borne invasion by Gram-negative organisms might have occurred. In Adamson's (1949) careful necropsy study of lymph-nodes coliform strains isolated from different parts of the body were usually antigenically alike, and the isolation of such organisms was often associated with intra-abdominal disease. He isolated proteus organisms, for instance, from lymph-nodes at 14 necropsies, and reported that seven of the subjects concerned had had gastro-intestinal disease and a further four had renal infections. Again, Brooke and Slaney (1958), observing the occasional development of jaundice after colonic excision for ulcerative colitis, showed that in patients with this condition portal bacteraemia could often be demonstrated. Finally, the numerous reports in recent years on acute bacteraemic shock in prostatectomy patients have also drawn attention to blood-borne invasion by enterobacteria, and, indeed, raise the query whether some of the subjects in the present necropsy series may not have died as a result of unsuspected bacteraemic shock.

Summary

A combined pathological and bacteriological necropsy study was made between September 1961 and October 1962 at a number of general hospitals in England to find the incidence of deaths in hospital from staphylococcal infection.

The survey covered 470 subjects who had died in hospital, and a control group of 125 necropsies on persons who had died outside hospital. The major part of the work was done at eight centres.

In all, 41 (8.6%) of the 470 hospital subjects had staphylococcal sepsis as the immediate cause of death. They included 30 with staphylococcal pneumonia, five with enterocolitis, three with septicaemia, two others with sepsis after operation or needling, and one with exfoliative dermatitis. In many instances staphylococcal pneumonia was a terminal event in patients who would not have been expected to survive. Probably, however, between 2.1 and 4.7% of the patients would not have died when they did if they had not acquired a staphylococcal infection.

In at least three of the five deaths due to enterocolitis the administration of a broad-spectrum antibiotic probably led to the patient's death.

Staph. aureus and coliform organisms were isolated from a large proportion of lungs at necropsy. The significance of these findings is discussed.

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Role of Airborne Transmission in Staphylococcal Infections*

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The importance of physical contact, especially via the hands of personnel, in the spread of staphylococci to newborn infants has been indicated in previous studies from this hospital (Wolinsky *et al.*, 1960; Mortimer *et al.*, 1962). The results of one of these trials (Mortimer *et al.*, 1962) suggested that the airborne route was relatively unimportant. However, because the study nursery was small and there was less than optimum supervision of the nurses attending the infants, it was impossible to draw definite conclusions concerning the relative importance of airborne organisms in the transmission of staphylococci in the nursery. The present study was designed to define the importance of this route.

Materials and Methods

Eight bassinets were placed in a special room 16 by 18 ft. (4.9 by 5.4 m.) in two groups of four each, one group at each end of the room (see Diagram). A line was marked on the floor to separate the two groups. The four bassinets at the far end of the room were occupied by infants admitted direct from the delivery-room. These infants were designated AB (airborne) babies. They were retained in these positions until they were discharged from the hospital, usually when 3 to 5 days old, or until a culture positive for *Staphylococcus aureus* was recognized, at which time they were transferred to the main nursery. At the near end of the room two positions were reserved for X (index) babies. These were infants who had become naturally colonized in the nose or umbilicus, or both, with typable strains of *Staph. aureus* in the main nurseries of the hospital but who did not show overt signs of infection. In the other two positions close to the index babies were placed infants admitted direct from the delivery-room and designated T (physical transfer) babies. To eliminate the chance of infection during circumcision, only female infants were admitted to the AB and T positions.

