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Neonatal infection due to *Salmonella worthington* transmitted by a delivery-room suction apparatus

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SUMMARY

An outbreak of diarrhoea due to *Salmonella worthington* in five newborn babies, 5 weeks after a similar outbreak in 13 babies for which no cause had been found, occurred in the nursery of a maternity ward. The source of infection was traced to the contaminated rubber tubing of a mechanical suction apparatus. *S. worthington* was isolated from the rubber tubing and the Y connexion of the suction apparatus from which all the five infected babies had received suction. Reflux of contaminated amniotic fluid into the sterile catheter connected to the apparatus some time before use could have been the means of introducing the infected material to the oropharynx of the newborn babies, and amniotic fluid, acting as a good medium to support the growth of *S. worthington*, might be responsible for the long-lasting contamination.

INTRODUCTION

An outbreak of salmonellosis due to *Salmonella worthington* occurred among newborn babies in the nursery of a maternity ward in August 1974. Thirteen cases developed diarrhoea. Twelve of them recovered but one died of meningitis. A search for the source of infection was unsuccessful. Five weeks later, a second outbreak due to the same organism occurred in the same nursery with five newborn babies affected. The source of infection was therefore thoroughly investigated and was traced to the contaminated tubing system of a suction apparatus used in mucus extraction after delivery. The result of this investigation is reported here.

EPIDEMIOLOGY

The nursery involved belonged to a maternity unit of a general hospital. The unit dealt with about 700 deliveries a year and consisted of one labour ward, 22 antenatal and postnatal beds, the nursery and a small isolation nursery.

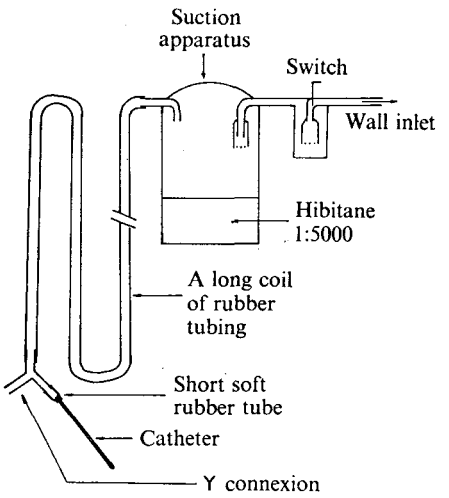

Fig. 1. Suction apparatus A (Vacuum control unit, ward type, British Oxygen Company Ltd) and its connexions.

The labour ward and the suction apparatus

The labour ward housed two beds, each with its own suction apparatus and resuscitation trolley. The suction apparatuses were both made by the British Oxygen Company Limited but differed in the model. One (apparatus A) was known as the vacuum control unit, ward type, while the other (apparatus B) was known as the vacuum regulator. Both were fixed to the wall about 4 ft. from the ground and were connected to the inlets of a centralized hospital vacuum pump. Hibitane in a dilution of 1/5000 was placed in these suction apparatuses (Fig. 1). The tubings, connectors and the apparatuses were cleaned with 1/5000 Hibitane when it appeared necessary, at the discretion of the ward sister. These tubings and connector, however, had not been changed or disinfected for at least 3 months before the investigation. French size-8 side-hole disposable Portex catheters were used for mucus extraction and were generally thrown away after use, although occasionally catheters were re-used after being cleaned in hypochlorite solution (Milton) as the hospital supplies were at times unpredictable. Catheters might be connected to the suction apparatus some time before use, especially at night.

The nursery

All babies were kept in the nursery except during feeding. They were fed by the nursery nurse in the first 24 h, then by the mothers. The milk came bottled and autoclaved at 110° C. for 10 min. from the milk kitchen, and was subject to regular bacteriological control. Nurses in the nursery worked in three shifts with reduced numbers in the afternoon and at night. There were four nurses during the morning shift in contrast to two at night. Masks and gowns were always worn by medical attendants. No visitors were allowed in the nursery.

