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Nasal carriage of staphylococci and post-operative staphylococcal wound infection

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SYNOPSIS One hundred patients undergoing major surgical operations in a provincial group hospital were studied bacteriologically daily to determine any relation between nasal carriage of staphylococci and post-operative staphylococcal wound sepsis.

Sixty-four patients were either carriers on admission and throughout their stay, or their noses became colonized at some time by ward strains. Six cases of staphylococcal wound or drain wound sepsis occurred in this group, four due to ward strains and two to the patient's own nasal strain. Four patients lost the nasal strain after admission and thereafter their noses remained free from staphylococci. There was no sepsis among these. Thirty-two patients never carried staphylococci in their noses at any time. There was no wound sepsis in this group but in two patients the drain wounds became infected with ward strains.

Grouping all cases of staphylococcal wound or drain wound sepsis there were three times as many caused by ward strains as by nasal strains.

In 10 of the 11 cases of wound or drain wound sepsis, including three cases due to Gram-negative bacteria, a physical cause in the shape of a drain, necrosis of skin edges, or loss of tissue was present, providing an entry for bacteria.

In a previous paper (Henderson and Williams, 1961) we described an attempt to reduce the post-operative staphylococcal sepsis rate in surgical wounds by nasal disinfection. However, the number of septic wounds in patients whose noses were disinfected by Naseptin was practically identical with the number among untreated controls, despite the facts that the nasal carriers of staphylococci had higher sepsis rates than the non-carriers and that the nasal carrier rate was reduced by the treatment.

There are several possible explanations of this apparent contradiction, *e.g.*, persistent colonization of an area in the nose other than that swabbed, or the derivation of both wound infection and nasal colonization from a common source outside the patient. Williams, Noble, Jevons, Lidwell, Shooter, White, Thom, and Taylor (1962), examining patients at weekly intervals, found that nasal colonization often preceded wound sepsis but without frequent swabbing the time relation could not be determined with any certainty. It was with a view to obtaining more precise information about the time relations of nasal colonization and wound infection that the present study was undertaken.

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METHODS

One hundred patients, male and female, admitted to the surgical wards of a provincial hospital between 30 April 1961 and 1 May 1962 were studied bacteriologically each day. The patients chosen were those who had been admitted for the more serious type of operation, because in the Public Health Laboratory Service (1961) study on surgical wound infection the highest sepsis rate was found in patients whose operations were more serious and consequently took longer to perform, who had the longest incisions, or who had to be drained.

The wounds of 70 of the patients were bandaged and dressed daily. The wounds of the remaining 30 patients were sprayed with Nobecutane and had no dressings. All the drained wounds were in the bandaged group.

On the day preceding operation or on the morning of operation, swabs, previously moistened in broth, were taken of the nose, hand, skin at the site of operation, and the floor beside the bed. On the day following the operation and on every day thereafter until the wound healed completely or the patient was discharged, swabs were

taken of the nose, hand, dressing, wound, drain opening, skin about 2 in. from the wound, and the floor. Impression plates were also taken of the bed-jacket, nightgown or theatre gown, whichever was being worn, the coverlet, and bed curtains.

The swabs were plated on blood agar and then broken off into Robertson's salt meat broth. After 24 hours' incubation at 37°C., inoculations were made from the salt meat broth onto nutrient agar plates containing 6% salt and phenolphthalein phosphate. These plates were then incubated at 37°C. for 24 hours, left on the bench for 48 hours, and examined in the usual way for colonies of *Staph. aureus*. All strains of *Staph. aureus* isolated were identified by phage typing.

Although the investigation was concerned principally with *Staph. aureus*, a study was also made, by conventional bacteriological methods, of other pathogens found infecting the wounds or drain wounds.

DEFINITIONS

In analysing the sources of the staphylococci found causing wound sepsis, the term 'nasal strain' was used for staphylococci that were present in the patient's nose on admission or that colonized the nose after admission to the ward. No wound infection was attributed to a patient's nasal strain unless it had been isolated from the nose at least 24 hours before being found in the wound.

The term 'ward strain' was used for staphylococci that infected wounds but were not the patient's 'nasal strain' as just defined; they were presumed to come from other patients or the staff in the ward.

RESULTS

STAPH. AUREUS SEPSIS Of the 100 patients, 55 had wounds which did not require to be drained, and 45 had a drain either in the centre or lower pole of the wound. Twenty-six of these, those with radical mastectomies, also had a second drain, a 'stab', in the axilla, some 2 or 3 inches away from the actual wound.

