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Bacterial contamination on the surface of hospital linen chutes

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Although linen disposal chutes have been used in hospitals for many years there has been a tendency to view them as a potential cross infection hazard. This suspicion, which in a few cases has led to their use being discontinued, may be dated from the publication of a report by Hurst, Grossman, Ingram & Lowe (1958). They regarded hospital linen and refuse chutes as a source of staphylococcal cross infection and showed that large amounts of air, heavily contaminated with *Staphylococcus aureus*, were being transferred to and from the chutes. This air movement may be brought about in two ways—the natural upward convection currents (stack effect) and the pumping or piston effect of material being dropped down the chute. Michaelsen (1963) demonstrated the beneficial effects of bagging linen and using an extract fan to ventilate the chute. He showed that these two precautions considerably reduced the airborne bacteria in the area of the chute. These measures along with good engineering construction, including reasonably airtight doors and a deceleration track, should contribute greatly to bringing airborne contamination to a satisfactory level. This is discussed more fully in our other reports (Reports, 1968).

One of the problems remaining is whether or not any facilities for chute cleaning should be provided in order that no significant contamination of the air is caused by bacteria on the inner chute surface. The aim of this study was to determine whether cleaning of the chute surfaces was necessary, and, if so, the frequency with which it should be done.

MATERIALS AND METHODS

Location and types of chutes studied

A total of 13 disposal chutes, located in eight hospitals, were studied. Given in Table 1 are those features of the 13 chutes which were considered likely to affect the amount of surface contamination on the inside of each chute. These were, the number of floors served by each chute, the hospital department and number of patients served by the chute, the method of disposal of the linen (in linen or polythene bags, or loose) and the arrangements for ventilating the chute. Apart from chute No. 9, which was plaster lined, and No. 8 which was 'Formica' lined the rest were made of metal. Both circular and rectangular chutes were included in the sample but the circular ones selected for this study were of large enough

diameter to allow samples to be taken of their internal surfaces using a Rodac plate. (Falcon Plastics, 5500 West 83rd Street, Los Angeles, 45, Calif. U.S.A.)

Only three of the chutes, all of which were used for the disposal of loose linen, employed a method of cleaning. Chute No. 1 was fumigated weekly with formaldehyde. Four pints of Liquor Formaldehyde B.P. was used. Exits and entrances were sealed and the length of time of fumigation was at least 8½ hr. The volume of the chute was approximately 210 cubic feet. Chutes Nos. 12 and 13 incorporated a water flush. When this was operated from the basement, the chutes were washed down with fresh water.

Table 1. *General description of the chutes studied*

Hospital	Chute no.	No. of floors served*	Department served	Approx. no. of patients	Method of disposal	Chute vented†
A	1	6	Maternity wards and operating theatres	180	Loose	No
B	2	2	Wards	95	Linen bags	No
	3	2	Wards	80	Linen bags	No
C	4	4	Children's wards and operating theatres	100	Linen bags	Yes
D	5	5	Surgical wards	300	Linen bags	Yes
	6	5	Medical wards	270	Linen bags	Yes
E	7	1	Children's ward (infectious diseases)	25	Linen and polythene bags	No
F	8	6	General wards and operating theatres	300	Polythene bags	Yes
G	9	3	Neurosurgical wards	60	Linen bags	Yes
	10	1	Operating theatres	—	Linen bags	Yes
	11	1	Operating theatres	—	Linen bags	Yes
H‡	12	3	General wards	66	Loose	Yes
	13	3	General wards		Loose	Yes

* The number of floors served does not include the basement or exit floor.

† Vented by an opening at the top, either to outside or into roof space; none of the chutes had mechanical extract ventilation.

‡ Both chutes at Hospital H served the same area, no. 12 being used for pre-rinsed soiled linen, no. 13 for dry dirty linen.

