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BRIEF REPORT

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Air ionisation and colonisation/infection with methicillin-resistant *Staphylococcus aureus* and *Acinetobacter* species in an intensive care unit

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Abstract *Objective:* To determine effect of negative air ions on colonisation/infection with methicillin-resistant *Staphylococcus aureus* (MRSA) and *Acinetobacter* species in an intensive care unit. *Design:* Prospective single-centre cross-over study in an adult general intensive care unit. *Patients:* 201 patients whose stay on the unit exceeded 48 hour's duration. *Intervention:* Six negative air ionisers were installed on the unit but not operational for the first 5 months of the study (control period). Devices were then operational for the following 5.5 months. *Measurements and results:* 30 and 13 patients were colonised/infected with MRSA and *Acinetobacter* spp., respectively, over 10.5 months. No change in MRSA colonisation/infection was observed compared with the 5 month control period. *Acinetobacter* cases were reduced from 11 to 2 ($p = 0.007$). *Conclusion:* Ionisers may have a role in the prevention of *Acinetobacter* infections.

Keywords *Acinetobacter* · Healthcare-associated infection · Ionisation · Nosocomial infection · *Staphylococcus aureus*

Introduction

Healthcare-associated infections affect approximately 10% of hospitalised patients and are associated with significant morbidity and mortality. They represent a substantial financial burden for healthcare providers and have attracted much interest in both the medical and lay press. Much of the effort expended in countering exogenously-acquired healthcare-associated infection is directed at interrupting transmission of microorganisms through direct contact, for example, through promoting good hand hygiene. Comparatively little attention has been paid to the importance of the airborne route of transmission in the epidemiology of healthcare-associated infection. Nevertheless, there is increasing evidence that significant Gram-negative bacterial pathogens, such as *Pseudomonas aeruginosa* and *Acinetobacter* spp., may be transmitted in this way [1]. Recognition of the importance of the

airborne route of transmission has led to the introduction of technologies to remove or inactivate airborne microorganisms, such as high-efficiency particulate arrestance (HEPA) filtration and UV-C irradiation. We report here on a pilot study of the effects of negative air ionisation on the incidence of nosocomial methicillin-resistant *Staphylococcus aureus* (MRSA) and *Acinetobacter* spp., infection/colonisation in an intensive care unit.

Materials and Methods

The study, approved by the Leeds Teaching Hospitals Trust research ethics committee, took place on a nine-bedded open plan area of an intensive care unit from July 2001 to May 2002. This has a floor area of 212 m^2 and is a ventilated and air-conditioned space. The unit was chosen because of a relatively high incidence of infections with MRSA and *Acinetobacter* spp. Six wall-mounted negative air ionisers (Air Ion Technologies, New Milton, Hants, UK) fitted with HEPA filters, which cleaned recirculated air before it passed over the ionising electrodes, were used. The negative air ion concentration in ward air was recorded with a portable ion counter (Air Ion Technologies). Environmental sampling took place at two sites on the unit bi-weekly for the duration of the study. Samples were obtained from bed frames, mechanical ventilators and LCD monitor screens, by swabbing and plating onto selective/differential media: Leeds Acinetobacter Medium [2] and mannitol salt agar supplemented with methicillin (for isolation of MRSA). Twice weekly air sampling was performed using a C90M cyclone air sampler (Burkard Manufacturing, Uxbridge, UK) with plating onto each medium as above. All sampling was performed in duplicate. Patients whose stay on the unit was expected to exceed 48 h were screened on admission to the unit, twice weekly thereafter and on discharge for *Acinetobacter* spp., or MRSA by obtaining swabs from groins, nose, mouth and rectum. Additionally, specimens obtained for routine diagnostic purposes were also used to identify infection or colonisation with these bacteria. Statistical analysis was conducted using the Mann–Whitney (two-sample Wilcoxon), sign, Spearman's rank correlation and χ^2 and Fisher's exact tests.

