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Sources of staphylococcal infection in surgical wound sepsis*

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There are, broadly, two ways of controlling post-operative staphylococcal wound sepsis. One is to take every possible precaution against every conceivable mode of infection. Attempts to do this are undoubtedly effective, and it is sometimes the only way of dealing quickly with a severe outbreak. But it is expensive of time, money, and temper and is so tedious that when the emergency is over, its complicated routine tends to degenerate into an ineffective ritual. Another defect of this method is that it encourages the expenditure of great effort on exotic precautions for no better reason than that someone has a bee in the bonnet about them. The other approach along which, one hopes, we are steadily moving is to determine the importance, under existing conditions, of each possible source or mode of infection and then to apply new or improved precautions against those that matter.

In this paper we report studies on the roles of the patients themselves (*self-infection*), and of the surgical team (*cross-infection*) as sources of staphylococci causing post-operative sepsis.

Self-infection has been recently much studied, with rather conflicting results. It has, however, been generally found that about half the cases of wound sepsis are caused by *Staphylococcus aureus* of the same phage type as that carried, before operation, in the patient's nose. This indicates that the nose may be an important source from which the wound is often infected; but it could mean no more than that hospitals are infested by staphylococci which, independently, infect noses and wounds. In some surveys, the former explanation was favoured by the finding that patients who were nasal carriers of *Staph. aureus* suffered sepsis much more often than those who were not carriers. In other surveys, however, this difference between carriers and non-carriers has been less evident or even absent. Moreover, patients whose nares are kept free of staphylococci by application of antibacterial creams suffer no less sepsis than untreated controls. This could be explained by the possibility that the nose—long thought of as the main site of staphylococcal

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carriage—is not the actual source of self-infection but is merely a regular concomitant of carriage in some more vital area such as the perineum (Hare & Ridley, 1958) or the skin of the operation area, from which wound infection more often occurs. In the survey at Poole Hospital we have studied wound sepsis in relation to the pre-operative presence of *Staph. aureus* not only in the nose but also on the skin of the operation area. Because the results were somewhat surprising, we planned a simplified check on them at Shotley Bridge Hospital where we also regularly swabbed the noses of surgeons and operating-room staff and compared the organisms carried by them with those cultured from septic wounds.

Members of operating-room teams who were symtomless carriers or suffering from staphylococcal lesions have often been incriminated as sources of infection during sudden outbreaks of sepsis. However, many cases of infection occur during the longer non-epidemic periods, and because we knew of no recent work in which infection from the surgical team was considered during such a period, we planned to study it at Shotley Bridge Hospital.

THE INVESTIGATION AT POOLE HOSPITAL

The investigation was made in one male and one female surgical ward of a 300-bed tuberculosis hospital. The two wards are on the same floor and have the same medical but different nursing staffs. Each ward consists of 8 single-bed, 3 two-bed, and 6 four-bed rooms; thus 76 beds were concerned in the survey. There is ample isolation accommodation in a separate building, to which septic patients were moved as soon as the diagnosis was made. The operating-suite is pressure-ventilated with filtered air. The survey lasted from April 1953 to May 1956.

Methods

Precautions against infection

As a result of a severe outbreak of infection before this investigation began, the level of 'infection-consciousness' was high and there had been a recent revision of precautions against infection (Blowers, Mason, Wallace & Walton, 1955). These precautions will not be described here, except those concerning the pre-operative preparation of patients' skin and surgeons' hands.

On the evening before operation the patient's head was washed but the skin of the operation area was not treated in any way. On the day of operation the patient bathed himself or, if not well enough to go to the bathroom, was given a blanket-bath. This was finished about an hour before operation and the patient did not return to the ward or his own bed, but went to a 'preparation room' and on to a trolley laid with sterilized blankets. The skin of the operation area was shaved, cleaned with 0·5 % aqueous cetrimide solution, dried with surgical spirit then ether, and painted with 2 % iodine in 70 % ethyl or iso-propyl alcohol. The area was not bandaged and the patient was dressed in a freshly laundered operation gown and cap. He waited in the preparation room until taken to the operation theatre. There, the skin was painted sometimes with three and never less than two applications of 2 % alcoholic iodine. Each was allowed to dry before the next was

applied or before the incision was made, thus ensuring that the disinfectant had at least 3 min. in which to act.

The surgeons and nurses scrubbed their forearms and hands, with ordinary soap and hot water, for 10 min. before every operation. The hands were rinsed in surgical spirit and dried on a sterile towel before the gloves were put on.

