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Staphylococcal sepsis in mothers and newborn babies

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INTRODUCTION

This study of staphylococcal infections arose from the impact of what was virtually an epidemic of breast abscesses, beginning late in 1958, among the mothers confined in the maternity units serving the Blackburn area. In the early part of the outbreak most of the organisms isolated from the lesions were *Staphylococcus aureus* with the same phage pattern, 52/52A/80; later on strains belonging to other phage types were isolated. As will be seen from Fig. 1 the outbreak was almost explosive in nature: there were only two cases in October and seventeen in November when the incidence reached 12 % of the total at risk. This high level was not maintained, but there was no appreciable fall in incidence for nearly 6 months. During the whole period covered by the study considerably more than 100 cases of breast abscess occurred; well over half of these were in primiparae and the infection was serious since most were caused by the epidemic type 80.

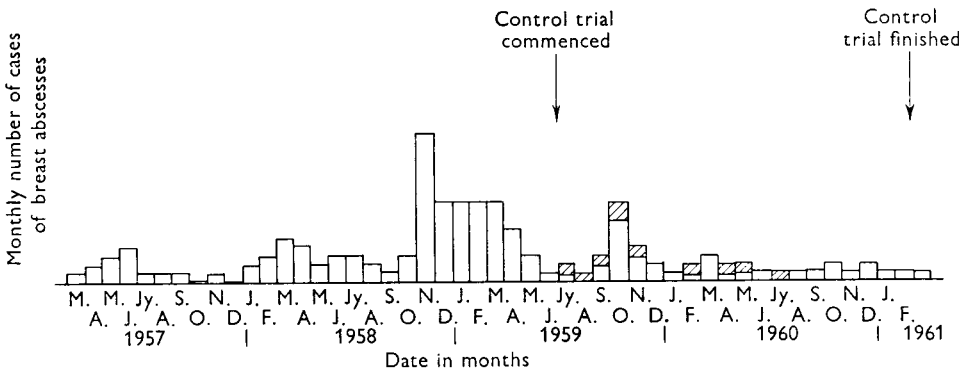

Fig. 1. Histogram showing the number of cases, by months, of breast abscess in the maternity units in Blackburn from March 1957 to March 1961. The controlled trial of the nasal cream commenced in July 1959 and from that date the cases occurring in the test group are differentiated by diagonal shading. □, Control group; ▨, test group.

INVESTIGATIONS

A concurrent study on the nasal carriage of *Staph. aureus* by children admitted to a local General Hospital showed that among the nasal carriers in the 6–12 years age-group 41 % of the organisms isolated belonged to phage type 80; this type was less common in the lower age-groups. The carrier-rate varied from about 23 % in the lowest age-group to about 13 % in children of between 6 and 12 years. About

6% of all with negative nasal swabs on admission acquired staphylococci during their stay in hospital. It was found that the application to the nasal mucosa of neomycin-hibitane cream was an effective method for treating the carrier condition. The cream was an I.C.I. preparation containing 0·5% neomycin and 0·1% chlorhexidine (hibitane), then in the experimental stage. The cream was introduced into the nares on a glass rod and spread over the whole surface of the nasal mucosa by gentle massage. The applications were made once a day and continued for 5 days. Swabs were taken on the 7th day and at weekly intervals after. The treatment was not universally successful; a single course might fail and relapses might occur, but in just over 70% of the carriers nasal swabs became negative after a single course and remained negative for an average stay of 8 weeks.

It seemed, therefore, that a suitable scheme could be devised for the application of the neomycin-hibitane nasal treatment of mothers and infants as a prophylactic measure which might well prove to be effective in reducing the high level of cross-infection existing in the maternity units. The proper assessment of the value of such a scheme would, however, demand a fully controlled trial in which all procedures, other than the particular one under test, would be common to two comparable groups of patients.

