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Monitoring for Airborne Particles during and after Surgical Operations on Tuberculosis Patients

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Ventilation control is essential for preventing nosocomial transmission of airborne infections, such as tuberculosis (1). A practical method to assess ventilation systems in health-care facilities involves monitoring airborne particles of a certain range in size using particle counters (2).

The monitoring was conducted in operating rooms (OR1 and OR8) in a hospital with 925 beds before, during, and after operations on patients who had tuberculosis. The OR1 and OR8 were of the same size: 91.8 m³ (6 m wide by 6 m deep by 2.55 m high). The OR8 had an anteroom of 38.25 m³ (5 m wide by 3 m deep by 2.55 m high). Both operating rooms were equipped with the same single-pass ventilation system in which, after air passes through the room, 100% of that air was exhausted to the outside. Two air-supply vents were located in the ceiling and four air-exhaust vents were near the floor in each corner. The vents were fitted with high-efficiency particulate air (HEPA) filters for air cleaning. The air supply and exhaust volumes were 1,357 and 1,537 m³/h for OR1, 2,079 and 2,829 m³/h for OR8, and 576 and 1,323 m³/h for the anteroom of OR8, respectively. Airborne particles with ≥ 0.3 , ≥ 0.5 , ≥ 1.0 , ≥ 2.0 , and ≥ 5.0 μm diameter in OR1 and OR8 were simultaneously counted using a laser particle counter (KC-03A1, Rion Co., Tokyo) placed on a stand 1 m in height, 50 cm from the wall, 50 cm left from an exhaust vent that was on the side of the corridor but opposite the door.

The fluctuation in airborne particles in an operating room is shown in Figure 1. The ventilator was turned on at 7:20 in the morning. Two nurses entered and left the room from 8:30 to 9:00 for preparation. The entrance time of a patient with three doctors and two nurses was 9:00, and the leaving time was 15:31. After leaving, no one was allowed to enter the room until the end of the monitoring period. Before the ventilator was turned on, little fluctuation in numbers of particles was observed. Particles of ≥ 0.3 and ≥ 0.5 μm diameter were $2 - 6 \times 10^3/\text{ft}^3$ ($7 - 20 \times 10^4/\text{m}^3$) and $2 - 6 \times 10^2/\text{ft}^3$ ($7 - 20 \times 10^3/\text{m}^3$), respectively, and larger particles were few. After the ventilator was turned on, the numbers of small particles immediately decreased. When the patient entered, numbers of particles increased and remained high with sharp fluctuations, i.e., $10^2 - 10^3/\text{ft}^3$ for ≥ 0.3 μm , $10 - 10^3/\text{ft}^3$ for ≥ 0.5 μm and ≥ 1 μm , during the operation. After the patient left, the number of particles decreased rapidly by a factor of $10^2/\text{ft}^3$ for ≥ 0.3 μm , $10/\text{ft}^3$ for ≥ 0.5 μm , and $<10/\text{ft}^3$ for ≥ 1 μm . These data confirmed the efficacy of the

ventilation system in the operating rooms and suggested that the short-term ventilation following the operation effectively removed contaminated air.

To assess the efficacy of operating room ventilation following operations, we monitored airborne particles after two operations each in two operating rooms. In OR1, it took about 15 and 16 min, respectively, for the airborne particles to decrease to the backgrounds levels (Fig. 2 A, B). In OR8, it took 36 and 18 min (Fig. 2 C, D). These data indicate that monitoring for airborne particles during and after surgical

