UMBILICAL CORD AS RESERVOIR OF INFECTION IN A MATERNITY HOSPITAL

BY

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Although much work has been done in recent years on *Staph. aureus* infections in maternity hospitals, the problem remains widespread and unsolved. Most hospitals experience outbreaks every few years, and sporadic cases occur at intervals in spite of all precautions. Minor infections such as spots and sticky eyes are a source of anxiety, and the occasional severe ones may cause death or prolonged illness. The fact that *Staph. aureus* is able to acquire resistance to antibiotic drugs means that treatment is likely to become more difficult and uncertain. Greater stress must therefore be laid on prevention.

From the bacteriological point of view there seem to be two aspects of the problem: (1) The ubiquity of *Staph. aureus* in a nursery as judged by the high proportion of positive samples from babies, the bedding, and other articles, and from the atmosphere. No other pathogenic organism is so widely distributed in the environment of a susceptible population. (2) The presence of some strains of increased virulence (Colbeck, 1949; Rountree and Freeman, 1955). At present there is no rapid or straightforward method of detecting virulent strains and excluding their carriers.

The problem which confronts us is therefore mainly one of cross-infection: how and where the staphylococci are maintained and how they spread from one patient to another.

The problem of cross-infection may be attacked from two angles: elimination of the reservoirs where the organisms flourish, and interruption of the routes by which they are spread. This paper is concerned mainly with the first of these points. There are many reservoirs of *Staph. aureus* in a nursery for newborn infants, but the nature of the umbilical cord suggests that it might be a particularly dangerous one. Cut off from its blood supply and separating by a process of dry gangrene, it must be an excellent medium for bacterial multiplication, as Cullen pointed out in 1916. The cord was described by Coventry and Isbister (1951) as an open wound with decreased powers of local resistance. Recent papers by Kwantes and James (1956) and Boissard and Eton (1956) on streptococcal infection support this analogy. The importance of such a wound has long been stressed by workers on hospital cross-infection. It has been shown how the dangers of spread from it may be decreased by the use of no-touch technique in a room supplied with filtered air, and by the protection of the wound with local applications under ample dressings. In contrast with this, it has become the custom recently in many maternity hospitals to do without cord dressings and binders, so that the cord stump is left in direct contact with the baby's clothes and bedding, and freely accessible to its hands. It is also handled every day by nurses who do not wear gloves. It thus seems to be ideally situated not only for the growth of organisms but also for their dissemination into the environment both by contact and by the air.

The umbilical cord has long been recognized as a site from which *Staph. aureus* may readily be recovered

(Cullen, 1916). Forfar *et al.* (1953) swabbed 120 babies at the time of separation of the cord (about the eighth day of life) and found an infection rate of 60%. Edmunds *et al.* (1955) recorded a rate of 40% in 604 infants of the same age. Coventry and Isbister (1951) found 54% of 50 babies to be carrying *Staph. aureus* on the cord by the third to fourth day and remarked on the special dangers of infection of this site. Isbister made further studies in 1951 and 1953. Her interest, however, was mainly clinical. She considered that infection of the cord might result in unsuspected liver damage, which in turn might be responsible for "physiological jaundice" and failure to thrive. The obvious complication of liver abscess and septicaemia is better known but rare.

The purpose of this paper is to draw attention to the cord as one of the main sources of staphylococci and to advance evidence that control of this reservoir more than others might be expected to lead to a diminished risk of virulent staphylococci being spread in a nursery.

Earlier Investigations

The investigations were made in a new maternity hospital, but earlier ones had been made in other maternity hospitals in the district to establish the extent of the problem. In these earlier investigations 74 babies out of 84, aged 4 days (88%), had given positive umbilical swabs in one hospital and 50 out of 59 (85%) in another. Nasal swabs had also been taken in these hospitals in an attempt to find out which was the more important reservoir of infection, nose or cord. In Table I are shown the results of the examina-

TABLE I.—Number of Times that the First Positive Swab was Obtained From Nose or Cord

Hospital	Nasal Swab Pos. First	Cord Swab Pos. First	Both Swabs Positive	Total No. of Swabs
A	7	34	19	60
B	6	37	24	67

tion of swabs of cord and nose to determine which site was infected first, and it appears that the cord was almost always infected before or at the same time as the nose. It was rare for the nose alone to be positive.

It was also thought to be of some importance to make a rough comparison of the amount of growth obtained from nasal and cord swabs taken in the first four days of life. Cord swabs proved to give a heavy growth of *Staph. aureus* more often than nasal ones, and the organism was frequently in pure culture. The results are shown in Table II.

