INFECTION IN THE NEWBORN INFANT

By J. L. HENDERSON, M.D., F.R.C.P.E.

Senior Lecturer, Department of Child Life and Health, Edinburgh University

This article is a review of the immunological peculiarities of the newborn infant and the incidence, clinical features, treatment, epidemiology and prophylaxis of neonatal infections.

Infective disorders are very common in the first month of life and are the principal cause of morbidity and mortality after the first few days. In the first few days after birth obstetrical factors are the chief cause of morbidity and mortality, and infections are uncommon since there has not been time for most of them to cause illness. Infective disorders are more amenable to preventive measures than any other cause of morbidity in the neonatal period, and the efforts being made to reduce their incidence are yielding very encouraging results, particularly in maternity hospitals and infants' institutions where the risk of contracting infections is so much greater than in the home. Since the unduly high neonatal mortality rate can most easily be reduced by measures which will curtail the incidence of infections in the newborn, a better and more general understanding of the epidemiology and clinical features of such infections is of prime importance.

Immunological Considerations

It was for long believed that the newborn infant has an enhanced resistance to infection. This is a fallacious and dangerous doctrine. The conception probably arose from the fact that the exanthematous infections are uncommon in the first few months of life.

The tissues of the newborn infant, immature and unaccustomed to infection, react to contact with bacteria in a different manner from those of older age groups. There is a lack of specific active immunity and local tissue response is poor. These handicaps are, however, compensated for in the early weeks by inheritance from the mother of specific passive immunity to numerous organisms and the occurrence of a defensive physiological leucocytosis.

In mammals such as man, with a haemochorial placenta, providing a thin placental barrier, gamma globulin, which carries the antibodies, passes across the placenta from the maternal to the foetal circulation. Most antibodies have the same titre in both individuals and others a lower titre in the foetal than in the maternal blood. Specific coliform antibodies have a much lower titre in the

foetal than in the maternal blood and, consequently, are absent unless the mother's titre is fairly high. Only about one-third of pregnant women possess pertussis antibodies. The lack of these two forms of specific passive immunity in the majority of the newborn accounts for the prevalence of coliform infections and whooping cough in young infants. In mammals with a thick placental barrier, and such constitute the majority of species, virtually no antibody-carrying gamma globulin passes across the placenta to the foetal circulation. It is a natural corollary to these anatomical and physiological facts that the colostrum in the anthropoids and other mammals with a thin placental barrier which permits the passage of antibodies, should have a minimal antibody content, and the colostrum of mammals with a thick placental barrier, not permitting the passage of antibodies, an abundant supply of antibodies. Nature thus ensures, by one means or the other, that all newborn mammals shall have some humoral antibody protection against bacteria to which they had not previously been exposed, and to which they would otherwise be easy prey.

It must be emphasized that the antibodies which the human foetus or newborn animal acquires from the mother confer a passive and therefore a short-lived immunity persisting for only a matter of weeks or, at most, a few months. It should also be reiterated that some antibodies are transmitted only to a small extent, if at all, and consequently afford no worthwhile protection.

Active immunity to the common organisms with which the infant comes in contact after birth is gradually acquired and immunity to the various epidemic diseases is acquired as a result of clinical or sub-clinical infection at any time. The development of active immunity is a slow process at any age, but much more so in the first six months of life at which period the immature reticulo-endothelial system responds poorly to antigenic stimulation, and produces a low level of humoral antibodies. This poor response to antigenic stimulation can be compensated for to a considerable extent when inducing immunity in the early months by increasing the strength of the antigenic stimulus. For instance, a satisfactory antibody response can be obtained in the first few months of life by giving larger immunizing doses of vaccine than are necessary at a later age.

Incidence of the Causes of Neonatal Death

The incidence of the principal causes of neonatal death in a consecutive series of 369 infant deaths which occurred in the Simpson Maternity Hospital, Edinburgh, over the three-year period 1940-42, is shown in Table 1. Routine autopsies are done in this hospital and the primary cause of death is assessed in each case in the light of the obstetrical, paediatric and pathological evidence. All the cases in this series were analysed by the author to ensure a uniform standard of analysis. The incidence of death from infection, rather than the total incidence of infection, is stressed here, because the importance of neonatal infection is proportionate to the mortality it causes. Perusal of Table 1 will show that primary infection is the second largest cause of death with an incidence of 22.0 per cent. of all deaths. It must be borne in mind that although the figures in this table are derived from a maternity hospital, and are probably representative of most maternity hospitals, the incidence of neonatal mortality from infection is probably a good deal lower in domiciliary practice where there is less risk of cross infection and, therefore, a lower incidence of neonatal infection in general. In the year 1946 54 per cent. of all births in Scotland were in maternity hospitals or registered maternity nursing homes; the corresponding figures for England and Wales were 40 per cent. in urban areas and 30 per cent. in rural areas.

The Department of Health for Scotland publication (1947) on 'Neonatal Death Due to Infection' is a useful study of the problem of infection among infants born in maternity hospitals.

FIG. 1.—Correlation of the cause of death with the age at death in 369 infants.

Correlation of the Cause of Death with the Age at Death

This is shown in a series of 369 consecutive infant deaths in Fig. 1. The low incidence of mortality from infection in the first week and the high incidence of mortality from infection after the first week are strikingly illustrated. After the

TABLE 1
The Incidence of the Principal Causes of Neonatal Death in 369 Infants

Condition	No. of Cases	Incidence per cent.
Asphyxia	106	28.8
Infection	81	22.0
Intracranial haemorrhage ..	57	15.4
Developmental malformations	51	13.8
Prematurity	46	12.5
Miscellaneous	28	7.5

first week, more infants die from infections than from all other causes.

The Relative Incidence of Neonatal Infections

The relative incidence of the various neonatal infections which occurred in a consecutive series of 8,075 infants born in the Simpson Maternity Hospital in the three-year period 1940-42, is shown in Table 2. There are three very common infections—conjunctivitis, staphylococcal dermatitis and thrush. Gastroenteritis is less common and the remaining types of infection are uncommon.

TABLE 2
The Incidence of Various Neonatal Infections in a Total of 8,075 Infants born in the Simpson Maternity Hospital in the three-year period, 1940-42.

Disease	No. of Cases	Incidence per cent.
Conjunctivitis	906*	11.2
Staphylococcal skin infection	550	6.8
Thrush	395	4.9
Gastroenteritis	126	1.5
Infection of respiratory tract	42	0.5
Pneumonia, primary	11	0.14
Pyelitis	7	0.09
Omphalitis	6	0.07
Septicaemia	5	0.06
Meningitis	3	0.04
Congenital syphilis	?	?

