In the present series 83% of the babies remained free from nasal staphylococci, and when nasal colonization did occur it was seen on only one day in more than half of the carrier babies. Staphylococcal sepsis occurred in between 2.7% and 4.5% of the babies. It was of some interest that all the staphylococcal sepsis occurred on the fourth day or later, and perhaps might not have occurred in babies discharged from hospital within three days of birth.

Summary

A reduced incidence of nasal carriage of *Staph. aureus* and of sepsis has been achieved in a newborn nursery by the use of hexachlorophane soap for bathing, treatment of the cord with spirit and hexachlorophane powder, and daily application of neomycin cream to the babies' noses. Only 38 of 221 babies (17%) were nasal carriers of *Staph. aureus*, and only 10 of these had more than two positive swabs. The sepsis rate in carriers was 10.5%–13.2% as opposed to 1.1%–2.7% in non-carriers. Sepsis was not recorded in any baby before the fourth day.

We thank Dr. C. F. Harris for permission to conduct these trials, the sister in charge of the maternity ward and her staff for their co-operation, and Miss Bridget Harrison for technical assistance.

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NASAL DISINFECTION IN PREVENTION OF POST-OPERATIVE STAPHYLOCOCCAL INFECTION OF WOUNDS

BY

R. J. HENDERSON, M.B., Ch.B.
Public Health Laboratory, Worcester

AND

R. E. O. WILLIAMS,* M.D., M.R.C.P.
Staphylococcal Reference Laboratory, P.H.L.S., Colindale, London

Considerable emphasis has recently been laid on the part played by nasal carriage of staphylococci in leading to post-operative wound infection and on various other aspects of hospital cross-infection. Elek and Fleming (1960) postulate: "High nasal carriage rates in normal people combined with confined conditions in a hospital lead to a build-up of staphylococci in the surroundings; the noses of fresh individuals then become colonized in turn and void more staphylococci into the air and dust. . . . It is our belief that the crux of the problem lies in nasal carriage." Other observations point in the same direction. Williams *et al.* (1959), in a survey of

nasal staphylococci and sepsis in surgical patients, found that patients who were or became nasal carriers of staphylococci had three times as much post-operative staphylococcal wound sepsis as those who were never carriers, and that in roughly half the cases the sepsis was due to a staphylococcus of the same type as was found in the nose. Since many of the patients apparently became nasal carriers before they developed wound sepsis, it seemed possible that self-infection from the nose was important in the aetiology of septic lesions.

If this were true then there would be sense in attempting to prevent the colonization by staphylococci of the noses of patients admitted to surgical wards of a hospital, and one might reasonably expect to find a lowering of the sepsis rate where such an attempt had been successful. Gillespie *et al.* (1959) included nasal disinfection as one of the measures examined in their attempts to prevent wound infection and considered that it had value, but they made several modifications in the ward routine during their studies. This paper describes an experiment in which nasal prophylaxis was the only control measure tried.

Methods

The patients were men and women admitted to the general surgical wards of two hospitals in a provincial town, the hospitals being combined and operated as a group hospital. Both routine waiting-list and emergency cases were included, but patients with open fractures or operations on the rectum, anus, or genito-urinary tract were excluded, it being felt that the nature of these cases might predispose to sepsis.

On admission or as soon after as possible each patient's nose was swabbed, the swab being previously moistened with broth, and then a tube of nasal disinfectant cream† was given to patients whose hospital number ended with an even digit, and a tube of control cream to those where it was odd. The tubes were identical in appearance and were labelled by a piece of adhesive tape on which "even" or "odd" had been printed. The identity of the odd and even tubes was not disclosed to the sister or nursing staff on the wards, and in fact was known only to the hospital pharmacist and bacteriologist until the study was over.

A real attempt was made to apply either cream into the nostrils as soon as possible after admission, and this was usually done on the same day as admission. At week-ends, especially with emergencies, this was not possible, and patients admitted on Saturday afternoon or Sunday were not swabbed nor did they have the cream applied until Monday morning. In the case of waiting-list patients who were admitted in the afternoon, swabbing and application of cream took place next morning.

