J. Hyg., Camb. (1984), 93, 559–566
Printed in Great Britain

Bacterial contamination of floors and other surfaces in operating rooms: a five-year survey

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(*Received* 30 *January* 1984; *accepted* 29 *March* 1984)

SUMMARY

Bacterial contamination of floors and other surfaces in the operating suite has been investigated by contact impression plates during the past five years. Colony counts of the floors of operating rooms, cleaned with disinfectant, were 3·3 c.f.u./10 cm²; on the floors of semi-clean and dirty areas, cleaned with detergent, colony counts were 44·8 and 71·4 c.f.u./10 cm² respectively. The highest colony counts of 487·4 c.f.u./10 cm² were found in the dressing rooms, the floors of which were covered with carpets, cleaned with a vacuum cleaner. Mean bacterial numbers on surfaces of various equipment in operating rooms, cleaned with disinfectant, were 2·8 c.f.u./10 cm². Bacterial numbers on surfaces decreased markedly from 253·2 to 11·9 c.f.u./10 cm² following the use of disinfectant. Bacterial species found from various surfaces were mainly coagulase-negative staphylococci, derived from human beings. In the light of these findings the regular use of disinfectant for cleaning of the floors and other surfaces in operating rooms is advisable.

INTRODUCTION

The ultimate goal in the effective microbiological management of an operating department is to reduce postoperative wound infection. To achieve this goal, we have devoted great efforts to reducing bacterial numbers in all areas of the operating suite.

Weber *et al.* (1976) denied any relationship between floor contamination and postoperative wound infection rate. However, Hambraeus, Bengtsson & Laurell (1978*a*) reported that floor bacteria contributed up to 15 per cent of the flora of operating room air.

In this paper, we report bacterial contamination of the floors, walls and the surfaces of equipment in operating rooms. We also describe the measures taken to reduce heavy bacterial contamination. None of the previous published accounts of surface contamination has recorded extended observations for a period of five years.

https://doi.org/10.1017/S002217240006513X Published online by Cambridge University Press

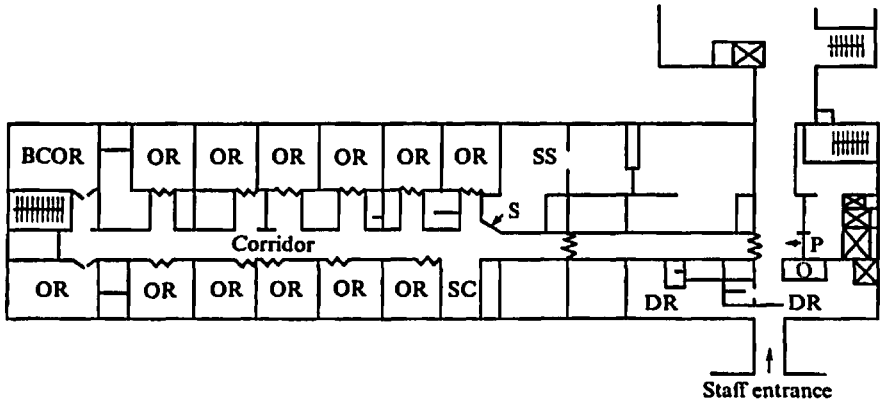

Fig. 1. Layout of the operating suite. OR, Operating room; BCOR, bioclean operating room; DR, dressing room; P, patients' entrance; S, sterile materials route; SC, scrub area; SS, sterile supply storage room; O, office.

MATERIALS AND METHODS

The operating suite of Nagoya University Hospital was opened in 1968. The suite is divided into three zones by two doors located in the middle corridor (Fig. 1). The left zone, which includes 13 operating rooms, is a clean area, the area between the two doors is semi-clean, containing doctors and nurses lounges, the right zone is the 'dirty' area, which includes dressing rooms and the patients' entrance area.

Patients are transported into the operating rooms through the patients' entrance, and staff enter the operating rooms through dressing rooms from staff entry. Sterile materials are carried directly to the clean area from the sterile supply storage room. In the clean area, materials, patients' and staff routes cannot be separated due to a common corridor system.

The unit was newly equipped with a positive-pressure ventilation system in 1978; in this system 100% outside air is supplied with no air recirculation. All operating rooms are equipped with HEPA filters capable of removing 99·97% of particulates $\geqslant 0{\cdot}5\ \mu m$ in size. There is one horizontal flow bioclean operating room at the left end of the corridor. The air exchange rate, with the exception of the bioclean operating room, is 20 changes per hour; in the bioclean operating room it is 180 changes per hour. All operating rooms are positively pressurized against the corridor.

