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IMPROPER USE OF VENTILATION MAY CAUSE SEVERE HEALTH HAZARDS IN HOSPITALS

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A bioaerosol survey was conducted in Kuopio University Central Hospital to study how well the hygienic needs of various wards were fulfilled during their renovation. The construction work was still going on in one part of the hospital and its effect on the microbial air quality in the adjacent areas was also investigated.

INTRODUCTION

Patients undergoing surgery and those severely immunodeficient should be protected from acquisition of potentially pathogenic airborne microbes. To achieve this modern hospitals are provided with an effective ventilation system.

During surgery susceptible tissues are often exposed for long periods of time to airborne microbes. In order to reduce microbial exposure, the use of plenum ventilation has become general practice in operation rooms. It is aimed both to remove bacteria dispersed by the operating team and to prevent entry of bioaerosols from adjacent spaces and outdoors. Most of the modern conventional operation rooms have a ventilation rate of about 20 air changes/h. In ultra clean systems, ventilation rate may exceed 600 air changes/h. Air is supplied through effective filters; even so-called high efficiency particulate air (HEPA) filters capable of removing 99.97% of the particles greater than 0.3 um in diameter may be used. Although no definite relationship between airborne microbial levels and postoperative nosocomial infections has been established, there is evidence that reduction of bioaerosol contamination in the operating room is an important part of infection control (1,2).

Immunosuppressed patients, such as transplant recipients and leukemia patients during chemotherapy have a high risk of acquiring infection from the hospital environment. Bacterial infections still account for most of the fatal infections in immunocompromised patients, but the incidence of fungal infections is rising and since antifungal therapy remains rather ineffective, fungal pathogens have become a major risk factor for the compromised patient. Aspergillus fumigatus is the most notorious agent. There are, however, several other fungal pathogens including Cryptococcus neoformans, Alternaria sp., Candida sp., and Fusarium sp.. While candida infections are endogenous in origin in most cases, opportunic mycoses caused by the other fungi are exogenous. Especially Aspergillus spores

originate mainly from outdoor sources. Therefore, aspergillus infections can be prevented by eliminating their access to rooms of immune suppressed patients (3,4).

This study was carried out to investigate how well the protection of the above mentioned two patient groups from airborne microbes was achieved in the newly renovated parts of Kuopio University Central Hospital. An environmental survey conducted before the renovation had revealed high bacterial levels both in the operation rooms and in the rooms of leukemia patients. At that time, the ventilation rates in operation rooms were low, 0.3-6.7 air changes/h. Most patient rooms had only natural ventilation.

Because aspergillus contamination has been reported to occur during construction work in hospitals (5) the effects of construction work, which was still going on in one part of the hospital, on the microbial air quality on the adjacent areas was also investigated.

The study reported here consists a part of a larger environmental survey in the university hospital. Most results obtained have merely local significance; therefore, only those observations which are considered to be generally interesting are presented here.

MATERIALS AND METHODS

Two similar operation rooms were compared. Room A was suspected to be the origin of an observed aspergillus eye infection whereas no abnormal postoperative infections had been noted in room B. Air supply of operation room A was believed to be the probable source of fungal contamination. Only mold spore sampling was carried out in these surgical wards. Bacteria were sampled in other surgigal wards, but those results (clearly lower levels than in the earlier study) were not generally interesting.

The six-stage Andersen impactor (Model 10-800, Andersen Samplers Inc., Atlanta, Ga) was used for sampling of viable fungal spores. A mofified malt extract agar (Hagem-agar) was used as a collection and culture medium (6). The plates were incubated aerobically in the dark at 20°C for seven days. The viable spore levels were counted as colony forming units (cfu) per m^3 by the positive-hole correction method (7). In addition to the operation rooms, air sampling included supply air ducts after filtration and the nearby corridors.

Supply air was introduced into the operation rooms through diffusers located in the upper corner of the back wall. Each room had its own filter system, which included a prefilter (45% efficient by NBS dust spot test) and a microfilter (95% efficiency). Ventilation rates were 16 air changes/h. No persons were present in the operation rooms during sampling.

Besides molds, bacteria were sampled in other hospital areas. Tryptone-glucose-yeast extract agar, which is a suitable growth medium for most heterotrophic bacteria, was used in the plates of Andersen sampler. The plates were incubated in the dark at 20°C for 6-7 days.

Leukemia patients had air-locked single-bed rooms. Supply air of each room was individually HEPA filtered. Air was exhausted from bathrooms. Rooms had swing doors. Two similar leukemia patient rooms were investigated. Strict isolation policy was employed for room C. The personnel were required to wear sterile protective clothing, head covers, and masks while entering the room. On the first day, the patient was allowed to open the window. The window was kept closed during the second sampling day. Only ordinary hygienic precautions were undertaken in room D. Samples were also taken in the corridor serving both rooms and outdoors. In addition, samples were collected from a treatment room of the dermatological ward to present conditions of maximum dispersal of skin bacteria.

