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Major Article

Is airborne transmission of *Acinetobacter baumannii* possible: A prospective molecular epidemiologic study in a tertiary care hospital

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Aerial spread
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Background: Understanding the dynamics of aerial spread of *Acinetobacter* may provide useful information for production of effective control measurements. We investigated genetic relationships between air and clinical isolates of *Acinetobacter baumannii* in an intensive care unit (ICU) setting.
Methods: We conducted a prospective surveillance study in a tertiary care hospital for 8 months. A total of 186 air samples were taken from 2 ICUs. Clonal characteristics of air isolates were compared with the prospective clinical strains and the previously isolated strains of ICU patients over a 23-month period.
Results: Twenty-six (11.4%) air samples yielded *A baumannii*, of which 24 (92.3%) isolates were carbapenem-resistant. The *Acinetobacter* concentration was the highest in bedside sampling areas of infected patients (0.39 CFU/m^3). Air isolates were clustered in 13 genotypes, and 7 genotypes (including 18 air strains) were clonally related to the clinical strains of 9 ICU patients. One clone continued to be cultured over 27 days in ICU air, and air isolates could be clonally related to 7-week retrospective and approximately 15-week prospective clinical strains.
Conclusions: The results of this study suggest that infected patients could spread significant amounts of *Acinetobacter* to ICU air. These strains could survive in air for some weeks and could likely still infect new patients after some months. Special control measurements may be required against the airborne spread of *Acinetobacter* in ICUs.
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Acinetobacter baumannii is a gram-negative nonfermentative coccobacillus responsible for various life-threatening infections in health care settings. Due to the considerable ability of this bacterium to develop resistance for many classes of antimicrobials, the infections caused by *Acinetobacter* frequently result in significant mortality and morbidity.[1] Studies have reported that more than 80% of *Acinetobacter*-infected patients in an intensive care unit (ICU) may die,[2] and such infections can be associated with prolonged ICU stays of 15 days or longer and hospital stays of 30 days or longer.[3]

In hospitals, infections due to *Acinetobacter* generally develop as a result of the acquisition of this bacterium by handborne transmission from a source,[4] by using contaminated medical tools or devices,[5] and prior colonization of the patients at admission.[6] However, despite extensive infection control efforts, the incidence of *Acinetobacter* has increased all over the world during the past decade.[7] This is partly due to the excellent ability of this genus to adapt to different physical and chemical environments; it is also likely due to incomplete understanding of the spreading dynamics of *Acinetobacter*.[8] Hence, increasing interest has been focused on the airborne transmission of this bacterium.[9]

Some authors have reported that indoor air may be contaminated by *A baumannii* in hospital settings, and a genetic link between air isolate and an infecting strain has been demonstrated in a few studies.[10,11] However, no data exist about how long an aerial *Acinetobacter* can survive in ICU air, and whether an airborne strain can cause an infection in a prospective patient.

During early 2007, the Hospital Infection Control Committee (HICC) of our medical center developed an initiative to reduce health care-associated infections in our hospital, including a number of actions, such as active surveillance of nosocomial pathogens,

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implementation of standard infection control measurements, hand hygiene campaigns, frequent staff education, and standardization and enforcement of sterilization and disinfection procedures. Consequently, the rate of health care-associated infections was reduced by more than 5-fold in some clinics, and the incidence of many common nosocomial pathogens was substantially reduced. However, the incidence of *Acinetobacter* increased by more than 2-fold in our ICUs during the same period. Therefore, we conducted this study to understand the dynamics of *Acinetobacter* spread by air in 2 ICUs being actively used throughout an 8-month prospective and a 23-month retrospective period. We think that the results of this study may provide useful information for infection preventionists to consider particular measurements against possible airborne *Acinetobacter* threat.

MATERIALS AND METHODS

Setting and study design

A prospective surveillance study was conducted in Turgut Ozal Medical Center, an 1,140-bed teaching hospital with 255 ICU beds in 15 different wards. Two medical ICUs (ICU-I and ICU-II) (20 beds total) were selected as the cohort area for this study. All ICUs of the facility were being ventilated by a high- efficiency particulate arresting air conditioning system complying with the requirements of Deutsches Institut für Normung 1946-4:1999 standards. No human subject was used in this study.