General procedures for control of cross-infection

Before describing the details of the scheme for the controlled trials of the nasal cream, mention must be made of a number of measures adopted early on in the outbreak in an attempt to deal with the high level of cross-infection, which were applied throughout the maternity units. In addition to environmental disinfection and efforts to improve individual stands of nursing hygiene, the measures included:

Laundry procedures

All woollen articles (except for a very few special articles) were replaced by those made of cotton material—these were mainly blankets and babies clothing—which would withstand high temperature treatment in the laundry. Articles laundered by this process were found to be virtually sterile when returned to the unit. There were comparatively few articles which were not suitable for high temperature treatment and special care was taken in the handling, transport and storage of these.

Nursing staff. All members of the nursing staff were aware of the dangers of infection being carried to patients from septic lesions on their own face or fingers. This was further stressed and so also was the importance of adequate hand-washing between attending to each patient; a chlorhexidine detergent was provided for this purpose. Strict observance of the 'mask and gown' techniques was the rule whenever a baby was handled. Frequent hand-washing was also urged for all members of the medical staff.

A regular system of nasal swabbing for the detection of staphylococcal carriers was applied to every member of the nursing staff employed in the maternity units. Any nurse yielding a positive swab was at once given a full course, five daily applications, of the neomycin-hibitane cream. After 2 days rest from treatment,

further swabs were taken for bacteriological examination, the results of which determined any additional treatment with the cream, but the regular swabbing procedure continued throughout the study.

Controlled trial of neomycin-hibitane cream

The maternity services administered by the Blackburn and District Hospital Management Committee included two hospital wards, each under consultant obstetricians with their own medical and nursing staff, and two maternity homes on the periphery of Blackburn which were adequately staffed with nurses but in which the patients were attended by their own general practitioners.

The hospital and maternity home organization was well suited for the carrying out of controlled trials of the neomycin-hibitane cream since the four separate units could be conveniently paired so that one hospital ward and one maternity home provided accommodation for the test group of patients and the other two units provided similar accommodation for the control group of patients. The two pairs were of equal size—the total numbers of mothers and infants for the period of the test were 1273 of each in the test group and 1223 of each in the control group. The general procedures indicated briefly above were standard throughout the four units and in addition to treatment of bed linen, blankets and hospital clothing; nursing technique, nasal swabbing and treatment of all staphylococcal carriers there were several other details of common procedure. Thus, as far as possible, the conditions provided in the test and control units were the same except on two occasions, once before the experiment started and once in a control unit later on when the level of cross-infection became so high that the unit was closed temporarily for cleaning and disinfection. Since all members of the nursing staff were equally subject to the same bacteriological control for the staphylococcal carrier state the movement of nurses was not of great importance. There was, however, one serious oversight to which reference will be made later; members of the domestic staff were not examined for the carrier state and, where necessary, treated, until very late in the trial.

Procedure in test unit

On the day of the birth of the infant neomycin-hibitane cream was applied, as described above, to the nasal mucosa of each mother and her baby and the application was repeated daily throughout the period of their stay in hospital. The umbilical stump received the standard treatment with Sterzac—a hexachlorophane powder.

Procedure in the control unit

None of the mothers or infants in the control unit were given any nasal applications of the neomycin-hibitane cream during their period in hospital. Apart from this the treatment was identical with those in the test unit; the infants in both groups received the Sterzac powder for the treatment of the umbilical stump, which was the standard method. All the control infants were nasally swabbed at regular intervals from the day of birth. The results of the bacteriological

examination of these swabs provided information about the changing nasal flora and alterations in carrier rates which proved to be of value in indicating new hazards.