*Approximate figure based on accurate records kept for six months and including all cases (151) with positive bacteriological findings, but excluding silver nitrate reactions. The long-term incidence is probably about half this figure.

There is a much higher incidence of infection among premature than among mature infants, because the former are more susceptible to infec-

tion than the latter, while in maternity hospitals an even more important cause of the higher incidence in premature infants is the much longer duration of their stay in hospital with a proportionate increase in the risk of cross infection.

Grouping of Infections according to the Time of the Initial Infection

Infections in the newborn may be classified according to whether they are contracted before, during or after birth.

Antenatal Infections. These are few in number because of the protection from infection enjoyed by the foetus in utero. It is generally believed that the healthy placenta is impermeable to microscopic organisms and that such organisms can infect the foetus only when they produce placental lesions. Some believe, however, that in exceptional circumstances any organisms that produce a maternal blood infection may pass the placental barrier and infect the foetal blood stream. More evidence on this fascinating question is needed, but it is extremely difficult to obtain.

Syphilis is the only common antenatal infection and infection of the foetus seems to depend on the development of preceding placental lesions. Congenital tuberculosis, of which there have been almost 100 cases recorded in the literature, apparently arises from placental tubercles, and not from tuberculous bacillaemia if the placenta is healthy.

Ultra-microscopic viruses, unlike microscopical organisms, are small enough to pass the placental barrier and infect the foetus. Since the human foetus is not protected from maternal virus diseases such as measles, rubella, smallpox, chickenpox and mumps it is providential that these diseases are rare in pregnant women. They are uncommon in adults because the vast majority of people are immunized in childhood, either through having a clinical, or more likely, a sub-clinical infection. The effect of a virus disease on the foetus depends on the type of the disease and the stage of foetal development. It is now known that foetal organs during the stage of differentiation, in the second month of gestation, are particularly susceptible to damage by noxious influences such as specific forms of nutritional deficiency or infection with the rubella virus. In 1941, Gregg, in Australia, discovered that women who develop rubella in the second month of pregnancy usually give birth to infants with congenital malformations, particularly cataract, which have been produced by the rubella virus damaging the relevant tissues in the organogenetic stage of development. Maternal rubella does not cause foetal malformations when contracted after the second month of pregnancy.

This is the only infection known, so far, to produce congenital malformations, but there may be others. Some virus diseases may cause intra-uterine death with miscarriage, and it is of interest that women who develop measles in later pregnancy tend to have a premature labour, and their infants may be born with measles or develop it within a few days of birth.

Natal Infections. Infections are more often contracted during birth than before, though their manifestation does not usually occur until a few days later. Prolonged labour favours vaginal and uterine infection, particularly when the membranes rupture early. Inoculation of the baby's eyes, respiratory passages and areas of traumatized skin is facilitated. A variety of organisms may infect infants in this way and cause infections such as conjunctivitis, pneumonia and dermatitis in the early days of life. The chief are staphylococci, streptococci and *B. coli*.

Other intrapartum infections may arise which are dependent on preceding infection of the maternal passages. Gonococcal conjunctivitis is usually contracted in this way, and oral thrush may be so. Inoculation with the spirochaete of syphilis from a primary lesion on the maternal vulva is a rare occurrence.

Post-Natal Infections. This is much the largest and most important of these three groups of infection, and epidemiological considerations assume great importance in the common infections contracted during the neonatal period. Conjunctivitis, staphylococcal dermatitis and oral thrush, the three common neonatal diseases, are all contracted after birth in the great majority of instances.

Staphylococcal Infections

Increasing attention has been given in recent years to the prevalence of staphylococcal disease in maternity hospitals, where its endemicity is a constant menace to infants and adults alike.

The *Staphylococcus aureus* is much the most common cause of neonatal infection, particularly in maternity hospitals. The chief manifestations are dermatitis, of which there are several forms, and conjunctivitis, but omphalitis, septicaemia, pneumonia and otitis media may all be caused by this organism. Staphylococcal infections also commonly affect mothers and nurses, and the prevalence of virulent strains is usually shown by a rise in the incidence of both neonatal and adult cases of staphylococcal disease.

Staphylococcal Dermatitis

Staphylococcal lesions of the skin are very common in the newborn and there are several varieties. The common forms, in order of frequency, are pustules, paronychia and bullous impetigo. Less

TABLE 3

The Incidence of the Various Types of Staphylococcal Infection (Based on the Type of the Initial Lesion) in 424 Infants in the year 1942.

Type of Lesion	No. of Cases	Incidence per cent.
Conjunctivitis	212*	50.0
Pustules	115	27.1
Paronychia	53	12.5
Bullous impetigo	26	6.1
Boils	10	2.4
Cellulitis and abscesses	5	1.2
Pneumonia	3	0.7

*Equivalent of 106 in six months of accurate recording.

common forms are furuncles, cellulitis with abscess formation, mastitis and pemphigus. The relative frequency of the various types of lesion in a consecutive series of infants at the Simpson Maternity Hospital is shown in Table 3.

CLINICAL FEATURES. *Pustules* may occur singly or in small or large numbers and they usually occur in groups, but may be discretely distributed. Large ones are unmistakable, but small ones may be confused with (a) miliaria, (b) small milial sebaceous concretions which are particularly common on the face in the newborn, or (c) urticaria, the lesions of which often show a small central vesicle in newborn infants.

Paronychia is usually multiple, affecting several fingers, and it often occurs on both hands. Both sides of the finger are affected as a rule. Infection probably enters at the torn base of a tag of skin. The condition may not progress beyond a small area of inflammation, though a small focus of suppuration often develops in the centre of the area. This focus usually dries up and forms a little scab which eventually separates, but occasionally a larger pustule will form which may burst (Fig. 2). Infrequently, the infection may spread and cause complications. It may invade the nail fold producing a true onychia or involve the nail bed, in which case the nail may be shed. Sometimes the infection spreads in the skin of the finger, causing septic blistering. Thrombosis of the terminal digital arteries is a rare but dangerous complication, for it produces necrosis of the terminal phalanx and gangrene of the tip of the finger.

Bullous Impetigo is less common than the two preceding infections, but more liable to occur in epidemic form, a fact which suggests that it is a manifestation of exalted virulence or of the prevalence of an unusually virulent strain. There may be one lesion, but there are usually a few (Fig. 3) and they are often widely dispersed. They appear without the warning of preceding inflammation and vary in size from a few mm. in diameter

to an inch or two. They contain clear or slightly turbid fluid which soon becomes more purulent and the fluid is not under much tension. If untreated the vesicles increase in size and number and when they rupture the underlying moist reddish dermis is exposed. When large areas of skin become affected the condition is known as pemphigus. In benign vesiculation of the newborn, small blisters, seldom exceeding 1 cm. in diameter, arise in the first few days of life, usually on the fingers, and they do not enlarge, are more tense and contain bright yellow sterile fluid.