Different cleaning procedures were applied in accordance with the degree of cleanliness required in the operating suite. In clean areas, after every operation the floors are cleaned with a wet mop soaked in disinfectant (approximately 0·1% benzethonium chloride) and water. If an operation is judged as 'dirty', the floors and walls of the operating room are cleaned with suitable disinfectant and unused for 3 h. Areas such as sterile supply storage rooms are mopped with the same disinfectant once every day.

Corridors, semi-clean and dirty areas, except dressing rooms, are cleaned with a dry mop every morning, and thoroughly cleaned with a wet vacuum cleaner using detergent every Sunday. The floors of dressing rooms are covered with carpets and are, therefore, only cleaned by vacuum cleaner.

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Until April 1979 the surfaces of equipment in operating rooms were cleaned with soap and water. However, in May 1979 heavy contamination of patients' pillows was found in several operating rooms; following this, pillows were cleaned with disinfectant (0·1% chlorhexidine, 0·1% benzethonium chloride or 70% ethyl alcohol) every morning. The surfaces of equipment examined were operating lights, tables, anaesthesia equipment, monitors and pillows, and other similar equipment used in the operating room.

Bacterial examination of the unit started in December 1978; thereafter, periodic examination of the floors, walls, and surfaces of equipment was carried out at 4- to 6-month intervals. Initially floor sampling sites comprised 22 randomly selected sites. In 1980 the sampling sites were increased to 30, and at each examination the same sampling site used – 10 in operating rooms, seven in clean areas, four in semi-clean areas, five in dirty areas except dressing rooms, and four in dressing rooms.

'Eiken' Stamp Agar impression plates filled with brain–heart infusion agar (diameter 36 mm, 10 cm^2 in area, Eiken Kizai Co. Ltd., Tokyo, Japan) were used as sampling media. However, after June of 1981 improved 'Eiken' Stamp Media BHI was used; this contains lecithin, Tween 80, Lubrol W and thiosulphate as residual disinfectant neutralizers.

Impression plates were brought into contact with the surface for 5 s and then incubated aerobically at 37 °C for 48 h, after which colonies were examined. Identification was carried out on 111 bacterial colonies obtained from the floors and other surfaces.

RESULTS

Floor bacteria

Thirteen periodic examinations of the floor bacteria were carried out in the past five years. Changes in bacterial numbers in different areas in the operating suite are shown in Fig. 2. Colony counts of the floors of operating rooms were the lowest in all of the five areas; counts per plate (10 cm^2) were maintained below 10 except in April 1979. Changes in colony counts in clean areas other than operating rooms were similar to those of the operating rooms. Throughout the entire study, the highest colony counts were always found on the floors of doctors' and nurses' dressing rooms. The floors of this area are covered with carpets and the personnel walk on bare feet. The changes of bacterial numbers are related to the differences in cleaning procedures. Seasonal change of bacterial number was not observed in operating rooms and clean area.

The total number of bacteria in the five-year period in different areas can be seen in Table 1. The lowest colony counts were 3·3 c.f.u./plate in operating rooms, and 5·2 c.f.u./plate in clean areas. The highest counts were 487·4 c.f.u./plate in dressing rooms. Semi-clean and dirty areas were 44·8 and 71·4 c.f.u./plate respectively. Differences in the bacterial number compared with operating rooms were statistically significant in semi-clean areas ($P < 0·001$), dirty areas ($P < 0·001$) and dressing rooms ($P < 0·001$). However, there were no differences in bacterial numbers between operating rooms and clean areas.

Sampling from operating room floors was usually performed in an empty room. However, 26 samples were taken during an operation. The average colony count

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Table 1. *Floor bacteria in the operating suite*

	Operating room	Clean area	Semi-clean area	Dirty area	Dressing room
Sample number	274	84	118	147	78
Total colonies	913	439	5289	10503	38014
c.f.u./plate (10 cm²)	3·3	5·2	44·8	71·4	487·4
Mean *	1·0	1·7	5·1	7·1	19·2
±s.d.*	±1·5	±1·5	±4·4	±4·5	±10·6
P†	–	N.S.	0·001	0·001	0·001

* Mean value and S.D. of square root transformation of each sample. Despite the use of a square root transformation of data, the S.D. values are frequently greater than the mean count due to great variability in counts recorded.

† *P* values are given for comparisons made with the operating room, using the *t* test.