The study nursery was staffed by eight special nurses who were divided into two groups, one to care for the AB babies and the other to care for the X and T babies. Every effort was made to prevent the members of one nursing group from having contact with the members of the other group. They were not permitted to cross the line dividing the nursery except to enter and leave and to wash at the sink at the far end of the room. A few of the special nurses were temporary or

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permanent staphylococcal carriers. They were assigned to the group caring for the X and T infants. Only one nurse carried a strain of the same type as did some of the carrier infants, but none of the study babies acquired this strain in the absence of an appropriate index baby. None of the personnel caring for the AB babies was a nasal carrier. All equipment, such as scales, linen, bottles, etc., was kept separate for the two groups of study babies. If it became necessary for anyone other than the special nurses to touch any of the study infants, the infant was immediately removed from the nursery and from the study. Physical examinations of the infants were performed by either of two study physicians, neither of whom was a nasal carrier of organisms similar to those of the index baby.

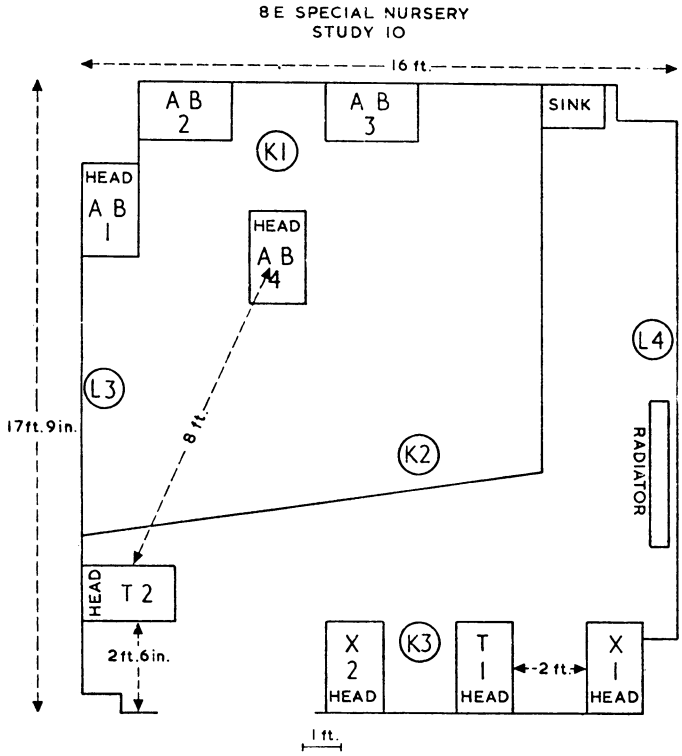

Diagram of study nursery. K 1, 2, and 3 and L 3 and 4 are locations of settling-plates. X 1 and 2 are bassinet positions of infant carriers; T 1 and 2 and AB 1, 2, 3, and 4 are bassinet positions of "physical transfer" and "airborne" infants, respectively.

Cultures were obtained by a cotton swab, which was then streaked direct on to the surface of phenol-red/mannitol-agar containing 10% salt. Cultures were taken according to the following routine: anterior nares and umbilicus of each infant on admission to the nursery and each morning thereafter; the same sites 5 to 14 days after the babies had been sent home; anterior nares of each mother on admission; anterior nares of all nursery and delivery-room personnel once a week; anterior nares of all others who entered the special nursery for any reason. In addition, five settling-plates of the same medium were uncovered and placed in marked positions throughout the room for two hours each day.

For the first 22 days of the study all babies were handled in routine fashion. Each nurse put on a clean scrub uniform and washed her hands carefully for three minutes with a detergent containing hexachlorophane (Phisohex) on arrival for duty. A 10-second wash of the hands was performed after handling each infant. On the twenty-third day the procedure was changed so that the nurses handling the X and T babies did not wash their hands between babies and were allowed only to rinse their hands in running water if that became necessary. In addition, before ministering to a T baby they were required to handle an index baby by changing its diaper. For the last 30 days of the study the procedure on the X and T side was changed again in order to derive further information on the effect of handwashing on the spread of staphylococci. At this time an extra bassinet position was introduced so that there would be four T babies and only one X baby. Two of the T babies continued to be handled without handwashing, but before tending to the other two the nurses cleaned their hands with the routine 10-second hexachlorophane wash after handling the X baby.