Pemphigus is the septic vesiculation and exfoliation of large areas of skin. It is a grave condition associated with severe toxæmia and is now rarely seen in maternity hospitals. In dermatitis exfoliativa (Ritter's Disease) which is usually streptococcal, there is no vesiculation, but exfoliation of large areas of skin occurs. This condition is equally serious.

Furuncles sometimes occur in the newborn. They usually look more like small abscesses than boils. The occipital region is one of the most common sites, but they may occur in any situation, are usually multiple and often widespread.

Cellulitis and abscess formation are occasional manifestations of staphylococcal infection. It may develop under a superficial infection such as a pustule, but there is often no apparent portal of entry. The area involved is sometimes large. Suppuration develops quickly in the newborn, unless vigorous and prompt penicillin therapy is adopted.

Mastitis is by no means rare and arises in the physiologically enlarged breast. It usually progresses to suppuration.

TREATMENT. *Prophylaxis* is very important. The practice of not bathing newborn babies until after discharge from hospital, which is increasing, probably reduces the incidence of staphylococcal skin infections. The face is cleaned if necessary after birth and the buttocks as indicated, and there is no unpleasant aroma such as might be expected. The risk of contact infection is much reduced, the skin is subjected to much less trauma, the infant is less exposed, and there is a great saving of nurses' time.

The importance of immediate isolation of all infants who develop a staphylococcal lesion, however small, cannot be over-emphasized. Moreover, all lesions, even the most trivial, should be assiduously treated, owing to the ever-present danger of a much more serious local lesion or of a generalized infection developing.

Therapy will depend on the type and severity of the lesion. Any loose skin, as in bullous impetigo, should be completely removed and affected areas

should always be covered with a dry dressing to prevent contacting clothes or the baby's fingers from infecting other areas of the skin. Superficial lesions should be treated locally with 5 per cent. penicillin cream or 1 per cent. gentian violet in aqueous solution twice daily. Systemic penicillin should be given in all cases, giving 20,000 units orally in each feed, and four-hourly during the night in a little milk.

It has been shown by Henderson and McAdam (1946), and other workers, that the administration of penicillin by the oral route is reliable in the first month of life when given in larger doses than would be adequate if given intramuscularly. Ten thousand units usually produces a therapeutic level in the blood which is maintained for five hours. Twenty thousand units given in each feed provides an ample therapeutic margin. In hospital practice penicillin for oral administration is usually dispensed in 1 drachm of normal saline, but in domiciliary practice it is more convenient to crush and dissolve in each feed two 10,000-unit tablets.

It is disturbing to find a poor response to penicillin therapy in a considerable minority of cases of staphylococcal infection. The staphylococcal strains in these cases are found to be penicillin-resistant, some moderately and others highly, and very large doses up to 10 or 20 times the normal dose may be necessary to overcome the resistance of the organism and cure the disease in such cases. Surgical procedures, such as incision and drainage, will be necessary when an abscess forms and in some cases with mastitis, boils or onychia.

Conjunctivitis

Staphylococcal infection is much the most common cause of infective conjunctivitis in the neonatal period and accounts for more cases than all other forms of infection combined. Conjunctivitis in the newborn will be described in detail in a later section.

Other Staphylococcal Infections

The *Staphylococcus aureus* may cause infection in several parts of the body, in addition to the eyes and skin, which are the most common sites of infection by this organism. It is often found in omphalitis, broncho-pneumonia, aspiration or primary, otitis media and septicaemia, while osteomyelitis is essentially a staphylococcal disease.

Epidemiology of Staphylococcal Infections

Epidemiological studies of staphylococcal disease are hampered by the lack of a satisfactory method of identifying the various strains of the organism. The method now most commonly

used for detecting pathogenicity is that based on the capacity of pathogenic staphylococci to coagulate plasma. The term coagulase-positive is, therefore, synonymous with pathogenicity, but this test gives no indication of the degree of pathogenicity. There is no simple method of identifying the most virulent strains, but it is now possible to classify pathogenic staphylococci into a large number of types by means of highly specific staphylococcal phages, and some relation may be found between these types and the degree of pathogenicity. Chapman *et al.* (1937) have been experimenting with the production of media selective for pathogenic staphylococci. A reliable and simple method of identifying the various strains of staphylococci would greatly facilitate epidemiological studies. The recent development of serological and phage typing has made it possible to relate infection in nurses to infection in infants in a number of epidemics.

The infant at birth has about the same titre of staphylococcal antitoxin as the mother, but it seems to have little protective value. Experimental work suggests that the chief value of the antitoxin is to assist in combating systemic infection, but it seems unable to prevent the organism from causing local lesions. When the skin is inoculated with a culture of *Staphylococcus aureus* the organisms diminish rapidly owing to a well-marked bactericidal action which the skin has been shown to have on many organisms, but the staphylococci may not completely disappear. Moreover, it is clear that staphylococcal lesions develop very readily at the site of small traumatic lesions on the skin.

About 30 per cent. of adults are nasal carriers of *Staphylococcus aureus* and individuals with staphylococcal skin lesions have a much higher nasal carrier rate. Recent work has shown that the infants in maternity hospital nurseries may be expected to show a high incidence of pathogenic staphylococci in the nose; the incidence of *Staphylococcus aureus* rises from zero at birth to a figure that appears usually to be well over 50 per cent. and may approximate to 100 per cent. It is important to remember that the faeces in many cases are infected and also the skin. The most important sources of infection, however, are those infants with slight superficial infections such as a few small pustules, a 'sticky' eye or 'damp' umbilicus. In such circumstances, the organism is multiplying rapidly, is present in greater numbers, is more virulent and possibly increasing in virulence. Benians (1943) found at the height of an epidemic of bullous impetigo and other staphylococcal skin lesions in the newborn, in a maternity hospital, that 85 per cent. of the

maternity nurses were nasal carriers. The rate fell to 25 per cent. six months after the outbreak.

Spread from one individual to another is either by direct contact or through the agency of objects, such as clothing, instruments and ointment. It has been shown, for instance, that infected clothes may not be sterilized in laundries and that infected personnel in laundries may contaminate them. The air and dust may become infected through shaking infected clothing and the organisms by aerial dissemination settle directly on babies or, more likely, on all manner of objects which will be handled by nurses and thus contaminate their hands. Clearly then infection must be regarded as coming from direct or indirect contact with nurses, domestic staff, doctors, mothers, other infants or visitors.

