

**Bacterial contamination in a modern operating suite.
4. Bacterial contamination of clothes worn in the suite**

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SUMMARY

Clean clothes in the staff dressing rooms were heavily contaminated with bacteria, mainly *Bacillus* sp., but *Staphylococcus aureus* were found on 14% and *Clostridium* sp. on 10% of the garments examined. A comparison of the occurrence of *Staph. aureus* on shirts worn by staff in wards and operating departments showed ward shirts to be contaminated more heavily and with more strains. Examination of sterile gowns worn by surgeons showed that 70% were contaminated with *Staph. aureus* after operation. Of the strains isolated 31% were identical with those carried by the surgeon or by the patient operated on, but for the remainder no source could be found.

INTRODUCTION

It is generally accepted that doctors, nurses, other members of the staff and visitors should not be allowed to enter an operating suite in their street clothes or working clothes used in the wards. They are supposed to change to special clothes used only in the operating suite. One reason for this is to prevent people from bringing any bacteria they might have on their own clothes into the unit. Surprisingly little has, however, been done to study whether clothes used in the ward are actually more contaminated than those used in the operating suite. Also, clothes used in the operating suite should at least be free from potentially pathogenic bacteria after being laundered.

The special protective gown used during operations is supposed to prevent dispersal of bacteria by theatre staff. Several workers have, however, shown that most protective gowns do not prevent this dispersal (Duguid & Wallace, 1948; Charnley & Eftekhar, 1968; Sykes, 1970; Whyte, Vesley & Hodgson, 1976). These studies have usually concerned only the staff's own bacteria.

Some workers have, however, shown that nurses' clothing is generally contaminated with bacteria from the patient they nurse (Lidwell, Towers, Ballard & Gladstone, 1974). It has been shown in a burns unit that bacteria carried on nurses' clothing pass through the protective gowns and that this is probably the most important manner of spread (Hambraeus, 1973).

The purpose of this investigation was to test the bacteriological standard of clothes delivered from the laundry, to find out if clothes used in the wards were

more contaminated than those used in the operating suite and, finally, to see if the surgeon disperses not only his own bacteria but also others he might have acquired during his work.

MATERIALS AND METHODS

Staff clothing routine

The staff change their clothes in changing rooms which are divided into a dirty locker area and a clean dressing area. One may choose trousers with a knitted short-sleeved shirt or a cotton blouse, or a cotton dress. When leaving the operating suite for shorter periods the clothes are put into a locker and used again when re-entering. No clothes are, however, used for more than one day. Staff assisting at operations wear sterile cotton surgical gowns of conventional type, masks, and gloves. All clothes are delivered from a laundry situated about 160 kilometres from the hospital.

Laundrying procedure and transport

The clothes are washed in a tunnel machine. Maximum temperature during the washing procedure is 85–90 °C and maximum pH > 11. The machines are not running at night and during Saturdays and Sundays. They are not always emptied before periods of standstill. The clothes are packed on trolleys covered with plastic and transported to the hospital in lorries.

Clean clothes investigated

Samples of clean clothes of all kinds were taken from the store-room where clothes are kept after arrival from the laundry and also from the cupboards in the staff changing rooms.

Comparison between clothes worn in the operating suite and those worn in a surgical ward

In these experiments the staff were provided with sterile short-sleeved shirts in the morning. In the ward the shirt was usually worn under a jacket. In the operating suite it was used as part of the working dress and worn under the sterile surgical gown during operations. All shirts were examined after one day's use.

Surgical protective gowns

Two series of experiments were carried out. In the first the gown used by the surgeon was investigated after the operation. In the second a sterile towel was pinned to the front of the surgical gown and both towel and gown were investigated. After each operation nose and throat swabs were taken from the surgeon and the patient. Settle plates were exposed in the operating theatre during the whole day.

Sampling technique

The clothes were washed in 1 litre peptone water in a standardized way. The bacterial content of the water was determined by filtration according to a technique earlier described in detail (Hambraeus, 1973). Settle plates were used to estimate airborne contamination.