The first few patients were given the tubes of cream and told what to do; but it soon became obvious that further instruction was required, and the routine adopted was to swab the nose, squeeze some cream on to the patient's finger-tip, and then ask the patient to insert the finger in each nostril in turn and to spread the cream round the inside of the alae nasi. The patient was then instructed to insert the cream four times daily and if necessary to ask for a second tube. A second nasal swab was taken 10 days or so later, usually at the same time as a swab was taken from the wound.

†The cream was "naseptin," containing chlorhexidine hydrochloride 0.1% w/w, neomycin sulphate B.P. 0.5% w/w, supplied together with the tubes of inert base by Imperial Chemical Industries Ltd.

*Now at Wright-Fleming Institute of Microbiology, St. Mary's Hospital Medical School, London.

Swabs, also moistened with broth, were taken of the surface of the wound, usually when the stitches were removed, but earlier if sepsis occurred, when it was the practice to repeat the swabbing at weekly intervals until the wound healed. If more than one wound swab was taken on account of sepsis, a further nasal swab was taken at the same time as each wound swab. The nasal and wound swabs were inoculated on to blood-agar plates and the swab tips were then broken off into 10 ml. of 6% NaCl broth. The plates were incubated for 24 hours and any coagulase-positive staphylococci isolated were further identified by phage-typing. The broths were incubated for 48 hours and subcultures made on to blood-agar plates. Staphylococci were dealt with as from the direct plates.

No neutralizing agent was added to the broth cultures to inhibit the action of naseptin on the swab. Dr. K. G. Green, of Imperial Chemical Industries Ltd., in a personal communication, suggested the use of 0.5% ferrous sulphate in a lecithin/lubrol medium as a neutralizer, but this was not found to be satisfactory. The procedure then decided upon was as follows. When the broths into which the naseptin swabs had been broken off were sterile after 48 hours, small inocula of staphylococci were added and the tubes reincubated. This routine was followed for about 300 swabs, and in all cases there was a heavy growth of staphylococci, thus showing that no significant quantity of naseptin cream was carried over.

In all, 850 cases were admitted to the study between the beginning of January and the end of September, 1960. Records were kept on a modification of the form used in the Public Health Laboratory Service (1960) survey and four variations of the state of the wound noted: (1) clean; (2) clean but infected—that is, a perfectly clean wound yielding pathogens on swabbing; (3) septic but not infected—that is, a septic wound yielding no pathogens; and (4) septic and infected—that is, a wound showing clinical sepsis and yielding a pathogen. "Clinical sepsis" meant any deviation from normal healing and included stitch abscess, serous discharge, healing by granulation, and marginal erythema, but 51% of all the septic wounds showed frank discharge of pus.

Results

Of the 850 cases, 66 (7.8%) became clinically septic and infected, 163 (19.2%) were clean and infected, and 16 (1.9%) were septic but not infected (Table I). The sepsis rate was thus slightly lower than that found in the Public Health Laboratory Service (1960) survey of

TABLE I.—Incidence of Sepsis and Infection Among 850 Patients

	No.	%
Sepsis with infection	66	7.8
.. without	16	1.9
Infection sepsis	163	19.2

wound infection in England and Wales. The percentage of the septic cases yielding *Staph. aureus* (47.5%), either alone or with other organisms, was also lower (Table II).

TABLE II.—Bacterial Species Found in Wounds

Clinical State of Wound	No. of Wounds	Staph. aureus Alone		Staph. aureus + Other Pathogens		Esch. coli Alone		Other Pathogens		No Pathogens	
		No.	%	No.	%	No.	%	No.	%	No.	%
Septic ..	82	28	34.1	11	13.4	19	23.1	8	9.7	16	19.5
Clean ..	768	72	9.3	5	0.6	62	8.0	24	3.1	605	78.7

Since the naseptin prophylaxis was aimed only at controlling staphylococcal infection, sepsis due to other organisms has been ignored in the remaining analyses.

