact with the

patient's environment. However, other measures should be proposed even if they do not yet correspond to usual hospital practices: first, the room should be cleaned not before dressing a colonized wound, but after. Moreover, specific precautions should be taken when making beds (wearing a mask and closing the door to the room, for example). This study thus confirms that the hospital environment may be an indirect reservoir and vector of cross-transmission and once again raises the question of potential "air-borne" type transmission of *S. aureus*.

Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.

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References

- [1] InVS. Enquête nationale de prévalence des infections nosocomiales, France, juin 2006. Saint Maurice: Institut de Veille Sanitaire; 2009.
- [2] Société Française d'Hygiène Hospitalière (SFHH). Surveiller et prévenir les infections associées aux soins. *Hygienes* 2010;18:1–167.
- [3] Duckro AN, Blom DW, Lyle EA, Weinstein RA, Hayden MK. Transfer of vancomycin-resistant *enterococci* via health care worker hands. *Arch Intern Med* 2005;165:302–7.
- [4] Pittet D. Compliance with hand disinfection and its impact on hospital-acquired infections. *J Hosp Infect* 2001;48(Suppl. A):S40–6.
- [5] Bhalla A, Pultz NJ, Gries DM, Ray AJ, Eckstein EC, Aron DC, et al. Acquisition of nosocomial pathogens on hands after contact with environmental surfaces near hospitalized patients. *Infect Control Hosp Epidemiol* 2004;25:164–7.
- [6] Talon D, Excoffon L, Tiv M, Pinçon A, Gbaguidi-Haoré H, Bertrand X. Environmental reservoirs of methicillin resistant *Staphylococcus aureus* in patients' rooms: Potential impact on care practices. *British Journal of Infection Control* 2008;9:10–4.
- [7] Asoh N, Masaki H, Watanabe H, Watanabe K, Mitsusima H, Matsumoto K, et al. Molecular characterization of the transmission between the colonization of methicillin-resistant *Staphylococcus aureus* to human and environmental contamination in geriatric long-term care wards. *Intern Med* 2005;44:41–5.
- [8] Lemmen SW, Hafner H, Zolldann D, Stanzel S, Lutticken R. Distribution of multi-resistant Gram-negative versus Gram-positive bacteria in the hospital inanimate environment. *J Hosp Infect* 2004;56:191–7.
- [9] Boyce JM, Potter-Bynoe G, Chenevert C, King T. Environmental contamination due to methicillin-resistant *Staphylococcus aureus*: possible infection control implications. *Infect Control Hosp Epidemiol* 1997;18:622–7.
- [10] Sexton T, Clarke P, O'Neill E, Dillane T, Humphreys H. Environmental reservoirs of methicillin-resistant *Staphylococcus aureus* in isolation rooms: correlation with patient isolates and implications for hospital hygiene. *J Hosp Infect* 2006;62:187–94.
- [11] Legat S, Crouzet T, Thouverez M, Talon D. Réservoirs environnementaux d'*Acinetobacter baumannii* dans les chambres des patients: impact potentiel sur la transmission croisée. *Hygienes* 2008;16:187–94.
- [12] Obee P, Griffith CJ, Cooper RA, Bennion NE. An evaluation of different methods for the recovery of methicillin-resistant *Staphylococcus aureus* from environmental surfaces. *J Hosp Infect* 2007;65:35–41.
- [13] Shiomori T, Miyamoto H, Makishima K, Yoshida M, Fujiyoshi T, Udaka T, et al. Evaluation of bedmaking-related airborne and surface methicillin-resistant *Staphylococcus aureus* contamination. *J Hosp Infect* 2002;50:30–5.