Editorial

The Design of Isolation Rooms

Robert L. Marier, MD, MHA

In their study of ventilation efficiency in the design of protective isolation rooms, Marshall et al have demonstrated that effective distribution of air in ventilated rooms is critical to the control of airborne contamination.[1] The methods used are elegant and will provide engineers and others involved in the design of protective isolation rooms with improved methods for design of environments that are intrinsically safer. The approach, as suggested by the authors, might well be extended to other applications in hospitals and to other environments in the hospital or elsewhere wherever protection of people from airborne pathogens is a concern.[2]

The use of inert tracer gases to investigate the performance of ventilation systems is well established and may be used to measure overall ventilation rates and distribution (mixing) of air in occupied buildings.[3] In one method, a quantity of tracer (inert gas) is injected into a volume of air (building) and allowed to mix. The ventilation rate (I) in air changes per hour (ACH) is given by the following equations where "t" is time (h), C_o is initial concentration of tracer, C_t is final concentration of tracer, Q_l is the ventilation or airflow rate (CF/h), and V is the volume of the space being measured.[3]

(1) $I = (1/t)\log_e (c_o/c_t)$
(2) $I = Q_l / V$

In a second method, tracer gas is injected into a test volume at a constant rate and is allowed to reach equilibrium. The ventilation rate (Q_l) is given by the following equation where f is the tracer injection rate and C_{eq} is the equilibrium tracer concentration.

(3) $Q_l = f/C_{eq}$

The ventilation rate (I) in air changes per hour (ACH) is calculated by dividing the ventilation rate by the volume of the space being measured (equation b).

Ventilation efficiency is only one of several factors that are critical to the control of airborne pathogens for both protective and infectious (respiratory) isolation. Ventilation rate (air changes per hour) is a second factor that must be considered, according the *Guidelines for Construction of Hospitals* published by the American Institute of Architects.[4] A minimum of six changes per hour are required for both. The requirement for operating rooms and special procedure areas is 15 changes per hour.

Air movement relative to adjacent areas is a third factor that must be considered in the design of isolation rooms. For protective isolation rooms, and for operating rooms and special procedure areas, the movement of air relative to adjacent areas must be positive, and, for infectious isolation, it must be negative.[4] Tracer gases might be used as well to detect leakage from negative-pressure rooms by introducing the tracer gas in the room and sampling outside.

Air movement within a patient room or special procedure area is critically important with respect to the microenvironments that may exist.[5] For patients in protective isolation (burns) or in operating rooms (selected procedures), there must be a flow of air sweeping pathogens away from patients or the operative site. Laminar air flow systems have been designed for this purpose. For patients in infectious isolation, air should flow in the other direction, away from providers.[5] In special procedure areas, systems should be developed to contain infectious aerosols.

For protective isolation, the air supply must be free of pathogens. High-efficiency particulate air (HEPA) filters should be used for this purpose.[4] For

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infectious isolation, HEPA filters should be used on the return air if air is being recirculated or exhausted near public areas or air intakes. Controlling sources of contamination inside the rooms or in spaces around the rooms (ceilings) and controlling colonization of the patients also must be given attention.

An alternative approach to the use of tracer gases involves the use of particle generators with measurement of the distribution and mixing of air by means of particle counters. The advantage of this approach versus tracer gases is that it is possible to produce particles of defined sizes, which permits not only the dispersal of particles but the assessment of the efficiency of filtration. This technology routinely is used to test and rate air in clean rooms for industrial use, and it was used by the author in testing a ventilation filtration unit designed specifically for respiratory isolation rooms.[6]

It should be noted that it is possible to measure the volume and direction of airflow in rooms directly with equipment designed for this purpose. Smoke sticks and other visual systems may have some usefulness as well in assessing the direction of air flow.

Risk factors for transmission of infection include not only the concentration of bacteria in the air but also the duration of exposure (length of surgical procedure or duration of immunosupression) and susceptibility of the host (patients and staff).

Finally, with respect to infectious isolation, it should be noted that protection of patients and staff depends on a hierarchy of controls, including in order of importance, identification and treatment of patients, isolation of patients, and use of protective devices by staff.[5]

These considerations suggest that protection of patients and staff must include a broad set of considerations, with reduction of all risk factors and implementation of effective and redundant control systems.

It is likely that the primary application of new methodologies using tracer gas for measurement of ventilation and ventilation efficiency near term will be in the design of more effective infectious (respiratory) isolation facilities.

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Educational Blitz in Texas

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The Texas Department of Health's Division on Infectious Disease Epidemiology and Surveillance (IDEAS) recently initiated an educational program for Texas public health professionals. The two major components of the new program are continuing medical education (CME) and a biweekly newsletter, *Disease Prevention* News. The IDEAS Division CME staff sponsor quarterly conferences at state, regional, and local health departments. The newsletter, produced in cooperation with the CDC, is sent to nearly 9,500 professionals in the state and also is available on the Internet's World Wide Web. For further information on the CME program or newsletter, contact Julie Rawlings, IDEAS Division, Texas Department of Health, (512) 458-7228.

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