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# Decreased Colonization of Newborn Infants with *Staphylococcus aureus* 80/81: Cincinnati General Hospital, 1960–1972

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The changing pattern of colonization of newborn infants with *Staphylococcus aureus* was studied by examination of 25,662 nasal and umbilical cultures obtained at weekly intervals from 9,216 infants during 1960–1972. The frequency of colonization of infants in the newborn nursery with *S. aureus* 80/81 decreased significantly during 1963–1965 and has remained low since that time. This change in colonization was unrelated to the use of hexachlorophene for bathing infants or to changes in sensitivity to the commonly used systemic antibiotics, penicillin and kanamycin. A similar decrease occurred with *S. aureus* lysed by the group 2 phages, but this decrease rebounded to the earlier level after cessation of hexachlorophene use.



Despite a vast array of antimicrobial agents, colonization and disease caused by gram-negative bacilli, *Staphylococcus aureus*, and, more recently, group B *Streptococcus* remain a major problem in the management of newborn infants. The frequency of neonatal staphylococcal disease increased worldwide during the 1950s [1–3]. The concurrent availability of phage typing permitted identification of epidemic strains of *S. aureus* which characteristically were lysed by the phages 80 and 81. Bacteriologic surveillance of *Staphylococcus* among infants and personnel was a widely recommended component of infection control in newborn nurseries. The results of surveillance cultures obtained from infants in the nursery of Cincinnati General Hospital during 1960–1972 are presented in this report.

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## Materials and Methods

*Nursery units.* The studies were carried out in the newborn and premature nurseries of the Cincinnati General Hospital. Infants weighing > 2,260 g are transferred from the delivery room directly to the full-term newborn nursery. Most of these infants are discharged with their mothers on the fourth or fifth day post-partum. Those with potentially contagious diseases are transferred to a separate observation nursery. Infants weighing < 2,260 g and all infants requiring special treatment or frequent observation are admitted to the premature nursery, where they remain until discharge.

*Nursery procedures.* Handwashing with hexachlorophene was employed throughout the entire study with use of the procedures previously described [4]. All personnel donned clean gowns upon entering the nursery. Caps and masks were not used. Silver nitrate was used in eyes of infants for prophylaxis against *Neisseria gonorrhoeae*.

Before June 1965, infants in the full-term nursery were bathed with tap water alone. Between June 1965 and June 1967 infants were bathed with undiluted 3% hexachlorophene by a modification [4] of the technique previously described [5]. Infants were bathed on admission to the nursery and then once daily throughout their stay in the hospital. Since June 1967 no antibacterial agent has been used for the bathing of infants in the newborn nursery. Daily bathing with hexachlorophene was never done in the premature nursery; these infants were bathed with tap water alone throughout the study.

*Bacteriologic procedures.* In the full-term nursery, specimens were obtained for bacteriologic cultures on a given day of each week from all maximally exposed infants, including infants being discharged on that day and all infants more than seven days of age. In the premature nursery, specimens were obtained at weekly intervals from all infants. Specimens were obtained with dry, cotton-tipped applicators from the external nares and from either the umbilical stump or the skin of the healed umbilical site.

Swabs were streaked directly onto mannitol-salt agar and after incubation were evaluated for colonial morphology, production of pigment, fermentation of mannitol, and production of coagulase. Organisms positive for mannitol and for coagulase were designated *S. aureus*. Antibiotic sensitivity patterns and phage typing were performed on all mannitol-positive, coagulase-positive *S. aureus*. Antibiotic sensitivities were performed by a disk method with seven different antibiotics; disks with 2 units of penicillin and 5 $\mu$g of kanamycin were included. Since the sizes of the zones of inhibition were not recorded from the beginning of the study period, antibiotic resistance referred to the absence of any zone of inhibition. Although this could not be correlated with clinical resistance, it did allow comparison of changes in the sensitivity of the organisms. Organisms lysed by either of the phages 80 or 81 were designated 80/81. Organisms lysed by any of the phages 3A, 3B, 3C, 55, or 71 were designated as group 2. Infants harboring either 80/81 or group 2 *S. aureus* at any time were designated carriers of these strains.

