

Nasal and skin carriage of *Staphylococcus aureus* by patients undergoing surgical operation

BY SHEILA POLAKOFF, I. D. G. RICHARDS*

M. T. PARKER AND O. M. LIDWELL

Cross-Infection Reference Laboratory, Colindale, London, N.W. 9

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It is generally accepted that the nose is the most frequent site of carriage of *Staphylococcus aureus* in man, and regular swabbing of the nose has been used in many epidemiological investigations as a means of sampling the staphylococci carried by hospital patients and staff. It is common experience, however, that no source can be found among the nasal carriers present in the ward for a substantial minority of the strains acquired by patients or present in the ward air (see, for example, Shooter *et al.* 1963; Lidwell *et al.* 1966). Persons with negative nasal swabs occasionally carry *Staph. aureus* elsewhere on the surface of the body and there is evidence that some of them—especially those carrying the organism in the perineal region—may be of particular significance as dispersers of the organism into the environment (Hare & Ridley, 1958; Ridley, 1959; Solberg, 1965). Bøe *et al.* (1964) examined 3508 patients on admission to hospital, and found that 12·8% carried *Staph. aureus* on the perineal skin; 4% had positive perineal but negative nasal swabs.

We took the opportunity, while carrying out an investigation of the aerial dispersion of *Staph. aureus* in the operating theatre at the West Herts Hospital, Hemel Hempstead (Lidwell, Polakoff & Richards, 1967) to obtain cultures from several sites on the body-surface of patients immediately before operation.

METHODS

The investigation was carried out on 361 patients of two general surgeons, and included nearly all of those operated upon in the course of 124 morning sessions during 18 months. The patients were bathed and shaved in the ward, but received no other pre-operative skin treatment there. A freshly laundered pack for each patient was delivered to the ward on the morning of the operation; it contained a canvas stretcher, a drawsheet, a cotton cellular blanket, cotton leggings, and a gown. Patients were dressed in gown and leggings about an hour before the operation. They were anaesthetized in the theatre annexe while on the stretcher on which they had been brought from the ward. They were then wheeled into the theatre and the blanket was removed.

Swabs for bacteriological examination were collected from the nose, perineum, axilla and hand in the theatre while the patient was being prepared for operation. A cotton-wool swab, which had first been moistened with nutrient broth, was used

* Present address: Department of Child Health, University of Glasgow.

to sample both anterior nares, six circular sweeping motions being made in each. The swab was then placed in a test-tube containing 2 ml. broth for transport to the laboratory.

Other skin sites were sampled with a large swab made by wrapping several layers of 1 in. wide cotton gauze bandage round the end of a 6 in. \times $\frac{3}{4}$ in. wooden throat spatula and tucking in the end. This swab was moistened with broth and then rubbed to-and-fro six times on the chosen surface. The gauze end was then pushed off with a separate sterile applicator into a screw-capped jar containing 10 ml. broth.

The perineal swab was taken from the skin area extending from 1 in. in front of the anus to the base of the penis in the male, and to the lower border of the symphysis pubis in the female. The axillary swab was taken from the whole of the left axilla, and the hand swab from the dorsum of the right hand and wrist.

All swabs were transported to the laboratory at the end of the operating session and were at ambient temperature in the meantime. The interval between the collection of the swabs and the inoculation of primary plates was usually between $1\frac{1}{2}$ and 4 hr., and did not exceed 5 hr.

The following bacteriological media were used: 7% horse-blood agar and nutrient agar with 7% added sodium chloride (salt agar). Inoculated plates were examined after 1 and 2 days' incubation at 37° C. Nasal swabs were rubbed on a separate blood-agar plate and then returned to the tube of broth, which was incubated overnight and re-plated on salt agar. For all other swabs, one loopful of broth from the jar was inoculated on a blood-agar plate and another on a salt-agar plate. The broth was also incubated overnight and then subcultured on a salt-agar plate.

One representative of each colonial type on each plate which resembled *Staph. aureus* was subcultured and a coagulase test was performed. Each coagulase-positive culture was phage-typed and tested for resistance to penicillin and tetracycline by streaking up to filter-paper strips impregnated with antibiotic.

Two cultures of *Staph. aureus* isolated from the same patient were considered to belong to distinct strains if their phage-typing patterns differed by two or more strong reactions (Williams & Rippon, 1952) or if their sensitivity to one or both antibiotics was different.

