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# Antibiotic resistant staphylococci acquired during the first year of life

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SUMMARY

Nasal swabs were taken from 492 babies born consecutively to residents of two South Wales towns soon after their discharge from maternity hospitals. *Staphylococcus aureus* was isolated from 352 babies (72%) and in 79 (22%) of these it was resistant to at least one antibiotic. By the time these babies were a year old the prevalence of both sensitive and resistant strains had fallen, so that only 12% still carried nasal staphylococci, but 64% of these organisms were then resistant to penicillin. Administration of penicillin to the baby seemed to be a more important factor in selecting resistant organisms than other antibiotics given to the baby, any antibiotic treatment to other members of the household, or discharge from hospital.

## INTRODUCTION

Surveys carried out between 15 and 25 years ago showed that most babies leaving maternity hospitals carried *Staph. aureus* in their noses, and the majority of these bacteria were resistant to penicillin (Barber *et al.* 1953; Hurst, 1957; Williams, 1961). It was suggested that 'antibiotic-resistant strains among the general non-hospital population will be increased steadily by babies born in hospital' (Hurst, 1957). In 1962 Miller, Galbraith & Green endeavoured to relate the carriage of resistant staphylococci to the recent history of the subjects concerned and concluded that admission to hospital was the major factor.

Since the time of these studies considerable efforts have been made to discourage the presence of antibiotic-resistant staphylococci in hospitals. A survey was therefore conducted to discover the current prevalence of *Staph. aureus* in the noses of babies who are discharged from hospital, the proportion that are resistant to antibiotics, and the relative importance of hospital stay and antibiotic treatment in the emergence of resistant strains.

## THE SURVEY

The population comprised all infants born in hospital to mothers who were residents of two South Wales towns (Caerphilly and Barry) from October 1975 to April 1976. The infants were visited a few days after leaving hospital by a nurse who took a swab from both nostrils and delivered it the same day to the laboratory. Subsequent swabs were taken at 3-monthly intervals in Caerphilly and approximately 4-monthly intervals at Barry, the final swab being taken when each child was 1 year old. The mothers were asked to retain the containers of all medicines and tablets prescribed for any member of the family. Since the name of the drug was always written by the pharmacist on the container it was thus possible for all antibiotic treatment to be recorded by the nurse at each visit. Careful enquiry was also made about the occurrence of any septic lesion either in the baby or any other member of the household.

## MATERIALS AND METHODS

Specimens were submitted on sterile broth-moistened swabs which were then cultured on blood agar plates aerobically and anaerobically. After overnight incubation at 37 °C a slide coagulase test was performed on any suggestive colonies and confirmation obtained by tube coagulase if necessary.

Routine sensitivity tests were carried out on all coagulase-positive colonies. For this purpose single colonies were emulsified in 3 ml sterile peptone water and spread on a lysed blood agar plate (Oxoid DST agar plus 6% lysed horse blood plate) using a swab. An Oxoid Multodisk no. 3810E* plus a neomycin disk (10 μg) were then applied. The plates were then incubated overnight at 30 °C. Control plates were included with each batch using the Oxford staphylococcus as the control strain. Another blood agar plate was also inoculated from the same colony and later used for phage typing.

## RESULTS

The study included 495 babies who were born in three local hospitals. Another six babies were born at home during the relevant period and were not included. An initial swab was taken from 492 infants soon after their discharge from hospital. Table 1 shows the numbers of babies from whom sensitive and resistant strains of *Staph. aureus* were isolated soon after discharge from hospital. One baby produced two strains, one resistant to penicillin and the other sensitive; this baby is counted only among those with a resistant organism.

Table 2 shows the results of culture of successive swabs; the numbers of infants show some variation as some were unobtainable on certain occasions and others moved out of the area. Here and in subsequent tables strains of *Staph. aureus* shown as resistant to penicillin include a few that were also resistant to another

* The disk contained the following antibiotics: Penicillin G, 1·5 μg; Erythromycin, 10 μg; Fusidic acid (sodium salt), 10 μg; Clindamycin, 2 μg; Methicillin, 10 μg; Tetracycline, 10 μg; Co-trimoxazole, 25 μg; Gentamycin, 10 μg.