*Period of study.* The results of surveillance cultures obtained from newborn and premature infants during 1960–1972 are presented. The 19-week period from May to October 1963, when purposeful colonization with *S. aureus* 502A was employed for the control of staphylococcal disease [6], has been omitted from this study. During the two-year period from 1965 to 1967, infants were bathed with hexachlorophene in the full-term nursery. The frequency of colonization of infants during this two-year period is compared to the frequencies in the two-year periods immediately before and after this period.

## Results

*Colonization with S. aureus.* During the entire period of 1960–1972, a total of 25,662 surveillance cultures were obtained from 9,216 infants (figure 1). Before the period when hexachlorophene was used, 60%–75% of infants acquired *S. aureus* before discharge from the newborn nursery. Daily bathing with hexachlorophene was associated with a significant decrease in colonization of infants with *S. aureus* (to 6.6%; $P < 0.0005$), followed by a gradual but significant increase to 47% during the four years after cessation of this bathing procedure. Although infants in the premature

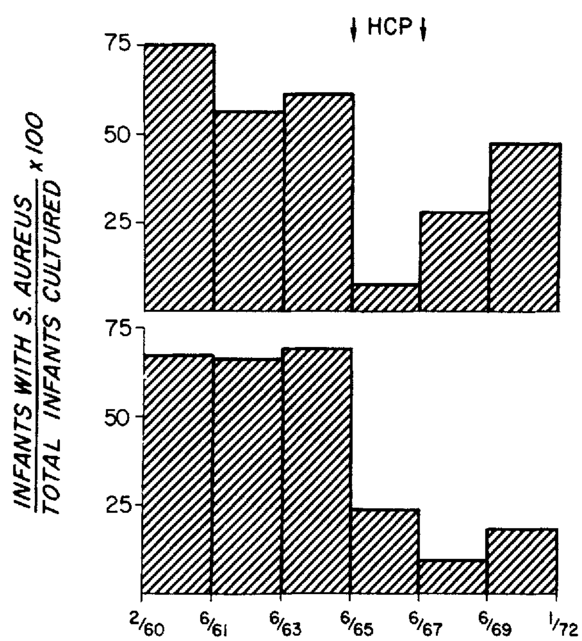


**Figure 1.** The incidence of colonization with *Staphylococcus aureus* of infants in the newborn (above) and premature (below) nurseries. Arrows indicate beginning and end of period of hexachlorophene (HCP) use.

nursery were never bathed with hexachlorophene, colonization with *S. aureus* decreased significantly from 69% to 23% ($P < 0.0005$) in this nursery during the period of hexachlorophene use and continued to decline to 8.7% during the following two years. The changes in colonization with *S. aureus* in the premature nursery, although statistically significant, were not as great as those in the newborn nursery, and occurred later; in addition, colonization returned more slowly to the prehexachlorophene levels.

*Colonization with S. aureus 80/81.* The frequency of colonization with *S. aureus* 80/81 is expressed (figure 2) as the proportion of infants colonized with 80/81 relative to the total number of infants colonized with *S. aureus*. In the newborn nursery this proportion decreased significantly from 17.8% during 1961–1963 to 6.0% during 1963–1965 ($\chi^2 = 35.9$, $P < 0.0005$). Because the colonization rate of 17.8% may be unduly high, the rate during 1963–1965 was compared to the average colonization rate during the entire period from 1960 to 1963. The decrease in colonization with *S. aureus* from 15.3% during this period to 6.0% in 1963–1965 remained highly significant ($P < 0.001$). A similar decrease was observed during 1963–1965 compared to colonization in the preceding years, when the results were expressed as the number of infants cultured. Colonization of infants with *S. aureus* 80/81 decreased before the introduction of hexachlorophene for bathing and before the decrease in total colonization with *S. aureus* previously presented. During the period of hexachlorophene use, the incidence of infants colonized with *S. aureus* 80/81 relative to the number of infants colonized with total *S. aureus* decreased further from 6.0% to 4.3% ($\chi^2 = 0.32$, $P < 0.6$). During the four years after cessation of hexachlorophene use, the incidence of colonization with *S. aureus* 80/81 remained unchanged, although the rate of colonization with *S. aureus* increased.