RESULTS

A swab was collected from each of the four sites (nose, perineum, axilla and hand) in 361 patients. Table 1 shows the number and percentage of swabs from each site in which *Staph. aureus* was found by direct plating (+ + +) or only by enrichment (+), and the total positive by both methods. The nasal carrier-rate was 40%, and seven-eighths of the isolations were made by direct plating; 12% of the perineal swabs were positive, nearly half of them by direct plating; isolations from the axilla (7%) and from the hand (24%) were in most cases made only by enrichment culture. Heavy carriage was thus characteristic of the nose and, to a lesser extent, of the perineum, but carriage in the axilla and on the hand was usually scanty.

In Table 2, the distribution of *Staph. aureus* cultures with different patterns of sensitivity to penicillin and tetracycline is shown. The cultures were divided into

the following groups: S: sensitive to penicillin and to tetracycline; P: resistant to penicillin but sensitive to tetracycline; R: resistant to tetracycline and, with a few exceptions, also to penicillin.

The total of the three columns S, P and R exceeds the total number of positive swabs because two or more distinct strains were isolated from some of the swabs. The figures in the three columns represent the number and percentage of swabs from each source which contained staphylococci in the corresponding resistance-category.

Table 1. *Isolation of Staphylococcus aureus by direct plating and by enrichment culture from swabs of the nose, perineum, axilla and hand of 361 patients*

(+ + +, by direct plating; +, only by enrichment. Percentages in parentheses.)

	<i>Staph. aureus</i> isolated		
	+ + +	+	Total
Nose	128 (35)	18 (5)	146 (40)
Perineum	20 (6)	25 (7)	45 (12)
Axilla	2 (< 1)	22 (6)	24 (7)
Hand	13 (4)	74 (20)	87 (24)

Table 2. *Antibiotic resistance of Staphylococcus aureus strains from the nose, perineum, axilla and hand*

(S, sensitive to penicillin and tetracycline; P, resistant to penicillin, sensitive to tetracycline; R, resistant to tetracycline. Percentages in parentheses.)

	Total swabs positive	No. (and percentage) of swabs containing organisms with the following sensitivities		
		S	P	R
Nose	146 (40)	92 (25)	48 (13)	15 (4)
Perineum	45 (12)	27 (7)	11 (3)	8 (2)
Axilla	24 (7)	10 (3)	10 (3)	4 (1)
Hand	87 (24)	44 (12)	33 (9)	12 (2)

Although the carrier-rate for resistant organisms in the nose was higher than that at other sites, the proportion of the organisms carried that were resistant was somewhat greater at the other sites than in the nose. Thus, only 15 of 146 cultures isolated from the nose (10%), but 24 of 156 from other sites (15%) were 'multiple resistant' (R).

The age- and sex-distribution of carriage at each site is summarized in Table 3, which shows the percentage of swabs positive on direct culture, with the total percentage of positive swabs in parentheses. The nasal carrier-rate was, as expected, higher in the young patients. Carriage on the skin of the axilla and the hand was also rather more common in the young than in the old. Perineal carriage, on the other hand, appeared to occur with equal frequency at all ages. There was no significant difference between the carrier-rates in males and females at any of the sites, either in the totals or within the age groups.

Table 4 shows the number of positive cultures from the perineum, axilla and hand in relation to the nasal carrier-state. Carriage at all sites was significantly related to the presence of *Staph. aureus* in the nose. Among the 146 patients with positive nose-swabs, 36 (25%) were perineal carriers, 20 (14%) were axillary carriers, and 68 (47%) were hand-carriers. The corresponding figures for the 215

Table 3. *Relation of age and sex to carriage-rates for Staphylococcus aureus*

(Percentages of swabs positive by direct plating, with total percentage positive (direct + enrichment) in parentheses.)

Age (years)	No. examined	Percentage positive			
		Nose	Perineum	Axilla	Hand
0-9	34	50 (50)	6 (9)	0 (12)	3 (35)
10-19	26	62 (69)	12 (19)	5 (15)	15 (54)
20-29	20	50 (55)	5 (15)	5 (10)	5 (15)
30-39	51	31 (33)	2 (10)	0 (4)	2 (16)
40-49	74	30 (35)	5 (12)	0 (7)	3 (26)
50-59	66	30 (35)	5 (17)	0 (8)	3 (21)
60+	90	30 (38)	7 (10)	0 (2)	2 (19)
Sex					
M	219	37 (42)	6 (12)	<1 (6)	5 (28)
F	142	32 (39)	5 (13)	1 (8)	1 (18)
Total	361	35 (40)	6 (12)	1 (7)	4 (24)

Table 4. *Number of perineal, hand, and axillary cultures positive for Staphylococcus aureus in nasal carriers and non-carriers*

(+++ , positive on direct plating; + , positive only on enrichment.)