It has been stated above that under present conditions most infants in maternity hospitals are infected with potentially pathogenic staphylococci by the time they are discharged, showing that the present methods of preventing the spread of contact infection are ineffective. Fortunately, the majority of the strains are of low virulence, so that most of the infants remain healthy and only a few suffer from trivial lesions, but these trivial infections may be the forerunners of serious epidemics when more serious staphylococcal lesions, such as bullous impetigo, pemphigus, cellulitis or staphylococcal pneumonia may develop in some of the infants; mastitis, staphylococcal infection of the genital tract or other staphylococcal lesions in some of the mothers; and staphylococcal lesions in members of the staff. Ludlam (1947), from whose excellent review of the epidemiology of staphylococcal infections much of the foregoing information has been obtained, believes the most practical way of finding the adult source of staphylococcal infection is to examine all adults who enter a maternity unit for septic lesions and to take a nasal swab from each, paying particular attention to any adult contact who repeatedly yields a profuse growth of pathogenic staphylococci. Nurses in these circumstances should be debarred from entering a maternity unit and transferred, if possible, or, less desirably, carry out a particularly rigid hygienic regime. Ludlam emphasizes that a more effective but more arduous way of identifying adult sources of infection is to type the staphylococci isolated from adults by routine nasal swabbing as described above, and at the same time the staphylococci isolated from infants, mothers or nurses with staphylococcal lesions.

Knott and Blaikley (1944) in the Maternity Unit at Guy's Hospital investigated the epidemiology of staphylococcal infections over a period of two years, and by introducing a more enlightened

routine were able to reduce the incidence of staphylococcal infection greatly, and to bring to an end the occurrence of repeated epidemics of staphylococcal infection which had previously hampered the smooth functioning of the unit. They emphasized three main epidemiological points:

(a) The more virulent strains of *Staphylococcus aureus* which are responsible for active lesions are usually introduced to a previously clean department by human carriers, skin, respiratory or vaginal, temporary or permanent.

(b) Since masks were worn at all times, and infection spread rapidly in spite of them, direct contact, especially hand contact, must be extremely important.

(c) Frequently handled ward equipment such as feeding bottles were often infected, and much more likely to pass on infection than ward dust, which was surprisingly free from pathogenic strains even during epidemics.

The following are the principal prophylactic measures recommended and successfully adopted by Knott and Blaikley:

(1) To avoid contact spread the routine nursing of both mother and baby should be guided strictly by all those principles accepted as essential in performing surgical dressings.

(2) All nurses have their nose, throat and hands cultured before commencing work in the maternity department. All whose cultures contain pathogenic staphylococci are debarred, given non-surgical and non-septic work and re-examined at intervals until free.

(3) All nurses working in the department have these cultures repeated each fortnight and when they develop colds. All growing staphylococci are at once debarred, but allowed to return if the organisms are shown to be non-pathogenic on further investigation.

(4) All mothers are swabbed immediately on admission. The nose, throat, hands and the vagina are all swabbed. Also any inflammatory lesion, however small. They remain in a small admission ward until the results are known. If negative, they pass into the main wards. If positive, they go to a small separation unit where they remain until the organism is shown to be non-pathogenic. If pathogenic, they are admitted to an isolation unit.

(5) Babies are handled only when absolutely necessary.

(6) Always before and after handling a baby, or tending a recently confined mother, nurses must invariably wash their hands and forearms under a strong spray of water turned on by foot or elbow as in a surgical theatre. They then dry the

hands on small sterile towel squares which are used only once, thrown into a basket and then laundered.

(7) To reduce handling of babies and damage to their skin, the babies are bathed as infrequently as possible, only at birth and when the cord separates.

(8) After each baby is bathed the whole of the bath and its equipment is very thoroughly washed down before being used again.

(9) Each day's supply of dusting powder, olive oil or similar applications is sterilized.

(10) Only fathers are allowed to see babies and they must wear masks. They may not handle babies. Babies are not kept in the ward during visiting hours.

(11) Mothers and babies infected with pathogenic strains of *Staphylococcus aureus* are removed to an isolation unit away from the main department.

Knott and Blaikley also recommend that nurses should always wear masks when attending to babies and mothers and whenever they are in the nurseries, but I believe that this practice, though a useful additional precaution, is less important than the 11 precautions enumerated above.

Such a routine conscientiously carried out would greatly reduce the incidence of staphylococcal and other forms of cross infection such as thrush and epidemic gastroenteritis in our maternity hospitals, and epidemics would be rare. Epidemics are always a serious reflection on hospital conditions and management. The Guy's unit is small and the preventive routine so successfully operated there is, therefore, relatively easy to carry out, but the experiment has proved how successful such a routine can be, and is a challenge to larger maternity units in general to leave no stone unturned and make a determined attempt to introduce a prophylactic routine based on the same fundamental principles. The shortage of nurses at the present time is a serious obstacle, but a clear conception of preventive principles by the responsible authorities would ensure a notable reduction in the present rate of staphylococcal infection in particular and neonatal infection in general. Knott and Blaikley believe that 'continuous bacteriological control in a maternity department far exceeds in value intermittent bacteriological testing, and does not involve a prohibitive amount of work or number of exclusions of either staff or patients.'

Conjunctivitis

Conjunctivitis is the most common neonatal infection. It is usually very mild. A moderate degree with a little sero-purulent discharge, but

no swelling or inflammation of the eyelids, is common. Only a small minority of cases is acute, with palpebral oedema and inflammation and a profuse discharge.

Conjunctivitis in the first two days of life is common when irritating prophylactic instillations are used at birth. Silver nitrate, which is the principal agent used for this purpose, is very irritating when used in the standard 1 per cent. solution, and not infrequently causes an acute chemical conjunctivitis with blepharospasm and a profuse serous discharge. It subsides spontaneously within two or three days. A $\frac{1}{2}$ per cent. silver nitrate solution is quite strong enough for prophylactic purposes. This should be kept in a well-stoppered bottle to prevent concentration by evaporation.

