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Environmental Contamination due to Multidrug-resistant *Acinetobacter baumannii* surrounding Colonized or Infected Patients

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Abstract

BACKGROUND—Multidrug-resistant *Acinetobacter baumannii* (MDR-AB) is an important nosocomial pathogen associated with significant morbidity and mortality.

METHODS—We conducted a prospective cohort study of intensive care unit patients colonized or infected with MDR-AB at a tertiary-care hospital from October 2008 to January 2009. For each patient, 10 surfaces in the patient room were sampled and evaluated for the presence of *A. baumannii*. Pulsed-field gel electrophoresis (PFGE) was performed on all environmental isolates and a clinical isolate if available.

RESULTS—50 rooms were sampled; 48% (24/50) were positive at one or more environmental sites. Supply carts (10/50, 20%); floors (8/50, 16%); infusion pumps (7/50, 14%); and ventilator touch pads (5/44, 11.4%) were most commonly contaminated. Patients with a recent history of MDR-AB were no more likely to contaminate their environment than patients with a remote history (51% vs. 36%, p-value = 0.50). In 85% (17/20) of cases the environmental isolate was classified as genetically similar to the patient isolate.

CONCLUSIONS—For patients with MDR-AB, the surrounding environment is frequently contaminated, even among patients with a remote history of MDR-AB. Surfaces often touched by healthcare workers during routine patient care are commonly contaminated and may be a source of nosocomial spread.

Acinetobacter baumannii has emerged as an important nosocomial pathogen and infection with this organism has been associated with increased patient morbidity, mortality and healthcare costs[1, 2]. Despite current standard practices in infection control, such as the use of barrier precautions and emphasis on hand hygiene, *A. baumannii* continues to gain ground in the healthcare setting[1]. This organism is unique among gram-negative bacilli in its ability to persist in the environment for prolonged periods of time[3] and environmental contamination has been linked to hospital outbreaks suggesting a role in nosocomial transmission[4]. A focus

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on the development of new strategies aimed at reducing environmental contamination of *A. baumannii* may be warranted to prevent ongoing nosocomial spread of this pathogen. While *A. baumannii* is often found in the environment during hospital outbreaks, knowledge relative to the specific environmental sites commonly contaminated in the non-outbreak setting is incomplete. Filling this knowledge gap may offer a new level of defense against this pathogen by allowing for enhanced, targeted cleaning in areas at highest risk for transmission[5]. In this study, we examine a prospective cohort of intensive care unit patients known to be colonized or infected with MDR-AB to determine how frequently the environment surrounding the patient becomes contaminated and which environmental surfaces are most commonly contaminated.

METHODS

Setting

This prospective cohort study was conducted at the University of Maryland Medical Center (UMMC), a 656-bed tertiary care center located in Baltimore, Maryland. The study was carried out in four intensive care units (ICU), including: medical, surgical, cardiac surgery and trauma ICUs.

Design

The prospective cohort consisted of adult (> 18 years of age) patients with a recent or remote history of MDR-AB who were admitted to one of the above ICUs from October 8, 2008 to January 28, 2009. Patients were identified using the UMMC central data repository, a relational database that contains clinical and administrative data. A history of MDR-AB was defined as isolation of *A. baumannii*, susceptible to 2 or fewer classes of antibiotics, from any clinical or surveillance culture obtained at UMMC. Patients whose positive culture was obtained within the 2 months prior to the date of study inclusion were considered to have a *recent* history of MDR-AB; all other patients (those patients who had cultures positive for MDR-AB more than 2 months prior to the date of study inclusion) were considered to have a *remote* history of MDR-AB. Patients identified as having either a recent or remote history of MDR-AB were selected at random for environmental sampling. In order to be included in the study, patients had to have occupied their current room for at least 24 hours prior to the time of environmental sampling; this criterion was included in order to provide enough time for the environment to become potentially contaminated. According to hospital standards, environmental cleaning of patient rooms is performed daily using detailed 12-step process which includes cleaning and disinfection of multiple surfaces in the room using a quaternary amine based product.

