

**STAPHYLOCOCCUS AUREUS IN THE MILK OF NURSING
MOTHERS AND THE ALIMENTARY CANAL
OF THEIR INFANTS**

A REPORT TO THE MEDICAL RESEARCH COUNCIL

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INTRODUCTION

In January 1940, Dr W. H. Bradley (M. of H.) sent us single specimens of faeces from six new-born infants suffering from 'green hurried stools'. All six specimens yielded cultures of *Staphylococcus aureus*; and that of 2 days' old infant A gave an especially rich growth. No further specimens were received and the subsequent histories showed that five of the infants recovered under treatment with 'grey powder', but the infant A died in the sixth week from 'marasmus and dehydration'. While there was no proof that *Staph. aureus* caused the condition of 'green hurried stools' or the death of infant A, it seemed desirable to us to investigate the incidence of this micro-organism in the intestines and throats of both morbid and healthy new-born infants and the milk of their mothers; and during the period from January 1940 to January 1941 more than 2500 swabs of materials from these sources were examined.

The greater part of the investigation was made on materials from nursing mothers and their infants at the maternity unit of about forty-five beds at hospital P. The method of collecting the breast secretion was to cleanse the nipple with sterilized water and dry it with sterilized gauze, then expel about two jets of milk to flush the duct orifices, and receive the next jet on a sterile throat swab which was not allowed to come into contact with the nipple or the patient's skin. The swabs were taken by the medical officer in charge of the unit, or the senior sister, and sent to the emergency laboratory 27 miles distant. Although some swabs reached the laboratory within a few hours of taking, the greater number did not arrive until 20 hr. old.

THE INCIDENCE OF *STAPHYLOCOCCUS AUREUS* IN MOTHER AND INFANT

During the first 4 months of 1940, a high proportion of the mothers' milk and babies' throat and rectal swabs yielded cultures of *Staph. aureus*. However, the swabbing during this period was promiscuous and from many cases only a single swab was obtained, or swabs were not taken from both the mother and her infant. In order therefore to get more information on the incidence of *Staph. aureus* in mother and baby and the possible connexion between these infections, alternate day swabbings were made of selected groups of mother and baby, from parturition to discharge from the hospital on the ninth to fourteenth day of the puerperium. During the 8 months to the end of 1940, when the work was interrupted by conditions arising from enemy action, eighty-two groups of mother and baby were examined at hospital P, with the results shown in Table 1, first part. In only three of the eighty-two groups was *Staph. aureus* not obtained from either mother or baby.

To find if the high incidence of *Staph. aureus* was peculiar to hospital P, a similar investigation was made at the maternity unit of hospital S, situated 26 miles distant

Table 1. *Incidence of Staphylococcus aureus in the mother's milk and her baby's throat and rectum, in selected groups of mother and baby*

Source	No. and percentage of cases yielding <i>Staph. aureus</i>		Total swabs	Swabs yielding <i>Staph. aureus</i>
	No.	%		
Part 1, hospital P (82 groups):				
Mother's milk	76	92.7	455	283
Baby's throat	75	91.5	451	294
Baby's rectum	61	74.4	451	143
Part 2, hospital S (5 groups):				
Mother's milk	4	80.0	69	37
Baby's throat	5	100.0	63	29
Baby's rectum	2	40.0	63	3

from hospital P, during the period from July to September 1940, after which work at this hospital was brought to an end by the evacuation of the patients to a safer area. At hospital S, in addition to other examinations, a series of five mothers and their babies were swabbed *daily* during their stay in hospital, with the results shown in Table 1, second part.

By the identification of the *Staph. aureus* types concerned and detection of minor strain peculiarities it was found that, with a few exceptions (some possibly attributable to the presence of more than one type), the coccus cultivated from the mother's milk was of the same kind as that from the baby's throat and, usually, also that from its rectum. This observation raised the question of priority of infection of the mother's breast or the baby's throat. Indeed, it may be assumed that the initial appearance of the coccus in either will quickly be followed by its presence in both.

In a series of eighty-seven mothers and their babies the coccus was found first in the baby's throat in thirty-three cases, first in the mother's milk in fifteen cases and simultaneously in mother and baby in thirty-nine cases.