The incidence of the various organisms isolated in a consecutive series of infective conjunctivitis in the Simpson Maternity Hospital is shown in Table 4. Direct inoculation of a blood-agar plate was made from the conjunctival sac and a direct smear was also made. Organisms were isolated in 151 cases and none in 63 cases. There was a great preponderance of *Staphylococcus aureus*, 72 per cent. of cases with a pure culture being due to this organism, and 70.2 per cent. of all cases, whether pure or mixed infection, being infected with it. *Staphylococcus albus* was isolated from 9.9 per cent. of cases, and diphtheroids from 11.9 per cent., both these organisms being associated with others in most cases. Eight other organisms were isolated on a few occasions, including *Streptococcus viridans* in 5.3 per cent., *B. coli* in 4.6 per cent. and pneumococcus in 4 per cent. The gonococcus was isolated from only two of the 151 cases, in pure culture in both instances. Though relatively uncommon, and much less often seen than in former times, gonococcal conjunctivitis remains the most important form of conjunctivitis in the newborn, since it is the only form which may destroy an eye in a few days if treatment is neglected. Virus conjunctivitis was not looked for and some of the negative cases may have been of this nature.

TREATMENT. The introduction of sulphonamide and penicillin has revolutionized the therapy of conjunctival infections. Treatment is much simpler and more effective. Since 80 per cent. of cases yielding a positive culture are staphylococcal, initial treatment should always be with penicillin, and this agent should be continued until either a penicillin-resistant and sulphonamide-sensitive organism, such as *B. coli* or a diphtheroid, is isolated on culture—21.9 per cent. of the cases in this study yielded such organisms in mixed or pure culture—or until, in the absence of bac-

TABLE 4
The Incidence of the Various Types of Infective Conjunctivitis in the Newborn.

Bacterium	No. of Cases			Incidence per cent.
	Pure Culture	Mixed Culture	Total	
Staphylococcus aureus	95	11	106	70.2
" albus	5	10	15	9.9
Diphtheroids	9	9	18	11.9
Streptococcus viridans	6	2	8	5.3
Pneumococcus	3	3	6	4.0
Gonococcus	2	0	2	1.3
Bacillus coli	6	1	7	4.6
" proteus	2	1	3	2.0
" pyocyaneus	2	1	3	2.0
" lactis aerogenes	1	0	1	0.7
" Morax-Axenfeld	1	0	1	0.7
Negative film and culture	—	—	63	

Infants with a pure culture 132
 " " mixed 19
 " " negative 63
Total of infants with infective conjunctivitis .. 151
Incidence of infective conjunctivitis 11.2 per cent.

teriological investigation, the conjunctivitis fails to show much improvement in three days—presumably because the infecting organism is a penicillin-resistant bacillus. In both of these circumstances the treatment should be changed to sulphonamide, usually with success.

In mild cases crystalline penicillin should be administered locally by instilling one or two drops into the conjunctival sac before and after each feed. In cases of moderate or severe degree it should be instilled as often as possible, at least hourly in a moderately severe case, and every few minutes in the early stages of treating a severe case. In severe cases systemic penicillin should also be given. The penicillin solution for instillation should contain 2,500 Oxford units per cc. of normal saline in the less severe cases, and 10,000 units per cc. in severe cases, and 20,000 units should be given three- or four-hourly in each feed and four-hourly in a little milk during the night when systemic administration is also considered necessary.

Sulphonamides can be given locally or systemically according to the severity of the condition. Sodium sulphacetamide, 10 per cent. solution in normal saline, or 2½ per cent. in ointment, is the form in general use for local treatment, and it should be instilled before and after each feed in mild cases. Sulphacetamide is soluble and non-irritating, whereas most of the other sulphonamides are insoluble and alkaline and are, therefore, unsuitable for local treatment. In more severe cases sulphonamide should be given orally in a form such as sulphamezathine or sulphadiazine in doses of ¼ gr. four-hourly. When the in-

fecting organism is susceptible to sulphonamide therapy, as in gonococcal or pneumococcal conjunctivitis, which are both acute and severe, as a rule, the response to sulphonamide given by the oral route is dramatic and the disease is cured in two to four days.

When the eyelids tend to adhere in conjunctivitis and impede the free drainage of discharge a drop of liquid paraffin instilled into the sac will ensure free drainage. Conjunctival lavage, which was the bulwark of treatment in the pre-chemotherapeutic era, is unnecessary.

Chronic Conjunctivitis

Recurrent conjunctivitis and unduly 'indolent' conjunctivitis which may persist for months in young infants in spite of persistent treatment are common. They are usually caused by poor drainage from the conjunctival sac owing to a congenital stenosis of the naso-lachrymal duct. Ophthalmologists advise conservative treatment in these cases and seldom attempt to dilate the duct, because adequate canalization and drainage will occur within a few months when the tendency to conjunctivitis will subside. In the meantime the mild conjunctivitis should be minimized by instillation of the solution appropriate to the infecting organism. Dacryocystitis occasionally develops in such cases; firm pressure over the sac at regular intervals evacuates accumulated mucus into the conjunctival sac from which it escapes.

Thrush

Oral thrush is a common infection in young infants, particularly in maternity hospitals and

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other institutions. The incidence in the Simpson Maternity Hospital in the period 1940-42 was 4.9 per cent. (Table 2), but a better understanding of the disease and increased vigilance reduced it to 1.8 per cent. in the period 1944-46. It is caused by the fungus *Monilia albicans*, a generally distributed organism which occurs in the mouth in about 14 per cent. of the adult population (Todd, 1937). The incubation period is about four days or more. A photomicrograph of a specimen obtained from a thrush lesion in the mouth of an infant in a maternity hospital is shown in Fig. 4. Fortunately, the organism is pathogenic only in the early months of life in health, but may become so in older infants and children, and even in adults, as a secondary invader in local conditions, such as ulcerative stomatitis or in conditions of severe general debility.

CLINICAL FEATURES. Thrush seldom develops before the latter part of the first week and may occur at any time in the following few months. It is much more common in bottle-fed than in breast-fed babies, and also in those who stay longer in hospital, such as premature babies.

The lesions begin as whitish-grey, pin-head colonies on any part of the buccal mucosa or on the dorsum of the tongue. They are adherent because the mycelial strands of the organism penetrate the mucosa. If untreated, the colonies multiply and enlarge and they may coalesce to form large plaques. The tongue is the most commonly affected part of the mouth, and the palate is more often affected than the inside of the cheeks. Severe infection may lead to ulceration and secondary infection. The pharynx also may become involved; one cannot say in what proportion, but probably in a minority of cases. Invasion of the oesophageal wall occurs occasionally and is a serious complication, and the disease may spread even further and involve the gastric mucosa. In a series of 20 cases of oesophageal thrush, Ludlam and Henderson (1942) found gastric involvement in four. Fig. 5 shows numerous thrush lesions of the oesophagus and stomach in a pathological specimen. Intestinal thrush appears to be rare, though it is likely to be missed; it may occur in the small intestine, usually the lower ileum (Fig. 6) or in the colon. Macgregor and Henderson (1943) published two cases of thrush in the lower ileum in which the condition was found at autopsy.