There was practically no difference in the total *Staph. aureus* sepsis rate between the naseptin-treated group (5.0%) and the controls (4.6%) (Table III). This is surprising because the naseptin seemed to be controlling nasal carriage to a large extent. Thus in Table III, 346 (82.4%) of 420 treated patients either had *Staph. aureus* eradicated from the nose or their noses remained uncolonized. Only 49 (11.7%) acquired a staphylococcus or a new type of staphylococcus in the ward. For the controls the corresponding figures were 223 (54.0%) and 120 (29.1%) of 413. Moreover, among the controls the incidence of sepsis was much lower in the non-carriers and those who cleared spontaneously—4 (1.8%) of 223—than it was in the patients who acquired staphylococci—13 (10.8%) of 120. The same trend could be seen in the naseptin-treated patients, but it was striking that of the 266 patients who were persistently non-carriers 12 (4.6%) developed sepsis, compared with 2 (1.1%) of 189 persistent non-carriers in the control group. Though the naseptin seemed to control nasal carriage, it did not reduce the sepsis rate to the extent that might have been expected.

The incidence of symptomless wound infection is also shown in Table III. The treated patients had a slightly though not significantly lower rate than the controls, but, as with sepsis, the carriers had a higher rate than the non-carriers.

Of the 21 naseptin-treated patients with wound sepsis, 4 had staphylococci of the same type in nose and wound, three of them having acquired the strains in their noses

TABLE III.—Incidence of *Staph. aureus* Sepsis and Infection in Relation to Nasal Carriers

Nasal <i>Staph. aureus</i>		Naseptin-treated						Controls					
On Admission	Subsequently	No.	<i>Staph. aureus</i> Sepsis		Symptomless <i>Staph. aureus</i> Sepsis		No.	<i>Staph. aureus</i> Sepsis		Symptomless <i>Staph. aureus</i> Sepsis		No.	%
			No.	%	No.	%		No.	%	No.	%		
—	—	266	12	4.6	11	4.2	189	2	1.06	7	3.7		
+	—	80	2	2.5	7	8.7	34	2	5.8	2	5.8		
Total non-carriers at subsequent swabbing		346	14	4.0	18	5.2	223	4	1.8	9	4.0		
+	+ different type	12	1	8.3	2	16.6	25	3	12.0	4	16.0		
—	—	37	5	13.5	9	24.3	95	10	10.5	14	14.7		
+	+ same type	25	1	4.0	4	16.0	70	2	2.8	18	25.7		
Total carriers ..		74	7	9.3	15	20.2	190	15	7.8	36	18.9		
*Total patients ..		420	21	5.0	33	7.8	413	19	4.6	45	10.8		

* 17 patients who died before observations on sepsis could be made are excluded from this table.

after admission. Nine of the 19 control patients with sepsis had staphylococci of the same type in nose and wound, seven having acquired the strain in the wards. However, it should be noted that 18 of the 40 septic wounds were infected with staphylococci of type 52/80, and this strain also very commonly colonized the patients' noses.

Discussion

No obvious benefit resulted from application of the disinfectant cream to the nose; the number of septic wounds in treated patients was practically identical with the number among controls, despite the facts that the nasal carrier rate was reduced by the treatment and that carriers had higher sepsis rates than non-carriers.

There are several possible explanations of this apparent anomaly. The simplest would seem to be that the reduction in the carrier state was only apparent. The follow-up swabs were taken between one and a half and two hours after the last application of the cream, and such tests as were made seemed to demonstrate absence of sufficient carry-over to affect the cultures, but there may have been persistent colonization of some other area than that swabbed. This might explain the unexpectedly high sepsis rate in the non-carriers of the naseptin group.

Alternatively, the anomaly could be explained by assuming that the wound infection was not derived from the nose but that both wound infection and nasal colonization were acquired from a common source. Then elimination of nasal carriage could not be expected to reduce the risk of sepsis, except in so far as it reduced the total number of sources of infection in the ward. In our wards the number of patients applying the disinfectant cream at a given time was less than half—allowing for the numbers using the control cream, fresh admissions not yet using either, and patients not included in the trial, such as those with urinary operations, colostomies, etc., many of whom were certainly carrying staphylococci in their noses.