UMMC Cleaning and Disinfection Policies and Procedures

Environmental Services policies at UMMC call for daily in-room housekeeping activities following a standardized 12-step approach that includes cleaning and disinfection of all patient furniture and spot cleaning of floors using a quaternary germicidal cleaner. At the time of this study, there were no formal policies mandating daily cleaning of patient care equipment (e.g. ventilators, infusion pumps). At patient discharge equipment is cleaned and disinfected by nursing staff or through a central processing department. Compliance with these policies and procedures was not measured as part of this research study and is unknown.

Data Collection

Environmental samples were obtained while the patient occupied the room. Ten surfaces in each room were sampled: door knob, bedrails, bedside table, vital sign monitor touch pad,

nurse call button, sink, drawer handles of the in-room supply cart, infusion pump, ventilator surface touch pad, and the floor on both sides of the patient bed. At each site, an area of approximately 10 cm^2 was sampled using a sterile cotton swab previously moistened with phosphate-buffered saline. Sampling was performed in accordance with Healthcare Infection Control Practices Advisory Committee (HICPAC) recommendations for environmental surface sampling[6].

Microbiologic Methods

After collection, each of the environmental swabs was immersed in 5 ml of brain-heart infusion (BHI) broth supplemented with 6 μg/ml of imipenem and mixing was achieved via placing the solution on the vortex for 10 seconds. The broth was incubated overnight at 35°C and after incubation was subcultured to a MacConkey II agar plate (Becton Dickinson, Sparks, MD) and a MacConkey II agar plate supplemented with 6 μg/ml of imipenem. Non-lactose fermenting organisms were identified as *A. baumannii* using standard methods. All patient cultures were performed by the UMMC clinical microbiology laboratory as part of the patient's standard care and according to CLSI criteria[7].

Molecular Methods

Molecular typing using pulsed-field gel electrophoresis (PFGE) was performed on all environmental isolates and a representative patient isolate for patients with a recent MDR-AB positive culture. Isolates were digested with *ApaI* as described by Arlet et al[8], and the resulting fragments were separated by electrophoresis in 1% agarose gels on a contour-clamped homogenous-field machine (CHEF-DR II, Bio-Rad, Richmond, CA). Electrophoresis was performed at 120V for 18.5 hours, with pulse times ranging from 7 to 20 seconds. After electrophoresis, gels were stained with ethidium bromide and photographed under ultraviolet illumination. The band patters were compared by means of the Dice coefficient using the unweighted pair-group method to determine band similarity using the criteria established by Tenover et al to define pulsed-field type clusters[9]. According to these criteria, band patterns were classified as identical (no band differences), closely related (3 or less band differences), possibly related (four to six band differences) and unrelated.

RESULTS

A total of 479 samples were collected from 50 rooms (housing 50 unique patients) during the study period. Twenty-one environmental sites (1 bedrail, 11 bedside tables, 3 nurse call buttons, and 6 ventilators) were missing from 20 patient rooms and thus were not sampled. In all, 9.8% (47/479) of samples were positive for growth of *A. baumannii*; and 48% (24/50) of patient rooms sampled were positive for growth of *A. baumannii* at one or more environmental sites. Drawer handles of supply carts (10/50, 20%); floors (8/50, 16%); infusion pumps (7/50, 14%); ventilator touch pads (5/44, 11.4%) and bed rails (5/49, 10.2%) were most commonly contaminated; followed by nurse call buttons (4/47, 8.5%), vital sign monitor touch pads (3/50, 6%), sinks (2/50, 4%), door knobs (2/50, 4%) and bedside tables (1/39, 2.5%).

