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Major article

Real-time measurements of airborne biologic particles using fluorescent particle counter to evaluate microbial contamination: Results of a comparative study in an operating theater

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Background: Airborne bacterial contamination poses a risk for surgical site infection, and routine surveillance of airborne bacteria is important. Traditional methods for detecting airborne bacteria are time consuming and strenuous. Measurement of biologic particle concentrations using a fluorescent particle counter is a novel method for evaluating air quality. The current study was to determine whether the number of biologic particles detected by the fluorescent particle counter can be used to indicate airborne bacterial counts in operating rooms.

Methods: The study was performed in an operating theater at a university hospital in Hefei, China. The number of airborne biologic particles every minute was quantified using a fluorescent particle counter. Microbiologic air sampling was performed every 30 minutes using an Andersen air sampler (Pusong Electronic Instruments, Changzhou, China). Correlations between the 2 different methods were analyzed by Pearson correlation coefficients.

Results: A significant correlation was observed between biologic particle and bacterial counts (Pearson correlation coefficient = 0.76), and the counting results from 2 methods both increased substantially between operations, corresponding with human movements in the operating room.

Conclusion: Fluorescent particle counters show potential as important tools for monitoring bacterial contamination in operating theatres.

Surgical site infections (SSI) are serious problems in modern medicine and can result in nosocomial infections, reoperation, and even death.[1] It is generally accepted that airborne bacterial contamination is the main factor causing SSI, and clean environments in operating theaters could effectively reduce the incidence of SSI.[2-4] Recently, microbiologic monitoring of air quality has garnered attention, and a variety of technologies and instruments have been applied to monitoring airborne bacterial contamination.[5] Conventional methods used for detecting airborne bacterial counts include 2 steps, microbiologic air sampling and bacterial culturing, which take 2-3 days in total, limiting the effectiveness and timeliness of reporting airborne bacterial contamination.

Using fluorescent particle counters provides a new method for evaluating air quality by detecting the number of biologic particles in the air.[6] The measurement of biologic particle counts is less demanding than conventional methods and offers real-time results. Our previous study reported the results of a laboratory evaluation of the fluorescent particle counter used in this experiment, in which the solutions of each sample were prepared by aerosol generators. The results demonstrated the discrimination

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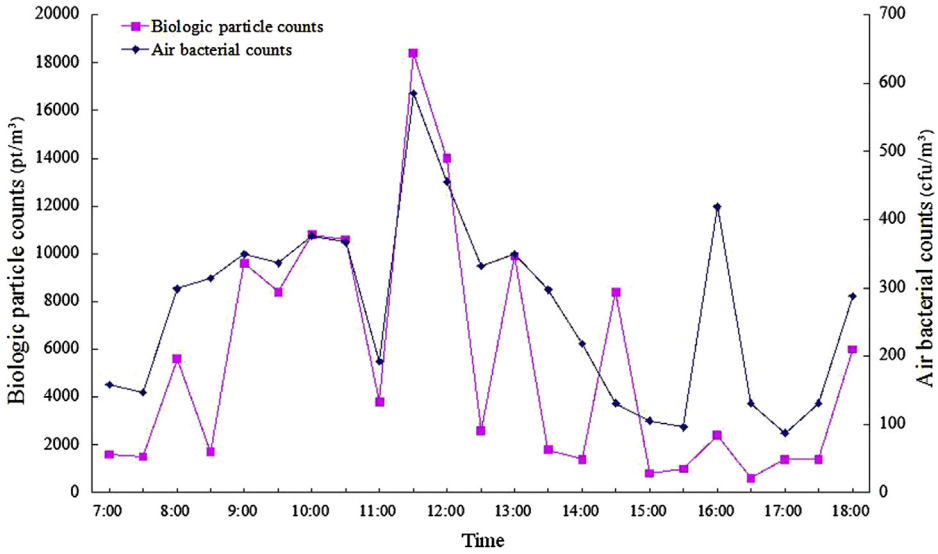

Fig 1. Line chart of biologic particles and airborne bacterial counts from 7:00 AM-6 PM with a half-hour time interval. Pearson correlation coefficient was 0.76. *cfu*, colony forming units; *pt*, particles triggered.

capability of bioaerosols from nonbioaerosol background components and the ability to distinguish different types of bioaerosol particles.[7] However, the relationship between microbiologic air sampling and fluorescent particle counting has not been reported. The present study focused on the application value of fluorescent particle counter in operating rooms and also evaluated the variations of biologic particle counts and the factors influencing the measured results.

METHODS

This study was performed over a period of 11 hours on July 19, 2012, in an operating room of the Anhui Provincial Hospital in Hefei, China. From 7:00 AM-6 PM, there were 3 consecutive operations performed in this operating room. Airborne bacterial counts were measured using an Anderson air sampler (Puseng Electronic Instruments, Changzhou, China) every 30 minutes. Concurrently, biologic particle concentrations were detected using a fluorescent particle counter every minute. Throughout the study period, detailed information from the operating room was recorded, including use of surgical equipment, specific medical practices, activities of the medical staff, and times when cleaning took place.

Microbiologic study

Microbiologic measurements were performed using an impactor air sampler (Anderson Air Sampler; PSW 6-level mesh impact type of air microorganism sampler), which was positioned at a height of 1.1 m and was 1.5 m away from the operating table. Samples were collected at a flow rate of 28.3 L/min for 5 minutes. The collected air samples were plated onto blood agar (bioMérieux Industry, Shanghai, China) and incubated at 35°C for 48 hours. Microbiologic results were expressed as colony forming units (cfu) per cubic meter.

Fluorescent particle counting

Biologic particles were measured using a fluorescent particle counter (BAC-6825, Institute of Optical Precision Machinery, Anhui, China). The counter was placed next to the Anderson air sampler at the same sampling height. According to the counter instructions, the experimental settings were as follows: the flow rate was 1.0 L/min, the ultraviolet current was 1.46 A, and the photo multiplier tube voltage was 550 V. The counter sampled continuously and recorded the number of biologic particles per minute, expressed as particles triggered per cubic meter.

Statistical methods

Results from the 2 sampling methods were analyzed using SPSS version 16.0 software (SPSS Inc, Chicago, IL). A Pearson correlation analysis and 1-way analysis of variance were used to examine the associations between the biologic particle and airborne bacterial counts.

RESULTS

A total of 46 experimental results, 23 from the fluorescent particle counter and 23 from the Anderson air sampler, are presented in Figure 1. The 23 pairs of data were obtained at the same time every 30 minutes from 7:00 AM-6 PM. Airborne bacterial counts ranged from 87-585 cfu/m^3, whereas the number of biologic particles ranged from 600-18,400 pt/m^3. A significant correlation was found between the number of airborne bacteria and biologic particles (Pearson correlation coefficient = 0.76).

The whole study could be divided into 3 different periods. The first was defined as the stationary periods when there was no medical activity in the operating room, which included static period 1 (7:01 AM-8:00 AM) and static period 2 (1:31 PM-5:30 PM). The second was the operation periods, defined as the time from the initial incision to wound closure, and this included operation 1 (9:25 AM-9:57 AM), operation 2 (10:50 AM-11:20 AM), and operation 3 (12:28 PM-12:57 PM). The third was the preparation periods, during which the medical staff conducted preoperative procedures and postoperative cleaning, including preparation 1 (8:01 AM-9:24 AM), preparation 2 (9:58 AM-10:49 AM), preparation 3 (11:21 AM-12:27 PM), and preparation 4 (12:57 PM-13:30 PM). The mean values of biologic particle and bacterial results for each period are shown in Table 1.