Method of surface sampling

Rodac plates were used throughout this study (Hall & Hartnett, 1964). These disposable plates, 2¼ in. in diameter, were filled to the brim with agar medium and the agar allowed to set to form a meniscus on the uppermost surface. The lids were replaced and the plates incubated for 24 hr. at 37° C. to check their sterility before being stored at 4° C. In this series of experiments the plates were filled with 16 ml. of Blood Agar Base No. 2 (Oxoid Ltd)., usually containing 0·1 % phenolpthalein diphosphate penta Na salt. The phenolpthalein disphosphate was added as an aid in distinguishing colonies of *Staphylococcus aureus* (Barber & Kuper, 1951). When

sampling was carried out after formaldehyde sterilization 2 % sodium sulphite was added as a neutralizer to the medium. To take a sample, the agar meniscus was pressed against the surface under investigation. The Rodac plates were then incubated for 36 hr. at 37° C and counted. When plates with sodium sulphite in the media were used the incubation time was extended to 72 hr. Any colonies resembling *Staph. aureus* were tested for coagulase production and certain of these were phage typed. This was done by the standard set of phages supplied by the Staphylococcus Reference Laboratory, Colindale, London.

Number and type of surfaces sampled during the survey

In order to establish the amount of bacterial contamination present in disposal chutes, all eight hospitals mentioned previously were visited twice, with 1 month between each visit. Chute No. 1 was sampled the day before it was fumigated. Chutes Nos. 12 and 13 were sampled only once as a large amount of data concerning their surface contamination was being accumulated in another series of tests.

It was the aim at each visit to take four surface samples of the chute at each chute exit or entrance and at least one sample from the floor at each chute exit or entrance point. This was carried out throughout the survey with minor variations, e.g. no floor samples were taken at Chutes Nos. 1 and 4 as they were on the outside of the buildings, on a balcony.

The method of study of the build-up of bacteria on a clean duct surface

It was necessary as part of this study to establish the time for bacteria to build up on a linen chute which had been cleaned. This was carried out at chutes Nos. 1, 12 and 13. These were the three chutes which employed a method of cleaning, but no reliance was put on these methods. The following method was used instead.

Six pieces of polyvinyl material, adhesive on one side (Fablon), were attached to the inside surfaces of chutes Nos. 1, 12 and 13 at ground floor and basement levels. They were sterilized before and after attachment by washing down with 70 % ethanol in water. Each sheet was divided into a series of numbered sampling squares. Random number tables were used to group these squares into sets of six in order to ensure unbiased sampling. One set of six samples was taken, from each sheet after they had been fixed in position and sterilized. Samples were then taken in chutes Nos. 12 and 13 after 12 hr., 1 day, 2 days, 3 days, 6 days, etc., the final set being taken after 42 days. In the case of chute No. 1, samples were taken at 4, 14, 22, 39 and 46 hr. The practice of washing down chutes Nos. 12 and 13 with fresh water, which was described earlier, was discontinued during these tests. Chute No. 1 was sterilized with formaldehyde immediately before the start of the test.

The method of study of the efficiency of the two cleaning methods used

Fifty-two Rodac dishes on two occasions (a total of 104) were used to assess the cleaning efficiency of the water flushes on chutes 12 and 13. Samples were taken

immediately before and after this process. The efficiency of the formaldehyde sterilization method at chute No. 1 was tested once using 56 dishes. The positions sampled were as for the general survey.

RESULTS

Survey of bacterial contamination on the surface of linen disposal chutes

Table 2 shows the average bacterial count for each chute surface on the two visits, together with the mean count. These results are presented in the conventional manner as the number of bacterial colonies per Rodac plate. The chutes have been placed in the table in order of the amount of bacterial surface contamination.

Table 2. *The average test results, with the chutes ranked in order of bacterial surface contamination ('cleanliness'). All the counts are given as average numbers of bacterial colonies per Rodac plate.*

(Figures in parentheses thus ( ), give the average chute counts with the results from the sloping entry connexions omitted.)

Order of cleanliness	Chute no.	Average counts on the chute surfaces			Average floor count	% of *Staph. aureus* isolated from chute
		Test 1	Test 2	Mean		
1	11	3·3	1·0	2·1	5·3	0
2	10	5·1	1·8	3·4	12·3	2·0
3	9	6·3	2·7	4·5	107	0·4
4	4	3·8	11·7	7·7	—	0
5	8	6·8	10·6	8·7	125	0·6
6	7	7·2	11·8	9·5	88	0
7	6	8·1	19·2	13·6	93	1·1
8	2	13·7	21·4	17·5	109	0
9	1	28·6	26·9	27·7	—	0·1
		(9·6)	(14·3)	(12·4)		
10	3	12·3	47·8	30·1	169	0·2
11	5	39·2	32·9	36·1	164	4·0
12	12	41·5	—	41·5	422	0·5
		(19·7)		(19·7)	163*	
13	13	53·8	—	53·8	385	0·5
		(41·2)		(41·2)	126*	

* Average floor counts with the results from the basement floor omitted.

