CONCISE COMMUNICATION

# Infrequent Air Contamination With *Acinetobacter baumannii* of Air Surrounding Known Colonized or Infected Patients

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Using a validated air sampling method we found *Acinetobacter baumannii* in the air surrounding only 1 of 12 patients known to be colonized or infected with *A. baumannii*. Patients' closed-circuit ventilator status, frequent air exchanges in patient rooms, and short sampling time may have contributed to this low burden.

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*Acinetobacter baumannii* causes a variety of healthcare-associated infections with increased morbidity and mortality.[1] Studies have demonstrated a potential for airborne transmission of *A. baumannii*, which has important implications regarding reducing transmission of *A. baumannii* in the hospital setting. However, lack of detail about air sampling techniques and absence of patient-level information make it difficult to draw conclusions.[2–4] The aim of this study was to assess air contamination with *A. baumannii* in an endemic situation using a validated air sampling impaction method and to examine associated patient factors.

## METHODS

This study was conducted at the University of Maryland Medical Center in Baltimore, Maryland, from May 1 through December 31, 2013. Subjects were enrolled from the medical, surgical, and cardiac surgery and trauma intensive care units. All rooms are single patient occupancy. Rooms have at least 6 air changes per hour and a minimum relative humidity of 30% in winter and 60% in summer. Active surveillance screening for *A. baumannii*, with perianal sampling at each admission, was performed in all study intensive care units during the study period per infection prevention policies. Patients were identified as infected or colonized with *A. baumannii* if they had any culture (surveillance or clinical) positive for growth of *A. baumannii* within the preceding 10 days.

For each patient, air surrounding the patient was sampled for 1 hour, 3 feet from the head of the bed, with a Six-Stage Viable Andersen Cascade Impactor (ThermoScientific) using standard methods described in other airborne transmission studies.[5] Previous studies have shown that relative humidity is stable during the first hour of air sampling, which makes conditions ideal for survival of viable bacteria.[5] After that period there is a potential for drying of the agar plate, which may result in difficulty culturing the bacteria. The impaction method is designed to separate particles from air flow and embed them onto an agar surface. The Six-Stage Viable Andersen Cascade Impactor has a vacuum pump that draws air at a speed of 28.3 liters/minute through 6 layers of agar plates, each layer composed of orifices of decreasing diameter, representing the human respiratory tract (Figure 1). All air sampling was performed between the hours of 9 AM and 5 PM. RambaCHROM *Acinetobacter* selective agar (Gibson Bioscience) plates were used for all air samples; this agar selects for *A. baumannii* regardless of susceptibilities.[6] Plates were then incubated at 37°C in ambient air for 24 hours. Identification confirmation and susceptibility testing were performed using the Vitek II system (bioMérieux).

Patient demographic and clinical data was obtained. Multidrug-resistant *A. baumannii* was defined as susceptible to 2 or fewer classes of antibiotics, a standard definition used in other studies.[7] For patients with a sputum sample positive for *A. baumannii,* presence of pneumonia as defined by Centers for Disease Control and Prevention/National Healthcare Surveillance Network criteria was noted.[8]

## RESULTS

Air surrounding 12 patients known to be infected or colonized with *A. baumannii* was sampled. *A. baumannii* was identified from the air samples surrounding 1 (8%) of the 12 patients. Table 1 gives the characteristics of all patients sampled, including patient 1 who had the positive air sample. The mean age of the group was 59 years; 4 (33%) were women. Most patients (7 [58%]) were transferred from another acute care hospital, 1 (8%) from long-term care, and the remaining 4 from home. Multidrug-resistant *A. baumannii* was found in 7 (58%) of 12 patients. Sputum culture was positive for *A. baumannii* in 9 (75%) of 12 patients and 2 (22%) of these patients met criteria for pneumonia. Closed-circuit mechanical ventilation was present in 7 (58%) of 12.

## DISCUSSION

We cultured *A. baumannii* from air surrounding only 1 of 12 patients who were infected or colonized with *A. baumannii.* This patient had the longest length of stay at 77 days and it is possible that his environment may have been more saturated owing to time. However, the lack of *A. baumannii* found differs from the small number of other studies where *A. baumannii* has been found more frequently in the air.[2–4] Published studies on this topic are few, use differing air

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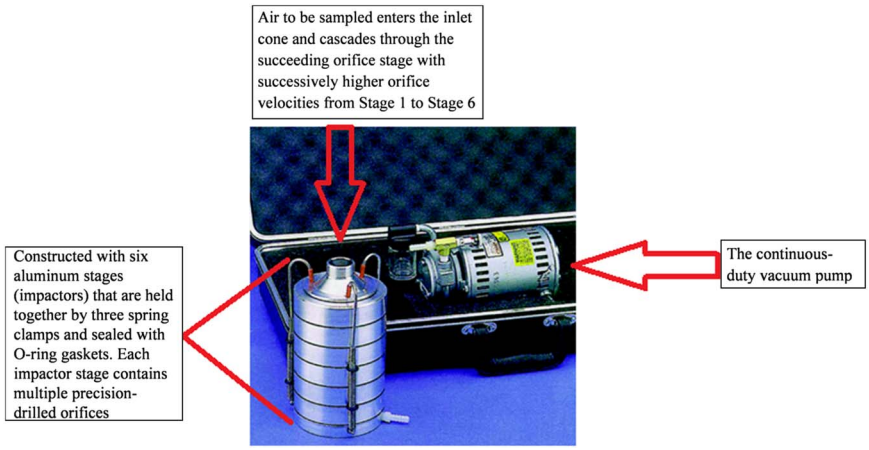


FIGURE 1. A six-stage Viable Anderson impactor used for active air sampling.