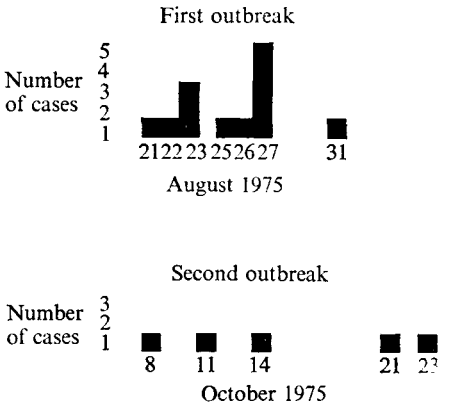

Fig. 2. Distribution of cases of *Salmonella worthington* infection in the two outbreaks.

The outbreaks

The first salmonella outbreak occurred in August 1974 with 13 babies infected, and the second outbreak occurred in October with 5 babies infected. The distribution of cases by day of onset is shown in Fig. 2. Diarrhoea was the common presentation in all babies, some with mucus and blood in the stool, and *S. worthington* was isolated from the stools or rectal swabs from all of them. In the first outbreak, the time between birth and the development of diarrhoea ranged from 1 to 3 days. One baby developed meningitis and died, *S. worthington* being isolated from his cerebrospinal fluid. It seems likely that these babies were infected in the maternity unit. The search to find the source of infection was unsuccessful. Cultures of various objects and solutions in the nursery and delivery room were all salmonella-negative. The suction apparatuses, however, were not included in the investigation.

The second outbreak, in which a series of five babies developed diarrhoea, occurred in October. Four out of the five babies were delivered in the early hours of the morning. The average duration between birth and the development of diarrhoea was 1·6 days with three babies developing diarrhoea within 24 h. after delivery (Fig. 3). This suggested that the infection might have occurred at or shortly after delivery. Further investigation revealed that the only piece of equipment with which these full-term, vaginally delivered newborn babies had come into direct contact was suction apparatus A used for oropharyngeal suction. This particular suction apparatus had been used for all the five babies because it was preferred by the nurses. During the period, from the birth of the first infected baby to the birth of the last infected baby, 25 babies were delivered vaginally in the ward. Of these, 15 were born at night and 10 were born in the day. Thus, the infection rate for babies born at night was 4 in 15 or 27% while for those born in the day it was 1 in 10 or 10%.

Babies with symptoms were isolated and treated. The duration of the illness varied from 4 to 16 days. The symptoms were confined to the gastro-intestinal tract. Parenteral ampicillin and gentamicin were given to two of them. All recovered

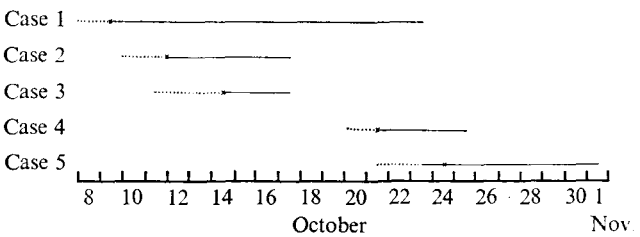

Fig. 3. The relation between the time of birth and the onset of symptoms in the infected babies of the second outbreak, 1975. . . . . ,Interval between birth and onset of symptoms. ——, Duration of illness. ×, First positive isolation of *S. worthington* from stools.

well. The contacts of the infected babies were either isolated or sent home after rectal swabs were taken. The nursery was closed and thoroughly disinfected.