Table 1 *Acinetobacter* spp. and MRSA colonisation/infection and environmental levels of *Acinetobacter* spp., MRSA and total viable counts during periods when ionisers were out of use/in use, respectively (*MRSA* methicillin-resistant *Staphylococcus aureus*)

	Ionisers off		Ionisers on‡		Statistical significance
Study period	2/07/01–27/11/01		28/11/01–17/12/01 & 8/01/02–15/05/02		– –
Number of study days	149	–	148	–	–
Number of study patients	95	–	106	–	–
Acinetobacter spp.					
Infections/Colonisations (number)	11.0	–	2.0	–	–
Infections/Colonisations (%)	11.6	–	1.9	–	0.007
Combined sites – Isolates (median, range)					
Airborne*	0, 0	($n=30$)	0, 11.5	($n=60$)	0.0002
Monitor**	0, 0.5	($n=30$)	0, 5	($n=60$)	0.017
Ventilator grille**	0, 5	($n=30$)	0, 2.5	($n=60$)	0.206
Bed base**	0, 0.2	($n=30$)	0, 3	($n=60$)	0.002
MRSA					
Infections/colonisations (number)	15.0	–	15.0	–	
Infections/colonisations (%)	15.8	–	14.2	–	0.843
Combined sites – isolates (median, range)					
Airborne*	0, 8.5	($n=30$)	0, 6.5	($n=60$)	0.004
Monitor**	0, 57	($n=30$)	0, 6	($n=60$)	0.646
Ventilator grille**	0, 5	($n=30$)	0, 11	($n=60$)	0.651
Bed base**	1.5, 171.5	($n=30$)	0.5, 32	($n=60$)	0.054
Total viable count					
Combined sites – isolates (median, range)					
Airborne*	2.5, 59.5	($n=30$)	6, 49.5	($n=60$)	0.014
Monitor**	4.5, 82	($n=30$)	4.5, 48	($n=60$)	0.700
Ventilator grille**	3.75, 35	($n=30$)	5, 42	($n=60$)	0.259
Bed base**	19.5, 157	($n=30$)	9.75, 178.5	($n=60$)	0.020

‡ Ionisers not functional in part of ionisers-on period (see text)

* CFU/m^3

** CFU

Results

The ionisers were installed but not in operation for the first 5 months (control period) and were then switched on for the next 5.5 months. During the control period, the negative air ion count averaged 146 ions cm^{-2} (typical of an air-conditioned building), but rose to a maximum of 1,900 ions cm^{-2} when the devices were operational. Two hundred one (201) patients were entered into the study. Thirty were colonised/infected with MRSA and 13 with *Acinetobacter* spp. (Table 1). The incidence of MRSA-infected/colonised patients remained unchanged over the study ($p = 0.843$). However, for *Acinetobacter* spp., there were two cases when the ionisers were in operation, compared with 11 when they were not ($p = 0.007$, Fisher's exact test). It should be noted that four cases of *Acinetobacter* colonisation/infection occurred in late December 2001/early January 2002, after the relative humidity of the air in the ICU became extremely high as a result of a faulty humidifier in the air conditioning system. This is important, as high humidity prohibits negative air ion production [3]. Thus, although the ionisers were deemed to be operational, they were non-functioning. Even if these cases are included in the ionisers-on period, there was still an overall reduction in *Acinetobacter* infection/colonisation compared with the ionisers-off period, although statistical significance is no longer observed.

The results from environmental sampling showed that, at both sampling sites, *Acinetobacter* spp. isolates increased significantly when the ionisers were in operation; however, there was no consistent effect observed for MRSA isolates (data not shown).

Discussion

Multiple antibiotic-resistant *Acinetobacter* spp. have emerged as significant healthcare-associated pathogens, especially for critically ill patients, and these bacteria have become endemic in many intensive care units [4]. There has been much interest in strategies to prevent or reduce nosocomial transmission of these bacteria. There is increasing evidence that the airborne route of transmission is important in the epidemiology of *Acinetobacter* infections [5]. Our study intended to evaluate the use of negative air ionisation as an intervention to interrupt the spread of *Acinetobacter* in this manner. Although a reduction in infection/colonisation of patients with these bacteria was noted, there was, however, an increase of *Acinetobacter* spp. in the air as well as on inanimate surfaces. Whilst the latter might have been expected as a result of electrostatic and gravitational deposition, the former appears to be a paradoxical finding. However, this might be explained by the fact that aggregates of bacteria formed as a result of contact with ions might be better able to survive air-sampling processes that are known to be inimical to the survival of Gram-negative bacteria [6].

Our observations provide further evidence that the airborne route of transmission is important in the epidemiology of nosocomial *Acinetobacter* infections and suggest that control of these infections with negative air ionisation is promising and worthy of further investigation.

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