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PREVENTION OF STAPHYLOCOCCAL SEPSIS IN A MATERNITY HOSPITAL BY MEANS OF HEXACHLOROPHANE

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In a previous paper (Gillespie *et al.*, 1958) we showed that infants who became heavily colonized by *Staphylococcus aureus* within a day or two of birth subsequently developed septic lesions of the skin more often than other infants. This tendency was particularly pronounced with staphylococci of phage patterns 52A/79 and 80, which were the most virulent strains prevalent in the hospital. The application to the umbilical area of a dusting powder containing hexachlorophane greatly reduced the staphylococcal colonization of the umbilicus and groin, and reduced the colonization of the perineum and nose to a smaller extent.

We report here some further results obtained in the same investigation. The clinical and bacteriological effects of applying hexachlorophane powder from earlier in life and to a wider area of skin were studied. Changes in nursery routine which reduced the contacts between infants and nurses were investigated.

The basic nursery techniques were described in our previous paper. Some changes then introduced were continued: namely, the disinfection of blankets and garments; the use of hexachlorophane soap for hand-washing; and the sealing, with "octaflex," of umbilical-cord stumps, which were then left uncovered. Chlorhexidine ("hibitane") hand-cream was withdrawn, however, so as to simplify the present trial.

Effect of Hexachlorophane Powder

Fig. 1 shows the results of direct plating of swabs taken from the carrier sites of most infants admitted to nurseries 2 and 3 of the Bristol Maternity Hospital. (Swabs from infants treated with hexachlorophane were soaked before use in 1% "tween 80" broth and plated on nutrient agar similarly fortified.) Enrichment culture in salt meat broth gave slightly more positive cultures but did

not affect the general patterns of the graphs. From February 26 until August 17, 1958, hexachlorophane powder ("ster-zac") was applied to the umbilicus and the front of the abdomen of every infant admitted to nursery 2, and this was repeated every time the napkin was changed, until the cord separated. From August 18, 1958, until June 15, 1959, the infants were first powdered in the labour room before they went to nursery 2, and the powder was applied repeatedly to the whole trunk, including the buttocks, perineum, axillae, and groins as well as the umbilicus, until the infants left hospital. The more liberal use of the powder did not improve the protection of the umbilicus and groin, but perineal and nasal colonization was further reduced (Fig. 1). In nursery 3, where no powder was used until February 13, 1959, the colonization of all four carrier sites continued at much higher levels than in nursery 2 (Figs. 1 and 2).

After the introduction of powdering of the umbilical area, the incidence of staphylococcal lesions of the skin fell from 19/365 (5.2%) to 7/343 (2.0%) (see Table).

Effect of Hexachlorophane Powder on the Incidence of Staphylococcal Skin Lesions

	Nursery 2			Nursery 3
	7.7.57-24/1/58	26/2/58-17/8/58	18.8.58-15/6/59	19/5/58-12/2/59
Area powdered ..	None	Umbilicus	Whole trunk	None
No. of infants ..	365	343	554	464
„ with skin sepsis	19 (5.2%)	7 (2.0%)	5 (0.9%)	34 (7.3%)

The difference was statistically significant ($\chi^2=5.0$; $P<0.05$). Subsequently, with the more liberal use of the powder, the incidence of sepsis fell again, to 5/554 (0.9%). In the control nursery 3 the incidence of sepsis in a comparable period remained high, at 7.3% (see Table), and there occurred a small outbreak of pemphigus neonatorum caused by a penicillin-resistant

Fig. 1.—Effect of hexachlorophane powder on staphylococcal colonization of infants. N=Nose. P=Perineum. U=Umbilicus. G=Groin. *Perineal swabs were not taken before May 3. Numbers of perineal swabs on 2nd, 4th, 6th, and 10th days were 96, 75, 63, and 32 respectively.

type-80 staphylococcus, and a series of pustules caused by a penicillin-resistant strain with the phage-pattern 79. Both strains spread widely in the nursery but did not spread to nursery 2 on the floor immediately below, despite several interchanges of staff.

Because of the pemphigus, nursery 3 was closed to new admissions on September 2, 1958. After all the infants had been discharged the walls, floor, and furniture were disinfected, and bedding was changed.

FIG. 2.—Effect of reducing contact between infants and nurses (see text). N=Nose. P=Perineum. U=Umbilicus. G=Groin.