Table 2, which was compiled from the results both of daily and alternate day swabbings and shows the earliest day of the puerperium on which the coccus was found present in the different situations, also tends to support the view that in the majority of cases infection of the baby's throat precedes that of the mother's milk; a view which is rendered more probable by the fact that, from the methods used, the prospect of cultivating the coccus when few were present was greater in the case of milk swabs than throat swabs. Only one of the fifty-eight mothers referred to in Table 2 showed *Staph.*

Table 2. *Earliest day of the puerperium on which Staphylococcus aureus was cultivated, in a series of fifty-eight women and their babies*

Source of culture	Day of the puerperium and number of initial cultures											
	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	None
Mother's milk	1	7	6	16	9	6	3	5	2	1	1	1
Baby's throat	1	12	12	14	6	5	3	2	.	.	.	3
Baby's rectum	.	5	4	4	3	6	4	5	3	3	4	17

aureus in her milk during the first 24 hr. of the puerperium, but it was present also in her baby's throat. The colostrum of eight women, taken before parturition, did not yield *Staph. aureus* in any case. For further light on the question of an essential role of the baby in infection of the mother's milk, the milks of lactating women who had not nursed their babies were examined, and Table 3 gives the results from twenty-eight mothers of full-term stillborn infants.

Table 3. *Examination, for Staphylococcus aureus, of the milks of twenty-eight lactating women who were not nursing babies*

	Women			Swabs	
	Total	Yielded <i>Staph. aureus</i>	Percentage	Total	Yielded <i>Staph. aureus</i>
At hospital P	15	3	20	77	4
At hospital S	13	3	23	121	3
Totals	28	6	21.4	198	7

Staph. aureus was found once only in each of five women of the stillbirth series, and once in both breasts in a sixth woman. This very transient occurrence of the coccus is in striking contrast with its persistence in the milk of nursing mothers. It is clear, however, that the introduction of the *Staphylococcus* into the mother's milk is not wholly dependent on the intervention of the baby. The source of the infection in these six cases is not known, but it is noteworthy that a throat swab of one of the six women yielded a *Staphylococcus* of the same type as that cultivated from her milk. Unfortunately, throat swabs were not obtained from any other women of this group.

The numbers of *Staph. aureus* found present in the milk swabs were often very great, and this, to some extent, must be attributed to multiplication of the cocci in the milk-soaked swab during the 20 hr. delay in warm weather before the swabs were examined. However, in a small number of cases in which it was possible to make an immediate examination of the freshly drawn milk, the number of *Staph. aureus* present was also very high, as shown by direct microscopical examination, and immediate platings which, in some cases, gave semi-confluent growths of the coccus. It is a striking observation that the infants swallowing such large quantities of the micro-organism, and possibly its products, remained normally healthy.

The identity of the Staphylococcus aureus strains cultivated

In identifying the strains, attention was paid to the following characters: pigmentation, haemolytic power, action on gelatin, lactose and mannitol; and the staphylocoagulase reaction (p. 479). The serological grouping was based on slide agglutination tests with the following sixteen sera kindly supplied by the late Dr F. Griffith: Cowan's groups I, II and III, and others marked ϕ . 1, ϕ . 18, ϕ . 22, ϕ . 23, ϕ . 31, ϕ . 38, ϕ . 42, S. 4, 726, Pink, Allman, Bourne and Stone. It was not possible, in the existing circumstances, to prepare homologous agglutinating sera for the strains under examination. Suspensions of living or dead cocci from broth or agar cultures were used in the earlier agglutination tests, but all the results given in this paper are based on tests with thick suspensions (working at approximately 3000 millions of cocci in 1.0 c.c.) of living cocci from 20 hr. old cultures on agar.

The commonest type found at hospital P was a deeply pigmented golden *Staphylococcus*, haemolytic to horse or rabbit cells in agar but weak or uncertain in its action on sheep cells in saline suspension; liquefying gelatin and fermenting lactose and mannitol with acid formation, usually within 24 hr., at 37° C., and giving a relatively strong coagulase reaction. It was agglutinated by Cowan's group I, ϕ . 1, ϕ . 38, and S. 4 sera only, but after long cultivation some of the strains became weakly susceptible to agglutination by some of the other sera. This type, only for the convenience of this paper, is arbitrarily designated *Type C. 1a*. Another common type having the same general characters as type C. 1a, but agglutinable by all three Cowan group sera and all or nearly all the other test sera, is designated *Type C. x*. There is reason to suspect that this serologically unspecific type is a variant of type C. 1a; it appeared, sometimes, in primary cultures in association with type C. 1a, and some strains of type C. 1a presumed to be pure acquired the C. x character during cultivation. A similar catholic agglutinability was also a feature of strains of *Staph. aureus* not related to type C. 1a, from other sources.