TABLE II.—Rough Comparison of Amount of Growth Obtained From Nasal and Cord Swabs Taken on First Four Days of Life

Age (in Days)	No. of Babies Swabbed	Growth from Nose			Growth from Cord		
		Heavy	Mod.	Light	Heavy	Mod.	Light
0	12	—	1	11	1	2	9
1	22	6	1	15	13	6	3
2	17	3	—	14	13	—	4
3-4	5	1	—	4	5	—	—

It was found also that 8 out of 22 babies with a positive nasal swab on the first day of life had become negative on the second. Only 5 out of 37 cord swabs showed a similar loss of the organism, and two of these were overgrown with *Proteus sp.* This suggests that the isolation of *Staph. aureus* from a nasal swab may not necessarily represent the multiplication of organisms there but merely that they have been filtered off from the air.

These preliminary investigations indicated that *Staph. aureus* infection of the umbilicus occurred early and in abundance.

Present Investigations

The investigations were carried out in a maternity hospital which had been opened only a few months previously. In controlled studies the cord stumps were painted with bactericidal dyes to see if this would influence the spread of infection.

The maternity hospital where this investigation was carried out was arranged conveniently on three floors, A, B, and C. There were five small wards and some single rooms for the mothers on each floor, and a nursery, which was divided into several large and small cubicles. The babies were kept in the nurseries during the night, but spent the day with their mothers in the wards. The number of babies varied between about 8 and 21 on each floor, and up to 10 or 12 slept in the same room in the nursery. The nurseries were well ventilated and had windows on three sides, so that much sunshine entered the rooms. They were cleaned with vacuum cleaners and dusted with wet cloths. The junior nursing staff on the different floors were changed every few weeks, but the medical staff and senior nurses remained the same, for the most part, on each floor.

Immediately after delivery the cord of a newborn baby was clamped by the accoucheur, ligated, and cut. The baby was put in a cot and any treatment or cleaning-up considered necessary was carried out with ungloved hands. The cord was inspected frequently to make sure that it was not bleeding; it was sometimes handled or squeezed during this inspection. About six hours after birth it was re-ligated and cut short to about an inch (2.5 cm.); surgical spirit was then applied and the cut end sealed with collodion. If the cord was thick, with an abnormal amount of Wharton's jelly, this was squeezed out before the second ligation was applied. Every day, between 7.30 and 9 a.m., the babies were cleaned, weighed, and bathed (if the cords had separated), and other routine nursing procedures were carried out. Cords were treated with spirit. The nurses' hands were washed with soap and water between the care of each baby and dried on a hand towel.

Bacteriological Technique.—Swabbing was done at the same time each day, just before the midday feed. At this time the babies had not been handled for several hours. Dry swabs were used for the nostrils, but for the skin they were moistened in nutrient broth. Skin swabs were taken from an area about 2 in. (5 cm.) in diameter at the lower end of the sternum. Three 4½-in. (11.5-cm.) settling-plates were put down daily on each floor, one in each of the two busiest nursery cubicles and one in the vestibule. They were not put down until all the babies had been removed from the nursery, so that the finer particles and droplets would be sampled rather than splashes and particles from blankets. There was little activity while the plates were exposed, which was between 9 a.m. and 1 p.m. Agar plates containing 2.5% sheep blood (Marks, 1952) were used both for swabs and settling-plates. They were incubated aerobically at 37° C. overnight and left on the bench for another 24 hours before being read. *Staph. aureus* colonies were identified by their colour and colonial appearance and by the zone of lysis which the majority showed on sheep-blood plates. They were all tested by the slide coagulase test of Cadness-Graves *et al.* (1943) and a tube test was done on all giving a doubtful result. The number of *Staph. aureus* colonies on each settling-plate was recorded. At the time of reading both sets of plates it was not known whether they belonged to the test or to the control group.

Treatment of Umbilical Cords with Triple Dye.*—For the purpose of the investigation, triple dye was applied to the cord of each baby immediately after its birth and every morning until separation took place. It was painted on to the whole of the cord stump and about an inch (2.5 cm.) of the surrounding skin. It appeared to be fixed to the tissues quickly, for it stained the clothes very little and did not spread to the rest of the baby's skin.

*Brilliant green 2.29 g., proflavine hemisulphate 1.14 g., crystal violet 2.29 g., water 1,000 ml.