Table 1. Bacterial contamination of clean clothes

Type of clothes	No. investigated	No. of bacteria per l wash water (median value)	No. of clothes with		Other species (except <i>Bacillus</i> spp.)	No. of clothes
			<i>Staph. aureus</i>	<i>Clostridium</i> spp.		
Trousers	19	16×10^3	1	—	<i>Moraxella</i>	1
Short sleeved shirt	19	4×10^3	4	3	—	—
Blouse	20	28×10^3	3	2	<i>Moraxella</i>	4
Dress	22	1.6×10^3	3	3	<i>Corynebact. bovis</i>	2
					<i>Corynebact. bovis</i>	1
					<i>Moraxella</i>	1
					<i>Neisseria</i>	1
Total	80		11	8	<i>Moraxella</i>	6
					<i>Corynebact. bovis</i>	3
					<i>Neisseria</i>	1

Bacteriological technique

Throughout the investigation sheep blood agar plates were used. They were incubated at 37 °C and read after 24 and 48 h. Presumptive *Staph. aureus* colonies were tested for deoxyribonuclease production. Positive strains were phage-typed with the international set of phages (Blair & Williams, 1961).

RESULTS

Bacterial contamination of clean clothes

In all, 80 different items of clothing were studied over a 2 year period. The majority were taken from cupboards in the changing rooms and a few from the store-room where clothes are kept after delivery from the laundry. The degree of contamination was high in both groups. The results are given in Table 1.

The median value of the total number of bacteria found varied between 1.6×10^3 and 28×10^3 c.f.u./l wash water. The majority of bacteria isolated were *Bacillus* species. However, as can be seen from Table 1 other species were also found, i.e. *Staph. aureus* and *Clostridium* sp. on 11 and 8 items, respectively. *Moraxella* and *Corynebacterium bovis* were found on 6 and 3 items and on one occasion a *Neisseria* sp. *Staph. aureus* and *Clostridium* sp. were found only on clothes stored in the changing rooms and then only in small numbers. *Moraxella* sp. and *C. bovis* in large numbers were found both on clothes taken from the store-room and from the changing rooms.

Comparison between clothes worn in an operating suite and in a surgical ward

Table 2 shows the total number of *Staph. aureus* found on shirts worn by members of the operating staff and by staff in a surgical ward. They have been divided into 'carriers' and 'non-carriers', i.e. persons with or without *Staph. aureus* in the upper respiratory tract. As can be seen *Staph. aureus* could be isolated from 36% of shirts worn by non-carriers in the operating suite and from 64% of

Table 2. Comparison of the number of *Staph. aureus* found on 98 short-sleeved shirts worn in an operating suite and in a surgical ward

No. of <i>Staph. aureus</i> per 1 wash water	Non-carriers		Carriers	
	Op. staff	Ward staff	Op. staff	Ward staff
0	21 (63.6 %)	10 (35.7 %)	7 (50 %)	5 (21.7 %)
30	3	—	—	—
— 100	6 } (36.4 %)	5	2	6
— 300	3	8	3	2
— 1000	—	3 } (64.3 %)	2	4
— 3000	—	2	—	4
> 3000	—	—	—	2

Non-carriers – no *Staph. aureus* isolated from the upper respiratory tract.

Carriers – *Staph. aureus* isolated from the upper respiratory tract.

Table 3. Occurrence of various staphylococcal phage-groups on clothes

Phage group	Source			
	Operating suite		Surgical ward	
	Shirt worn by non-carrier	Shirt worn by carrier	Shirt worn by non-carrier	Shirt worn by carrier
Group I	3	6	8	8
Group II	1	—	1	4
Group III	4	1	8	5
187	—	—	1	1
Mixed group	—	—	2	2
Not typable	3	1	4	10
Total no. strains	11	8	24	30

the shirts worn by non-carriers in the surgical ward. The corresponding figures for carriers were 50 % and 78 % respectively. The degree of contamination seemed to be slightly higher both among carriers and non-carriers in staff from the surgical ward than in operating suite staff.

The result of phage typing can be seen from Tables 3 and 4. As could be expected strains belonging to group I and III were the commonest. It is also obvious that the isolation of more than one strain was commoner on shirts used in the surgical ward. In all 54 strains were isolated from surgical ward shirts and 19 from operating staff shirts.

Of these 14 and 2, respectively, were identical with strains from the upper respiratory tract of the wearers. In Table 4 strains with the same phage pattern as strains isolated from the upper respiratory tract of those wearing the shirt have not been included. More than twice as many different types were isolated from shirts used in surgical wards as from those used in the operating suite.

Contamination of surgeons' protective gown with *Staph. aureus*

In the first series of 24 surgical gowns worn by about the same number of surgeons *Staph. aureus* were isolated from 12. In all 16 strains were found but only

Table 4. Number of different strains isolated from shirts worn in an operating suite and in a surgical ward*

No. strains	Op. staff	Ward staff
1	13	18
2	2	7
3	—	—
4	—	2
Total no. of strains	17	40

* Strains with the same phage type as that isolated from the person wearing the shirt are not included.