About one-third of the strains cultivated at hospital S differed from type C. 1a in not reacting with serum ϕ . 1. They were also, on the whole, less deeply pigmented, usually slightly less coagulative, and when tested with some old agglutinating sera, not used for the present records, were sharply differentiated from type C. 1a. This type is designated *Type C. 1b*. Strains not agglutinable by any of the Cowan group sera or the other test sera are designated *Type C. 0*, and a type agglutinable only by Cowan's group II and 726 sera is designated *Type C. 2a*. Other types were met which differed from those already designated by failing to ferment mannitol or lactose or both, or in some other respect: these types were not sufficiently common to merit separate description and are referred to as undesignated.

The predominance of type C. 1a at hospital P is shown by the analysis of cultures from 103 healthy mothers and their babies, given in Table 4. The figures for cultures from mothers' milk and babies' throats and rectums considered separately are not comparable, as, in some cases, swabs were taken only from throat or rectum but not from both, and a few swabs yielded more than one type of *Staph. aureus*. Another analysis of *Staph. aureus* types, but dealing with those from mothers' milk only, gave the following proportions: At hospital P, from 156 women, including three who had not nursed babies, type C. 1a 79%, type C. x 15.3% and other types 5.7% (other types included four of type C. 0, two of C. 1b, two of C. 2a and one undesignated). At hospital S there was no

predominance of a single type, and the proportions from twenty healthy women, including three who were not nursing babies, were type C. 1b 35%, type C. 1a 30%, type C. x 10%, type C. 0 5% and undesignated 10%.

Table 4. *Incidence of the different types of Staphylococcus aureus in 103 mothers and their babies at hospital P*

Type of <i>Staph. aureus</i>	Mother's milk	Baby's throat	Baby's rectum	Total
C. 1a	81	75	55	211
C. x	17	11	9	37
C. 2a	1	1	0	2
C. 0	5	1	3	9

Table 4 confirms the relationship of the infection in the baby's throat to that in the mother's milk. Unfortunately, a study on a similar scale was not made of the staphylococci in the mother's nose and throat, but throat swabs were taken from some of the women, and when these yielded *Staph. aureus* it was frequently of an undesignated type. In a group of eight women at hospital P *Staph. aureus* was got from both breast and throat, but in only two of the women did the type from the breast correspond with that from the throat; in one case it was type C. 1a and in the other (from the stillbirth group) type C. 2a. In the remaining six women the staphylococci from breast and throat did not correspond, but in two the type from the breast agreed with that from the baby's throat: the babies of the other four women were not swabbed.

The association of the Staphylococcus aureus types with pathological conditions in mothers and babies

Flushed breast is an inflammatory, non-suppurative and usually very transient condition of the lactating mamma, with local erythrema, heat, tenderness and sometimes pain, and a brief general febrile reaction in which the temperature may rise to 102 or 103° F. It may be the forerunner of mammary abscess. At hospital P forty-one cases of flushed breast were examined, in six of which both breasts were affected. *Staph. aureus* was cultivated from the milk in *all* cases and the following types were identified: type C. 1a alone from thirty-six, type C. x alone from three, and types C. 1a and C. x together from two. Twelve of the forty-one cases occurred in women who were being swabbed throughout the puerperium, and in all of these the same single type of *Staphylococcus* was present in the milk before, during and after the period of flushed breast. If type C. x be accepted as a variant of type C. 1a, all forty-one cases were associated with the same kind of *Staphylococcus*.

At hospital S eight cases were examined and four of these yielded type C. 1b, two type C. 1a and two type C. 2a. Three of these women, who had been examined daily during the preceding normal period, carried the same type throughout. The experience at hospital S suggests that flushed breast is not associated with any one type of *Staphylococcus*, and the predominance of type C. 1a in the hospital P cases may be explained by its predominance in normal mothers and babies.