Oral thrush is usually a mild and somewhat 'indolent' infection and the oral lesions usually do not cover much of the mucous membrane. If untreated, the lesions will cease to spread, in most cases, after reaching such a stage and usually persist for many weeks before gradually subsiding

without ever having interfered with the feeding or progress of the infant. Nevertheless, it is dangerous ever to regard thrush as a benign condition, and it is generally so regarded, because it does become a severe and serious disease in a considerable minority of cases. It may then prove fatal, as in 13 of the 20 cases of thrush oesophagitis to which I have referred. Severe oral thrush, with inflammation, ulceration and secondary infection of the buccal mucosa, causes some degree of anorexia and malaise, while oesophageal involvement produces severe anorexia and vomiting and, in fatal cases, aspiration broncho-pneumonia. Thrush oesophagitis cannot be diagnosed with certainty during life and it is not known, therefore, what proportion of the less severe cases recover. Similarly, thrush ileitis and colitis, which cause diarrhoea, can only be diagnosed post mortem, and the death rate cannot be determined. It should be borne in mind, however, that careful inspection of the mouth reveals oral lesions in a high proportion of cases with involvement lower down the alimentary tract.

DIAGNOSIS. Oral thrush must be differentiated from milk curds which are not adherent, white fibrous nodules which are a normal feature in the gums, and the median raphe of the palate, and from furring of the tongue which is uniform, unlike the granular appearance of thrush. Also from a sloughing traumatic ulcer following injury to the palate by a mucous extractor. When in doubt, the diagnosis should be confirmed by scraping off a colony or plaque and teasing it out on a slide in 10 per cent. potassium hydroxide. Microscopic examination with minimal illumination will show the mycelium and spores and the debris will have been dissolved (Fig. 4).

TREATMENT. *Prophylaxis* is fundamental in institutions. The babies of mothers who suffered from vaginal thrush in pregnancy should be specially carefully watched for the development of oral thrush. All infants who develop thrush should be isolated immediately to prevent cross-infection. It is a rule in well-run maternity hospitals for the mouth of every baby to be carefully inspected for thrush each morning by the sister-in-charge or a responsible staff nurse.

Therapy consists of the application of 1 per cent. gentian violet in aqueous solution to the mouth twice a day until the lesions have practically disappeared, and then once a day for another week to prevent relapse. This is necessary because the spores persist in the mouth for a week or two after disappearance of the lesions, which, incidentally, usually linger longest between the corrugations on the fore-part of the hard palate. Such persistence of infection after clinical recovery

FIG. 2.—Paronychia. The index finger shows an ulcerated lesion, and the distal part of the finger is hyperaemic. Paronychia is usually milder.

FIG. 3.—Bullous Impetigo affecting both arms. The size of the vesicles is very variable.

FIG. 4.—Oral Thrush. A teased scraping from an oral lesion cleared in 10 per cent. potassium hydroxide, unstained, and examined in restricted light. Pseudomycelial strands and many blastospores are seen (X300).

FIG. 5.—Oesophageal and Gastric Thrush. Many whitish colonies, some confluent, are seen adhering to the mucosa of the oesophagus. Some very large plaques of thrush cover portions of a generally congested gastric mucosa; the very large plaque in the upper part of the specimen is darkened by haemorrhage into it.

FIG. 6.—Intestinal Thrush. Lower ileum showing many whitish, adherent thrush colonies.

necessitates continued isolation until discharge, unless bacteriological cure is demonstrated.

EPIDEMIOLOGY. Thrush vaginitis is one of the principal causes of leucorrhoea in pregnancy and the infants of infected mothers may develop thrush within a few days of birth, though they usually seem to escape infection. Most of the cases in maternity hospitals are caused by cross-infection via the hands of nurses. Ludlam and Henderson (1942) isolated *Monilia albicans* from the throat of 33 per cent. of a series of 60 nurses in the Simpson Maternity Hospital, and from the fingers of three out of 42 nurses swabbed when bottle-feeding infants. The disease developed in all infants from whose mouths the organism had previously been isolated, though relapse did not always occur when the organism was isolated after thrush lesions had disappeared. Oral thrush was accompanied by infection of the infants' hands in 50 per cent. of cases and by infection of the faeces in all cases. It was also isolated from 50 per cent. of samples of pooled breast milk. Exposure of culture plates in the nursery and changing rooms for long periods did not produce a single thrush colony, which seemed to eliminate air-borne infection as an important epidemiological factor.

The nurses' hands appear to be the main vehicle in the dissemination of thrush, as in the dissemination of the *Staphylococcus aureus* and the prophylactic principles and routine are the same in both infections.

Gastroenteritis

This is much the most serious of the common neonatal infections. It may be primary and caused by a variety of organisms, known and unknown, or it may be secondary. Infective gastroenteritis is always potentially an epidemic disease whatever the causal organism, and its gravity makes it the most dreaded of all neonatal infections in maternity hospitals. In most epidemics no casual organism can be found and many have, therefore, assumed that a virus is the probable cause, but this is a debatable hypothesis. Some believe that since young infants tend to react to various types of infection by diarrhoea, epidemic neonatal diarrhoea may be produced by a variety of organisms. Some suspect certain strains of *Bact. coli* which are normally non-pathogenic in older children, but which readily cause a number of neonatal infections such as meningitis and pneumonia. McClure (1943), for instance, found haemolytic *B. coli* in a greater proportion of sick than of healthy infants in an epidemic he investigated. Moreover, the beneficial effect of sulphonamide in epidemic gastroenteritis reported by Henderson (1943) and

numerous other workers is more suggestive of a bacterial than a virus aetiology. A few years ago Light and Hodes (1943) claimed to have isolated a virus in four outbreaks of neonatal diarrhoea, but no confirmatory evidence has been obtained since from other epidemics. Epidemics have been described in which the following organisms have been suspected—*B. coli mutabile*, *B. mucosus*, *B. proteus* and *B. pyocyaneus*, while Gale *et al.* (1944) have isolated beta-haemolytic group D streptococci in large numbers from some epidemics and believe that the high tyrosine decarboxylase activity of these organisms may cause severe toxæmia and diarrhoea in very young infants, as in very young rats. Clearly there is much speculation about the aetiology of epidemic diarrhoea in the newborn, but few concrete facts have yet emerged from the many attempts to elucidate this baffling disease. It is probable that there are several distinct aetiological organisms and that some of these cause a generalized disease of which gastroenteritis is one of the features. The great variability of the incubation period in different epidemics also suggests an inconstant aetiology. It varies from a few to 21 days. In a small proportion of epidemics known pathogens such as *Salmonellae* and *B. dysenteriae* Sonne have been isolated, and these can usually be linked up with adult carriers.