Table 1. *Nasal staphylococci isolated soon after babies left hospital*

| | Number of babies | % |
|---|---|---|
| No. *Staph. aureus* isolated | 140 | 28·5 |
| Sensitive Staph. only | 273 | 55·5 |
| Resistant Staph. | | |
| To penicillin only | 65 | |
| To penicillin and tetracycline | 4 | |
| To tetracycline only | 7 | |
| To tetracycline and erythromycin | 1 | |
| To co-trimoxazole only | 2 | |
| To any antibiotic | 79 | 16·1 |
| Total | 492 | 100·0 |

Table 2. *Results of successive swabs*

| | Caerphilly swabs | | | | | Barry swabs | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Months | | | | | Months | | |
| | First swab | 3 | 6 | 9 | 12 | First swab | 4 | 8 | 12 |
| No Staph. isolated | 83 | 135 | 188 | 196 | 201 | 57 | 148 | 152 | 190 |
| Sensitive Staph. | 118 | 75 | 40 | 17 | 10 | 155 | 55 | 22 | 8 |
| Staph. resistant to penicillin | 37 | 28 | 9 | 18 | 22 | 28 | 18 | 13 | 12 |
| Staph. resistant to other antibiotics | 8 | 4 | 1 | 1 | 0 | 6 | 1 | 3 | 1 |
| Totals | 246 | 242 | 238 | 232 | 233 | 246 | 222 | 190 | 211 |
| % with a staphylococcus | 66 | 44 | 21 | 16 | 14 | 77 | 33 | 20 | 10 |
| % of Staph. resistant | 28 | 30 | 20 | 53 | 69 | 18 | 26 | 42 | 62 |

Table 3. *Antibiotic history before second and subsequent swabs*

| | Penicillin to baby | Ampicillin/ amoxycillin to baby | Other antibiotic to baby | Antibiotic only to family | No antibiotic |
|---|---|---|---|---|---|
| No Staph. isolated | 158 | 130 | 117 | 150 | 655 |
| Sensitive Staph. | 24 | 22 | 11 | 32 | 138 |
| Staph. resistant to penicillin | 30 | 9 | 5 | 17 | 59 |
| Staph. resistant to other antibiotic | 0 | 1 | 2 | 0 | 8 |
| % of Staphs. resistant | 56 | 31 | 39 | 35 | 33 |

antibiotic. In both towns there was a steady rise in the proportion of babies with no *Staph. aureus* in the nose. By 12 months 88% of babies were in this group. If *Staph. aureus* was isolated from these babies it was usually resistant to at least one antibiotic, in contrast to those obtained from the newborn.

In Table 3 the results of the second and subsequent swabs are classified according to the antibiotic treatment given since the previous swab. Babies who had received more than one type of antibiotic are shown only in the first appropriate column.

Table 4. *Swabs from babies after treatment with penicillin*

| | Caerphilly babies (months) | | | | Barry babies (months) | | | |
|---|---|---|---|---|---|---|---|---|
| | 3 | 6 | 9 | 12 | 4 | 8 | 12 | Totals |
| No Staph. isolated | 12 | 20 | 31 | 30 | 22 | 19 | 24 | 158 |
| Sensitive Staph. | 5 | 6 | 1 | 0 | 5 | 4 | 3 | 24 |
| Staph. resistant to penicillin | 6 | 3 | 6 | 2 | 5 | 4 | 4 | 30 |

Table 5. *Comparison of results from* 440 *babies swabbed at start and at* 12 *months*

| | First swab | | |
|---|---|---|---|
| | Staph. present | No Staph. present | Totals |
| Final swab | | | |
| Staph. present | | | |
| Observed | 48 | 5 | 53 |
| (Expected) | (37·5) | (15·5) | |
| No Staph. present | | | |
| Observed | 263 | 124 | 387 |
| (Expected) | (273·5) | (113·5) | |
| Totals | 311 | 129 | 440 |

$\chi^2 = 11{\cdot}6$ (1 D.F.), $P < 0{\cdot}001$.

When babies had been treated with penicillin most strains of *Staph. aureus* isolated were resistant in contrast to those obtained after exposure to other or no antibiotic. One erythromycin-resistant organism was isolated and this came from a baby who had been treated with erythromycin.

Treatment given only to another member of the family was not associated with any obvious excess in the prevalence of resistant *Staph. aureus*. Fourteen babies were admitted to hospital at some time during their first year; the next swab produced a sensitive strain of *Staph. aureus* in five cases, a penicillin-resistant organism in two, and no staphyloccus whatsoever in the remaining seven.