Breast abscess. Only one case of surgical mastitis occurred during the investigation at hospital P. This case was observed over a period of 5 weeks, at first with normal breasts, then bilateral flushed breast followed by recovery and, after a few weeks of normal lactation, a recurrence of bilateral flushed breast leading to a right-sided mammary

abscess. From the milk, during the normal and flushed breast periods, and the pus of the abscess *Staph. aureus* of types C. 1a and C. x was isolated; the cultivation of type C. x was intermittent but type C. 1a was always present. No other micro-organism was found in the pus or milk. Whatever uncertainty there may be of the connexion between the staphylococci in the milk and the condition of flushed breast, there is no reason to doubt their causative connexion with the breast abscess.

Other pathological conditions were not specially investigated but the following, which occurred in a maternity unit, all yielded *Staph. aureus*:

Purulent conjunctivitis in the infant. Three cases; one of which yielded type C. 1a which was also present in the baby's throat and the mother's milk; the other two yielded undesignated types.

Vesicular skin lesions. One, in a mother, yielded type C. x which was also present in her milk and in the baby's throat, and two in babies yielded type C. x and an undesignated type respectively.

Green hurried stools. No cases except the six referred to in the opening paragraph of this paper were encountered. The *Staph. aureus* types from the faeces of these six babies were identified as type C. x from the fatal case and one other baby, type C. 1a from three and type C. 1b from the sixth.

Vaginal discharges of three women, a perineal abscess and a condition of pyelitis all yielded *Staph. aureus*, but in no case corresponding to any of the types described from mothers' milk or babies' throats.

THE STAPHYLOCOAGULASE REACTION AND ITS SIGNIFICANCE

The property of coagulating citrated plasma *in vitro* is possessed by certain types of *Staph. aureus* and some of *Staph. albus*. Many observers, including von Daranyi and Gross (quoted by Fisher, 1936), regard this reaction as evidence of pathogenicity, and some, like Kemkes (quoted by Fisher, 1936) and Chapman, Berens, Peters & Curcio (1934) accept it also as an index of the virulence of the coccus. The value of the test as a *measure* of virulence or pathogenicity may be prejudiced by the fact that the clotting can be caused by two separate agencies: a free coagulase and the direct action of the living cocci.

In the present work the reagents used for the test were filtered, citrated human plasma, prepared for transfusion, and 20 hr. old active broth cultures, or fresh living suspensions in isotonic saline of 20 hr. old cultures of the staphylococci on agar. The coagulative strains of *Staph. aureus* from mothers' milk and babies' throats and rectums clotted the plasma only when living cultures were used: the reaction was not given by these cultures when killed by heat (60° C.), chloroform, alcohol, phenol, formol or anilin dyes. No evidence of the presence of *free* coagulase was found in the supernatants obtained by high-speed centrifugation of young or old living broth cultures, nor was it liberated by grinding the cocci in a Griffith's tube; but the deposited cocci from the broth cultures were fully coagulative and the ground-up cocci were reduced in coagulating power apparently only in proportion to the cocci killed by the grinding. As supernatants free of coagulase were obtained, it was not considered necessary to resort to filtration.

Coagulation was related to active multiplication of the cocci, as the following experiment showed: Gentian violet, in a series of diminishing strengths, was added to a set of

uniform mixtures of young broth culture and plasma, and it was found that coagulation did not occur in the bactericidal zone of the dye nor in its *bacteriostatic* zone, although in the latter zone the number of living cocci present in a tube was very many times greater than that necessary to initiate coagulation if active growth were proceeding. Beyond the bacteriostatic zone, in the direction of diminishing concentrations of the dye, coagulation proceeded in the first few tubes apparently in proportion to the multiplication of the cocci, and from thence more uniformly. Additional evidence was furnished by the failure of old living broth cultures to cause coagulation until active growth was re-established.

The rapidity and *intensity* of the reaction varied with the temperature of incubation (and the rate of growth), and was greater in tests incubated at 37° C. than in similar tests kept at room temperature for an indefinite time; no coagulation occurred in mixtures kept in the refrigerator (1–2° C.) from the start. In this respect it is noteworthy that control cultures of staphylococci which developed *free* coagulase caused coagulation at refrigerator temperature.

It is evident from these observations that the strains of *Staph. aureus* cultivated from mothers and babies at the two hospitals and designated C. 1a, C. x, C. 1b and C. 2a, although giving a strong coagulase reaction, do not develop a free coagulase.