Nose, skin, and wound swabs

Nose and back swabs were taken from each patient on the day of admission to hospital, then once each week and on the day of operation. Ordinary cotton-wool swabs on wooden sticks were moistened in 7·5 % salt-meat broth (Maitland & Martyn, 1948). One swab was used for both anterior nares and another was rubbed over the right and left subscapular areas. Each swab was broken off into salt-meat broth. After overnight incubation at 37° C., these enrichment cultures were plated on phenolphthalein-diphosphoric acid agar (Barber & Kuper, 1951) which was incubated overnight. Phosphatase-positive colonies were tested for coagulase production by the slide technique (Cadness-Graves, Williams, Harper & Miles, 1943) and strains of *Staph. aureus* were saved for bacteriophage typing in large batches.

Material from septic wounds and empyemata was collected and cultured in the ordinary way. The similarity or difference between bacteriophage-typable staphylococci was determined according to the principles suggested by Williams & Rippon (1952); untypable strains were assumed to be different from typable ones but the same as other untypables from the same patient.

Results

It was not always possible to foretell, when each patient was admitted to hospital, whether an operation would be performed; many, therefore, had nose and skin swabs taken unnecessarily. Swabs were taken from 728 patients but the following analysis concerns only 317 of them, on whom 520 operations were performed. From these, 2503 pairs of swabs were obtained with an average of 7·9 pairs from each patient, and ranging from 2 to 34. The operations were mainly lung resections and first- and second-stage thoracoplasties. Sepsis occurred after 30 (5·8 %) of the operations. There were 9 cases of intrapleural or other thoracic-space sepsis, 13 of moderate or severe parietal-wound sepsis, 2 involving an intra-thoracic space and the parietal wound, and 6 of minor wound-sepsis or stitch-abscess. The sepsis rates in the whole hospital for each of the years of the survey and for the year after it (1953–57) were 3·9, 6·2, 5·4, 1·1 and 2·3 %.

Frequency of nose and back carriage

Of the 317 patients on whom operations were performed, 54 (17 %) were consistent non-carriers of *Staph. aureus* (Table 1, column 1). Of the 263 (83 %) who yielded the organism on any occasion, staphylococci were cultured from both nose and back of 186, from the nose only of 58, and from the back only of 19. From some of these, however, staphylococci of any one phage type were isolated

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only once; if these organisms are regarded as being of the 'transient' rather than of the 'resident' bacterial flora, and the patients as non-carriers, carriage rates at the two sites were as shown in column 2 of Table 1. Among the regular carriers, back carriage very rarely occurred in the absence of nose carriage, but 44 (20 %) of the 219 nose carriers were not back carriers. When studying the relationship between staphylococcal carriage and wound sepsis, we have separately considered the consequences of 'carriage' and 'regular carriage' in the nose and on the skin.

Table 1. *Nose and back carriage of* Staphylococcus aureus *in* 317 *patients, based on isolations from* 2503 *weekly pairs of swabs.*

In column 1, carriage indicates that *Staph. aureus* has been isolated on one or more occasions; in column 2, regular carriage indicates that *Staph. aureus* has been isolated on two or more occasions (Poole Hospital)

	Number of patients with	
	(1) Carriage	(2) Regular carriage
Nose and back	186 (59 %)	175 (55 %)
Nose only	58 (18 %)	44 (14 %)
Back only	19 (6 %)	4 (1 %)
None	54 (17 %)	94 (30 %)
Totals	317	317

Table 2. *Reliability of single nose and back swabs taken immediately before operation (Poole Hospital)*

	Nose	Back
Correct	380 (80 %)	267 (56 %)
'False positive'	10 (2 %)	10 (2 %)
'False negative'	84 (18 %)	197 (42 %)
Totals	474	474