Chutes Nos. 1, 12 and 13 had sloping connexion pieces at each entry point, whereas the entry doors of the others opened directly on to the side of the chute. During the survey these sloping surfaces were sampled and it was found that they yielded counts which were about four times higher than those on the vertical surfaces. The average count in the three chutes concerned was 87·0 colonies per plate on the sloping surface compared to 22·0 colonies per plate on the vertical part of the chute. The results were therefore recalculated with the data from the sloping surfaces omitted and this is given in Table 2.

Table 2 also lists the average count on the floor outside each chute. These figures were calculated for bacterial counts of the floor surface at each entry and exit point. The average count on the floors over all the hospitals was 153 colonies

per Rodac plate. Only four of the individual floor counts deviated noticeably from this average. Two of these were in the operating theatres and in line with the lower counts found previously in operating theatre areas (Report, 1964). Two floor counts which were unusually high (422 and 385 colonies per Rodac plate) were at chutes Nos. 12 and 13. This was caused by an extremely high count on the basement floor, which was usually covered by loose linen (approximately 1400 colonies per Rodac dish in each case). Recalculation of the floor counts excluding these high basement floor counts gave average floor counts of 163 and 126 colonies per Rodac dish for chutes Nos. 12 and 13, respectively. Other chutes into which bagged linen was deposited showed no marked difference between the bacterial contamination on the basement or exit room and the other floors.

Calculation of the average bacterial count on the inner surfaces of all the chutes showed that the amount of contamination was eight times less than on the floor outside the chutes (19·7 as compared to 153 colonies per plate).

Number of Staphylococcus aureus *present in the linen chutes*

Table 2 also gives the percentage of *Staph. aureus* isolated in each linen chute, this being the average of both sampling visits. It can be seen from this table that the percentage of *Staph. aureus* present in the chute varied from 0 to 4·0 %, the average figure being 0·7 %.

Phage typing was carried out on some of the *Staph. aureus* isolated from chute No. 5. This was to establish if the high concentration obtained from this chute was caused by one or possibly two dispersers of staphylococci. However, the results showed that this was not the case but that the *Staph. aureus* isolated were made up of a large number of different phage types.

The build-up of bacteria on 'cleaned' linen chutes

Table 3 shows the build up of bacteria at the ground floor and basement levels of chutes Nos. 12 and 13 from the time the surface was sterilized until 6 weeks later. Table 4 shows the build up of bacteria at the ground floor and basement levels of chute No. 1 but with the sampling period confined to 46 hr.

It can be seen that the specially prepared surfaces were initially almost sterile, the highest concentration found being 1·8 colonies per Rodac plate. The results illustrate the well-defined phenomenon known as the 'plateau' effect. This is characterized by an initial increase in bacterial contamination on a sterile surface to a final constant concentration of contamination. This is caused by the bacteria which die being replaced by new ones; the higher the contamination rate the higher the 'plateau' would be. Although the 'plateau' concentrations as shown in Tables 3 and 4 tended to be slightly erratic (the higher concentrations probably coinciding with greater chute usage) it can be seen in chutes Nos. 12 and 13 that the 'plateau' had been reached in 24 and 12 hr. respectively. Extremely fast recontamination was also found at the basement position of chute No. 1, a mean concentration of 71·0 colonies per Rodac plate being reached within 4 hr. The fast recontamination of this chute was probably caused by the linen held back during the sterilization process being disposed off soon after the completion of the cycle.