Results of Triple-dye Treatment of Cords of all Babies on One Floor

(a) Between January 25 and April 14, 1956, triple dye was painted on the cords of all the babies born on floor A, while those on floor B were left untreated. A fortnight was allowed to pass before the investigations began so that there would be time for any effect to become apparent. The investigations were as follows: (1) Nasal and skin swabs were taken from all babies on both floors when they were 4 days old. (2) Settling-plates were put down in the nursery on both floors. The number of *Staph. aureus* colonies on the three plates was recorded. The results are shown in Table III.

TABLE III.—Treatment of Umbilical Cords with Triple Dye

Swabs	Treatment of Cord	No. of Babies	No. of Swabs Positive	Difference	Standard Error
Nasal	Dye (floor A)	91	46 (50.5%)	} 24.2%	6.95
	No dye (" B)	91	68 (74.7%)		
Skin	Dye (" A)	91	32 (35.2%)	} 25.2%	7.61
	No dye (" B)	91	55 (60.4%)		

Average Number of *Staph. aureus* Colonies on Three Settling-plates

Treatment of Cord	No. of Days	Average Count	Difference	Standard Error
Dye (floor A) ..	62	4.77	} 4.93	1.14
No dye (" B) ..	62	9.70		

(b) Between April 14 and June 1 this procedure was reversed, babies on floor B being treated and those on floor A being used as controls. A fortnight was again allowed before investigations began. These were exactly the same as before. The results are shown in Table IV.

TABLE IV.—Treatment of Umbilical Cords with Triple Dye

Swabs	Treatment of Cord	No. of Babies	No. of Swabs Positive	Difference	Standard Error
Nasal	Dye (floor B)	54	19 (35.2%)	} 36.2%	9.16
	No dye (" A)	49	35 (71.4%)		
Skin	Dye (" B)	54	17 (31.5%)	} 39.9%	9.03
	No dye (" A)	49	35 (71.4%)		

Average Number of *Staph. aureus* Colonies on Three Settling-plates

Treatment of Cord	No. of Days	Average Count	Difference	Standard Error
Dye (floor B) ..	34	3.41	} 1.82	0.81
No dye (" A) ..	34	5.23		

When the cords of all babies on floor A were treated with the dye, both the nasal and the skin infection rates were reduced by a significant amount when compared with those on the control floor. This difference may have been due to variations in nursing technique or to the presence of heavy nasal carriers on one floor and not on the other. However, this seems unlikely, because when the dye was introduced on floor B, and discontinued on floor A, after only a fortnight's interval, both infection rates fell on floor B and rose significantly higher on floor A. The number of colonies on settling-plates showed a similar distribution. Thus it appeared that treatment of all babies' cords on one floor was associated with a lower infection rate of nose and skin and with reduced contamination of the air.

Results of Triple-dye Treatment of Cords of Alternate Babies

Over this period a second type of investigation was being carried out on floor C. The cord of every second baby born in this unit was painted with the dye, but treated and untreated infants were kept in the same nursery and handled by the same staff, so that, apart from the dye on the cord, all conditions were similar for both groups. Swabs were taken from each treated baby when it was 4 days old and from an untreated one of the same age, which acted as a

control. The techniques used were the same as before, but settling-plates were not put down. This floor also contains the premature unit, so special precautions were used here which were not employed on the other floors, such as the wearing of masks and the application of chlorhexidine ("hibitane") cream after washing the hands. Premature babies were not included in the investigation. The results are shown in Table V.

TABLE V.—Treatment of Umbilical Cords with Triple Dye on Floor C

Swabs	Treatment of Cord	No. of Babies	No. of Swabs Positive	Difference	Standard Error
Nasal	Dye	50	20 (40.0%)	—	—
	No dye	49	19 (38.8%)		
Skin	Dye	50	10 (20.0%)	33.1%	9.1
	No dye	49	26 (53.1%)		

This investigation was carried out in order to eliminate the effect on the infection rate of nursing techniques and nasal carriers. The results, however, showed an unexpected pattern. While the skin swabs of treated babies gave a significantly lower infection rate than those of the control group, the nasal infection rates were the same. The babies on this floor all breathed the same air, so this finding suggests that, though organisms may spread from the cord on to the skin, nasal infection comes mainly from the air. The nasal infection rate in both groups was lower than usual; it is possible that the treatment of the cords of half the babies in this unit had decreased the level of airborne contamination, which was reflected in the number of organisms inhaled by the babies. The additional precautions mentioned before may also have contributed to this reduction.