During this investigation we were only too conscious of the great labour of collecting and culturing weekly nose and skin swabs, and of phage typing the staphylococci. The possibility of conducting a similar investigation elsewhere prompted us to estimate the reliability of examining only one swab or one pair of swabs, taken immediately before each operation. We therefore compared the results of the immediate pre-operation swabs with those obtained from the weekly swabbings. A pre-operation result was assumed to be correct when it yielded staphylococci of a phage type previously isolated on any occasion from either site; or when it yielded no staphylococci from a patient whose weekly swabs had also been negative. Of the nose swabs taken immediately before the 474 operations suitable for this analysis, 380 (80 %) were thus judged to have given the correct answer (Table 2). On 10 (2 %) occasions *Staph. aureus* was isolated for the first time from the pre-operation swab; we cannot say whether these results indicated a last-minute change in the carrier state or the chance isolation of a transient strain. In the table we have recorded them as 'false positives' but recognize that some of

them may have been correct. On 84 (18 %) occasions the pre-operation nose swabs did not yield *Staph. aureus* from patients who had previously done so. These 'false negative' results are not surprising since very few of the regular carriers yielded staphylococci from every one of the weekly swabs. Thus pre-operation nose swabs gave a correct result on 80–82 % of occasions. Back swabs, similarly judged, were much less reliable, with an accuracy of only 56–58 %.

From these results we conclude that several swabs are needed for accurate determination of the carrier state. If repeated swabbing is impracticable a single pre-operation nose swab is an acceptable substitute but a single back swab is not.

Relationship between sepsis and carriage of Staphylococcus aureus

In each of the 30 cases of sepsis, *Staph. aureus* was recovered, in pure culture, from the aspirated fluid or wound. Phage comparison of these organisms with those already isolated from the nose and skin of each patient showed (Table 3) that on ten occasions the wound strains differed from those from the sites of carriage; whilst on six occasions, sepsis occurred in patients whose nose and skin had never yielded *Staph. aureus*. In these 16 cases, sepsis can be reasonably attributed to *cross-infection*. In each of the 14 other cases of sepsis, the wound

Table 3. *Frequency of sepsis after operations on carriers and non-carriers of* Staphylococcus aureus (*Poole Hospital*)

Carriers are patients from whom *Staph. aureus* was isolated from nose or back on any occasion; regular carriers are those from whom two or more isolations were obtained.

	Number of operations	Post-operative sepsis	Comparison of *Staph. aureus* from carriage-sites and wound	
			Same	Different
All patients	520	30 (5·8 %)	14 (2·7 %)	16 (3·1 %)
Non-carriers	78	6 (7·7 %)	—	6 (7·7 %)
Carriers: All	442	24 (5·4 %)	14 (3·2 %)	10 (2·3 %)
Nose only	87	3 (3·5 %)	1 (1·1 %)	2 (2·3 %)
Back (alone or with nose)	355	21 (5·9 %)	13 (3·7 %)	8 (2·3 %)
Regular carriers: All	379	23 (6·1 %)	13 (3·4 %)	10 (2·6 %)
Nose only	73	3 (4·1 %)	1 (1·4 %)	2 (2·7 %)
Back (alone or with nose)	306	20 (6·5 %)	12 (3·9 %)	8 (2·6 %)

staphylococci had a phage-sensitivity pattern the same as or closely related to that of staphylococci carried by the patient at some time before operation. In these 14 cases, sepsis might have been caused by *self-infection* from the nose or skin, or might have been due to cross-infection, from some external source, by staphylococci of a type that the patient was already carrying. There is no direct way of determining, for any one of these 14 cases, whether self-infection or cross-infection was responsible; but if it is assumed that carriers and non-carriers are equally susceptible to cross-infection, and that self-infection is an important additional

cause of sepsis in carriers, we should expect carriers to suffer a higher sepsis rate than non-carriers. Indeed, it can be calculated that if self-infection had been responsible for all the 14 cases in which wound strains and carriage-site strains were the same, the carriers would have had a sepsis rate about double that of the non-carriers; and that if none of them had been due to self-infection the sepsis rates of carriers and non-carriers would have been equal.

In fact (Table 3) the sepsis rates were 7·7 % for non-carriers and 5·4 % for carriers, indicating that self-infection played little or no part in these cases of sepsis. However, carriage of *Staph. aureus* on the skin of the operation area (alone or together with nose carriage) was associated with a higher sepsis rate than was nose carriage alone. This difference—which is not statistically significant—suggests that though self-infection was not a major cause of sepsis, it may have been responsible in a few cases.

Obvious cases of cross-infection, in which the nose and skin did not yield staphylococci similar to those from the wound, occurred more often in non-carriers (7·7 %) than in carriers (2·3 %). But this does not necessarily indicate that cross-infection is more frequent in non-carriers than in carriers. It is almost certainly explained by the fact that many of the cross-infections in carriers were by organisms similar to those already carried in the nose and skin and were thus not recognizable as obvious cases of cross-infection.