The incidence and mortality in the Simpson Maternity Hospital in the two four-year periods 1939-42 and 1943-46 are shown in Table 5. Increased vigilance and earlier diagnosis reduced the incidence by half in the latter period, while improved methods of treatment, and possibly less severe forms of the disease, caused a steep fall in the mortality from 43.1 per cent. to 17.5 per cent. (11.3 per cent. in the two-year period 1945-46).

CLINICAL FEATURES. Infective gastroenteritis is much more common in bottle-fed than in breast-fed infants. It seldom develops until the second part of the first week, but usually after the first week. The affected infant develops malaise, with anorexia, listlessness and pallor. Diarrhoea is not the first symptom and it may not begin for 12 to 36 hours. The severity of the diarrhoea varies greatly. It may be watery with an uncountable number of stools in the day when the diagnosis will no longer be in doubt, or there may be only slightly increased frequency and looseness of the stools. In the latter circumstances, the diagnosis may remain uncertain for a few days, particularly in sporadic cases where there is less reason to suspect the disease. A noticeable increase of mucus in the stools is seen in only a minority of cases, as a rule, and blood is seldom seen. Vomiting is a feature in about half of the cases, also

TABLE 5

The Incidence and Mortality Rate of Gastroenteritis in the two Four-Year Periods 1939-42 and 1943-46

Period	Live Births	Cases		Deaths	
		Number	Incidence per cent.	Number	Incidence per cent.
1939-42	10,484	188	1.79	81	43.1
1943-46	12,241	120	0.98	21*	17.5*

* In the two-year period 1945-46 there were eight deaths with a mortality rate of 11.3 per cent.

pyrexia. Signs of dehydration appear within a day or two in all cases except the mildest, and progress very rapidly in acute cases. The weight falls steeply, except in mild cases. Screaming sometimes occurs, presumably because of colic. Abdominal distension may occur in advanced cases and is a serious sign, and sclerema is a grave development.

TREATMENT. *Prophylaxis* is much the most important aspect of the handling of this disease. Suitable isolation facilities should be available in all maternity hospitals to isolate immediately, as a precautionary measure, all infants who develop malaise, particularly anorexia, a lagging or falling weight or any looseness of the stools. Most such infants will not have gastroenteritis, but only by prompt precautionary action will epidemics of gastroenteritis in nurseries be prevented. When gastroenteritis is diagnosed in such an isolated baby, all the babies in the nursery from which that baby came should be presumed to be infected, and no further babies admitted to that nursery until all have been discharged or for a period of three weeks.

Therapy consists of the complete withdrawal of milk feeding for a variable number of days until the appetite returns, and half normal saline containing 5 per cent. glucose is given two-hourly *ad lib.*; a daily intake of 3 oz. per lb. body weight must be ensured. This fluid is usually taken well and gavage feeding is not often necessary. Sulpha-succidine or sulphaguanidine should always be given from the outset in a dose of 5 gr. per lb. per day. Improvement with a return of appetite occurs in one to four days when these measures are adopted. Dilute milk feeding with half-strength breast milk, or a low fat artificial milk, such as sweetened condensed or half-cream dried, is then commenced at alternate feeds and, if well tolerated, the mixture is given at every feed the following day and then gradually strengthened.

In severe cases with much dehydration or toxæmia, intravenous fluid and electrolyte therapy should be inaugurated without delay. Oral saline and glucose should be continued *ad lib.* in these

circumstances as advised, but if there is much vomiting, oral feeding should be completely stopped until vomiting ceases and general improvement occurs. Lack of space forbids a detailed account of current practice in parenteral fluid, electrolyte and maintenance therapy. This can be obtained from paediatric textbooks and articles on the subject by Darrow (1946), Govan and Darrow (1946), Butler and Talbot (1944) and Henderson (1947).

Penicillin, 20,000 units four-hourly by mouth, should be given in all cases to minimize the possibility of secondary infection.

Respiratory Tract Infections

Nasopharyngitis is not uncommon. It is most often contracted from a mother who has a 'cold', but sometimes from one of the staff or a visitor. The chief symptom is nasal obstruction which readily occurs in the narrow passages of the infant. The infant becomes snuffly and feeding is rendered difficult and is subject to repeated interruptions. Immediate isolation is necessary because colds are highly infectious. Failure to do this may cause an epidemic in which some infants will be likely to develop complications, such as otitis media, infection of the lower respiratory tract or bronchopneumonia. Penicillin and sulphonamide should be given in all these complications, but it is even more important to endeavour to avoid these complications by commencing these drugs as soon as the naso-pharyngeal catarrh shows signs of becoming purulent. Nasal obstruction can often be relieved and feeding assisted by instilling into the nostrils before feeds drops consisting of ephedrine $\frac{1}{2}$ per cent., sodium chloride 1.3 per cent., *Aq. Dest. ad.* 100 per cent. Oily drops should never be used, since aspiration may cause pneumonia.

Otitis Media

This infection is difficult to diagnose in the newborn unless otorrhoea develops, because the eardrums are very difficult to see at this age even by otologists. It occurs not infrequently, especially in upper respiratory tract infection.

because the eustachian tubes are short and wide at this age and infection easily passes along them. It should always be borne in mind as a possible cause of obscure illness, as in older infants. The organism is usually either a pneumococcus or *Staphylococcus aureus*, but may be a haemolytic streptococcus. Penicillin should be given systematically by the method advocated elsewhere.

Pneumonia

There are several pathological types of pneumonia in the newborn. They have been admirably described by Macgregor (1939). She showed that the 177 consecutive cases of pneumonia analysed by her could be divided according to their outstanding pathological characters into four distinct groups as follows :

- (1) Pneumonia associated with aspiration of contents of the amniotic sac or vagina, (a) in the dead-born, (b) in the live-born.
- (2) Pneumonia associated with other pulmonary conditions due to stress of birth or otherwise peculiar to the newborn, (a) atelectasis, (b) haemorrhage.
- (3) Bronchopneumonia and allied types such as pneumonia caused by aspiration of vomitus.
- (4) Septicaemia with secondary involvement of the lungs.