After the reopening of the nursery on September 11 there were no more lesions caused by the epidemic strains, but the infants became colonized by other staphylococci almost as quickly as before. Of the first 10 infants admitted, five became nasal or umbilical carriers by the fourth day of life (and two of these later developed staphylococcal lesions of the skin) compared with 7 of the 10 admitted immediately before the closure. The staphylococci which spread among the infants after the nursery was reopened probably came from carriers among the nursery staff. This experience confirmed our belief that precautions directed solely against inanimate vehicles of infection such as walls and furniture are likely to prove disappointing.

While nursery 3 was closed all full-term infants had to be admitted to nursery 2. But, despite the consequent overcrowding, there was no perceptible increase in staphylococcal cross-infection, thus demonstrating the efficiency of the disinfectant powder.

In a period of 18 months more than 1,000 infants have been treated with hexachlorophane powder without irritation of the skin or other harmful effects.

Effect of Reducing Contact Between Infants and Nurses

Most infants remained in their nurseries except when feeding, the design of their mothers' rooms making it

difficult for more than a few to practise "rooming-in." Nurses carried infants one at a time to their mothers, each infant being wrapped in a "pack" consisting of a blanket contained within a pillow-cover. Complementary feeds were given by nurses, who held the infants and did not change gowns afterwards. Napkin changes were carried out with the infants on nurses' laps. It seemed that some of this contact was avoidable, and that it might be an important channel of cross-infection. Accordingly, on December 2, 1958, new methods of handling infants were introduced into nursery 3 (where hexachlorophane was not used) and their effects were observed for the ensuing 11 weeks. Wheels were fitted to cots, and infants were wheeled to their mothers and picked up by them unless the mother's condition contraindicated this. Infants remained in their cots while napkins were changed and complementary feeds given. These modifications did not greatly reduce contact with nurses' hands, but contact with their uniforms was much reduced.

The changes in routine, though faithfully carried out by the nurses, had no appreciable effect on cross-infection (Fig. 2). The incidence of sepsis was unaffected: 8 out of 99 infants developed lesions of the skin, compared with 5 out of 100 infants in the previous 11 weeks. These results are in line with those of Forfar and Maccabe (1958), who found that the wearing, by nurses, of gowns individual to each baby made no significant difference to staphylococcal cross-infection.

Discussion

The incidence and severity of staphylococcal sepsis in maternity hospitals depend on many variable factors, including the virulence of the prevalent staphylococci, the degree of overcrowding in the nurseries, the facilities for "rooming-in" infants with their mothers, and the standard of nursing. Yet another factor may be the average age of the infants. The umbilicus, probably the most important of all carrier sites in early life, tends to lose its staphylococci after the first week (Gillespie *et al.*, 1958). Consequently, a nursery from which infants are discharged when 6 or 7 days old may have a higher staphylococcal load than one in which the infants are kept for a few days longer.

To be effective, precautions against cross-infection must be based on epidemiological knowledge. The ultimate sources of the staphylococci are adults, mainly nurses. But when a staphylococcus from an adult carrier colonizes a newborn infant it is then more readily spread to other infants. The chief *immediate* sources from which most newborn infants in a nursery acquire staphylococci are the other infants.

In order to prevent cross-infection, precautions may be taken against the routes and vehicles of spread of the organisms. But there are many routes, and the closure of only one or two may have little effect. Thus, while contact with contaminated bedding and with the overalls of nurses must play some part in cross-infection, precautions directed solely against these vehicles had no detectable effect. These failures do not mean that the precautions were valueless. They might have value if combined with other precautions.

The hands of the nurses, even when they wash after handling every infant, are important vehicles of staphylococci, and cross-infection was appreciably reduced when the nurses used a disinfectant hand-cream (Gillespie *et al.*, 1958).

Cross-infection may be reduced by keeping infants in separate rooms with their mothers (Hutchison and Bowman, 1957). But for "rooming-in" to be effective, contact with nurses must be kept to a minimum. Some contact is unavoidable, especially in the first few days of life, when it is most likely to lead to dangerous colonization. Consequently the provision of separate rooms cannot be the whole answer to the cross-infection problem.