Discussion

These results leave little doubt that the umbilical cord acts as a reservoir from which *Staph. aureus* may be spread. The importance of this depends on how far the second aspect of cross-infection may be brought under control—the transfer of organisms from one patient to another.

There are many ways in which this occurs in a maternity hospital, and the problem has been discussed in numerous papers. Most workers agree that the medical and nursing staffs are the chief source of the organisms (Parker and Kennedy, 1949; Forfar *et al.*, 1953; Rountree *et al.*, 1956). Once the organism has been introduced into the nursery, however, the spread seems to be mainly from one baby to another. Some workers stress the airborne route in this (Wallace and Duguid, 1952), while others consider that contact infection plays the greater part (Allison and Hobbs, 1947; Blaikley, 1952). In old-fashioned hospitals with poor ventilation and little sunlight the airborne route probably plays a large part in the spread of infection. It can be reduced considerably by methods such as treatment of blankets, oiling of floors, spacing of beds, etc. Even when all these procedures are carried out, however, organisms will still reach the air as long as infected patients are present. A limit is soon reached at which no further measures could be applied, in a place such as a nursery, without severe disorganization of the routine work. Clarke *et al.* (1954), for example, have shown that when applied alone these measures reduced the total numbers of organisms in the air in a surgical ward, but did not affect the cross-infection rate.

Contact infection is equally difficult to eliminate entirely, although it seems that better precautions could be taken than are in use at the moment. It does not seem to be appreciated, for instance, in many maternity hospitals, that soap and water will not remove staphylococci from the skin, although this is made clear by Colebrook (1930), Colebrook and Maxted (1933), and a Medical Research Council Memorandum (1941). Some findings which I obtained in the course of another investigation may illustrate this point. (1) A visit was paid to the nurseries while the morning routine of

changing and cleaning the babies was going on. The hands of 11 nurses were swabbed before and after they were washed in the usual way. Six were positive for *Staph. aureus* on both occasions, one acquired the organism and one lost it. The staphylococci isolated were of the phage-type endemic at the time, not the nurses' nasal strains. (2) Swabs were taken from door-handles of cubicles and hand-towels in the nurseries over a period of several months; 49% of 147 door-handles were positive for *Staph. aureus* and 47% of 53 towels. (Eight per cent. salt-broth enrichment was used for these swabs.) (3) The average time which a nurse was able to spare for hand-washing between the handling of each baby was 15 seconds.

Price (1938) found that, while hands were never completely sterilized by washing with soap and water, two minutes was the average time taken for the removal of "transient" organisms. Colebrook and Maxted (1933) reported that staphylococci could still be recovered from the hands after they had been washed for as long as five minutes. In order to limit this degree of hand contamination various skin disinfectants may be used, but many are not suitable for prolonged use. Chlorhexidine cream has not this disadvantage, and has been shown by Murray and Calman (1953, 1956) to be effective against *Staph. aureus* in laboratory tests. Colebrook (1955) suggested that gloves which could be disinfected on the hands might be used with advantage. It would certainly seem reasonable for nurses to wear gloves when handling the cord stump or when looking after babies with clinical infections.

It thus appears that at present the control of cross-infection by blocking routes of transfer is still imperfect. This makes it doubly important to eliminate, so far as is possible, the chief reservoirs of pathogenic organisms. It is necessary to distinguish between places where *Staph. aureus* can often be obtained, such as the air and fomites, and places where it actually multiplies. It will always be present because of the high nasal carrier rate; we must concentrate on reducing its numbers rather than attempt to banish it entirely from nurseries.

The main reservoirs are generally considered to be: (a) Any open lesion, whether in mothers, staff, or babies. These cases should be isolated. (b) The nostrils and skin of adult carriers. The work of Gould (1955) and Rountree *et al.* (1956) suggests that the use of nasal ointments containing antibiotics such as neomycin, gramicidin, and bacitracin may help to prevent the introduction and spread of organisms from this source. It would not be possible to use these continuously, however. (c) The babies themselves form the remaining reservoir of infection as well as its main target. After the first few days of life, *Staph. aureus* can usually be isolated from the nose, mouth, eyes, cord stump, faeces, and the skin as a whole. Of these, the cord is not only the site from which spread is most likely to occur, but it is also the easiest to treat. It would be difficult to eliminate *Staph. aureus* from the other sites without using antibiotic drugs, which is not to be recommended as a routine. Local treatment of the cord, on the other hand, appears to be effective and free from side-effects or complications. Whether cord dressings should be reintroduced instead of or as well as this procedure is a question that might well bear investigation.