Among the patients occupying the 50 rooms sampled, 39 (78%) had a recent positive culture for MDR-AB. Patients with a recent history of MDR-AB were not significantly more likely to contaminate their environment than patients with a remote history (51% vs. 36%, p-value = 0.50).

Among the 24 patient rooms in which an environmental culture was positive for *A. baumannii*, 20 patients had a recent history of MDR-AB. For these, the median (range)

number of days from patient culture collection to environmental culture collection was 4 (0 to 23). In 17 of 20 instances, environmental isolates were genetically similar (identical or closely related) to the patient isolate by PFGE (Table 1). A single pulsed field type (PFT_3) predominated among all patient and environmental isolates; however, these patients were not clustered in the same geographical area of the hospital nor did their hospital stays overlap in time (data not shown).

DISCUSSION

Current guidelines call for "regular" cleaning of hospital surfaces[6], however, details regarding the frequency of cleaning and which surfaces may be most contaminated, and thus most likely to lead to transmission, are absent. In a recent review, Dancer calls for "increased or targeted cleaning" to prevent nosocomial transmission; however, also states that details related to specific site and the risk of transmission are still needed. Our study shows that for *A. baumannii* the patient's surrounding environment is frequently contaminated (48% of the time), even among patients with a remote history of MDR-AB and that surfaces often touched by healthcare workers during routine patient care are the most commonly contaminated.

Laboratory-based studies and outbreak investigations have demonstrated that *A. baumannii* has a unique ability to survive for prolonged periods of time in the environment[10–12]. Few studies, however, have sought to describe the frequency of contamination and identify the environmental surfaces most commonly contaminated in the endemic setting. Two previous studies sampled environmental surfaces surrounding patients known to be colonized or infected with MDR-AB and identified A. baumannii in 2.3% (24 patients, 513 samples) and 7.3% (12 patients, 151 samples) of samples; compared to 9.8% in our study[13, 14]. Information regarding the frequencies of contamination for each site is not provided and so comparisons among studies and to our study cannot be made. Also, most of the prior studies were done outside the United States and were with different genotypic *A. baumannii* strain types.

The sites most commonly contaminated in our study, such as the supply carts, infusion pumps, ventilator touch pads and bed rails are also sites that are commonly touched by healthcare workers during routine patient care. These results are consistent with studies of other important nosocomial pathogens[15–17], such as methicillin-resistant *Staphylococcus aureus*, vancomycin-resistant *Enterococcus* and *Clostridium difficile*, and suggest that more emphasis needs to be placed on the cleaning and disinfection of these surfaces. However, other studies have shown that cleaning of these sites (in particular, electrical equipment) is often overlooked due to uncertainties between environmental service employees and nursing staff regarding responsibility of duties[5, 15, 17]. Education of both environmental services and nursing staff, enhanced cleaning of frequently contaminated areas, and potentially routine screening of environmental surfaces to ensure adequate cleaning may be warranted. In part as a response to the results presented here, UMMC instituted a new policy for the cleaning and disinfection of ventilators once per shift, by respiratory therapists.

Another important finding in our study is that patients with a recent history (within 2 months prior to the time of environmental sampling) of MDR-AB colonization or infection were not significantly more likely than those with a remote history of MDR-AB to contaminate their environment (although, there was a trend for higher contamination of the environment among patients with a recent history of MDR-AB). Classification of colonization/infection status was based on the results of cultures performed by the primary medical team and although surveillance cultures were not performed by research staff on the same date of environmental culture collection to confirm colonization/infection status, these findings

suggest that patients remained colonized. This finding supports existing literature which suggests that patients may be persistently colonized with MDR-AB[18]. Based on the results of this study a case could be made for continuing the use of barrier precautions for all patients with a history of MDR-AB and future studies may be necessary to determine the effectiveness of active surveillance for the detection of MDR-AB colonization.