The technique of the staphylocoagulase test

The common procedure is to set up mixtures of broth culture and plasma in arbitrary proportions of the two reagents. Observations in the present work, however, showed that coagulation (by living cultures) is influenced by an optimal proportion of culture to plasma in the coagulating mixture, and this optimum can be determined (as in antibody-antigen precipitation reactions) by titrating a series of diminishing concentrations of culture against a uniform dose of plasma and incubating the test at 37° C. The mixture showing earliest coagulation is the optimum of the series. The test can be set up with three or four rows of similar graduated culture dilutions and each row titrated against a different concentration of plasma, in a series of increasing dilutions of the plasma. It will be found that the *optimal ratio* (O.R.) of the two reagents is the same in every row in which coagulation occurs within a time limit of about 2 hr. The O.R. can also be determined by titrating a series of diminishing concentrations of plasma against a uniform dose of *Staphylococcus* culture.

As the proportions of plasma and culture in the mixture deviate from the optimum in the direction of excess of either reagent, the coagulation reaction is progressively delayed and finally inhibited. Inhibition is reached earlier on the side of culture excess, and this, in part, is due to growth during incubation of the test which further increases the excessive proportion of the cocci. In the direction of plasma excess the reaction is also delayed but inhibition is much less marked, as growth of the cocci reduces the disproportion between the two reagents.

With strong coagulators the reaction usually occurs over a fairly wide range of mixtures of culture and plasma on both sides of the optimum, so that almost any test employing an arbitrary ratio of the two reagents, which does not involve a great excess of either, especially the culture, will serve for their detection; but with weak coagulators the range of the reaction may be restricted to the optimal mixture or to a narrow zone in its neighbourhood, and, moreover, the *plasma* : *culture* optimal ratio is much higher than

in the case of the strong coagulator; that is to say, a relatively stronger concentration of the plasma must be used. It is probable, therefore, that weak coagulators may not be detected by a test in which the plasma is arbitrarily diluted in a higher degree than the broth culture. With weak coagulators clotting is relatively slow, so that a significant increase in the number of cocci may take place before clotting occurs, and the *plasma:culture* ratio of the optimal mixture at the *time of clotting* may have become lower than it was when the test was set up. This, in part, may explain the apparent high *plasma:culture* O.R. of weak coagulators.

Quantitative estimation of the staphylocoagulase reaction

Samples of different plasmas may vary in their coagulability by staphylococci, and it is well to select stocks suitable for the test and, when replacing, to record the comparative coagulabilities of the old and new stocks. Kept in the cold, a sample of citrated human plasma may be used over several months, if it does not undergo spontaneous clotting.

In quantitative determination of the coagulating power of *living* cultures by tests incubated at 37° C., the possibility of error arising through variation in the quantity of one of the reagents, by growth, must be kept in view and avoided as far as possible by increasing the velocity of the reaction and taking the earliest possible readings. Probably the best method for comparative quantitative measurement is to determine the O.R. of the reagents by setting up three or four rows of similar series of progressive dilutions of the culture, using isotonic saline as diluent, and titrating each row against a different concentration of plasma, arranged in regular series. The point of earliest clotting is found for every row by frequent examinations during incubation at 37° C. To avoid the effects of growth, incubation at 37° C. should not be prolonged beyond 2 hr. The alternative system of testing a series of progressive dilutions of plasma against a uniform dose of culture may also be used, but a sharp optimal reaction is not so easily detected by this method as by that recommended.

The O.R. method for comparative quantitative estimation of coagulase action was used in the earlier examinations of the cultures from the maternity units and was found suitable when small numbers of cultures were involved but, because of the time and labour consumed, it was discontinued when large numbers had to be dealt with, and the reading of the dilution extinction end-point of reaction of one of the reagents was adopted. The system employed was to titrate a series of diminishing concentrations of the plasma against a uniform dose of the culture (following the arrangement of the Widal agglutination test). This system has the advantage that the reaction end-point is fixed by the inhibitory effect of the relative excess of cocci and is not affected by any subsequent increase in the proportion of cocci by growth. The alternative arrangement of titrating a series of progressive culture dilutions against a uniform dose of plasma is not suitable, as the end-point of reaction in the direction of culture dilution is not fixed but continues to extend as the multiplication of the cocci proceeds. The plasma dilution end-point of coagulation varies with the density of the culture suspension used, rising with weaker and falling proportionately with stronger suspensions, but it is advisable to use strong suspensions to avoid prolonged incubation. As the reaction approaches its end-point from dilution of the plasma the density of the clot formed diminishes from a solid fibrinous column to a fine semi-solid-reteform, loose-reteform and suspended funi-