The rationale of the nasal prophylaxis rests on observations, such as those of Williams *et al.* (1959), Weinstein (1959), and Colbeck *et al.* (1959), showing that nasal carriers experience a higher post-operative wound sepsis rate than non-carriers. It has to be added that other studies have failed to show any great excess of sepsis in carriers—for example, P.H.L.S. (1960) and extensive unpublished studies of Bassett *et al.*, cited in Williams *et al.* (1960). In part the differences in experience probably derive from the differences in method. Thus in the P.H.L.S. survey a single nasal swab was taken at the time of admission, and the present study would also have shown no difference on this basis. In part the differences must also reflect differences in the place in which infection of the wound occurs: in the St. Bartholomew's Hospital study of Williams *et al.* (1959) ward infections were thought to be predominant. In other situations (including perhaps the present one) theatre infections seem to have been more common. Possibly also the characteristics of the infecting staphylococci are important.

It is more difficult to assert that, even if carriers experience high rates of wound sepsis, the wound infection is derived from the nose rather than that both are derived from a common source. Williams *et al.* (1959) found that nasal colonization often preceded the wound sepsis, but without very frequent swabbing the time relation cannot be determined with any great

certainty. In a situation where most of the infections occur at the time of operation, an association of sepsis with nasal carriage might often represent infection of the nose from the wound. In the present study both nose and wound colonization were very commonly observed together at the first post-operative swabbing, even though the majority of the wound infections were due to staphylococci acquired in the hospital.

Attempts were made by Weinstein (1959) and by Gillespie *et al.* (1959) to control wound sepsis by nasal prophylaxis. Weinstein was quite unsuccessful. Gillespie and his co-workers claimed some success, but in their report they did not distinguish clinical sepsis from symptomless infection, and it may be significant that in our work there was a suggestion that symptomless infection, though not sepsis, might have been lower in the naseptin group than in the controls. Gillespie *et al.* observed their greatest reduction in wound infection when many other precautions as well as nasal prophylaxis were used and, moreover, they treated all the patients in the ward. It may be that the effect of the nasal treatment was less on the individual patient than on the ward as a whole.

It is curious that, in 49 patients, the use of naseptin was unable to prevent the acquisition of a *Staph. aureus* in the nose. In some of these cases it appeared that application of cream had been irregular. Some of the patients were elderly, some were hard of hearing, and a few were senile, and such patients could not be expected to remember to insert cream regularly let alone efficiently. A few patients, after operation, found themselves with a rubber tube in their nasal passage to assist in the emptying of the stomach; others had both arms immobilized by intravenous drip apparatus, also making application of cream difficult. Some of the failures were thus accounted for, but there is equally no doubt that in many cases the cream had been regularly and carefully applied, yet colonization was not prevented.

In a further 25 cases the staphylococci present in the nose on admission were not eradicated. This may not have been so important, as often the strain in the nose on admission was not one of the strains usually found in surgical wounds. Nevertheless, prevention of colonization of the nose by staphylococci by application of a nasal cream, or the eradication of a staphylococcus already present, is not as easy as is sometimes suggested in the literature.

Summary

A controlled trial to test the effect of nasal disinfection with "naseptin" on the post-operative wound sepsis rate was made in 850 surgical patients. No influence on the rate was observed.

Nasal carriers experienced a higher sepsis rate than non-carriers, especially among the controls; in the latter nearly half the patients with sepsis harboured a staphylococcus of the same type in nose and wound.

It is suggested that nasal colonization in a surgical ward is a measure of the staphylococcal contamination of the environment and may only be an indirect cause of wound sepsis.

We are indebted to Dr. K. G. Green, of Imperial Chemical Industries Ltd., for his interest and co-operation in this investigation and for arranging the supplies of naseptin and the control cream; to the surgeons of the group hospital for permission to investigate wound sepsis among their patients; and to the sisters and nurses of the ward concerned

for keeping records, controlling the issue of cream, and much other help without which the investigation would not have been possible.

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SELF-CONTAMINATION OF PATIENTS WITH STAPHYLOCOCCAL INFECTIONS

BY

RONALD HARE, M.D.