The babies who had received penicillin are shown again in Table 4. The results of the different swabs are shown separately. It is apparent that the resistant strains tended to appear after exposure to penicillin at all stages in the survey and could not be explained merely by a common association with time.

There were 440 babies from whom both an initial and 12 month swab was obtained. The results on these two occasions are compared on Table 5. Those from whom *Staph. aureus* was obtained on the first occasion were much more likely to be carrying this organism at 1 year than those from whom it was not initially isolated. Forty-eight babies yielded *Staph. aureus* from both swabs and comparison of the phage types showed that only fourteen of these babies had the same strain (none untypable) on the two occasions. There was no greater incidence of septic lesions in these 48 babies or their families than in the others.

Table 6 shows the 229 Caerphilly babies from whom all five swabs were obtained.

Table 6. *Changes in Staphylococci in* 229 *Caerphilly babies from whom* 5 *swabs were obtained*

| | First swab | Months 3 | 6 | 9 | 12 |
|---|---|---|---|---|---|
| New strains | | | | | |
| Sensitive | 109 | 36 | 16 | 7 | 7 |
| Resistant | 43 | 11 | 4 | 9 | 8 |
| Strains originally sensitive | | | | | |
| Still sensitive | — | 28 | 14 | 6 | 2 |
| Now resistant | — | 10 | 2 | 6 | 10 |
| Strains originally resistant | | | | | |
| Still resistant | — | 10 | 3 | 4 | 4 |
| Now sensitive | — | 6 | 7 | 3 | 1 |
| Total sensitive | 109 | 70 | 37 | 16 | 10 |
| Total resistant | 43 | 31 | 9 | 19 | 22 |
| No Staph. isolated | 77 | 128 | 183 | 194 | 197 |

The organisms cultured are grouped at each swabbing to show whether they had been previously isolated at any time as determined by phage type from the baby concerned. (Untypable strains of *Staph. aureus* isolated from successive swabs are assumed to be the same organism in this table.) Persistent strains are classified according to whether they were sensitive or resistant to any antibiotics the first time they were isolated. They are further sub-divided into sensitive and resistant strains on each occasion. At first the new strains were usually sensitive, but during the last 6 months most new strains were resistant. Furthermore persistent organisms tended to acquire rather than to lose antibiotic resistance, usually to penicillin.

## DISCUSSION

When these results are compared with those obtained from surveys conducted 15–25 years ago, two main points emerge. The percentage of babies leaving hospital with nasal *Staph. aureus* (72%) is remarkably similar to the figures reported by Barber *et al.* (1953) (74%) and Williams (1961) (65%). On the other hand the proportion of these organisms resistant to penicillin appears to have declined from 88% and 61·5% in the 1953 and 1962 surveys respectively to 22·4% (79 out of 352) now resistant to any antibiotics in the present study. Perhaps the antibiotic policies which have been adopted in recent years have reduced the proportion of resistant organisms but not the total prevalence of *Staph. aureus* in the newborn. In hospitals where hexachlorophane has been liberally used, a much lower prevalence of nasal staphylococci has been reported (Forfar, Gould & Maccabe, 1968; McAllister *et al.* 1974).

Although most babies yielded *Staph. aureus* on their discharge from hospital, these organisms were lost fairly quickly and by 1 year could only be cultured from a small minority. The presence of *Staph. aureus* on these two occasions was associated more frequently than could be explained by chance even though the organisms were usually of different phage types. This confirms the observations of

Hurst (1957) that 'babies who do not become carriers within the first 2 months of life are unlikely to do so later'. It also suggests that the carrier state is not necessarily dependant upon the type of *Staph. aureus* acquired.

The proportion of organisms resistant to antibiotics increased during the first year of life so that the majority of strains of *Staph. aureus* isolated from 1-year old babies in both areas were resistant, usually to penicillin. Previous treatment with penicillin seemed to be the most important factor; the administration of ampicillin and amoxycillin did not show this effect. Treatment with other antibiotics did not show any obvious relation to subsequent resistance except in one case of resistance to erythromycin. Treatment given to other members of the household seemed to be unimportant.

Resistance to penicillin is probably not a serious hazard in view of the availability of many other antibiotics. Perhaps it is reasonable to conclude that practioners encountering an infection in a 1-year-old child which they think is staphylococcal should avoid the use of benzyl-penicillin since the organism will probably be resistant to that drug.

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