Bacteriological findings

On 17 October and thereafter, rectal swabs were taken from all the babies, the mothers and all the medical and non-medical staff. These included 11 babies, 11 mothers, 5 doctors, 15 nurses and 10 auxiliary staff. Swab specimens were also taken from various objects in the nursery and delivery room. On 22 October, 6 swabs were taken from the Y connexion and the distal and proximal ends of the rubber tubing leading to the suction apparatus A. These swabs were examined for *Salmonella* by the selective migration procedure of Chau & Huang (1976). All the salmonella cultures isolated were subjected to detailed identification by conventional biochemical and serological tests. *S. worthington* was isolated from the rectal swabs of the 5 infected babies and *S. derby* from the rectal swabs of a symptomless baby. A symptomless carrier of *S. worthington*, the mother of the third infected baby, was detected among the 11 mothers examined. Her stool culture had been negative for *Salmonella* on admission, and again on 10 October. *S. worthington* was first isolated from her stool on 17 October, i.e. 3 days after her baby's stool culture was positive for this organism. Examination of the medical and non-medical staff detected 4 symptomless carriers of *S. anatum*, who were then transferred out of the unit, but failed to reveal any *S. worthington* carrier. The most important finding was that *S. worthington* was isolated from 3 out of the 6 swabs taken from the connector and the rubber tubing of suction apparatus A, while cultures of suction apparatus B and other equipments and solutions in the nursery and delivery room were negative for salmonellas. In addition, all the milk samples taken from the centralized milk kitchen were found to be sterile. All the *S. worthington* strains were sensitive to the following antibiotics when tested by the disk sensitivity-test method: keflin (25 μg.), trimethorprim (2·5 μg.), kanamycin (30 μg.), gentamicin (10 μg.), chloramphenicol (25 μg.), ampicillin (25 μg.) and carbenicillin (100 μg.).

The suction apparatus was disinfected and the tubings and connectors changed. Twenty-five additional swabs were taken from different parts of both suction apparatuses and no *Salmonella* was detected. No further cases of salmonella infection occurred thereafter.

EXPERIMENTAL STUDY

The short interval between birth and onset of symptoms, the isolation of *S. worthington* from the connector and rubber tubing of the suction apparatus, and the successful control of the outbreak after care was taken to prevent the contamination of the suction apparatus indicated that the contaminated delivery-room suction apparatus was most probably the source of infection. The questions then follow of how the aspiration system was contaminated and how the contaminated material was introduced to newborn babies. With further observation, it occurred to us (*a*) that the liquor (amniotic fluid) aspirated from babies might be a good culture medium for the growth of *Salmonella* and (*b*) that reflux of the aspirated material from the rubber tubing through the Y connexion to the disposable sterile suction catheter might occur if the latter was connected in position some time before use. To test such possibilities, two experiments were carried out.

Culture of S. worthington *in the liquor*

The aspirated material contained in the rubber tubing was composed mainly of amniotic fluid and mucus. Amniotic fluid was therefore collected during delivery by lower segment Caesarian section and sterilized by filtration through a membrane filter. Samples of the sterile amniotic fluid were inoculated with 10^3–10^4 organisms of the *S. worthington* strains isolated. After leaving at room temperature, which ranged from 28° to 32° C., the number of *S. worthington* organisms increased to 10^8 or more. Regular subculture from these artificially infected amniotic fluids showed that *S. worthington* survived during the 2 months' period of observation. Chlorhexidine (Hibitane) in the dilution of 1/5000 contained in the suction apparatuses was found effective in the killing of *S. worthington* organisms added to it when tested by a method similar to the in-use test of disinfectant (Kelsey & Maurer, 1972).

Reflux of aspirated material to the sterile suction catheter

The suction apparatus was tested in the same manner as in normal use. The suction apparatus was connected to a long coil of rubber tubing which in turn was connected to a Y connexion. One of the distal limbs of the Y was connected to a short rubber tubing simply to facilitate connexion to the suction catheter (Fig. 1). The other distal limb was occluded intermittently to control the suction process. To test the possibility of reflux, 5 ml. of indigocarmine dye was sucked up into the suction apparatus A via one suction catheter. Suction was applied for one further minute to clear the system. The used suction catheter was now discarded and a clean one substituted. The rubber tubing was then left on the labour room bed with the catheter hanging down from it to about 2 ft. above the floor level and the suction apparatus was then switched off. Ten minutes later the dye was seen flowing in a stream down the length of the short soft rubber tubing and coming out of the unoccluded limb of the Y connexion to stain the bed. After 35 min. a 1·5 cm. column of dye had advanced 16 cm. into the suction catheter. Reflux was thus proved to occur easily and rapidly owing to the presence of a 2 ft. hydrostatic pressure.