In the premature nursery, routine daily bathing of infants with hexachlorophene has never been done. The frequency of colonization with *S. aureus* 80/81 relative to total *S. aureus* colonization decreased significantly, from 10.7% during the six years before the period of hexachlorophene use to 5.9% during the six years after the introduction of hexachlorophene ($\chi^2 = 6.22$, $P < 0.02$).

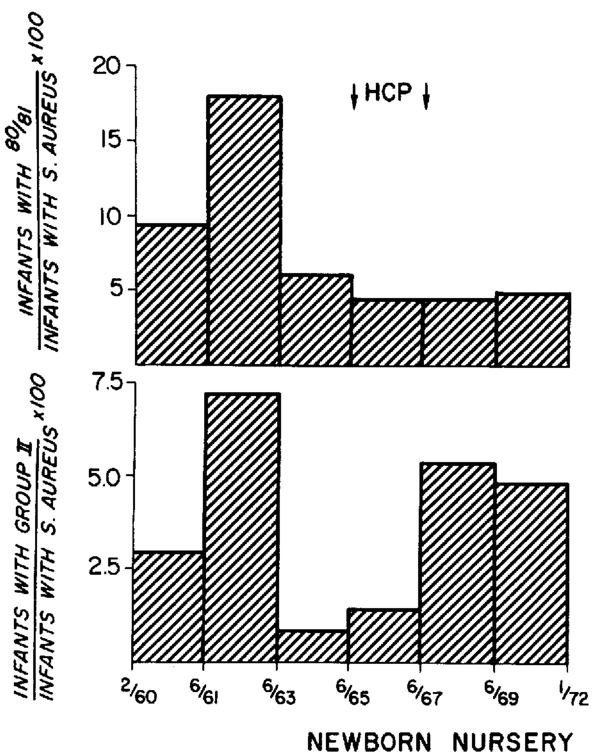


**Figure 2.** The incidence of colonization of infants in the newborn nursery with *Staphylococcus aureus* 80/81 compared to the incidence of *Staphylococcus aureus* lysed by the group 2 phages. Arrows indicate beginning and end of period of hexachlorophene (HCP) use.

*Antibiotic sensitivities.* Penicillin and kanamycin were the antibiotics commonly administered for systemic infection between 1963 and 1971 in both the newborn and premature nurseries. Despite changes in colonization, resistance of *S. aureus* to these antibiotics did not increase. Penicillin resistance of *S. aureus* isolated from infants in the newborn nursery remained unchanged throughout the study period, with 89% resistant organisms during 1960–1961 and 92% during 1969–1971.

Information on kanamycin resistance was available only beginning in 1963. In the newborn nursery, resistance of *S. aureus* of all phage types remained unchanged from 1963 to 1969. The frequency of kanamycin-resistant *S. aureus* during this six-year period was 7.5%–9.0%.

However, in 1969–1971 the frequency of kanamycin-resistant organisms decreased significantly, to 1.7% compared with 8% during the preceding two-year period ($\chi^2 = 19.2$, $P < 0.01$). A similar decrease in kanamycin resistance occurred with *S. aureus* 80/81, with 18.2% kanamycin-resistant organisms in the newborn nursery in 1967–1969 compared with 11.5% in 1969–1972. However, the total number of *S. aureus* 80/81 isolated during each of these periods was too small for meaningful statistical interpretation.