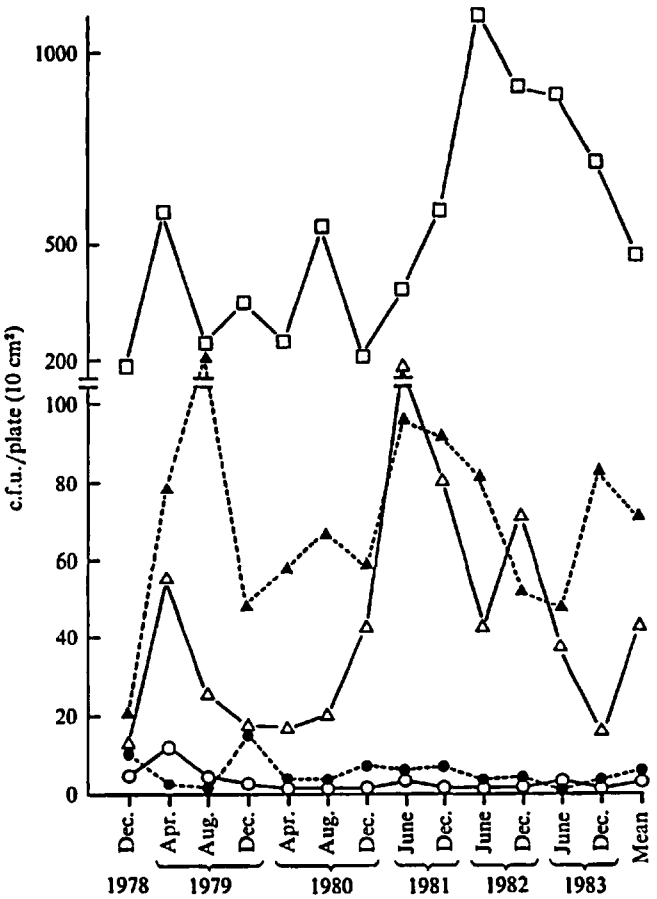

Fig. 2. Change of floor bacteria counts in various areas of the operating suite during five-year period. ○–○, Operating room; ●...●, clean area; △–△, semi-clean area; ▲...▲, dirty area; □–□, dressing room.

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Table 2. *Surface bacteria of equipment in operating rooms cleaned with disinfectant*

	Operating room no.							
	2	4	5	6	8	11	12	Total
Sample number	16	14	20	9	10	18	14	101
Total colonies	72	30	44	18	13	29	75	281
c.f.u./plate (10 cm²)	4·5	2·1	2·2	2·0	1·3	1·6	5·4	2·8
Mean *	1·5	1·0	1·1	0·7	0·8	0·8	1·8	1·1
±S.D.*	±1·5	±1·1	±1·0	±1·3	±0·9	±1·0	±1·5	±1·2

* Mean value and S.D. of square root transformation of each sample.

Table 3. *Effect of disinfectant in cleaning of floors and surfaces of equipment in the operating suite*

	Operating room floor		Surfaces of equipment	
	With disinfectant	Without disinfectant	With disinfectant	Without disinfectant
Sample number	9	19	150	34
Total colonies	2	215	1780	8610
c.f.u./plate (10 cm²)	0·2	11·3	11·9	253·2
Mean†	0·2	2·6*	1·7**	7·5
±S.D.†	±0·5	±2·2	±2·5	±14·3

* P 0·005, ** P 0·001.
† Mean value and S.D. of square root transformation of each sample.

was 4·0 c.f.u./plate, which is not significantly higher than that of 3·3 c.f.u./plate in operating rooms not in use.

Surface bacteria

The number of bacteria on the surface of various pieces of equipment is shown in Table 2. On each occasion, the equipment of one operating room was examined. A total of 101 samples was obtained from seven operating rooms and the average colony count was 2·8 c.f.u./plate.

Generally, the bacterial number on vertical surfaces is small in comparison with horizontal surfaces. A total of 35 samples obtained from walls of operating rooms in three examinations yielded 55 colonies (1·6 c.f.u./plate). Since wall contamination was very low, examination of walls was discontinued after August 1979.

Cleaning with and without disinfectant

The effect of disinfectant on bacterial numbers on the floors and other surfaces can be seen in Table 3. In operating room No. 7 cleaning the floor with disinfectant was interrupted for a week. Consequently, bacterial counts increased from the control level of 0·2 to 11·3 c.f.u./plate, this difference is statistically significant ($P < 0·001$).

After May 1979, equipment in operating rooms was cleaned with disinfectant.