The sepsis rate was higher in drained wounds (17·8% of 45) than in undrained (5·4% of 55, Table I). In two (4·4%) the strain of *Staph. aureus* infecting the wound or drain wound was the nasal strain. In three (6·6%) the infecting strain of *Staph. aureus* was a ward strain. In the other three (6·6%) the organisms were Gram-negative bacilli. The three undrained wounds that became septic were all infected with a ward staphylococcus.

Nasal carriage of *Staph. aureus* was more frequent than previously recorded in this hospital, 68 of the 100 patients being carriers for some period during their stay in hospital (Table II). Twenty-one patients had *Staph. aureus* in their noses on admission and carried it throughout, the same strain being isolated from the nasal swab daily. Forty-three patients acquired a strain of *Staph. aureus* at some time while in hospital and in 26 of these the strain acquired was phage type 52/52A/80.

Of the 21 patients who carried the same strain in

TABLE I

POST-OPERATIVE WOUND SEPSIS

Type of Wound	*No. of Wounds*	*Number of Wounds with Sepsis*			
		Staphylococcal		*Not Staphylococcal*	*Total*
		Nasal Strain	*Ward Strain*		
Undrained	55	—	3 (5·5%)	—	3 (5·5%)
Drained	45	2 (4·4%)	3 (6·6%)	3 (6·6%)	8 (17·8%)
	100	2	6	3	11

TABLE II

STAPHYLOCOCCAL INFECTION OF WOUNDS, DRAIN WOUNDS, AND CONTAMINATION OF WOUND SURFACES

Nasal Carriage	*No. of Patients*	*Sepsis of*				*Surface Contamination of Clean Wounds*	
		Wound		*Drain Wound*			
		Nasal Strain	*Ward Strain*	*Nasal Strain*	*Ward Strain*	*Nasal Strain*	*Ward Strain*
Same strain of *Staph. aureus* throughout stay in hospital	21	—	1	2	—	6	3
Staph. aureus in nose on day of admission, thereafter not isolated	4	—					1
Nose colonized by *Staph. aureus* while in hospital	43	—	2		1		14
Staph. aureus never present in nose	32	—			2		4
Total	100	0	3	2	4	6	22

their noses throughout, two (9·5%) infected their drain wounds with their nasal strain. One infection occurred on the fourth day following operation and the other on the thirteenth day. The phage types were 7/47/53/75+ and 187 respectively. The wound of one patient (4·7%) was infected by a ward strain, type 52/52A/80, on the third day after operation.

Of the 43 patients who acquired a ward strain in their noses while in hospital, three (6.9%) had their wounds infected by ward strains. In two of these infection of the wound occurred on the same day as colonization of the nose and in each case the strain infecting the wound and colonizing the nose was type 52/52A/80. In the third patient the strain colonizing the nose was type 80, that infecting the wound was 75/42D, and infection of the wound occurred on the thirteenth day following operation. In no case was the nose colonized in the ward before the appearance of wound infection.

TABLE III

PATIENTS WITH STAPHYLOCOCCAL WOUND SEPSIS[1]

Wound	*Phage Type of Wound* Staph. aureus	*Day after Operation* Staph. aureus *Isolated*	*Distribution of Wound Staphylococcus in Wound and Environment No. of Daily Samples Yielding Staphylococci/No. of Samples Examined*			
			Before Wound Infection		*After Wound Infection*	
Self Infections						
1 Radical mastectomy	7/47/53/75–	4	Nose	7/7	Drain wound	15/15
					Main wound	6/15
					Dressing	4/15
					Floor	3/15
					Skin	5/15
2 Radical mastectomy	187	13	Nose	13/13	Main wound	10/11
			Bed-jacket	4/12	Bed-jacket	3/11
			Coverlet	1/12	Coverlet	2/11
			Hand	1/13	Skin	8/11
					Hand	4/11
					Nose	11/11
					Floor	1/11
Ward Infections						
3 Bilateral Trendelenburg	52/52A/80	3	Bed-jacket	1/1	Main wound	6/13
			Floor	1/2	Skin	6/13
					Floor	5/13
					Curtain	1/13
4 Thoraco-oesophagectomy	52/52A/80	13	Floor	1/13	Main wound	3/5
					Dressing	1/5
					Bed-jacket	3/5
					Coverlet	3/5
					Skin of nose	1/5
					Hand	2/5
					Floor	3/5
					Nose	5/5
5 Gastrectomy	52/52A/80	3	Coverlet	3/3	Drain wound	11/14
			Bed-jacket	3/3	Bed-jacket	10/14
			Dressing	3/3	Coverlet	13/14
			Skin	1/3	Skin	3/14
			Hand	2/3	Hand	8/14
			Floor	3/3	Floor	13/14
			Nose	1/3	Nose	10/14
6 Radical mastectomy	75/42D	2	Nil		Wound	6/15
					Bed-jacket	3/15
					Coverlet	1/15
					Skin	3/15
					Hand	2/15
					Floor	3/15
7 Radical mastectomy	80	4	Nil		Drain wound	8/8
8 Radical mastectomy	75/77/42D	2	Hand	1/3	Drain wound	10/15
					Dressing	4/15
					Bed-jacket	1/15