'Regular carriers' from whom *Staph. aureus* was isolated more than once from nose or back suffered sepsis rates that were not significantly higher than those of all carriers.

Acquisition of 'hospital staphylococci'—effect on sepsis rate

The indications that self-infection played an insignificant part in causing wound sepsis led us to wonder whether carriage of 'non-hospital staphylococci', at the time of admission to the ward, was preventing nose and skin acquisition of more virulent organisms which, if acquired, might have caused self-infection. We therefore compared the sepsis rate of patients who retained the staphylococci they were

Table 4. *Acquisition of hospital staphylococci—effect on sepsis rate (Poole Hospital)*

	Number of operations	Post-operative sepsis	Comparison of *Staph. aureus* from carriage sites and wound	
			Same	Different
Non-carriers	78	6 (7·7 %)	—	6
Carriers of strains not acquired in hospital	177	9 (5·1 %)	5	4
Carriers of strains acquired in hospital	265	15 (5·7 %)	9	6

carrying on the day of admission, with the sepsis rate of those who became carriers in hospital or whose own strains were replaced by 'hospital strains'. Table 4 shows that the sepsis rates of these two groups were very nearly the same and that neither

was greater than the sepsis rate of non-carriers. Moreover, the ratio of obvious cross-infections to possible self-infections was about the same in each group. Thus, even carriage of 'hospital staphylococci' similar to those responsible for many of the serious infections, did not increase the liability to sepsis.

All these results from Poole Hospital suggested that self-infection was very infrequent if, indeed, it was occurring at all. This unexpected finding led us to wonder whether we were observing an unusual phenomenon. We therefore decided to check it by observations at Shotley Bridge Hospital.

THE INVESTIGATION AT SHOTLEY BRIDGE HOSPITAL

This was conducted in the thoracic surgical unit of a 538-bed general hospital in a rural area. The unit occupies four modernized war-time Emergency Medical Service huts and a single-story brick building, there being 96 beds in all. At first all were in large open wards, but later two beds in each ward were separated into cubicles. There is no formal isolation unit but separate wards were used for 'clean' and for 'dirty' patients. The plenum-ventilated operating suite, of modern design, is in a separate building and has no indoor communication with the wards. The survey lasted from February 1956 to January 1960.

Methods

Precautions against infection

The methods for pre-operative preparation of patients' skin and of surgeons' hands were essentially those used in Poole Hospital. Some surgeons and nurses, however, used 2% hexachlorophene soap or a 3% hexachlorophene detergent-cream instead of ordinary soap for the pre-operative scrub, and omitted the alcohol hand-rinse.

Nose, skin and wound swabs

Because the hospital was 40 miles from the investigating laboratory and because the turnover of patients was quicker than in Poole Hospital, it was not practicable to examine weekly nose and skin swabs from each patient. We therefore relied, for determination of the pre-operative carrier-state, on one nose swab taken in the anaesthetic room. The swabs were immersed in salt-meat broth and were posted to the Public Health Laboratory, Middlesbrough, where they were incubated and subcultured. A preliminary investigation showed that *Staph. aureus* in the swabs consistently survived during the delay that this involved. The pre-operation nose swab was sometimes forgotten and patients on whom this happened have been excluded from the survey.

Wound and pus swabs were cultured in the hospital laboratory by Dr W. Stewart and *Staph. aureus* strains were sent to Middlesbrough for phage typing.

Nose swabs were taken every 3 months from all surgeons, anaesthetists, nurses, and others who worked in the operating-rooms; these swabs were treated in the same way as those from the patients.

Results

During the four years of the survey 2974 thoracic operations were performed. These were mainly lung operations for carcinoma and bronchiectasis, and heart operations for valvular and congenital lesions. Surgical sepsis due to *Staph. aureus* occurred after 75 (2·5 %) of the operations. However, full bacteriological data were available for only 2480 of the patients and it is on this smaller series that the analysis is based. Of these patients, 55 (2·2 %) suffered staphylococcal sepsis, the nature of which is shown in Table 5.

Table 5. *Nature of staphylococcal sepsis in* 55 *patients (Shotley Bridge Hospital)*

In five patients two forms of sepsis, and in one patient three forms, occurred together.

