A simple bed-making routine results in considerable dissemination from both wool and cotton fabrics. Spread to other beds appears to occur both by direct contact and by the aerial route.

The number of viable organisms recovered from the infected bedding fell by 90% after the first 72 hours.

The significance of these results and those of other workers in relation to the problem of hospital cross-infection is discussed.

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CONTROL OF STAPHYLOCOCCAL INFECTION IN A MATERNITY HOSPITAL

CLINICAL SURVEY OF THE PROPHYLACTIC USE OF HEXACHLOROPHANE

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The problem of staphylococcal infection in maternity units has been studied by many investigators during the last two decades (Knott and Blaikley, 1944; Allison and Hobbs, 1947; Barber *et al.*, 1953; Edmunds *et al.*, 1955; Forfar *et al.*, 1955; Gillespie *et al.*, 1957).

It is generally agreed that most infants in maternity units become colonized by staphylococci soon after birth and are then the most important immediate source of infection (Cunliffe, 1949; Parker and Kennedy, 1949; Hutchison and Bowman, 1957; Forfar and Maccabe, 1958). Gillespie *et al.* (1958) came to the same conclusion and showed that the sites of heaviest colonization are the umbilicus, nose, groin, and perineum. They also showed that infants who became heavily colonized by the second day of life subsequently suffered from clinical infection more often than other infants.

The umbilicus, which is an open wound, is especially liable to colonization by staphylococci and streptococci (Coventry and Isbister, 1951; Boissard and Eton, 1956; Kwantes and James, 1956).

Various techniques of nursing care of the newborn infant have been advocated to prevent spread of infection, but the observation of Farquharson *et al.* (1952), that the use of hexachlorophane solution for bathing newborn infants was followed by a much reduced incidence of clinical staphylococcal infection, is of particular interest and importance. Jellard (1957) also reported a reduction of cross-infection after the application of another disinfectant, triple dye, to the umbilicus.

Gillespie *et al.* (1958) evaluated several methods of reducing staphylococcal cross-infection in the nurseries of the Bristol Maternity Hospital. They found that the most striking reduction was attained when colonization of the umbilicus and skin was prevented by means of a dusting powder containing hexachlorophane ("ster-zac") which could be applied repeatedly to a large area of the body surface. Subsequently (Simpson *et al.*, 1960) they showed that the best results were obtained by starting to apply the powder before the infant left the labour room and by continuing to apply it to the whole trunk, including the umbilicus and perineum, every time the napkin was changed. The incidence of septic lesions of the skin was reduced from about 6% to less than 1%.

In this paper we describe the effects of using the same method in the maternity unit of Southmead General Hospital, Bristol. This is a much larger maternity unit than the Bristol Maternity Hospital, and for several years has suffered from a higher incidence of severe staphylococcal lesions among infants and mothers. This situation may have been partly due to the fact that this maternity unit is extremely busy and often overcrowded and has a large number of pupil midwives and medical students in training, so that it is not easy to maintain rigid standards of technique.

However, another reason for the more severe infection was probably the endemic presence in the hospital of a type-80 staphylococcus which for several years caused many infections, in the maternity and general wards of the hospital, of a severity which resembled those first described by Rountree and Freeman (1955).

Before the introduction of hexachlorophane, several measures had been adopted to reduce cross-infection; sterilization and aseptic techniques had been reviewed, and chlorhexidine hand-cream was used by the nurses, but the incidence of sepsis remained high. A series of swabs taken from the umbilici of the infants during the winter of 1956-7 showed a high rate of staphylococcal colonization, comparable with that described by other authors.

Material and Methods

The maternity unit contains 140 beds, between 3,650 and 3,750 live births occur there annually, and about one-fifth of the mothers are admitted in emergency as unbooked cases. Most of the lying-in beds are in two modern single-story pavilion-type buildings, which have no undercover communication with each other. Each block accommodates 44-48 mothers in single, double, or four-bedded rooms. "Rooming-in" is practised in the single and double rooms, provided the condition of mother and child permits. The remaining

babies are nursed under good conditions in two large nurseries on each block, the population of each nursery ranging from 6 to 16 infants. Near each nursery is an isolation room to which any infected infant is immediately removed. There is a separate modern isolation block with its own labour room suite, where mothers with known or suspected infection are delivered and nursed.

The premature-baby unit has improvised and inadequate accommodation on one block and is constantly overcrowded with an annual admission rate of about 350 infants, about one-sixth of whom are admitted to the hospital within 24 hours of birth at home, or in other maternity units.