This study has several potential limitations. To our knowledge, this is the largest sample of patients colonized or infected with MDR-AB for which the frequency of environmental contamination was evaluated; however, we are still limited by small sample size and the lack of a comparison group; larger multicenter comparative studies may provide more generalizability to these results and strengthen causality. Although this study was strengthened by the use of molecular typing to ensure the environmental isolate was genetically similar to the patient isolate, we were not able to determine which came first, environmental contamination or patient colonization/infection. Despite this limitation, however, identification of environmental contamination demonstrates the potential risk of nosocomial transmission. Also, since our methods used an imipenem-enriched broth to identify *A. baumannii* from environmental cultures, isolates which were imipenem-susceptible may have been missed. This would however, would suggest that the prevalence of environmental contamination by *A. baumannii* is potentially greater than what is presented here. Finally, while contamination of commonly touched environmental surfaces with *A. baumannii* is a potential source for nosocomial transmission, this study did not evaluate healthcare worker or patient movement and thus we cannot demonstrate patient-to-patient transmission as a result of environmental contamination.

In conclusion, we found that the environmental surfaces of patients who are colonized or infected with MDR-AB are frequently contaminated, even for those patients with a remote history of MDR-AB. In addition, surfaces often touched by healthcare workers during routine patient care are commonly contaminated and may be a source of nosocomial transmission. Future prospective studies in which surveillance cultures are obtained from the patients, their immediate environment (as has been done for other important hospital pathogens[19, 20]) and from healthcare workers would be helpful in determining the causal direction and nosocomial transmission of this pathogen as a result of environmental contamination. Furthermore, novel techniques such as enhanced cleaning of high-risk areas and routine screening of the environment to ensure adequate cleaning may be necessary and requires further investigation.

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TABLE 1

Molecular Typing Results of Clinical and Environmental *Acinetobacter baumannii* Isolates.

	Positive Clinical Culture (Pulsed-Field Type)[a]	Positive-Environmental Culture (Pulsed-Field Type)[b]	PFGE results[*]	Time (days) from Clinical[a] to Environmental[b] Culture
1	Catheter Tip (3F)	Nurse call button (3F)	Identical	10
2	Bronchial (3K)	Infusion pump (3K)	Identical	1
3	Wound (5)	Supply cart (4E), Floor (3F)	Unrelated	5
4	Bronchial (3K)	Door knob, Infusion pump (3K)	Identical	5
5	Bronchial (6)	Supply cart (7)	Possibly related	0
6	Sputum (3F)	Infusion pump (3F)	Identical	2
7	Biopsy (3F)	Vital sign monitor (3G)	Closely related	4
8	Catheter Tip (9)	Supply cart (9)	Identical	1
9	Sputum (4A)	Ventilator (4A) Sink (4B)	Identical Closely related	1
10	Sputum (3F)	Supply cart, Infusion pump (2 strains), Floor (3F)	Identical	4
11	Blood (3C)	Ventilator (3C)	Identical	3
12	Surveillance (8)	Vital sign monitor, supply cart, infusion pump, floor (3F) Ventilator (3A)	Unrelated Unrelated	23
13	Bronchial (1A)	Floor (1B)	Closely related	12
14	Body Fluid (3H)	Floor, bedrails, supply cart, infusion pump, ventilator (3H) Door knob (3I)	Identical Closely related	15
15	Sputum (3F)	Bedrails, Nurse call button, infusion pump (3F) Supply Cart (3J)	Identical Closely related	6
16	Surveillance (4C)	Supply cart (4D)	Closely related	2
17	Wound (2)	Floor (2)	Identical	6
18	Sputum (4D)	Bedrails, Supply cart (4D)	Identical	2
19	Sputum (3A)	Nurse call button (3B)	Closely related	3
20	Surveillance (3D)	Supply cart, Ventilator (3D) Sink (3L), Bedrails (3E), Vital sign monitor (3F)	Identical Closely related	5

[*] PFGE Results listed represent a comparison of the isolate identified in the environment to the patient isolate and are based on Tenover's criteria