Strains of *Staph. aureus* were identified by phage typing and by determination of the antibiotic sensitivity pattern. The 22 typing phages and the techniques of Blair and Carr (1960) were used, except that the old 44A phage was substituted for 42D and the concentration was 100 times the routine test dilution. The antibiotics included in the sensitivity tests by the disk method were penicillin G, streptomycin, erythromycin, tetracycline, chloramphenicol, novobiocin, kanamycin, and bacitracin. From each culture at least two colonies were tested. Whenever doubt existed about whether or not two cultures represented the same strain, several additional colonies from each were tested simultaneously.

An infant was considered to have become colonized with a strain of *Staph. aureus* if the organism was recovered consistently from his cultures or if at least 10 colonies were isolated from the cultures taken later at home.

Results

A summary of the results is shown in Table I. Sixteen of the 158 AB babies acquired strains of *Staph. aureus* that were identical with those carried by index babies in the nursery at the same time. For nine of these acquisitions no other source but the index babies was recognized, and these are designated "definite acquisitions"; in seven others the organisms possibly could have come from neighbouring AB infants who harboured the same strain for a day or two before they were removed from the nursery. These are called "possible acquisitions."

TABLE I.—*Acquisition Rates of Staphylococci from Index Baby*

Group	No. Exposed	Acquisitions	
		No.	%
Airborne	158	16*	10
Physical contact:			
Total	126	49	38
Handwashing	21	3	14
No handwashing	105	46	43

* 9 "definite," 7 "possible" (see text for explanation).

In the physical contact group (T babies) there were 49 acquisitions of the index type in a total of 126 babies, an acquisition rate approximately four times that of the AB group. The rate for the babies handled with hand washing was 14%, and for those who were handled without handwashing it was 43%.

The results of the cultures on the settling-plates are summarized in Table II. Strains identical to those of the index babies were frequently isolated from all of the plates. They were found most often on the one (K 3) nearest the index babies. Most of the recovered colonies of *Staph. aureus* represented index types; the others were usually untypable.

TABLE II.—*Results of Settling-plate Cultures; Number of Days on which One or More Colonies were Recovered**

	Location of Plates†				
	K 1	K 2	K 3	L 3	L 4
Index type	27	27	36	24	32
All *Staph. aureus*	36	36	46	36	38

* Index baby present for 166 days.
† See diagram.

The data in Table III show the rapidity with which organisms were acquired by the various groups of study infants. In this table all positive babies are distributed according to the

number of days of exposure prior to the first positive culture. In the physical contact group 73% of the acquisitions had occurred by the third day, whereas among the airborne babies the exposure time was somewhat more prolonged; only 38% had occurred by the third day.

TABLE III.—*Duration of Exposure Until Initial Positive Culture*

Group	Days					
	1	2	3	4	>4	Home*
Airborne (AB):						
Total	1	2	3	3	2	5
Definite†		1	2	1	2	3
Physical contact (T)	3	25	7	4	2	7

* Five to 14 days after hospital discharge.
† See Table I and text for explanation.

In previous trials at this hospital and in many similar studies reported in the literature the umbilicus was usually the site of initial staphylococcal colonization. It seems reasonable to assume that when colonization occurs as a result of airborne particles the nares more often would be positive first. An analysis of these relationships is shown in Table IV. It may be seen that in the physical contact group the nose became colonized first in only 6% of the acquisitions, but among the airborne babies 25% of the acquisitions were first demonstrated in the nose. When only the nine definite AB acquisitions are considered this difference is more striking: in three of them (33%) the nose was positive first.

TABLE IV.—*Site of Initial Colonization*

Group	Nose	Umbilicus	Nose and Umbilicus Simultaneously
Airborne:			
Total	4 (25%)	9	3
Definite*	3	4	2
Physical contact	3 (6%)	42	4

* See Table I and text for explanation.