DISCUSSION

Infection due to *S. worthington* is rare in this area. It was first isolated from a case of gastro-enteritis in 1970. Since then only one other case was encountered up to 1974. Thus this outbreak aoused our immediate attention. The source of infection in this salmonella outbreak could be attributed to the suction apparatus A because (1) all the five infected babies received suction from it, (2) the interval between birth and the onset of symptoms was less than 24 hr. in three out the five babies, (3) *S. worthington* was isolated from the rubber tubing and connector attached to the apparatus but not elsewhere, (4) although phage-typing of *S. worthington* was not available, the antibiogram of all the *S. worthington* strains isolated showed the same pattern, (5) regular disinfection of the tubings and the apparatus brought a halt to the outbreak.

One can argue that the third case might have been infected by his mother, who was a symptomless carrier of *S. worthington*. However, this cannot explain the occurrence of the first two cases, who were infected before the admission of the carrier, and the last two cases, who had no contact with this carrier at all. It was more likely that the mother acquired salmonella infection from her baby or elsewhere in the ward, because her stool culture was negative on admission and *S. worthington* was isolated from her faeces 3 days after her baby excreted this organism.

Cross-infection did not appear to play a part because (1) the last two cases were born in the unit after the first three cases had been transferred out of the nursery and the nursery had been disinfected, (2) none of the staff who handled babies had positive stool cultures for *S. worthington*.

S. worthington could have been introduced into the suction apparatus by faecally contaminated amniotic fluid. This acted as a good medium for the growth of *S. worthington*, which could survive in it for a long period, as demonstrated by the experimental study. Failure of frequent and adequate disinfection of the tubing system led to the persistence of the contamination in the tubing, in spite of the presence of disinfectant in the suction apparatus proper. With the suction apparatus switched off, gradual downward flow of the contaminated aspirates into the sterile suction catheter occurred when the latter was attached to the distal end of the tubing some time before use. This happened more frequently at night and might be related to the higher frequency of infection for babies born at night.

The size of the inoculum of *Salmonella* probably depended on how long the suction apparatus was switched off with the sterile catheter in place. Although after the initial contamination the number of salmonella organisms in the tubing system should diminish with time, growth of *Salmonella* in the liquor freshly aspirated may increase the number of salmonella organisms to a huge amount. Thus, theoretically an initial contamination can be responsible for a long-lasting outbreak or several outbreaks. However, we do not know whether the two outbreaks in the nursery were due to contamination of the tubing system on one single occasion or on several occasions.

Outbreaks of salmonellosis in nurseries do occur from time to time (Abrams

et al. 1966; Epstein, Hochwalk & Ashe, 1951; Marzetti *et al.* 1973; Rubenstein & Fowler, 1955; Szanton, 1957; Watt *et al.* 1958). However, as far as we are aware only the two outbreaks among newborn infants reported by Rubenstein & Fowler (1955) have been traced to contaminated delivery room resuscitators. They suggested that infection of the newborn babies was due to contamination of the atmosphere of the delivery room with salmonella organisms by the air exhausted from the resuscitators. In our case, however, the air in the labour room was unlikely to be seeded with salmonella organisms as the suction apparatuses obtained their negative pressure from a centralized vacuum pump via wall inlets. Another point of interest was that the open end of the distal limb of the Y connexion was occluded by the operator's thumb to obtain suction. The experiment has shown that reflux occurred here too. The operator's hand could be contaminated in this way, although we could not assess its relative importance.

The detection of *S. anatum* carriers among the staff was not unexpected because *S. derby* and *S. anatum* were the two most common serotypes isolated from human carriers in Hong Kong (Chau & Huang, 1971). On the other hand, the detection of a symptomless carrier of *S. derby* among the newborn babies was of significance because it indicated there could be other routes of infection in the maternity unit. Whether this baby was infected by his mother or by the staff is not known. Since the discovery of the suction apparatus as the source of the infection, no further salmonella outbreak has occurred in the nursery up to the time when this report was prepared, 1 year after the outbreak.

It is important to trace the source of an outbreak of salmonella in a nursery, or else recurrence is the rule. The consequences are serious when apparatus used in the care of babies is contaminated. Hospitals should establish their own centralized control programmes for the investigation of infection occurring within the hospital (Westwood, Legace & Mitchell 1974), for the supervision of sterilization procedures, and for the bacteriological check-ups on food utensils and instruments.

When salmonella infection occurs soon after birth, the source may be the suction apparatus. The sterile suction catheter should be connected to the suction apparatus only immediately before use.

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