RESULTS

The introduction of the general measures at the beginning of the outbreak for the reduction of the high level of cross-infection throughout the four units, which included the temporary closing, disinfection and washing-down of the worst affected unit, took some time to be fully effective, but by the date when the controlled trials of the neomycin-hibitane cream commenced there had been a very significant reduction in the occurrence of breast abscesses and general sepsis. In studying the results over the whole experimental period (Table 1), the incidence of general sepsis, and the occurrence of breast abscess, in the test group shows a

Table 1. *Summary of all septic incidents in mother or baby following* 2496 *hospital confinements during period of experiment*

Site of infection	Test group		Control group	
	Mother	Infant	Mother	Infant
Breast	10	0	30	0
Eye	0	3	0	33
Other sites	2	8	0	56
Totals	12	11	30	89
	23		119	

striking reduction as compared with the control group. When, however, the histogram (Fig. 1) is examined the results appear to be less satisfactory. Although the occurrence of breast abscess was only 0·8 % (general sepsis, 0·9 %) in the test group as compared with 2·7 % (general sepsis 7·3 %) in the control group, a much lower figure would be expected if the sole source of infection came from the nasal dissemination of staphylococci by the infants, since this source in the test group was largely blocked by the neomycin-hibitane cream treatment. The continued occurrence of cases of mammary infection in the test group shown in the histogram (Fig. 1) indicates the probability of infection coming from sources other than the infant's nose. More extensive investigations of a number of these cases in the test group showed that they could be related to undisclosed carriers among the nursing staff—either new carriers or the relapse of previously treated carriers occurring between the routine swabbing periods—who were freely disseminating *Staph. aureus* of the same phage type as the organism isolated from the septic lesion. More important, however, was the discovery that certain members of the domestic staff, not included in the nose-swabbing and treatment scheme, were also persistent staphylococcal carriers. The evidence collected by these further investigations clearly indicated that missed carriers among the nursing staff were responsible for several mammary infections in both test and control groups and that six cases in the test group could be directly traced to two members of the domestic staff who were carrying respectively type 52/52 A/80 and 6/7/47. These disclosures came as

a result of additional studies to find an explanation for the continual trickle of mammary infections in the test group. When this information became available, an improved procedure for the detection and control of carriers was applied to domestic and nursing staff alike, but it was very late in the trial when this became feasible. Nevertheless from that time until the end of the trial there were no further cases of mammary infections in the test group. These additional studies also showed that each case of breast abscess in the test group could be related to a previously missed carrier in the hospital staff, not to an infant patient. The incidence of the condition in the test group, as compared with that in the controls, showed a reduction of two-thirds and had it not been for the 'missed carriers' among the hospital staff it is likely that the number of mammary infections in this group would have been negligible*.

Staphylococcus aureus, phage type 80

Fig. 2 compares the distribution of type 80 with the other types as they occurred over the period of the investigation, except at the very onset of the outbreak when the records are not quite complete. Typing of a sample of 80 strains showed that there were 44 belonging to type 80 while all the other phage types together

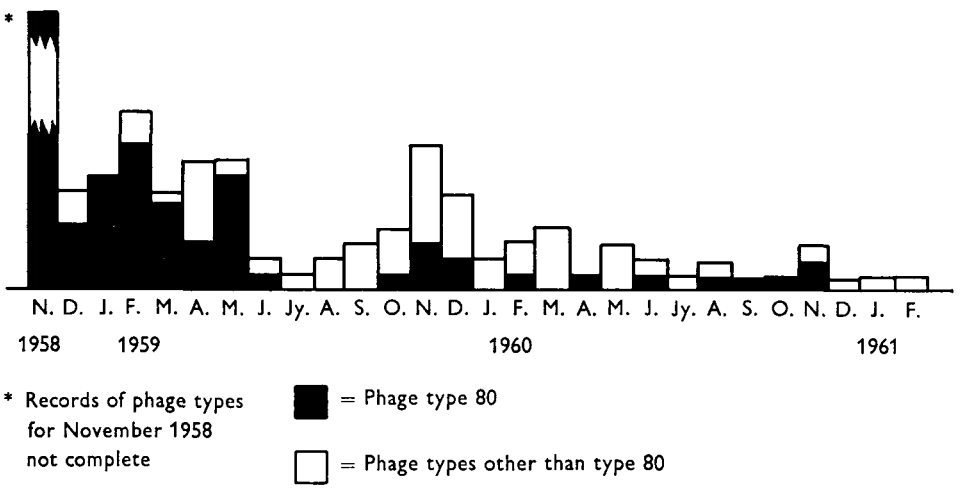

Fig. 2. Histogram showing the distribution of phage type 80, as compared with the other types, in the cultures isolated from the breast abscesses from the beginning of the outbreak until the end of the trial. The records for November 1958 are not quite complete; the total number of strains belonging to type 80 is not available for that period so the first column is shown as broken.