Table V shows the rates of airborne acquisitions according to bed position, and indicates that location was not important in determining colonization with the index type. The smallest number of acquisitions occurred in the bassinet position closest to the index infants (AB 4 in Diagram).

TABLE V.—*Acquisitions Among the "Airborne" Babies According to Bed Position*

Position Number*	Number of Acquisitions	
	Definite†	Possible
1	3	1
2	3	2
3	3	3
4	0	1

* See diagram.
† See text for explanation.

Discussion

This study represents an attempt to compare the relative significance of the airborne route with that of other routes in the transmission of staphylococci to newborn infants. It was designed to achieve optimum conditions for controlled observations. The results indicate that airborne transmission did occur, but at a very low rate compared with transmission via the hands of personnel. In addition, it was shown that scrupulously careful handwashing by personnel markedly reduced transmission of organisms by hands.

The conclusion that acquisitions of staphylococci did occur via the airborne route is based on the following evidence. First, the special nurses were carefully selected, thoroughly indoctrinated, and intensively supervised. Therefore it is extremely unlikely that there were unreported breaks in technique, such as contact between the nurses of one group and the infants of the other. Second, the recovery of the index strains of staphylococci on settling-plates at all sites in the room demonstrated that these strains were widely disseminated in the air. Transfer by large droplets (intimate contact) was unlikely because the carrier infants were separated from the babies being observed for acquisition of airborne organisms by a minimum of 7 ft. (2.1 m.). In addition, there was no apparent relationship between nearness of the bassinets and airborne transmission; the infants in the bassinet closest to the index baby (7 ft. (2.1 m.) away) showed the lowest rate of colonization. Finally, airborne transmission is suggested by the site of initial colonization in the infants who were exposed only to airborne organisms. The nasal cultures became positive prior to the umbilical cultures in 25% of these infants, compared with 6% of the babies who could have acquired the organisms by transfer on nurses' hands. This difference is not significant statistically, however.

None the less, two possible routes of colonization, other than the air, must be considered. First, the nurses who cared for the carrier infants washed their hands at the basin in one corner of the room and could have been the source of contaminated droplets. A slightly greater rate of acquisition of the index strains of staphylococci was observed in infants in the bassinet position nearest the sink (position AB 3). This observation, which would support the premise that organisms might have been disseminated by nurses washing at the sink, is refuted by the low incidence of recovery of organisms of the index types from a settling-plate that was placed on a shelf at bassinet-height between the sink and this nearest bassinet. It was present during the first 29 days of the study, and is not shown in the Diagram or the Tables. Index-type colonies were recovered from this plate on only three occasions during these 29 days, whereas during the same period of time these strains appeared on the other settling-plates on four to eight occasions each.

The other of the two alternative routes of colonization that must be considered is that of transmission from one infant to another within the group exposed to airborne transmission. Thus an infant in this group who acquired an organism via the air might transmit it to neighbouring infants during the 24 to 48 hours before his cultures were recognized as positive and he was removed from the nursery. After careful examination of the data it was concluded that nine of the 16 acquisitions could not have resulted from intra-group transmission, whereas seven might have occurred in this alternative manner.

Handwashing markedly reduced the acquisition rate in the babies who were attended by nurses who also cared for the infant carriers, thus confirming previous studies from this hospital (Mortimer *et al.*, 1962). Indeed, when these intensively indoctrinated and supervised special nurses employed a 10-second hexachlorophane wash between babies the acquisition rate was reduced approximately to that of airborne transmission. Under supposedly similar techniques performed by the regular nursery personnel in the previous study the rate of acquisition of staphylococci was reduced from 92% to 53% by handwashing. Presumably the more favourable results were a consequence of more diligent washing.

Thus the present study provides evidence that airborne transmission of staphylococci between infants in newborn nurseries does occur, though at a relatively low rate. In addition, the results serve to re-emphasize the importance of proper handwashing by nursery personnel in the control of spread of organisms between infants.