Record of Infection

Since 1949 fortnightly meetings have been held in this hospital to survey perinatal and neonatal mortality and morbidity, and the incidence of infection has thus been kept regularly under review. The paediatric registrar and senior house officer are responsible for the daily supervision of all sick and abnormal babies in the maternity department, and the name and ward of every baby in whom infection is found are entered in a diary against the date when it is first noticed. In this way a very accurate record has been available of the incidence of infection, and this has enabled us to evaluate the hexachlorophane method of skin care.

Care of the Skin and Umbilicus

Since 1950 the following technique of skin care has been standard throughout the department, including the premature baby unit.

Skin Cleansing.—At birth babies are wrapped in a sterile towel and are not bathed. Blood, meconium, and excessive vernix are removed from the face and hands only, using warm tap-water in a sterile bowl and sterile wool swabs. The skin is dried with sterile swabs. (Cleaning of premature and sick babies is postponed until the infant's condition permits.) The babies wear muslin napkins and a cotton nightgown which is changed at least once daily. Babies are changed in their cots, which are fitted with an individual locker containing a metal swab-tin with lid and benzalkonium chloride (0.01% solution), which is used routinely for cleansing buttocks. Healthy babies who remain in hospital for 10 days are sometimes bathed on the day of discharge for demonstration purposes to the mother and pupil midwives, but many babies are not bathed while in hospital; the skin is dried with clean muslin napkins.

Umbilical-cord Treatment.—(1) The cord is tied and divided between two sterile thread ligatures, 2½–3 in. (6.3–7.5 cm.) from the umbilicus and wrapped in a sterile gauze swab. (2) After six hours the cord is re-ligated and cut at ¼ in. (2 cm.) from the umbilicus. Collodion is painted with a sterile swab over the cut end and no dressing or binder is applied. (Early in 1957 plastic wound-dressing, sprayed over the whole cord, was substituted.) (3) After separation of the cord, the stump is left uncovered and is not cleaned unless discharge is present, when it is swabbed four-hourly with industrial methylated spirit and dusted with sterile zinc, starch, and boric powder.

Application of Hexachlorophane Powder

On April 27, 1958, care of the skin and umbilicus was altered to that advocated by Gillespie *et al.* (1958) as follows. (1) At six hours after birth the cord is re-ligated ¼ in. (2 cm.) from the umbilicus and incised, and the whole stump and surrounding skin are sprayed with

an antiseptic plastic solution ("octaflex"). (2) Hexachlorophane powder is then applied liberally to the trunk, particular care being taken to treat the umbilicus, groin, perineum, and axillae. (3) The cord and napkin area are subsequently powdered whenever the napkin is changed, and the trunk is powdered once daily with the routine change of nightgown.

One tin of octaflex spray was issued to each nursery; this sufficed for about 120 babies. Each baby was supplied with its own sprinkler tin of powder, the tins being returned to the dispensary for sterilization and reissue after discharge of the baby. Each tin contained enough powder for about 28 days' use.

This new technique was continued until April 25, 1959, and the incidence of skin sepsis was then compared with that of the previous year. No other alterations were made in the routine care of mothers and babies during the period under review.

Results

There were 3,721 live births in Southmead Hospital during the first year, from April 27, 1957, to April 26, 1958. Pustular dermatitis occurred in 247 infants, including two cases of pemphigus neonatorum, and 30 infants had staphylococcal abscesses—an overall incidence of staphylococcal sepsis of 7.4% of live births. During this period 344 infants were nursed in the premature-baby unit; 50 of these developed pustular dermatitis and three had staphylococcal abscesses—an incidence of 15.4%.

Within a month of the introduction of hexachlorophane powder on April 27, 1958, there was a pronounced and sustained fall in the incidence of staphylococcal sepsis of the skin among the infants. This improvement was most pronounced in the premature-baby unit, where the incidence of minor sepsis has always been a problem.

During the second year, from April 27, 1958, to April 26, 1959, among 3,650 live births there were 50 infants who developed pustular dermatitis and 4 infants had abscesses, an incidence of skin sepsis of nearly 1.5%. 352 infants were nursed in the premature-baby unit; of these 9 developed pustules and none had abscesses,

Staphylococcal sepsis in babies and mothers before and after use of hexachlorophane (zac) powder.

an incidence of 2.6%. The graph shows the monthly incidence of these infections during the years under review.