Purulent wound	27	Septicaemia	4
Empyema	18	Pyopericardium	1
Purulent drainage wound	7	Peritonitis	1
Deep wound abscess	4		

Table 6. *Frequency of* Staphylococcus aureus *sepsis in carriers and non-carriers; phage-type relationship between wound staphylococci and those carried by patients and surgical team (Shotley Bridge Hospital)*

	Number of operations (1)	Post-operative sepsis (2)	Wound staphylococci same as those from patient's nose (3)	Wound staphylococci different from those of patient's nose but same as those from: Surgeon (4)	Unscrubbed theatre staff (5)	Not traced (6)
All patients	2480	55 (2·2 %)	9*	12†	1	33
Carriers	1371	30 (2·2 %)	9*	9†	0	12
Non-carriers	1119	25 (2·2 %)	—	3	1	21

* Includes two untypable pairs and two that were also similar to staphylococci carried by a surgeon.

† Includes two that were also similar to strains carried by scrubbed nurses who were assisting at the operating table, and one that was carried also by an unscrubbed nurse.

Relationship between sepsis and nose carriage of Staphylococcus aureus

Of the staphylococci isolated from 55 septic lesions, 46 (84 %) differed from those carried in the patient's nose before operation, or had infected patients who were not nasal carriers. In only nine instances did the wound and nose staphylococci have similar phage sensitivity patterns and were thus possible cases of self-infection (Table 6). In two of these nine instances the nose and wound strains were both untypable and were only presumed to be the same; whilst in two others the wound strains were similar to those carried not only by the patient but also by the surgeon. The sepsis rates for carriers and non-carriers were almost exactly the same – 2·2 %.

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These results confirmed the finding at Poole Hospital, that nearly every case of post-operative surgical sepsis was caused by infection from a source not in the patient himself.

Relationship of sepsis to nose-carriage of Staphylococcus aureus *by the surgical team*

During the survey, nose swabs were taken from 82 members of the surgical team. Many of these were nurses in training who worked in the unit for only a short while, but from each of the permanent members of the staff up to 15 swabs were taken. For every member of the team a card was kept, recording the result of each swabbing. Records were kept of the names of all who were in the theatre at each operation.

Whenever a case of staphylococcal sepsis occurred, the responsible organism was compared, by phage typing, with those recently recovered from the noses of all persons who were present at the operation. The results of this comparison are shown in columns 4, 5 and 6 of Table 6. On twelve occasions a surgeon, twice a scrubbed nurse, and twice an unscrubbed nurse had recently carried organisms similar to those infecting the wound and thus were possible sources of infection. On thirty-three occasions, a possible source of infection was not traced, though this failure might have been less frequent if we had swabbed the theatre team more often.

Table 7. *Relationship between probable time of infection and possible source of infection* (*Shotley Bridge Hospital*)

	Wound staphylococci similar to those from nose of		
	Patient	Member of surgical team	Not traced
Infection probably during operation—35 cases	6 (17 %)	11 (31 %)	18
Infection probably after operation—20 cases	3 (15 %)	2 (10 %)	15

Phage similarity between a wound strain and that carried by a surgeon by no means proves that the surgeon was the source of infection, but we further examined this possibility in another way. The clinical details of each case of sepsis were carefully considered by a surgeon who, at that time, did not know the phage-typing results. He made a decision on whether infection probably occurred at the time of operation or afterwards, in the ward. Operating-room infections were thought probable when deep sepsis occurred beneath a clean parietal wound or when unusual pyrexia began within five days of operation. Of the 55 septic cases, 35 were attributed to infection during operation and 20 to infection later (Table 7). Identity of wound strains with patients' nose strains (possible self-infection) occurred with equal frequency in both groups; but identity between wound strains and those carried by a member of the surgical team occurred in 11/35 (31 %) of the presumed operating-room infections and in only 2/20 (10 %) of the ward infections. If the similarity of the wound and the surgeons' staphylococci was mainly coin-

cidental, the frequency of phage-type similarity should have been the same in each group. That it was not suggests that a member of the surgical team was the source of infection in up to 11 of the 35 cases of sepsis.

DISCUSSION

The general conclusion from these studies is that self-infection of surgical wounds, with *Staph. aureus* from carrier sites in the patient's own body, was a much less frequent cause of sepsis than was cross-infection from external sources. This conclusion is based on the observation, in both hospitals, that the sepsis rate was no higher among nasal-carriers of *Staph. aureus* than among non-carriers; and on the finding that patients whose sites of carriage yielded *Staph. aureus* more than once before an operation suffered significantly no more sepsis than those who yielded the organism once only.