[1]Sites never yielding the staphylococci are not entered in this table; nine sites were examined on each post-operative day.

Of the 32 patients who never carried *Staph. aureus* in their noses, two (6·2%) had their wounds infected by a ward strain on the second and fourth day after operation respectively. The phage types were 75/42D and 80.

Thus, of the eight infections of wounds or drain wounds due to *Staph. aureus*, two were caused by the patient's nasal strain and six by ward strains.

Surface contamination of clean wounds and drains is also given in Table II; 22 were contaminated by ward strains and six by nasal strains.

Table III shows the sources of infection recognized before the appearance of the wound sepsis, and the extent of environmental contamination subsequently. In the two cases of self-infection (cases 1 and 2 in Table III), all the swabs taken from the noses before the appearance of the infection yielded staphylococci of the infecting type, and in one case there was some contamination of other areas. Of the six patients whose wound sepsis was due to ward strains, only one had evidence of widespread contamination before the appearance of sepsis, though occasional positive cultures were obtained from three others.

ENVIRONMENTAL CONTAMINATION The daily swabbing and taking of impression plates gave an interesting picture of contamination in the environment. In those patients who were admitted carrying their own strain and who carried it throughout their stay, contamination was heaviest on the bed-jacket and coverlet. It was less heavy on the floor and very little reached the curtains (Table IV). Where patients acquired a strain in the ward the dispersal appeared to depend on the phage type of the staphylococcus; dispersal tended to be heavier from carriers of type 52/52A/80 than from other carriers. Some types made only a fleeting appearance, being isolated infrequently from the nose and they did not contaminate the environment to any great extent (Tables IV and V).

Where type 52/52A/80 colonized the patient's nose it then appeared in the environment more than twice as frequently as before colonization. Taking three sites in the environment—floor, bed-jacket, and coverlet—the number of patients yielding positive samples from all three sites after colonization of the nose by this strain was more than double the number before colonization. After the development of sepsis in a wound staphylococci of the infecting type almost always appeared in the environmental samples (Tables III and IV).

SEPSIS CAUSED BY GRAM-NEGATIVE BACILLI Three drain wounds were infected by Gram-negative bacilli. From one *Proteus* was isolated frequently, from another *E.coli* was isolated as well as being found in the patient's nose, while from the drain wound of the third patient *E.coli*, *Proteus*, *and Ps.pyocyanea* were all isolated.

TABLE IV

COMPARISON OF NOSE AND SEPTIC LESIONS AS SOURCE OF DISPERSAL OF STAPHYLOCOCCI

Environmental Sample	*Nasal Carrier*				*Septic Lesion*	
	Staph. aureus *in Nose on Admission*		Staph. aureus *Acquired in Ward*		*No. Nasal* Staph. aureus *of Same Type*	
	No. of Samples	*No. and % Yielding Nasal Strain*	*No. of Samples*	*No. and % Yielding Nasal Strain*	*No. of Samples*	*No. and % Yielding Lesion Strain*
Bed-jacket	202	67 (33·2)	493	92 (18·7)	53	4 (7·5)
Coverlet	202	63 (31·2)	493	97 (19·7)	54	1 (1·9)
Curtain	202	3 (1·5)	223	2 (0·9)	54	1 (1·9)
Floor	220	23 (10·5)	540	120 (22·2)	58	7 (12·1)