culose clot, and finally a layer of apparently lyophobic protein on the cocci which are precipitated without the formation of a definite 'clot'. In taking the end-point reading, the highest plasma dilution in which a definite clot occurred was recorded.

Comparative measurements made by o.r. determination and by plasma dilution end-point reading were in harmony, as shown by the following results of tests with several strains of type C. 1a, an undesignated type, culture 'M', from the nose of an infant not in the maternity unit, and a type C. 2a strain from human milk. Using suspensions of 1000 millions of cocci per c.c. from fresh broth cultures and one sample of human plasma, the optimal ratios, *plasma* : *culture*, were 0.25 : 1.00 for the C. 1a strains, 1.00 : 1.00 for culture 'M', and 2.00 : 1.00 for the C. 2a strain. The corresponding plasma dilution end-points of coagulation, using coccus suspensions of 250 millions in 1.0 c.c., were 1/32 for the C. 1a strains, 1/8 for culture 'M', and 1/4 for the C. 2a strain.

Cultures of types C. 1a and C. x from mothers and babies gave uniformly strong coagulase reactions, which served as an additional character in differentiating them from other arbitrary types. The few C. 1b and C. 2a strains available tended to lack uniformity in coagulating power but were, on the whole, weaker in this respect than the C. 1a strains.

DISCUSSION

Conceding that the presence of *Staph. aureus* in the mother's milk is related to the presence of similar staphylococci in her baby's throat and intestine, the question of priority of occurrence of the cocci in the mother or the baby arises, and is not easily solved by culture tests alone, for the ease of transference of the cocci during suckling makes it difficult to detect a difference in the time of infection unless the swabbing is done at very short intervals. Admittedly, satisfactory swabbing is more difficult in the case of the baby's throat than of its mother's breast; in a few cases the coccus was never cultivated from the baby's throat although constantly present in its mother's milk. Moreover, the common delay of 20 hr. before the swabs were examined would favour an increase of the cocci in the rich culture material of the milk swab, but might militate against the survival of small numbers of cocci on the throat swabs. Yet, despite these adverse factors, *Staph. aureus* was cultivated at an earlier date from the baby's throat than from its mother's milk in thirty-three out of forty-eight cases.

The maternity wards of hospital P were very suitable for a study of this nature, for the movements and contacts of the patients and their babies were well controlled, and there was no evacuation to shelters with consequent promiscuous contacts during air-raid alerts. The precautions observed by the medical and nursing staffs to prevent the introduction or spread of infection were above reproach, and no case of notifiable infection occurred in the wards during the period of the investigation. The mothers were separated from one another by intervals of 9 ft. and the woman attended to the toilet of her own breast. It seems, therefore, that the possibility of transmission of the staphylococci from mother's breast to mother's breast was remote. On the other hand, the cots in the babies' annexe were grouped together, often in contiguity, so that air-borne transmission from baby's throat to baby's throat was probable, and the nurse, albeit careful, might transfer the cocci through a succession of babies when attending to the toilet of their mouths.

The possibility of the mothers importing the staphylococci must not be overlooked,

but an examination of the breast secretion of a small group of women taken before parturition failed to show *Staph. aureus* in any. Only one mother in a group of eighty-two was found to have the coccus in her milk during the first 24 hr. of the puerperium, and in this case it was present also in the baby's throat. Unfortunately, little swabbing was done of the mothers' throats and noses, but a few cases yielded *Staph. aureus*, belonging chiefly to types not related to those common in the breasts and babies. However, in two women out of a group of eight from whom *Staph. aureus* was got from both breast and throat, the woman's milk and throat swabs yielded the same type of coccus. The transient occurrence of *Staph. aureus* in the milk of six out of twenty-eight women whose babies were stillborn, is additional evidence that the baby is not the only source of infection of the woman's milk. Despite this evidence of other sources of infection than the baby's throat, the predominance in the maternity wards of hospital P, for not less than a year, of a single type of *Staph. aureus*, is suggestive of a local focus of the staphylococcal infection, and it seems justifiable to postulate a continuous infection of the babies' throats arising from pre-existing cases or the environment of the babies' ward, and circulating chiefly as a throat-to-throat infection amongst the babies, with transference to the breasts of individual mothers, in whose milk the coccus multiplies, to be returned to the baby, sometimes in massive dose, when suckling.