Air sampling

Active air sampling was done by using an air IDEAL 3P device (BioMérieux, Marcy-l'Étoile, France) according to the manufacturer's instructions. This device is an impactor-type instrument that aspirates indoor air through a grid perforated with a pattern of 286 calibrated holes. The resulting airstreams containing microbial particles are directed onto the surface of a 100-mm agar plate. Use of the air IDEAL 3P device was validated by a third-party institution to meet International Organization for Standardization 14698-1 requirements for the control of clean rooms; it was shown to efficiently collect 100% of particles above 5 µm using the reference air sampling method of the UK Health Protection Agency.[12]

Air samples were taken from 4 previously defined points in ICU-I and ICU-II at 7- to 10-day intervals. Additionally, when a patient in these units was diagnosed with *Acinetobacter* infection, further air sampling was done on the same day from patient's bedside and from the previously defined sampling areas in the ICU. We collected 2 samples at a distance of 1 m from the bed, and 1 sample each at a distance of 2 m and 3 m, as indicated in Figure 1. Before each sampling session, control air samples were also taken under the blower vents.

Identification and antimicrobial susceptibility

Air-inoculated plates were incubated at 35°C for 24-48 hours. Any growing microorganisms were then counted, and colony-forming units were calculated per meter^3 air and identified with classic bacteriologic procedures and the Vitek II System (BioMérieux). Antimicrobial susceptibility of any *A baumannii* strains isolated was assessed using Vitek II susceptibility cards, and the results were evaluated according to Clinical and Laboratory Standards Institute criteria.[13]

Genotyping

All *A baumannii* strains were molecularly typed with DiversiLab System (BioMérieux), a repetitive sequence-based polymerase chain

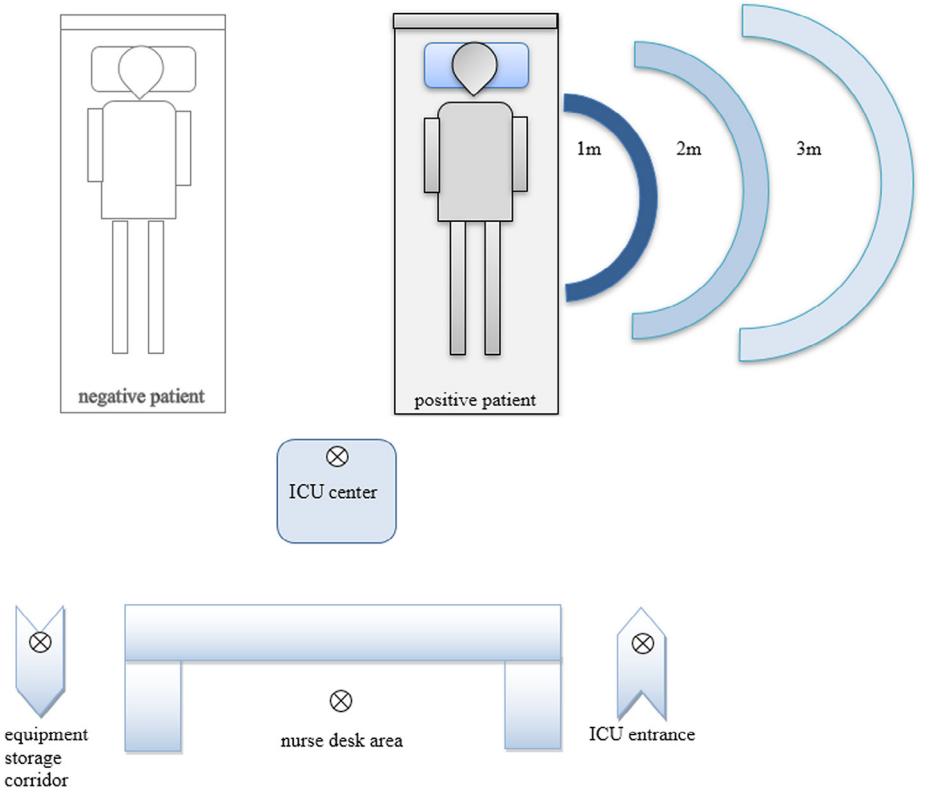

Fig 1. Air sampling areas in intensive care units (ICUs).

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