TABLE V

ENVIRONMENTAL CONTAMINATION WITH PHAGE TYPE 52/52A/80 AROUND CARRIERS OF THIS AND OTHER STRAINS

Environmental Sample	*Carrier State*						
	Acquired Phage Type 52/52A/80 in Ward		*Admitted with or Acquired Strain Other than Phage Type 52/52A/80*			*No* Staph. aureus	
	No. of Samples	*No. and % Yielding Phage Type 52/52A/80*	*No. of Samples*	*No. and % Yielding*		*No. of Samples*	*No. and % Yielding Phage Type 52/52A/80*
				Phage Type 52/52A/80	*Same Type as Patient*		
Bed-jacket	275	103 (37·5)	441	13 (2·9)	76 (17·3)	334	8 (2·4)
Coverlet	275	103 (37·5)	441	8 (1·8)	81 (18·4)	334	10 (3·0)
Curtain	103	1 (1·0)	401	8 (2·0)	8 (2·0)	311	1 (0·3)
Floor	201	147 (73·1)	480	79 (16·5)	44 (9·2)	366	49 (13·4)

DISCUSSION

Our aim in this work was to determine by daily bacteriological examination of patients undergoing major surgical operations whether the association of nasal carriage of *Staph. aureus* with post-operative wound sepsis, which has been demonstrated in several studies, reflected spread of staphylococci from nose to wound. In 100 wounds studied, staphylococcal sepsis developed in eight and 28 had silent staphylococcal wound contamination. Clearly the numbers are insufficient for any generalization but in only two of the cases of sepsis and six of the cases of contamination could the source of infection be shown to be the patient's own nose. The source of infection in most of the others was not discovered but was presumed to be the other patients or staff in the ward. It was notable that one phage type, 52/52A/80, was responsible for three of the cases of sepsis and 22 of the contaminations.

In previous studies, which have suggested that nasal staphylococci might be responsible for wound sepsis, *e.g.*, those of Williams, Jevons, Shooter, Hunter, Girling, Griffiths, and Taylor (1959), Williams *et al.* (1962), and of McNeill, Porter, and Green (1961) daily examinations of the wound and carrier sites were not made, so that it was not possible to determine the exact time relations of nasal and wound infection. In the studies of Williams *et al.* (1962) 42% of the cases of wound sepsis were due to staphylococci isolated from the nose before they were isolated from the wound (with the proviso that neither wound nor nose was swabbed daily), but it is possible that more of the infections seen at St. Bartholomew's Hospital would have been recognized as simultaneous with nasal colonization if more frequent swabbing had been adopted. In the St. Bartholomew's Hospital study the patients at greatest risk appeared to be those who became carriers while in hospital. In the present study the two cases of undoubted self-infection were due to staphylococci carried by the patients on admission to hospital and it was noteworthy that only two of the 26 patients whose noses were colonized by the prevalent type 52/52A/80 developed wound sepsis at any time.

The extensive environmental sampling carried out provided interesting information on the degree of contamination of the patient's bed and the surrounding floor. There was some suggestion that patients becoming carriers of staphylococci type 52/52A/80 tended to disperse these strains into the environment more than carriers of other strains, though the comparison is made difficult by the numbers of patients in the ward infected with this strain.

Nasal carriers tended to disperse staphylococci to a greater extent than patients with septic lesions with no nasal staphylococci of the same type. Again, however, the comparison is made more difficult by septic lesions in this category being few in number.

It was not thought likely that any of the infections occurred as a result of contamination in the operating theatre. Although no regular bacteriological sampling was carried out while the survey was going on, a strong positive pressure of air was maintained in the operating theatre, and previous examination had failed to show that any of the surgeons or member of the staff was a carrier of *Staph. aureus*. On the other hand it is noteworthy that, of the 11 cases of sepsis due to all pathogens, 10 had a route of entry for pathogenic organisms. In eight of the 10 it was a drain wound. In one of the other two, loss of tissue left a cavity under the wound which became infected, and in the other the skin edges necrosed, probably from interference with the blood supply, and sepsis occurred shortly after the wound had broken down.

The nasal carriage rate of 68% was higher than previously recorded in this hospital. Daily swabbing revealed that 15% to 20% of patients carried *Staph. aureus* in their noses for one or two days only; in previous investigations, when swabs were taken on admission and discharge only, these had been missed.

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REFERENCES

Henderson, R. J., and Williams, R. E. O. (1961). *Brit. med. J.*, **2**, 330.
McNeill, I. F., Porter, I. A., and Green, C. A. (1961). *Ibid.*, **2**, 798.
Williams, R. E. O., Jevons, M. P., Shooter, R. A., Hunter, C. J. W., Girling, J. A., Griffiths, J. D., and Taylor, G. W. (1959). *Ibid.*, **2**, 658.
——, Noble, W. C., Jevons, M. P., Lidwell, O. M., Shooter, R. A., White, R. G., Thom., B. T., and Taylor, G. W. (1962). *Ibid.*, **2**, 275.