The absence of any discernible ill effect on the baby suggests that the coccus concerned had little pathogenicity. Yet the same *Staph. aureus* types were found in the milk of all cases of flushed breast examined and in the pus of the only case of suppurative mastitis which occurred. The relation of *Staph. aureus* to flushed breast was uncertain, as cultures were attempted only from the milk and never from the affected breast tissues. The coccus seems to vegetate in the larger milk ducts and, in the majority of cases, causes no perceptible harm. An observation by the sister in charge of the maternity wards at hospital P, that flushed breast is always associated with a breach of the skin or mucous membrane, such as cracked nipple, may suggest a path to infection of the interstitial tissues. Alternatively, it may be supposed that the cocci migrate through the smaller ducts to the acini of the gland. More direct evidence of pathogenicity was furnished by the case of breast abscess and the isolated cases of purulent conjunctivitis and skin pustule.

Animal inoculations, in the existing circumstances, were not practicable, and the only experimental evidence of pathogenicity rests on the staphylocoagulase reaction which was given by actively growing cultures only of all the designated types of *Staph. aureus* from mothers' milk and babies' throats and intestines. That this reaction indicates pathogenicity of the coccus is not questioned, but its value as a measure of virulence would appear to demand further experiment. It is evident that the predominant C. Ia type in healthy mothers and babies showed little virulence, yet it gave a stronger coagulase reaction than some types of *Staph. aureus* from acute abscess, osteomyelitis and toxic food poisoning, which produced free coagulase. It would seem, therefore, that the kind of staphylocoagulase reaction which depends solely on the agency of actively growing cocci, without free coagulase, may not be a trustworthy index of their virulence; but virulence, and perhaps toxigenicity, may be more closely related to production of free coagulase.

SUMMARY

Investigations at two hospitals, P and S, showed *Staphylococcus aureus* to be commonly present in the milk of healthy nursing mothers and the throat and intestine of their babies. In hospital P, the proportion affected in a group of eighty-two mothers and their babies was over 90%. The condition may not be uncommon in maternity hospitals, but no information of its occurrence is available from private obstetrical practice. The cocci concerned seemed to be of low virulence, for babies swallowing relatively massive doses in their mothers' milk suffered no perceptible ill effect. On the other hand, the coccus was found in the pus of the only case of breast abscess encountered, and in some minor external pustular lesions. It was present in the milk of all the cases of flushed breast examined, but its causal connexion with this condition awaits proof.

The staphylococci, in the majority of cases, seemed to occur first in the baby's throat, possibly from a focus of infection in the babies' ward, and to be transmitted from baby to baby and from baby to mother, with a return infection, in larger amount, through the mother's milk. The mother's nose and throat must be included amongst other, but less frequent, sources of the infection.

The predominating type of *Staph. aureus* gave a relatively strong coagulase reaction which was caused only by actively growing cocci, but it would seem that the reaction caused by this agency is less trustworthy as an index of virulence of the coccus than one in which free coagulase also operates.

CONCLUSIONS

A high incidence of *Staphylococcus aureus* has been shown in the milk of nursing mothers and the throats and intestines of their infants. This condition was not associated with any serious disturbance of health, although the types of *Staph. aureus* identified were also found in some inflammatory and suppurative conditions in the women and their babies.

A mechanism existed in the hospitals for the transmission of the kinds of staphylococci described, amongst babies and from baby to mother, and this mechanism may also be effective for more virulent or toxigenic staphylococci, with graver consequences.

A technique of the staphylocoagulase test is described, with a suggestion of a method for comparative quantitative measurement based on the reaction of optimal proportions of staphylococci and plasma. The use of the test as an index of virulence of the staphylococci requires revision, for that form of the reaction which depends on the agency of actively growing cocci, without free coagulase, may be insufficient for this purpose.

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