Because we found no evidence suggesting the frequent occurrence of self-infection we studied, in the second part of this investigation, one possible source of cross-infection—the surgeons and other members of the operating-room team. Of the 35 possible operating-room infections, 11 (31 %) could have come from a member of the team. We have, however, little evidence to offer concerning the routes by which these infections might have occurred. If some of the carriers amongst the staff were active 'dispersers' of staphylococci, the infecting organisms could have been airborne; but air-sampling was done during many operations in this well-ventilated theatre and *Staph. aureus* contamination of the air was very slight indeed. Glove punctures, however, were very common—about 10 % for instrument nurses and 30 % for surgeons—and since nasal carriers of *Staph. aureus* so often are skin carriers too, we think that passage of skin organisms through damaged gloves was possibly the main manner of infection. When the investigation began we did, in fact, try to keep records of all glove punctures and intended to study them in relation to actual septic incidents. Unfortunately, the recording system broke down so we were not able to make this study which, we believe, would be well worth while. Meanwhile, we feel that improved detection and prevention of glove punctures occurring during operations might prevent some sepsis of the type that we have observed.

Several studies similar to ours have indicated that self-infection is more frequent than we found it to be (Colbeck, Robertson, Sutherland & Hartley, 1959; Weinstein, 1959; Williams, Jevons, Shooter, Hunter, Girling, Griffiths & Taylor, 1959; McNeill, Porter & Green, 1961), whilst yet other studies have yielded results similar to our own (Public Health Laboratory Service, 1960; Rountree, Harrington, Loewenthal & Gye, 1960; Lowden, Vaithilingham & Milne, 1962; Moore & Gardner, 1963). The wide divergence between these findings need cause no surprise, for the frequency of self-infection may be influenced by several factors that vary from one hospital to another. For example, strains of *Staph. aureus* inhabiting different hospitals may differ in their relative affinities for carriage sites and for wounds, and in their abilities to spread from carriage sites to a wound in the same patient. Carriage of *Staph. aureus* in the nose—the basis of most of the studies—is not

accompanied by skin carriage with equal frequency in all parts of the body, so operation wounds may be more liable to self-infection in some branches of surgery than in others. Lastly, the method of pre-operative skin preparation used in a surgical unit may profoundly influence the frequency of self-infection. Thus, shaving the skin on the day before rather than on the day of operation may allow time for cocci to multiply in abrasions, so that the surgeon's knife cuts through minute abscesses instead of through near-sterile skin; disinfectants differ widely in their efficacy on skin, while surgeons differ in the time that they allow the disinfectant to act before applying the knife. In some of the reports on self-infection the methods of skin preparation and disinfection were not described but if there were differences of method they might have contributed to the differences between results.

Henderson & Williams (1961) and Stokes & Milne (1962) found that patients whose noses were kept free from *Staph. aureus* by intranasal application of antibacterial creams suffered no less sepsis than untreated controls. This might be held to confirm reports on the relative infrequency of self-infection; but, alternatively, it might be explained by the fact that abolition of nasal carriage does not necessarily lead to abolition of skin carriage, and by the possibility that it is skin carriage rather than nasal carriage of staphylococci that increases liability to self-infection. Our findings only partly support this possibility: the sepsis rate of patients who were nose and skin carriers was, indeed, slightly greater than that of patients who carried only in the nose, but it was still no greater than that of non-carriers.

We have no doubt that self-infection can, and sometimes does, cause serious surgical sepsis, and that precautions against it must be rigidly maintained. But over-emphasis on the frequency of self-infection may deflect attention from important risks of cross-infection. It is in the hope of preventing this that the findings reported here are presented.

SUMMARY

1. In two hospitals, post-operative staphylococcal wound sepsis occurred with equal frequency in patients who were and in those who were not nasal carriers of *Staph. aureus*.

2. Nasal carriage of *Staph. aureus* was not always associated with skin carriage at the site of operation, but even patients who were skin carriers suffered no more sepsis than non-carriers.

3. Self-infection was a less frequent cause of sepsis than was cross-infection. Other investigations of this type have revealed conflicting findings on the frequency of self-infection. These may be due to differences in the epidemiological properties of staphylococci infesting the hospitals; to different methods of pre-operative skin preparation; and to the different types of operation concerned.

4. In one of the hospitals, 31 % of probable operating-room infections were with organisms similar to those carried by some member of the surgical team. In infections thought to have occurred in the ward, only 10 % showed this similarity. In 11 of 35 presumed operating-room infections, the source may have been a member of the surgical team.

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