At the first floor sampling positions of chute No. 1 it was found that there was little or no increase in the concentration of bacteria on the chute surfaces up till 46 hr. This chute was so constructed, that it was closed all the time except for the exit point and at the times when linen was being deposited. The whole chute, including exit and entrance, was attached to an external balcony. This meant that there would be very little, if any, temperature difference between the linen chute and the outside air and therefore very little ventilation caused by stack effect. The lack of ventilation of the chute was such that the smell of formaldehyde was

Table 3. *The build up of bacterial contamination on sterile surfaces of chutes Nos.* 12 *and* 13.

(Counts given as number of bacteria per Rodac plate.)

Elapsed time (days)	Chute No. 12		Chute No. 13	
	Basement	First floor	Basement	First floor
0	1·3	2·3	0·5	2·5
½	3·0	3·8	21·8	20·3
1	8·7	14·8	52·3	20·5
2	102·2	19·7	70·6	26·8
3	25·0	8·8	54·7	15·2
4	17·0	3·5	104·7	29·7
5	9·2	18·5	95·2	17·5
6	9·7	12·7	72·8	14·5
8	12·8	—	45·8	8·7
10	11·8	—	67·4	11·3
14	7·2	—	34·0	9·3
21	23·8	—	83·5	6·8
30	19·7	17·3	28·8	10·5
35	6·2	7·3	35·2	12·3
42	6·0	5·5	28·0	11·5

Table 4. *The build up of bacterial contamination on sterile surfaces of chute No.* 1

(Counts given as number of bacteria per Rodac plate.)

Elapsed time (hr.)	Basement	First floor
0	0	0·2
4	71·0	0·3
14	18·2	0·2
22	91·0	0·5
39	54·8	1·0
46	35·2	3·0

noticeable at the first floor entrance after a period of at least 46 hr. although the basement area where the chute stopped had cleared in less than an hour. This must be the explanation of the failure of the linen to recontaminate the first floor sampling position at the same time as the basement position was being recontaminated. Inspection of the results of sampling 6 days after sterilization showed that if the top floors had a lower concentration of surface contamination than the bottom floors, it was very insignificant.

Staphylococcus aureus were isolated in chute Nos. 12 and 13 but as they consisted of only 0·5 % of the total count in these chutes it necessarily meant that their isolation was intermittent. However, there was no indication of any build-up in these chutes. No *Staph. aureus* were isolated in chute No. 1.

The efficiency of the two cleaning methods used

The reduction in the number of bacteria sampled from the surface of the chute sterilized by formaldehyde was at least 98 %. Owing to the extra time required to sample and set up the experiment this test was carried out after 7 hr. of sterilization instead of the usual $8\frac{1}{2}$ hr.

The results of the two sets of samples taken at the chutes which use a water flush showed that the efficiency of this process lay between 65 and 80 %.

DISCUSSION AND CONCLUSIONS

Eight hospitals were visited and thirteen linen disposal chutes sampled in order that the amount of bacterial contamination on the inside surface of these chutes could be determined. Although no two chutes were identical in those features which could have possibly influenced the surface contamination it was found that the amount of contamination in each chute was fairly similar, the mean surface bacterial count per Rodac plate varying from 2·1 to 53·8 with an average of 19·7. Even though the range of concentrations on the duct surfaces was small many of the chutes had features which helped to explain their high or low surface contamination. Of the three 'cleanest' chutes, two served operating theatres and were therefore used less, and the third had a porous surface which is known to cause low counts (Angelotti & Foter, 1958). The slightly elevated counts on the 'dirtiest' chutes were caused by sampling of the sloping entry connexion, which had four times more surface contamination than the vertical surface. This higher value may however be considered a true reflexion of the surface contamination, since the entry connexion was an integral part of this type of chute.

The surface contamination of the three chutes for which some means of cleaning was employed (a water flush for Nos. 12 and 13 and fumigation for No. 1) was much higher than might have been expected. These three chutes showed the highest, second highest and fifth highest amounts of surface contamination respectively. Four possible reasons can be thought of to fully or partially explain the high surface concentration in these chutes. These are: (a) The cleaning process was inefficient. (b) These were the only chutes down which loose linen was deposited. (c) These chutes all had sloping entry connexions which, as mentioned previously, had counts four times higher than those on the vertical surfaces. (d) The water flushes in chute Nos. 12 and 13 gave moist conditions suitable for the growth of bacteria.