	Nose swab		
	+++	+	Negative
All nose swabs	128	18	215
Perineum			
+++	12	3	5
+	19	2	4
Negative	97	13	206
Axilla			
+++	2	0	0
+	17	1	4
Negative	109	17	235
Hand			
+++	11	0	2
+	50	7	17
Negative	68	11	195

patients with negative nose swabs were: perineal carriers 9 (4%), axillary carriers 4 (2%), hand carriers 19 (9%). Thus, though the presence of staphylococci on the skin might in many cases be attributable to contamination with nasal secretion, in other cases it was independent of nasal carriage.

The isolation of *Staph. aureus* from the skin by the enrichment method only

might be a consequence of recent contamination from an extraneous source, but the presence of the organism in numbers sufficient to be detected by direct plating probably indicates that it has colonized the body surface, particularly if the nose-swab is negative, or is positive only on enrichment. It is therefore of interest that eight of the 20 heavy perineal carriers (+ + +) were patients with few *Staph. aureus* in the nose (+), or with negative nose swabs. The two heavy axillary carriers, and all but two of the 13 patients with heavy hand carriage, had nose swabs that were positive for *Staph. aureus* on direct culture (+ + +).

Table 5. *Relative frequency of independent carriage of Staphylococcus aureus on the perineum, axilla and hand*

(+ + +, positive on direct plating; +, positive only on enrichment. Strains isolated from each site are divided as follows: line 1—same strain + + + in nose; line 2—nasal swab negative, contained a different strain, or the same strain +.)

Antibiotic resistance	No. of strains			
	+ + +		+	
	S + P	R	S + P	R
All nasal swabs	122	12	18	3
Perineum 1	10	1	23	3
2	5	4	0	0
Axilla 1	2	0	11	2
2	0	0	7	2
Hand 1	8	2	38	1
2	3	0	26	9

The extent of independent carriage in the perineum, axilla and hand was examined further in Table 5, in which the strains of *Staph. aureus* isolated from these three sites were divided into two groups of: (1) those in which the same strain was isolated from the nose by direct plating; and (2) those in which the corresponding nasal swab was negative, was positive for a different strain of *Staph. aureus*, or yielded the same strain in such small numbers that it could be detected only by enrichment culture.

The cultures from the three sites were subdivided further into those isolated on direct plating (+ + +) and those recovered only after enrichment (+), and because it appeared that there was an excess of antibiotic-resistant strains among the cultures isolated from the skin, also into those sensitive to both antibiotics or resistant only to penicillin (S + P) and those resistant to tetracycline (R).

There was clear evidence of a group of patients carrying *Staph. aureus* independently on the perineal skin. Nearly half of the heavy perineal carriers (9 out of 20) were not heavy carriers of the same strain in the nose. On the other hand, all 26 of the patients whose perineal swabs yielded a scanty growth of *Staph. aureus* were heavy carriers of the same organism in the nose. The distribution of antibiotic resistance in the strains that were carried independently in the perineum was also quite unlike that in the strains present in both nose and perineum, or indeed in the

nose swabs of all patients. Of cultures isolated by direct plating (+ + +), four of the nine from independent perineal carriers, but only one of 11 from perineal carriers who were also nose carriers of the same strain, and 12 of 134 from all nasal carriers were tetracycline resistant. This suggested that 'multiple-resistant' hospital staphylococci were more likely than other strains to cause independent perineal carriage.

When, however, axillary and hand carriage were examined in the same way, the pattern was quite different. The only two heavy axillary carriers, and 10 of the 13 heavy hand carriers also carried the same strain prolifically in the nose. In addition, the distribution of antibiotic resistance among strains carried on hands and axilla was not significantly different from that found among nasal strains, and none of the three strains carried heavily and independently on the hands was tetracycline resistant.

The nine patients who were heavy, independent perineal carriers included four males and five females. The organisms from two of the males and from two of the females were tetracycline resistant. Patients who were independent perineal carriers of tetracycline-resistant organisms had been in hospital on average 15 days (respectively 5, 12, 16 and 27 days); those carrying sensitive organisms had been admitted to hospital more recently (respectively 1, 1, 1, 3 and 6 days before operation).

DISCUSSION

Perineal carriage of *Staph. aureus* was less common among our patients, who had recently bathed and donned fresh clothing, than among the male medical students examined by Ridley (1959). He found the organism in perineal swabs from 13 of 40 students (32%) who were examined only by a direct cultural method, but the clothes of the subjects were often heavily contaminated with staphylococci at the time of sampling. Our patients were examined both by direct and by enrichment sampling, and the total perineal carrier-rate was 12%. This figure is similar to the one observed by Bøe *et al.* (1964) in Norwegian hospital patients who had been bathed and reclothed just before swabbing. The bacteriological methods used by these workers appear to have been of similar sensitivity to those used in the present investigation.