The microbial contamination caused by indoor construction work (demolition) was investigated in working site and adjacent areas. Sampling sites included the nearest area, so-called old lobby, and the waiting room of the dermatological clinic and a cafeteria which had entrances in the old lobby. For comparison, samples were also taken in the waiting rooms of the clinics for internal medicine and surgery which were located far from the construction site. Samples were taken both early in the morning when the amount of visitors was small and in the middle of the day when the amount of people present in the public spaces studied reached its maximum. Construction work had begun before morning sampling.

RESULTS AND DISCUSSION

No viable spores were found in the air of operation room B. The levels were also low (4-11 cfu/m^3) in its corridor. In the operation room A, which was suspected to be the origin of fungal infection, airborne mold spore level was 21 cfu/m^3. The spores originated mainly from the supply air because the spore level there was 14 cfu/m^3. Spore contamination was partly due to leakage from the corridor where mold spore count was high (110 cfu/m^3). This was caused by improper exhaust and supply air ratio.

Hence, the connection between the earlier operation-related Aspergillus infection and spore contamination of the operation room become plausible. The reason for the presence of spores in the supply air was found to be sealing leakage in the filter.

The total bacterial levels were very similar in both leukemia patient rooms. The range was 130-430 cfu/m^3 in room C and 190-420 cfu/m^3 in room B. Thus, the isolation procedures seemed have no effect. An even more surprising finding was that the bacterial levels in these air-locked and HEPA filtered rooms were not much lower than the levels observed in the corridor (190-500 cfu/m^3), in the bathroom (250-520 cfu/m^3), and in the airlock (330 cfu/m^3). The levels were higher than those found in the dermatological ward although the rate of desquamation probably greatly exceeded normal rate there.

Spore levels were also surprisingly high in room C (no spore measurements were carried out in room D). When the window was kept closed spore count was 110 cfu/m^3. As could be expected spore level was higher when the window was allowed to open (270

cfu/m^3). Spore levels observed in the corridor (240 cfu/m^3) and in the airlock (230 cfu/m^3) were also close to the room levels. The corresponding spore levels in outdoor air were 490 and 460 cfu/m^3.

The reason for these unexpected results was simple; the supply air fan had not been switched on after the renovation. Because the exhaust fan was on operation underpressure was created inside the leukemia patient rooms. Impure air was, therefore, flown to the rooms from the corridoor and from outdoors through the window cracks.

Both total bacterial and fungal levels were high in the construction area, 3590 and 1110 cfu/m^3, respectively. The effect of the demolition was also evident in the old lobby where both bacterial and fungal levels clearly exceeded the levels observed in other public areas. In addition, the bacterial level measured in the morning (790 cfu/m^3) was higher than the level during the visitor peak period (220 cfu/m^3). This difference did not appear in the mold spore results (morning 120 cfu/m^3, early afternoon 190 cfu/m^3). Some contamination possibly extented up to cafeteria because the bacterial level there was relatively high (240 cfu/m^3) in the morning and increased only slightly in the afternoon (280 cfu/m^3) in spite of considerable growth in the amount of customers. Mold spore level, however, remained low and stable (30 cfu/m^3). Both bacterial and fungal counts were low in the dermatological clinic, 70-190 cfu/m^3 and 45 cfu/m^3. Similar microbial levels were observed in the other two clinics.

CONCLUSIONS AND RECOMMENDATIONS

Sophisticated and expensive hospital ventilation systems which, in the first place, have been installed to prevent nosocomial infections can be effective only when maintained properly. This study indicated that negligence in these matters may lead to very serious consequences.

The technical mistakes observed were partly made possible by lack of active collaboration between the medical and technical personnel. Their communication was more or less haphazard; for example, infection committee consisted merely of medical staff.

The unfortunate consequences of technical malfunctions can also be avoided by installing alarm systems which warn patient care personnel of abnormal situations. The increase in costs due to these control devices is neglible when compared with the total expenditure of the technical systems and the extra costs caused by unnecessary nosocomial infections.

REFERENCES

1. Ayliffe GAJ (1982) Airborne infection in hospital. Journal of Hospital Infection 3:217-240.

2. Hambraeus A (1988) Aerobiology in the operating room. Journal of Hospital Infection 11(A):68-76.

3. Bodey GP (1988) The emergence of fungi as major hospital pathogens. Journal of Hospital Infection 11(A):411-426.

4. Rogers TR, Barnes RA (1988) Prevention of airborne fungal infection in immunocompromised patients. Journal of Hospital Infection 11(A):15-20.

5. Hopkins GC, Weber DJ, Rubin RH (1989) Invasive aspergillus infection: possible non-ward common source within the hospital environment. Journal of Hospital Infection 13:19-25.

6. Modess O (1941) Zur Kenntnis der Mykorrhizabildner von Kiefer und Fichte. Uppsala University.

7. Andersen AA (1958) New sampler for the collection , sizing, and enumeration of viable airborne particles. J. Bacteriol. 76: 471-484.