Precautions may also be directed against the sources of the staphylococci. It is impracticable to exclude all adult carriers from a hospital. An attempt might be made to exclude, or to treat, the carriers of exceptionally virulent strains; but such a policy would be difficult to enforce. If even a few staphylococci were allowed to enter the nursery, they might colonize some infants and multiply so as to form a large staphylococcal reservoir from which other infants would be cross-infected. Moreover, an infant who has been colonized by a virulent strain is a danger to himself as well as to other infants, and probably is a danger to his mother also. The prevention of the staphylococci from multiplying on the infants is an effective way of reducing cross-infection and sepsis. Fortunately, the infants' carrier sites, being superficial, are accessible to disinfectants. The use of hexachlorophane powder for more than a year has greatly reduced staphylococcal infection. Pustules and cutaneous abscesses, hitherto common, are now rare, their incidence among the infants having fallen from about 6% to less than 1%. The most pronounced effect of hexachlorophane on cross-infection was its reduction of staphylococcal colonization of the umbilicus and skin. Nasal colonization was reduced by more than half, but, despite this, about 40% of infants still left hospital as nasal carriers. In work now in progress in a nursery where hexachlorophane is used, this rate has fallen to less than 10% following the twice-daily application of a neomycin-chlorhexidine cream to the infants' nostrils, as suggested by Dr. K. G. Green (personal communication).

The reduction in staphylococcal infection among infants has been followed by a corresponding reduction among mothers. Hexachlorophane powder has been in routine use in most maternity hospital nurseries in Bristol for more than a year. During this period there have been remarkable reductions in the numbers of breast abscesses recorded by the hospitals and health department of the city (personal communications from Professor G. G. Lennon, Dr. Sheila Eades, Mr. H. K. Bourne, and Dr. Sarah Walker).

No single precaution can prevent all staphylococcal cross-infection. A high standard of nursing and the avoidance of overcrowding may in practice keep the incidence of sepsis sufficiently low; but this will depend partly on factors outside the control of the nursing staff, such as the virulence of the staphylococci which become prevalent in the nurseries. If appreciable numbers of infants or mothers suffer from sepsis, the additional use of hexachlorophane dusting powder is a worth-while and easy precaution.

Summary

The repeated application of hexachlorophane dusting powder to the umbilicus and the front of the abdomen greatly reduced staphylococcal cross-infection among newborn infants. Still better results were obtained by starting the treatment before the infants entered the

nursery, and by treating the whole trunk, including the groins, perineum, and axillae. The routine use of the powder has been followed by a greatly diminished incidence of staphylococcal sepsis in infants and mothers.

Changes in nursery techniques which reduced contacts between the infants and the nurses' uniforms failed to reduce cross-infection appreciably.

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CHRONIC MILK-ALKALI SYNDROME WITH GENERALIZED OSTEOSCLEROSIS AFTER PROLONGED EXCESSIVE INTAKE OF "RENNIE'S" TABLETS

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It has long been appreciated that the treatment of peptic ulcer with alkalis given in excess may lead to complications, and three distinct clinical states have been recognized. Acute alkalosis and temporary renal insufficiency from such a regime has often been described (Hardt and Rivers, 1923; Cooke, 1932; Kirsner and Palmer, 1942). Secondly, Cope (1936) reported four cases with hypercalcaemia as well as alkalosis and a raised blood urea that quickly responded to antacid withdrawal, though their renal abnormalities took several weeks to disappear. The existence of this syndrome has also been confirmed on many occasions (Scholz and Keating, 1955; Wenger *et al.*, 1957). Finally, Burnett *et al.* (1949) described the occurrence of the following syndrome in six patients each with a chronic duodenal ulcer which was being treated with large quantities of milk and absorbable alkalis: hypercalcaemia without hypercalciuria or hypophosphataemia, a normal serum alkaline phosphatase, marked chronic renal insufficiency with azotaemia, mild alkalosis, and calcinosis especially manifested by ocular lesions resembling a band keratitis. Some improvement in the clinical state was noted when the intake of milk and alkalis was reduced. Cases broadly corresponding to these have been reported since by McQueen (1952), Miller *et al.* (1952), Wermer *et al.* (1953), Dworetzky (1954), Dufault and Tobias (1954), Foltz (1954), Kyle (1954), Rodnan and Johnson (1954), and Snapper *et al.* (1954).

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