Skin carriage, whether in the perineal or axillary region or on the hand, was more frequent among nasal carriers of *Staph. aureus* than among non-carriers; but though hand and axillary carriage was usually scanty, half of the perineal carriers were heavy carriers in whom the organism could be detected by direct cultural methods. The isolation of *Staph. aureus* by direct plating indicated a recovery of at least 1000 colony-forming units from a skin swab.

Our main interest was in the frequency with which patients with negative nose-swabs might be unsuspected sources of *Staph. aureus* infection. A similar proportion of our patients (4%) as of those examined in Norway (Bøe, *et al.* 1964) had a positive perineal and a negative nasal swab when both direct and enrichment cultures were performed.

We examined the incidence of independent carriage of *Staph. aureus* in the

perineal region, and for comparison also in the axilla and on the hand. An independent carrier at one of these sites was defined as a person whose skin swab was positive for *Staph. aureus*, but whose nasal swab did not yield the same strain on direct plating, and would therefore not have been detected in routine epidemiological investigations. Independent skin carriage was considered to be heavy when the organism was isolated by the direct plating method.

Whenever *Staph. aureus* was found in small numbers in the perineal swab, the same strain was isolated by direct plating from the nasal swab. Among heavy perineal carriers, however, nearly half (9 of 20) were independent carriers. These were probably people in whom the perineum was the primary site of staphylococcal multiplication. Examination of perineal swabs by direct plating thus revealed that over 2% of the patients were potential sources of *Staph. aureus* which would not have been detected by routine nasal swabbing, and increased the number of carriers of *Staph. aureus* by 5%. C. O. Solberg states (personal communication, 1967) that, among 100 persistent carriers examined by a standardized test (Solberg 1965), there were 16 heavy dispersers, and that six of them (38%) were heavy carriers of the same strain on the perineal skin, whose nose swabs however yielded few staphylococci or were negative. This suggests that examination of nasal swabs only might leave undetected up to one-third of the more profuse aerial dispersers of *Staph. aureus*.

The distribution of antibiotic resistance among strains carried independently on the skin of the perineum was different from that found in perineal carriers who were also nasal carriers of the same strain, and in all nasal swabs. The proportion of tetracycline-resistant strains (R) isolated from heavy, independent perineal carriers (4 of 9) was significantly higher ($\chi^2 = 6.9$) than that among all heavy nasal carriers (12 of 134). Independent carriage in the axilla and on the hand was nearly always scanty, and the distribution of antibiotic resistance among the strains isolated was not significantly different from that found in strains isolated from the nose.

Most of the patients examined in the present investigation had recently been admitted to hospital, and the carrier-rate for tetracycline-resistant *Staph. aureus* was low (e.g. 4% in the nasal swabs). The independent perineal carriers of tetracycline-resistant staphylococci had been in hospital considerably longer on average than the rest of the patients. To confirm our finding that there was an excess of antibiotic-resistant 'hospital' strains among staphylococci carried independently on the perineal skin, and to define the conditions under which these organisms were acquired, a much larger investigation, in which nose and perineal swabs were examined serially, would be necessary.

Antibiotic-resistant staphylococci might reach the perineum in the faeces. Perineal carriers are not usually heavy faecal carriers of *Staph. aureus* (Solberg, 1965), but multiplication of the organism in the bowel contents earlier in the stay in hospital cannot be excluded. Alternatively, the organism might be conveyed directly to the perineum in the course of procedures carried out in the ward before operation. It is noteworthy that all four of the independent perineal carriers of 'hospital' staphylococci were among the 24% of the patients who underwent operations for disease of the genito-urinary system or the lower bowel (one each:

carcinoma of the bladder, carcinoma of the rectum, urethral stricture, hydro-nephrosis).

The knowledge that some important sources of *Staph. aureus* cannot be detected by the examination of nasal swabs adds to the difficulty of controlling staphylococcal infection in hospital wards. Repeated perineal swabbing is an unpopular measure. There is need for a simple and reliable means of sampling the personal environment of patients for *Staph. aureus* in a way which would reveal the independent perineal carriers.

SUMMARY

Nasal, perineal, axillary and hand swabs collected from 361 patients immediately before operation were examined for *Staphylococcus aureus*.

The organism was isolated more often from all three skin sites in nasal carriers of *Staph. aureus* than in non-carriers.

Twelve per cent of the patients, and 4% of those with negative nose swabs were perineal carriers. Two per cent were heavy perineal carriers of *Staph. aureus* strains which could not be isolated by direct culture from a nasal swab. Staphylococcal strains from these heavy, independent, perineal carriers were more often resistant to tetracycline than were strains from nasal carriers.

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