Table 5. Sources of *Staph. aureus* strains isolated from surgeon's clothes

Strains recovered from	Identical with		Other strains	Total no. of strains
	Surgeon's strain	Patient's strain		
Both gowns and towels	1	—	3 (3)	4 (3)
Gowns only	3 (1)	1 (1)	3	7 (2)
Towels only	—	1 (1)	7 (1)	8 (2)
Total no. of strains	4 (1)	2 (2)	13 (4)	19 (7)

Numbers in parentheses denote not typable strains.

three of these emanated from the 8 surgeons who were carriers of *Staph. aureus* in their respiratory tract. Two strains were identical with strains carried by patients, 10 of whom were carriers. The sources of the remaining 11 strains could be established. On the settle plates a total of 17 colonies of staphylococci were found on 12 occasions. None of them were identical with those found on the gowns.

In a second series of 20 operations attempts were made to improve tracing of the origin of the staphylococci found on the surgeons' gowns. For this reason a sterile towel was pinned to the front of the gown and both the towel and the gown were examined. There were 10 carriers among the surgeons and 8 among the patients. On 11 of the gowns and 12 of the towels staphylococci were found. The findings are summarized in Table 5.

On four occasions strains with the same phage pattern were isolated from both gown and towel, one of these was identical with the surgeon's own. Seven strains were found on gowns only, three of these had the same phage type as the surgeon's own; of the 8 strains isolated from towels only, none was identical with the surgeon's. During ten of the operations nose and throat swabs were taken not only from the surgeon but also from the rest of the staff, scrubbed as well as unscrubbed. None of the strains found on the clothes during these operations could be attributed to any of these persons. On the settle plates 16 colonies of *Staph. aureus* were isolated on nine occasions. None of them were identical with strains isolated from gowns or towels.

DISCUSSION

The aim of the use of special clothes in an operating suite is mainly to increase the hygienic standard. This is, however, a time-consuming and expensive procedure and it was therefore of interest to see how much it actually contributed to the hygienic standard.

The clean clothes investigated could be shown to be heavily contaminated with bacteria and this contamination is likely to have occurred in the laundry. The tunnel machine used there operated at a temperature and pH sufficiently high to disinfect the clothes but there was a definite risk of bacterial growth in the water if the machine was not emptied during periods of standstill. The bacteria found, *Bacillus*, *Moraxella* and *Corynebacterium* spp., are those that would grow under these circumstances, and these species have also been found by other authors (Church & Loosli, 1953; Reber, Koenig & Zinkernagel, 1962) on textiles contaminated in laundries. Even if the bacteria actually found on the clothes constitute no great danger to the patient, there is clearly a potential risk if the laundry processing is inefficient. *Staph. aureus* and *Clostridium* spp. were found on a small number of clothes taken from the changing rooms. It seems likely that these emanate from the staff and *Staph. aureus* has been shown to contaminate clean clothing during storage in wards (Lidwell, Towers, Ballard & Gladstone, 1974).

In this investigation it was found that shirts worn in the surgical ward were more heavily contaminated and had about twice as many strains with different phage types as shirts worn in the operating suite. This supports the practice that clothes used in other parts of the hospital should not be allowed in the operating suite.

It has been shown by several workers that conventional protective gowns do not prevent a dispersal of the person's own bacteria. It could be shown here that the protective gown prevents neither the spread of the person's own bacteria nor of the bacteria he might have acquired during his work in the operating suite. The total number of bacteria was high and from half the gowns *Staph. aureus* strains other than the person's own were isolated. This agrees with the results achieved in a burns unit (Hambraeus, 1973). About the same number of strains were isolated from the towels pinned to the front of the gowns indicating that an exchange of staphylococci takes place during operations. The origin of the majority of strains could not be found. This is a common finding in most work on *Staph. aureus* epidemiology and is perhaps not surprising considering the many different situations during which the clothes may have been contaminated. The results may also explain the difficulties encountered in proving whether an infection is acquired during operation or later, in the ward. It is, however, obvious that there is a risk of wound contamination and for clean operations the present protective clothing seems inefficient. It has been shown that a substantial decrease of dispersal can be achieved by using more impervious materials with a total body exhaust suit. This is, however, probably not the final solution and there is an urgent need for more research to improve the effectiveness of operating room clothing.

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