*Colonization with group 2 S. aureus.* Changes in colonization with group 2 *S. aureus* in the newborn nursery (figure 2) were initially similar to the changes with *S. aureus* 80/81. The number of infants colonized with group 2 *S. aureus* relative to the total number of infants colonized with *S. aureus* decreased from 7.2% during 1961–1963 to 0.8% during 1963–1965 ($P < 0.0005$). This low frequency of group 2 *S. aureus* persisted during the period of hexachlorophene use. However, in contrast to *S. aureus* 80/81, the frequency of group 2 organisms returned to prehexachlorophene levels following cessation of hexachlorophene use.

## Discussion

Epidemics of staphylococcal disease plagued newborn nurseries and maternity units throughout the western world from the 1940s into the early 1960s. The availability of bacteriophage typing of *S. aureus* as a practical epidemiologic tool allowed identification of *S. aureus* of the phage type 80/81 as the organism most frequently associated with these outbreaks. Because of the frequent occurrence of severe staphylococcal disease among newborn infants, numerous control measures were employed as methods of prevention of colonization of infants with these virulent organisms. Daily bathing of infants with hexachlorophene became a widely practiced method of decreasing colonization with *S. aureus*. The widespread routine use of hexachlorophene for bathing after 1961 was associated with a decrease in the frequency of severe staphylococcal disease among newborn infants. However, concurrent decreases in the frequency of staphylococcal disease have been reported in patients outside of the newborn nursery. In reports from both Denmark [7] and the United States [8, 9], this decrease in staphylococcal disease was associated with a decrease in the frequency of colonization of patients with *S. aureus* lysed by the phages 80 and 81.

In the present study the frequency of colonization of infants with *S. aureus* 80/81 relative to the total number of infants colonized with *S. aureus* decreased during the 12-year period from 1960 to 1972 in the full-term nursery at the Cincinnati General Hospital. This decrease began before the routine daily use of hexachlorophene for bathing infants in this nursery and remained unchanged during the period of hexachlorophene use. The frequency of colonization with *S. aureus* 80/81 decreased similarly in the premature nursery, although hexachlorophene was never routinely used for bathing in this nursery. Cessation of hexachlorophene use was associated with a significant increase in colonization with *S. aureus* in general and with group 2 *S. aureus* specifically, although colonization with *S. aureus* 80/81 remained unchanged.

In 1971 the Food and Drug Administration and the American Academy of Pediatrics recommended discontinuation of hexachlorophene for the bathing of newborn infants. Although the Center for Disease Control (Atlanta, Ga.) reported an increase in neonatal staphylococcal disease when use of hexachlorophene was discontinued [10, 11], the data failed to demonstrate a causal relationship between cessation of hexachlorophene use and staphylococcal disease [12]. Changes in colonization with *S. aureus* 80/81 were not reported, but the data indicated an increase in disease resulting from the emergence of unidentified virulent strains of *Staphylococcus*.

The decrease in the frequency of colonization of newborn infants with *S. aureus* 80/81 cannot be explained at present, but the changes were similar to those reported previously from other centers. Investigators in Boston [8] and Copenhagen [7] have reported a decrease in staphylococcal disease in adults associated with a decrease in the prevalence of *S. aureus* lysed by the 80 and 81 phages and a concurrent increase in group 3 *S. aureus*. These changes were accompanied by an increase in resistance of the 80/81 organisms to several antibiotics, including penicillin but not kanamycin. In contrast, in this study resistance to both penicillin and kanamycin remained unchanged throughout the study. The present report differed in that the population studied consisted of newborn infants in a hospital nursery where penicillin and kanamycin were the commonly used antibiotics.

This study demonstrated a decrease in the frequency of colonization of newborn infants with *S. aureus* 80/81. This change was unrelated to the use of hexachlorophene for bathing infants or to the emergence of resistance to the commonly used antibiotics.

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