There was no case of severe hypersensitivity to the chemicals, though three infants developed some redness of the skin in the napkin area which did not improve until the use of the powder was discontinued. We confirmed the experience of Gillespie *et al.* (1958) that there was no delay in separation of the cord.

Some months after the introduction of the hexachlorophane dusting powder, Professor Gordon Lennon informed us that there had been a reduction in the number of mothers who developed breast abscesses. Accordingly a survey was made of the incidence of breast abscesses in women delivered in this hospital and elsewhere in the city.

Many breast abscesses develop after the mother has left the maternity hospital and are then referred back to the casualty department or surgical wards of hospitals for surgical treatment. In Bristol, the practice is to refer mothers with breast abscesses to the two major casualty departments in the city, and a relatively small number are admitted direct to the wards.

Hospital records were searched for all cases of breast abscess treated by Bristol hospitals during the period of this survey. The place of delivery and the bacteriological report were ascertained for each patient.

During the year May 1, 1957, to April 30, 1958, 91 mothers who were delivered in Southmead Maternity Unit developed staphylococcal breast abscesses, an incidence of 2.4%. During the next year, when hexachlorophane was in use, there were 22 breast abscesses, an incidence of 0.6%. This difference is statistically significant.

The graph shows the monthly occurrence of breast abscesses in mothers delivered in Southmead Hospital as compared with the total number of breast abscesses treated in the hospitals concerned during the period under review (mothers delivered at Bristol Maternity Hospital were excluded from this comparison because hexachlorophane and other measures were in use there for most of this period). The curves show that the same trends of infection occur simultaneously in the Southmead mothers and babies. The incidence of abscesses in mothers delivered in other hospitals could not be calculated, but the number in the two years showed no significant change.

Discussion

In the prevention of cross-infection in maternity units, great stress has always been laid on the importance of aseptic nursery technique. We do not suggest that any relaxation in technique should be countenanced, but at the same time it must be emphasized that the maintenance of these techniques is very difficult outside the operating-theatre, and implies a rigidly disciplined staff who have adequate time, with infrequent interruptions in their work. Experience has shown that inevitably breaks in technique occur sometimes. There are also economic limits to the extent to which techniques involving the use of equipment and laundry can be applied.

It is therefore essential to realize the great importance of the "load of infection" provided by the rapidly proliferating staphylococci on the common sites of some infants as a major factor in cross-infection in nurseries.

Unless this load is actively reduced, measures intended to prevent the spread of the organisms among infants who are all handled by the same staff are likely to prove disappointing. The frequent and liberal use of hexachlorophane dusting powder has proved to be a cheap and effective means of reducing the load of infection and has greatly diminished the incidence of clinical infection in the infants and their mothers. The annual cost of hexachlorophane powder and plastic spray solution was £115, or sevenpence per baby.

Conclusions

This study, carried out in a large maternity unit where clinical staphylococcal infection had remained at a steady high level for several years, showed that the introduction of a new technique of treatment of the umbilicus and skin of the newborn infants with a dusting powder containing hexachlorophane produced a strikingly significant reduction in the incidence of clinical infections in both babies and mothers without causing any undesirable reactions. The treatment is simple to carry out and the cost is moderate.

We are grateful to Dr. W. A. Gillespie for all his helpful advice, and particularly for his assistance with the retrospective study of breast abscess; to the midwifery staff who co-operated so well in carrying out the treatment, and in particular Sister Carter, who gave valuable assistance with the pilot survey; and to Professor Gordon Lennon and Professor A. V. Neale, who read the manuscript and offered most valued criticisms.

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United Kingdom exports of drugs and medicines in 1959 reached the peak figure of £40.1m. The exports of vitamins were £2.7m. and of antibiotics £2.9m., although exports of penicillin declined. Exports of miscellaneous proprietary medicines rose by 11% to £11.7m. The major share of pharmaceutical exports went to Commonwealth countries, the principal customers being Australia (£4m.) and Nigeria (£2.6m.). The other chief markets were the Irish Republic (£2m.), New Zealand (£1.9m.), India (£1.4m.), the Union of South Africa (£1.4m.), Pakistan (£1.3m.), Canada (£1.3m.), Ghana (£1.2m.), and U.S.A. (£1.2m.). Exports to Canada exceeded £1m. for the first time. There was, however, a sharp decline in exports to China—recently a fluctuating market—from £918,000 (in 1958) to £175,000. The expansion in local manufacture and the financial shortages in India and Pakistan were responsible for slight falls in exports to those countries. (*Annual Report and Year Book, 1959-60*, Association of British Pharmaceutical Industry.)