totalled 36. The infections due to type 80 were generally more severe clinically than those due to other types and the infections developed more rapidly; the average time from the birth of the infant to the full development of the abscess was 26 days for type 80, for the others it was 33 days.

* Subsequent examination of laboratory records show that from August 1960 until the end of December 1961 there were 17 cases of breast abscess, all of which occurred where the nasal cream was not being used. There were no cases where the test routine (see above) was followed.

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Nasal flora of infants in control group

The study of the nasal flora of the infants in the control group yielded information which, although not fundamentally new, was of considerable interest in relation to the whole investigation.

There were 1223 infants in the control group and nasal swabs were taken from each one at frequent intervals during the first few days of life and at regular times later on. During the first 6 days of life 329 failed to show any significant evidence of staphylococcal colonization and although 139 subsequently acquired *Staph. aureus* in their noses the remaining 190 resisted the invasion of this organism throughout their period in hospital. On the other hand there were 300 infants out

Table 2. *Source of sepsis in mothers and infants in the control group (identical phage type of* Staph. aureus *in lesion and infant's nose)*

Type of infection	Source of infection	
	Baby's nose	Uncertain
Breast	25	8
Eye	27	6
Other	34	19
Totals	86	33
	119	

of the total of 1223 whose nasal mucosa, during the first 6 days of life, was found to be colonized by coagulase-negative staphylococci (*Staph. albus*); 27 % of this 300 failed to sustain their dominance and were later replaced by *Staph. aureus* as the colonizer. But in the comparable group where there was no evidence of any form of early staphylococcal colonization the subsequent invasion of *Staph. aureus* was successful in about 40 % of cases. These observations suggest that early colonization of the nasal mucosa by *Staph. albus* may enable this organism to establish itself so firmly that it is able to resist subsequent invasion by *Staph. aureus* to a significant extent.

DISCUSSION

Although the main purpose of the investigation described here was the assessment of a method designed to control the incidence of mammary infections in a maternity unit, the results have also provided information of value and interest on several problems that arose during the study. Much of this information was not essentially new but it served to emphasize the importance of considering, when investigating any hospital outbreak of infection, every possible source from which infection could be spread to the patients concerned. In the present study the possibility of new staphylococcal nasal carriers or the relapse of treated carriers in the nursing staff had been foreseen and provision for this was included in the scheme. The importance of the nurse-carrier has been shown by Rountree & Barbour (1951), Gould & McKillop (1954), Lepper, Jackson & Dowling (1955) and other workers. It had been hoped that the routine swabbing of the noses of all members of the nursing staff, with neomycin-hibitane cream treatment where necessary,

and the strict use of the 'mask and gown' technique would largely deal with this hazard. But in spite of the fact that the treatment of the nasal carrier with the cream was almost immediately effective, relapses occurred after an irregular and unpredictable interval so that, however well the routine nose-swabbing scheme was arranged, in practice dangerous dissemination of staphylococci could occur before it was recognized and effectively treated. In addition there was the previously unappreciated hazard among hospital staff, not thought to have contact with patients, who might be staphylococcal carriers. The influence of these two groups of persons on the true assessment of the method under trial is obvious from the results obtained; at certain stages in the trial the unexpected emergence of an uncontrolled source of infection upset the figures and had it not been for the fact that the experiment was prolonged beyond the original year a satisfactory conclusion might not have been possible.