This work was carried out during an inter-epidemic period, when there was very little *Staph. aureus* infection in the hospital. Where a large population of staphylococci has been allowed to accumulate, treatment of the cord by itself would probably make little difference to the cross-infection rate. All the known methods of control must be applied simultaneously if any impression is to be made on the prevalence of the organism. These may be summarized as follows: avoidance of overcrowding, isolation of cases, precautions against contact and airborne spread, and removal, if possible, of dangerous carriers. The purpose of this study has been merely to point out the similarity between the cord and an open wound, and to indicate how the danger of this as a source of infection may be reduced.

Summary

A study is described of the part played by the umbilical cord of the newborn infant as a source of infection in a maternity hospital.

The cords of one group of babies were treated with triple dye. Nasal and skin swabs were compared with those of an untreated group in another unit and counts made of *Staph. aureus* colonies on settling-plates put down in the two nurseries. After a fortnight, treatment was introduced into the unit which had previously acted as a control, and similar investigations were carried out.

There was a significant difference between the treated and untreated groups in respect of both the nasal and skin swabs and the numbers of *Staph. aureus* colonies isolated from settling plates.

In a second investigation, treated and untreated babies were kept together in the same nursery. Skin swabs again showed a significant difference, but the nasal infection rates were the same in both groups.

The practical value of these findings is discussed in relation to the prevention of cross-infection among newborn infants.

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In 1955 the British Council for Rehabilitation set up a working party to investigate "the gastric problem" in industry. The working party has now reported. Its chairman was Dr. F. AVERY JONES, and among its members were two professors of industrial health, six industrial medical officers, a physician, a psychiatrist, and a medical statistician. The report is very short (6 pages) and intended for lay readers. The principal conclusions are that gastric and duodenal ulcer are common among men to-day; that those prone to ulcer must avoid undue fatigue, anxiety, and irregular meals; and that both management and worker can help to reduce the problem. The report, entitled "Gastric and Duodenal Ulcer: A Modern Industrial Problem," can be obtained for 1s. 6d. from the British Council for Rehabilitation, Tavistock House (South), Tavistock Square, London, W.C.1.

BARBITURATE ANTAGONISTS TO SHORTEN DROWSINESS AFTER SEDATED B.M.R. DETERMINATIONS

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The reliability of determinations of the basal metabolic rate depends largely on the certainty of the patients being basal during the test. It has been shown that preliminary sedation to the point of sleep can ensure this in nervous patients (Bartels, 1949; Fraser and Nordin, 1955). This technique, however, may leave the patient drowsy and confused for a variable and sometimes prolonged period after the test. We have therefore conducted the clinical trial reported below to assess whether the drowsy period can be shortened with barbiturate antagonists.

Two substances, bemegride (β -ethyl- β -methylglutaramide; "megimide") and amiphenazole (2:4-diamino-5-phenylthiazole hydrochloride; "daptazole") have been advocated for the treatment of coma due to barbiturate overdosage (Shulman *et al.*, 1955). Bemegride is a specific barbiturate antagonist, while amiphenazole has a similar weaker action but also acts as a nervous and respiratory stimulant (Shaw *et al.*, 1954). It seemed likely that these drugs might also shorten the period of drowsiness and confusion following smaller doses of barbiturates.

Method

The trial was arranged on a series of 10 patients whose sedated B.M.R. was being determined in hospital on each of two successive days. After the B.M.R. determination on one day they received the antagonist bemegride, the other day being used as a control. On both days the rate of awakening was carefully assessed so that any consistent difference between rates of waking on the two days could be determined and perhaps attributed to the antagonist drug.

Drug Dosage.—On each day the patient was sedated with three oral doses of 200 mg. (3 gr.) of sodium amylbarbitone ("sodium amytal") at 7, 8, and 9 a.m. Subsequently, at 10.30 and 11 a.m. on one day, he or she received two oral doses of the antagonist bemegride (each of 150 mg. in a 0.5% solution), while on the other, or control day, he or she received two apparently similar doses containing only saline. In the case of four patients the observer also was unaware which was the control day.

Assessment of Wakening.—From 10.30 a.m. the patient's drowsiness was assessed at half-hourly intervals until fully awake, using the following criteria:

Appearance	Speech	Gait
Asleep 3 ..	Incoherent 3 ..	Gross impairment 4
Drowsy 2 ..	Slurred 2 ..	Moderate " 3
Normal 1 ..	Normal 1 ..	Slight " 2
		Normal " 1

Occasionally, observations on a control day were not followed through until the patient was completely awake.