Summary and Conclusions

The role of airborne organisms in the transmission of staphylococci between babies was studied under strictly controlled conditions in a small nursery with a group of special

nurses. The rate of transmission was between 6 and 10% to 158 newborns cared for in such a way that organisms from infant carriers could be transmitted to them only via the airborne route. In contrast, 126 infants who were handled by nurses who also handled the neighbouring carrier babies with little or no handwashing exhibited a 43% rate of acquisition of the carrier strains. A careful hexachlorophane wash of the hands of the nurses who cared for the carriers decreased the transmission rate to 14%. The carrier strains were often recovered from settling-plates exposed throughout the special nursery.

It is concluded that under ordinary circumstances airborne organisms probably account for only a small proportion of staphylococcal transmission in the nursery, and that efficient handwashing techniques can reduce staphylococcal spread appreciably.

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New Treatment of Some Chronic Tension States

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Birley (1964) reported a follow-up study, which he had started some years previously, of over a hundred patients given modified leucotomy on the advice of one of us (W. S.) at either St. Thomas's or Belmont Hospital during the past 15 years. One of the most interesting and unexpected findings was the frequency with which clear-cut depressive episodes had occurred months or years after the leucotomy. This was especially the case in those patients who had been operated on with the diagnosis of a " chronic tension state " in a good previous personality. These unexpected attacks of depression following leucotomy had also mostly then responded to treatment with antidepressant drugs and/or electric convulsion treatment (E.C.T.). The conclusion therefore seemed undeniable that in these patients there had often been a marked depressive component to the total picture, which had been overlooked prior to leucotomy. Because of this, E.C.T. had often been inadequately given, or even not used at all, for fear of aggravating the chronic tension state thought to be present.

Many such chronically tense and anxious patients are always being sent to the Department of Psychological Medicine at St. Thomas's Hospital for a final decision on whether or not a modified leucotomy would help them. Generally, however, the psychiatrists referring these patients have tried most other treatments before finally deciding to do so.

Birley's follow-up finding led to a serious reappraisal of our previous indications for leucotomy (Sargant, 1962). And as a result, and with very few exceptions during the last few years, no case of supposed chronic anxiety neurosis, obsessional ruminative illness, or tension state occurring in patients of good previous personality has now been given the operation without a prior trial of a very thorough treatment of any possible depressive component present. Both groups of antidepressant drugs have even been given in combination ; and E.C.T. also given at the same time.

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In many cases a modified form of continuous narcosis was given together with the drugs and E.C.T. to make the treatment easier in some especially tense patients. And one of us (C. W.) then noticed that when this modified narcosis was used in addition to the combined antidepressants and E.C.T. the patients sometimes seemed to respond very much better than when E.C.T. and the combined antidepressant drugs were used without additional narcosis.

We now report some very encouraging and quite unexpected results when these two groups of patients are examined as a whole and also compared with one another. It has been found in fact that a large number of patients complaining of chronic tension states can now be got well after many years of illness if the previous personality is good, and without the need to resort to leucotomy in the majority of them. The number of patients helped after having been ill for years on end is quite new in our experience, and seems to constitute, if confirmed, a real advance in the treatment of a group of often seemingly hopeless illnesses. And patients given narcosis combined with E.C.T. and the antidepressant drugs have been found to do surprisingly better than those given E.C.T. and the drugs alone.

Patients Treated

This paper examines a group of 73 consecutive patients suffering from long-standing " tension states " in good previous personalities, mostly referred to St. Thomas's by other psychiatrists during 1962–4 for a final decision about leucotomy. Cases of obvious endogenous and agitated depression, recurrent endogenous depression, gross hysteria, obsessional compulsive illness, and chronic personality disorder have all been excluded. The patients under discussion complained preponderantly of symptoms of prolonged tension or anxiety (see Table III). Depression was also complained of by 64% of patients. Often the illness was complicated by obsessional thoughts and even hysterical