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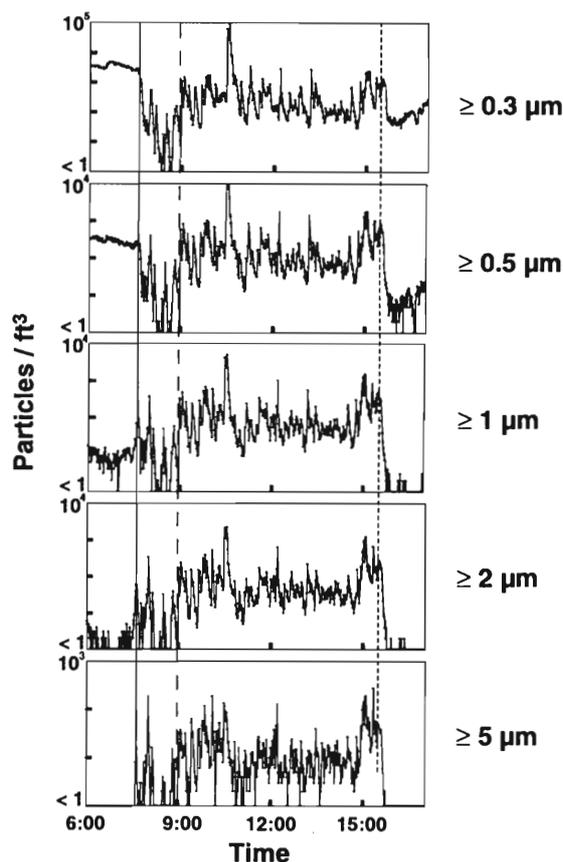


Fig. 1. Monitoring of airborne particles before, during, and after a surgical operation in an operating room (OR1). Number of airborne particles (average of counts for 1 min) of ≥ 0.3 , ≥ 0.5 , ≥ 1.0 , ≥ 2.0 , and ≥ 5.0 μm diameters are plotted in the vertical axis.

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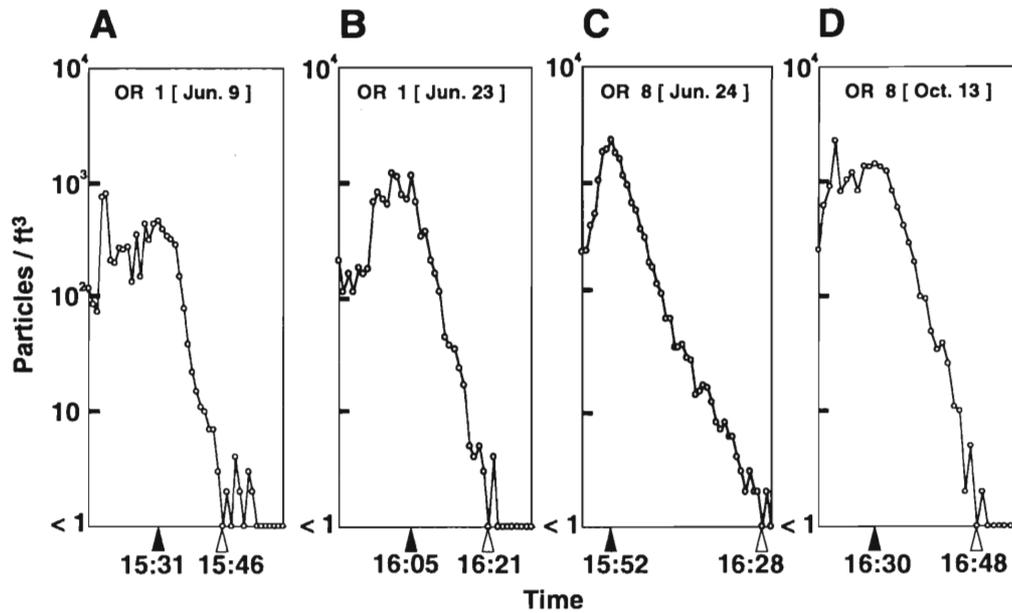


Fig. 2. Monitoring of airborne particles of $>1.0 \mu\text{m}$ diameter after operations in two operating rooms. Patients left the room at the times indicated by closed arrows.

operations is a practical method to evaluate the potency of ventilation system in operating rooms.

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