TABLE 1. Characteristics of Patients Infected or Colonized With *Acinetobacter baumannii* Who Had Surrounding Air Sampled

| Patient | LOS[a] | Days from culture[b] | Culture site[c] | PNA[d] | MDR[e] | Antibiotic[f] | MV[g] | UC[h] | CVC[i] | Diarrhea |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 77 | 7 | CA, S | No | Yes | NS | Yes | Yes | Yes | Yes |
| 2 | 17 | 7 | PA, S | No | Yes | S | No | Yes | No | No |
| 3 | 19 | 8 | S | No | Yes | NS | No | No | No | Yes |
| 4 | 8 | 1 | S | No | Yes | S | Yes | No | No | Yes |
| 5 | 11 | 8 | PA, S | Yes | No | S | Yes | Yes | Yes | Yes |
| 6 | 16 | 5 | S | No | No | S | Yes | Yes | Yes | Yes |
| 7 | 3 | 3 | PA, S | Yes | Yes | S | Yes | Yes | Yes | No |
| 8 | 10 | 4 | PA | … | Yes | NS | No | Yes | Yes | No |
| 9 | 10 | 7 | PA, W | … | Yes | NS | Yes | Yes | Yes | No |
| 10 | 65 | 6 | S | No | No | S | Yes | No | Yes | Yes |
| 11 | 6 | 6 | B | … | No | S | Yes | Yes | Yes | No |
| 12 | 11 | 5 | S | No | No | S | Yes | Yes | No | No |

[a]LOS = length of stay from hospital admission to time of air sample, in days.
[b]Days from time of most recent *A. baumannii* positive culture to time of air sample.
[c]Culture site, where B = blood culture; CA = catheter tip culture; PA = perianal surveillance culture; S = sputum culture; W = wound culture.
[d]PNA = presence of pneumonia as defined by the Centers for Disease Control and Prevention/National Healthcare Surveillance Network.[8]
[e]MDR = multidrug-resistant *A. baumannii*; an isolate was considered multidrug-resistant if it was non-susceptible to at least 1 agent in ≥3 antimicrobial classes.
[f]All patients were receiving antibiotics at the time of air sampling; S = the antibiotic received was susceptible and NS = non-susceptible.[7]
[g]MV = mechanical ventilation at the time of air sampling; all ventilation was closed-circuit.
[h]UC = urinary catheter present at the time of air sampling.
[i]CVC = central venous catheter present at the time of air sampling.

sampling techniques, and note minimal patient-level data, making it difficult to draw conclusions.[2–4]

Air sampling methods are categorized as passive or active.[9] The use of settle plates is a common method of passive air sampling. Uncovered agar plates are exposed to the air and when the plate is cultured one can identify which bacteria fell from the air onto the plate.[10] This technique is simple and inexpensive but not sensitive and gives no quantitative impression of bacteria in the air. Conversely, an active method, such as the air impactor used in this study, is more beneficial if one is trying to assess a concentration of inhalable viable particles.[10] Settle plates, however, have been used to identify *A. baumannii* in the air in outbreak settings. These studies are infrequent and provide little detail regarding patient-level factors. An *A. baumannii* outbreak investigation in 1987 using this technique was the first to suggest that it may be aerially disseminated.[2] A recent study of trauma intensive care unit patients colonized or infected with multidrug-resistant *A. baumannii* found that in 52% of cases the air surrounding patients was contaminated by use of settle plates.[3] A 2011 study performed in China, using an air impactor similar to what we used in this study, found *A. baumannii* in 16 air samples.[4]

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Air was sampled for just 10 minutes using the Six-Stage Viable Anderson Cascade Impactor. However, information regarding number of air samples taken, proximity of sampler to patients, or patient factors was not provided.

Our findings differ from other most recent studies on the topic.[3] Possible reasons for our findings are as follows. Most (9 [75%]) of the patients in this study were on closed-circuit mechanical ventilation system at the time of sampling. It is plausible that those on closed-circuit ventilation systems are less likely to have airborne dissemination. Another potential reason is the dilution effect by air exchanges. Our intensive care unit has at least 6 air exchanges per hour in patient rooms. This may contrast with older studies that may have taken place when ventilation of rooms would not have been as established and air exchange not as frequent.[2] Eight (66%) of 12 patients in our study were receiving antibiotics to which the *A. baumannii* was susceptible. The antibiotics received may have decreased the patient burden of *A. baumannii* and thus contributed to lack of aerial dissemination. Also, air contamination may not be continuous and may not have been captured in our 1-hour sampling time.

This study questions whether *A. baumannii* is commonly spread by airborne transmission. Perhaps publication bias has prevented the publication of other studies finding infrequent air contamination with *A. baumannii*. Further research is needed with a larger number of patients, under varying conditions, such as mechanical ventilation, with repeated and longer air sampling at different times. It would be important to note activities in the room, such as changing of linens and manipulation of the ventilator (eg, during suctioning). These studies could determine if and which patients are more likely to contaminate the surrounding air and establish a potential role for airborne transmission of this important pathogen.

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