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Table 4. *Bacterial species found on floors and surfaces of equipment in the operating suite*

Bacterial species	No. of colonies (%)
Coagulase-negative staphylococcus	75 (67·6)
Spore-bearing bacillus	17 (15·3)
Gram-positive rod	8 (7·2)
Micrococcus	5 (4·5)
Gram-negative rod	3 (2·7)
Pseudomonas species	2 (1·8)
Staphylococcus aureus	1 (0·9)
Total	111 (100·0)

Colony counts decreased significantly ($P < 0·001$) from 253·2 to 11·9 c.f.u./plate as shown in Table 3.

The lowest colony counts in the operating suite were found on the floors of the scrub area. Since 1979, 26 samples have been taken, and only two colonies have been found (0·08 c.f.u./plate). Presumably this is the effect of disinfectant dropped on the floor during scrub-up. In the operating suite, washable slippers are exclusively used and washed once a week with detergent.

Bacterial species

Identification of bacterial species was carried out on 111 colonies obtained from floors and other surfaces. As shown in Table 4, coagulase-negative staphylococci, derived from human beings, were the most common (67·6%). One *Staphylococcus aureus* colony was grown from a patient's pillow.

DISCUSSION

A new positive-pressure ventilation system was installed in our operating suite in 1978, and zoning arrangements introduced simultaneously. Our investigation was directed toward determining whether the zoning system, in combination with the cleaning procedures, had any effect on bacterial contamination of the floors and other surfaces in the operating suite.

There were significant differences in the number of bacteria on the floors of various areas in the operating suite; several factors may contribute to this. First, the difference in quality of the ventilation system; secondly, the difference in cleaning procedures; thirdly, the difference in traffic in these areas. We consider the major contributing factor to be the difference in cleaning procedures. Excellent evidence in support of this hypothesis is shown in Table 3. In one operating room, the use of disinfectant was discontinued for one week, as a result, the count of floor bacteria increased to 50 times above control level. In addition, the lowest colony counts were found in the floors of the scrub area. On the basis of our observations, we recommend regular use of disinfectant in cleaning the operating room floor after every operation.

The carpeted floors of the dressing rooms were impossible to disinfect. We recommend that floor carpet should not be allowed in any part of the operating suite.

There are several reports on the use of disinfectant on cleaning the floors. Vesley

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& Michaelsen (1964) and Ayliffe, Collins & Lowbury (1966, 1967) reported that the addition of disinfectant to the cleaning solution did not reduce the equilibrium level of bacteria on the ward floor. Froud, Alder & Gillespie (1966) reported heavy contamination of operating room floors washed with soap and water; however, Weber *et al.* (1976) reported a significant reduction in floor bacteria with the use of a germicidal detergent. Hambraeus, Bengtsson & Laurell (1978*b*) also reported that the floors in the inner zones of the operating suite cleaned with disinfectant showed low level of bacterial contamination.

In comparison with floor bacteria, very little contamination was found on vertical surfaces such as walls. These findings are similar to ward walls (Wypkema & Alder, 1962; Ayliffe, Collins & Lowbury, 1967; Petersen, Marshall & Collins, 1973) and operating room walls (Hambraeus, Bengtsson & Laurell 1978*b*, Froud, Alder & Gillespie 1966). Our results agree with these reports. Nevertheless, we treat walls the same as floors, cleaning them with disinfectant.

As a result of our investigation, we recommend that materials contaminated with patients' secretions, such as saliva, sputum and mucus, should be cleaned with disinfectant or discarded. This is especially true of patients' pillows, which are usually contaminated with secretions from mouth, nose and trachea. In one instance *Staph. aureus* was found on a pillow.

Contamination of the operating light was reported by Froud *et al.* (1966) and Hambraeus, Bengtsson & Laurell (1978*b*). Since operating lights are cleaned daily with disinfectant, we did not find any contamination.

We found coagulase-negative staphylococci and spore-bearing bacilli to be the two major species contaminating floors and other surfaces in the operating rooms. Staphylococci are usually human in origin and point to the restriction of traffic in operating rooms.

Although the relation between postoperative wound infection and cleanliness of operating room has not been clearly demonstrated (Weber *et al.* 1976), our study indicated that periodic examination of the operating suite is very useful to detect contamination and the treatment of such areas may contribute to a decreased postoperative wound infection which may be caused by extrinsic factors. To achieve this aim, the use of disinfectant in cleaning of the various surfaces in the operating suite as well as floors is, in our opinion, a most important measure.

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