*Professor of Bacteriology; Honorary Consulting
Bacteriologist, St. Thomas's Hospital, London*

AND

E. M. COOKE, M.B., B.S., B.Sc.

Infection Officer, St. Thomas's Hospital, London

*From the Department of Bacteriology, St. Thomas's
Hospital Medical School, London*

There is little doubt that staphylococci from an infective process in a patient or member of the staff of a hospital can be transferred to another individual in the same environment, and so parasitize his nose or an open wound. The exact route followed by the organisms from the donor to the recipient has not yet been determined, but it is probable that the first step in this process is transference of the organisms from the site of infection to the donor's skin, clothing, and bedding or objects in his vicinity. That such contamination can occur has certainly been shown regarding streptococcal infection of wounds (Willits and Hare, 1941) and of the throat (Thomas and van den Ende, 1941), and in the particular case of staphylococcal infections it has been found that hospital blankets may be contaminated by *Staph. aureus* (Blowers and Wallace, 1955; Schwabacher *et al.*, 1958), as may the floors of wards in which there are infected cases (Foster, 1960). There are also many other references in the literature to the presence of this organism on objects such as curtains and lockers in the vicinity of the infected cases. Nevertheless, little is still known of the number of organisms likely to be found on the person and bedding and in the environment generally of such patients, or the type of infection most likely to produce heavy and persistent contamination. The studies reported in this paper form part of an attempt to throw further light on these matters.

Methods

Sampling.—For infected processes, an ordinary cotton-wool swab was employed to obtain some of the exudate. A similar swab was employed to investigate nasal carriage, both nostrils being sampled with the same swab. Specimens from the skin were obtained by rubbing somewhat larger swabs soaked in broth over a 5-cm. square, giving an area of 25 sq. cm. For each hand one swab only

was employed, rubbed over both front and back of all the fingers and the thumb. Calculation showed that the total area sampled was about 150 sq. cm. The swabs, obtained as above, were rubbed over the whole surface of an agar plate. For the bedding, nightdress, or pyjamas, and the underclothing of ambulant patients, press-plates were employed, the fabric being sandwiched between the surface of the agar and a round wooden applicator (Ridley, 1959). The area investigated in this way was approximately 50 sq. cm. Sweep-plates (Blowers and Wallace, 1955) were employed for the outer clothing of the two ambulant patients, each plate being rubbed backwards and forwards the whole length of the garment. Specimens from the floor were obtained by the method described by Foster (1960), in which agar slabs, 50 sq. cm. in area, stiffened with bandage were applied direct to the floor and then returned to the lid of the Petri dish.

Isolation of *Staph. aureus*.—The medium employed for most of the estimations was ordinary nutrient agar, phenolphthalein phosphate agar (Barber and Kuper, 1951), used in previous investigations, having been found to possess no marked advantages. It was, however, found essential to allow the plates to stand at room temperature for 24 hours after the initial overnight incubation to permit the colonies to acquire their characteristic colour. The number of *Staph. aureus* colonies on each plate was then determined. Two, and when there was any doubt many more, colonies were picked and saved for examination after sub-cultivation. Ability to produce coagulase was confirmed by the slide method, and the strains were preserved on agar in bijou bottles until they could be phage-typed. This was carried out for us by our colleagues Dr. W. D. Foster and Dr. Eva Letchner, employing phage suspensions kindly supplied by Dr. R. E. O. Williams and Dr. Patricia Jevons, of the Central Public Health Laboratories, Colindale.

Results

Post-operative Infections

The results obtained with 10 such patients are given in Table I. The areas sampled in the case of two patients were, in general, heavily contaminated, and it is perhaps significant that these were the only really severe infections in the series. None of the remainder was mild or trivial, but there was very little contamination in the case of four, while the remaining four had some contamination, the distribution of which was patchy.

The surveys were all carried out on the third or fourth day from the time it had become evident that the wound was infected, but there was no indication that the contamination increased with the passage of time. Indeed, repeat investigations carried out with three patients (Table II) would suggest that it tends to remain stationary and then become less as the infection subsides.

Although all the patients were under treatment with antibiotics it is evident that this had not eliminated the infection, for heavy growths of *Staph. aureus* were in all instances obtained from the wounds. It is evident, therefore, that chemotherapy does not, in itself, reduce the risk of contamination.

Patients with an Infective Process Other than an Operation Wound

Eleven patients were studied, and it will be seen from Table III that there was very little self-contamination when the organisms were derived from such conditions