Cunliffe (1949) showed how readily the nasal mucosa of infants is colonized by staphylococci in the first few days of life and Parker & Kennedy (1949) demonstrated the high infectivity, to other patients in a hospital ward, of such infants. But although a significant proportion of infants in maternity hospitals acquire staphylococci either from other infants, nurses or various additional sources, the actual percentage carrier rate found at any one time is influenced by the degree of general cross-infection. Nevertheless, there appears to be another factor that plays a part of some importance: if there is early colonization of the nasal mucosa by *Staph. albus* instead of *Staph. aureus*, the organism seems to be able to establish itself sufficiently well in a large number of cases so that it is able to resist subsequent invasion by the more dangerous variety. The figures obtained in the present study fully support this thesis. Lepper *et al.* (1955) made observations of a similar sort with regard to student nurses and Anderson, Coulter & Keynes (1961) suggested the direct inoculation of the nasal mucosa of *Staph. aureus*-carriers with cultures of a selected strain of *Staph. albus*, after the original infecting organism had been cleared by a suitable anti-bacterial preparation, as a possible means of obtaining a more permanent protection for young nurses against invasion by coagulase-positive staphylococci to which they later would be exposed.

Recent studies by Simpson, Tozer & Gillespie (1960) and Corner, Crowther & Eades (1960) have drawn attention to the part played by the unprotected umbilical stump in disseminating *Staph. aureus*. Whatever part the umbilical stump may play in the spread of infection in maternity hospitals, and under certain conditions it might be considerable, in the present enquiry there was no evidence sought in this field. The standard Sterzac powder treatment of the umbilicus was applied equally to every infant whether in the test or control group and it was assumed that this source of infection was blocked in both groups.

In the early stages of the outbreak the predominance of type 80 made it difficult to trace sources of infection by the phage-typing method, but during the period of the controlled trial other phage types were fairly frequent and there was more reason for accepting the evidence that almost three-quarters of the septic conditions, including the mammary infections, could be related to the particular strain of *Staph. aureus* colonizing the nasal mucosa of the infant.

SUMMARY

A serious outbreak of staphylococcal infections in the maternity units in Blackburn was investigated. There were considerably more than one hundred cases of breast abscesses altogether, well over half of which occurred in primiparae. *Staphylococcus aureus*, phage type 80, was the predominating organism throughout the outbreak and at the peak period during the early part of the outbreak this type was responsible for nearly 80 % of the infections.

After the introduction of a number of procedures for the general reduction of cross-infection the incidence of breast abscess fell markedly and a controlled trial of an antibacterial cream, containing neomycin and hibitane, which was applied to the nasal mucosa of all infants and mothers in the test group of patients, was undertaken. The conditions obtaining in the test and control groups were identical in every way except that the control patients did not receive the neomycin-hibitane cream. There were about 1250 mothers and infants each in the test and control groups; the incidence of breast abscesses in the test group was 0·8 % and in the control group it was 2·7 %. The method adopted for the detection and treatment of carriers among the nursing staff broke down on two occasions; this fact and the emergence of an unforeseen source resulted in a larger number of infections than should have occurred. Had it not been for these incidents there is little doubt that the trial would have shown more conclusively the effectiveness of the neomycin-hibitane cream, by the method laid down, in reducing cross-infection.

Investigation of the bacterial flora on the nasal mucosa of over 1000 infants in the control group yielded results of considerable interest. Of 300 cases where there was early colonization by *Staph. albus*, this organism established its dominating position in 70 % of the cases and it was not subsequently displaced by *Staph. aureus*. The significance of this observation and the evidence favouring nasal dissemination of *Staph. aureus* as the most important cause of hospital cross-infection are discussed.

Thanks are due to a number of obstetricians, registrars, sisters and nurses for their help and a special debt of gratitude is owed to Dr M. T. Parker for his interest in the work and for the phage-typing of the many hundreds of cultures of *Staphylococcus aureus*. At that time Dr Parker was Director of the Public Health Laboratory, Manchester.

Generous amounts of the neomycin-hibitane nasal cream, then still in the experimental stage, were supplied by Messrs Imperial Chemical Industries through the courtesy of Dr K. G. Green.

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