It was shown, however, that the cleaning process was fairly efficient in chutes 12 and 13 (between 65 and 80 %) and highly efficient in chute No. 1 (at least 98 %). The possibility that water flushes in chutes 12 and 13 gave conditions suitable for growth of bacteria must be excluded as the considerable amount of hot air passing up the chute by stack effect ensured a rapid drying of the chutes. The average counts on the inner chute surfaces, with the samples taken on the sloping

surfaces omitted, are given in Table 2. It can be seen that this would have the effect of only slightly improving the relative positions of the three chutes.

It would therefore appear that the use of loose linen must have contributed largely to the high level of contamination of these three chutes, but that the methods of cleaning did not make them, at the time of sampling, any cleaner than the others. When cleaning was discontinued during the investigation of bacterial build-up in chutes Nos. 12 and 13 the surface contamination was found to be no higher than when they were regularly cleaned. The reason for this appears to be the rapid rate at which clean chutes become recontaminated. It was shown that the bacterial concentration on two chute surfaces studied (chutes Nos. 12 and 13) rose in 12 hr. in one chute and 24 hr. in the other, to a concentration which kept fairly steady for 6 weeks. In another chute (chute No. 1) a similar situation was demonstrated in which the bacterial concentration on the surface rose within 4 hr. to a concentration which showed no significant change after 1 week. However, at another sampling position in the same chute the rise was delayed at least 46 hr. It was assumed that the residual formaldehyde in this part of the chute was still exerting a lethal effect on the surface bacteria but there may have been some other cause such as the inability of sodium sulphite to neutralize the formaldehyde. However, the delay found in chute No. 1 would be of little significance as it could not be utilized in the normal hospital situation where chutes would be an integral part of the building. Apart from the difficulty of using such an irritant material, the normal 'stack' effect would ensure rapid elimination of the formaldehyde.

As *Staphylococcus aureus* is regarded as the organism most commonly associated with cross infection, the numbers present in the surface samples were determined. The number of *Staph. aureus* expressed as a percentage of the total sample varied between 0 and 4%, with an average of 0·7%. The 4% level of *Staph. aureus* occurred in only one chute, the remainder lay between 0 and 2%. However, as this was the only chute serving a block of surgical wards, this higher figure does not seem unreasonable. The average figure of 0·7% *Staph. aureus* is of the same order as that found on ward floors (Ayliffe *et al.* 1968). No evidence was obtained to suggest that there would be any build up of *Staph. aureus* in linen chutes.

Comparison of the amount of surface contamination on each chute with that of the floor outside the chute shows that the floor contamination was much higher. The over-all chute surface count was 19·7 colonies per plate, while the average floor count was 153—an eightfold difference. The floor samples appear to be typical of hospital floor samples but the chute samples are low in comparison to most hospital areas and would have been considered to be 'good' by standards laid down for ward floors. (Report, 1964; Pryor, Vesley, Shaffer & Walter, 1967). Although the release mechanism of bacteria from floors and chutes must be different, construction of linen chutes on the principles laid down in our previous reports (Reports, 1968) excludes the risk of cross infection from chutes except by a large source of airborne organisms within the chutes. Chute surfaces do not appear to fit into this category. It would therefore seem unnecessary to provide regular cleaning of the chute surfaces.

SUMMARY

A survey of 13 linen chutes in eight hospitals was carried out to assess the amount of bacterial contamination on the inner walls of these chutes. It was shown that the average bacterial count in these chutes was low by general hospital standards (19·7 bacterial colonies per Rodac plate). This concentration was eight times less than the average concentration found on the floor surface at each linen disposal and collection point (153 bacterial colonies per Rodac plate).

Three chutes sampled during the survey were periodically cleaned but appeared to derive only very limited benefits from the cleaning method they used.

Tests carried out on three linen chutes showed that the bacterial surface contamination of a sterilized chute could normally reach a maximum concentration in a period of between 4 and 24 hr.

It is concluded that so long as good engineering practices are used in the construction of linen chutes the bacterial contamination on their inner surface should not contribute to the problem of hospital cross infection. For this reason, and because of the impracticability of sterilizing linen chutes at very short intervals of time, it is considered that cleaning of chutes would serve no practical purpose.

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