The various types, their relative frequency and age incidence, as described by Macgregor, are shown in Table 6. As a general rule, to which only a few exceptions were found, cases belonging to groups 1 and 2 occurred in infants who were born dead or lived only three or four days after birth, while those belonging to groups 3 and 4 occurred later, being frequent from the fourth day onward. Two of the most common types are caused by aspiration of foreign matter: one follows the aspiration of liquor amnii and its contents, plus meconium, in severe asphyxia during labour, and the other is produced by the aspiration of milk or vomitus which occurs with

ease in infants with a weak cough reflex, particularly premature and feeble infants. It is an interesting fact that in asphyxial aspiration a sterile chemical pneumonia produced by bile salts may be found occasionally in stillborn infants, before it has been possible for infective pneumonia to develop. There were 11 such cases in Macgregor's series (Table 6). The type produced by aspiration of milk or vomitus seems to vary directly with the efficiency of nursing care and is less common when premature and weakly infants are fed by gavage.

The clinical features of pneumonia are usually atypical in the newborn. It is, therefore, often very difficult to diagnose unless extensive. Infants with pneumonia, as with other severe infections, often do not have any pyrexia, particularly when premature, and there is often no noticeable dyspnoea. Moreover, changes in the character of the breath sounds and the percussion note can only be detected when consolidation is very extensive. Fine crepitations are usually audible and constitute the most constant sign, but even they may be absent when the breathing is very shallow, as it often is in premature infants. X-ray examination is, therefore, important and often of great value, but the frequency of areas of atelectatic consolidation in the newborn often renders radiological evidence of consolidation equivocal.

TREATMENT. Penicillin, in the manner described elsewhere, and a sulphonamide in doses of $\frac{1}{4}$ gr. four-hourly should both be given in all cases of neonatal pneumonia. Because of the gravity of pneumonia in the newborn and the difficulty of diagnosing it, these drugs should be given prophylactically in circumstances where pneumonia is likely to develop, such as asphyxial aspiration with atelectasis, vomiting in weakly and premature infants where aspiration is likely to occur, upper respiratory infection and intracranial trauma with accompanying atelectasis. Such anticipatory treatment has undoubtedly reduced the incidence of pneumonia in these conditions and improved the prognosis. It seems likely that some cases of early pneumonia, treated

TABLE 6
The Pathological Types of Pneumonia in 177 Consecutive Cases in the Newborn with the Relative Incidence and Age Distribution (Macgregor, 1939)

Type of Pneumonia	Age in days						Total
	Stillborn	0-3	4-7	8-14	15-21	22-28	
Prenatal aspiration	11	31	2	—	—	—	44
Atelectasis	—	11	6	2	1	—	20
Haemorrhage	—	7	2	3	1	—	13
Bronchopneumonia and allied types .. .	—	6	16	25	18	17	82
Haematogenous lesions	—	—	8	3	3	4	18

with these drugs, now recover. Oxygen should be given if there is any cyanosis.

Omphalitis

Serious umbilical infection is now very uncommon, thanks to the strict aseptic technique practised when dressing the cord and umbilicus. Tetanus neonatorum is now extremely rare except in backward communities. The most dangerous infection under modern conditions is haemolytic streptococcal infection of the umbilical stump in the first few days, as the infection may enter the circulation before the vascular channels have become thrombosed. This rarely occurs and local omphalitis, occasionally complicated by peri-umbilical cellulitis, is the type most often seen nowadays. Haemolytic streptococci and Staphylococcus aureus, often in combination, are the principal causes of acute local infection. Treatment consists of the application of penicillin powder locally and the administration of penicillin orally, giving 20,000 units in each feed.

Mild infection of the unhealed umbilicus often occurs after separation of the cord, particularly when separation of a thick cord leaves a large raw area. In such circumstances, there is a slight seropurulent discharge and a reactive excrescence of granulation tissue usually develops. The friability of the latter may cause a few drops of blood to contaminate the discharge occasionally in a small proportion of cases. The infection is usually low grade and mixed in these circumstances, but haemolytic streptococci and Staphylococcus aureus often play a part, and the relatively indolent lesion tends to persist for a few weeks if untreated. The excrescence seems to be the chief cause of such persistence, for once it is removed complete healing occurs spontaneously in a couple of days. Treatment in the earlier days consists of washing and drying the umbilicus thoroughly twice a day and then dusting it with penicillin powder. When a polypus is found it should be removed as soon as possible, by torsion with Allis' forceps if very small, by ligation and strangulation if pedunculated and by repeated cauterization with copper sulphate if sessile.

Peritonitis

This uncommon infection is most often a complication of omphalitis, but it may be a manifestation of septicaemia, or complicate alimentary disease, such as untreated volvulus or other cause of unrelieved obstruction, or a perforation associated with enteritis, colitis or faulty surgical technique.

Septicaemia

This is uncommon, but by no means rare. It

may be the only manifestation of infection or be associated with infection elsewhere, such as staphylococcal dermatitis or omphalitis. It is usually either streptococcal or staphylococcal.

Infants with septicaemia usually have a high remittent temperature, but may have none especially if premature. Embolic manifestations, such as skin abscesses and osteomyelitis, may occur. The diagnosis is established by blood culture. If blood culture were performed much more often in ill infants with no local signs of disease, septicaemia would be found to be more common than many at present suppose. Prompt chemotherapy gives a reasonable chance of recovery.

Meningitis

Neonatal meningitis is not uncommon. The most common cause is B. coli, yet this type is virtually unknown after the first month or two of life. This remarkable phenomenon is no doubt a manifestation of the peculiar immunological characteristics of the newborn. Craig (1936) in his series of 21 cases found B. coli in 14 cases, the infection being mixed in four of them. Next came Staphylococcus aureus with six cases, two being mixed, then Streptococcus viridans with three cases. A pneumococcus, haemolytic streptococcus and an atypical salmonella were each found once. Meningitis is usually part of a generalized septicaemia, but one cannot always determine whether infection arose from haematogenous spread or by direct extension from a local focus. There is a greater tendency for it to occur in infants with local infections, particularly of the nasopharynx and mouth.

The classical signs of meningitis are often absent. Signs of intracranial disturbance arising after the first week of life should always suggest it. Ocular signs, increased tension of the fontanelle and mental restlessness are the most common. Fever may not occur, especially in premature infants, but is usual in advanced cases. Convulsions are rare.

Diagnosis is by lumbar puncture and cerebrospinal fluid features. Treatment depends on the causal organism, and since B. coli is the most common cause a sulphonamide is usually indicated in doses of $\frac{1}{4}$ gr. four-hourly. If no organism is found, penicillin should also be given. Recovery usually occurs with prompt treatment. Hydrocephalus is a not uncommon complication, so the cranial circumference should be watched by daily measurement.

Pyelitis

This acute infection is relatively uncommon, and is practically always caused by B. coli. There

seems to be no definite sex incidence at this age. The principal clinical features are high remittent fever, irritability and thirst, while convulsions may occur. Recurrent circulatory collapse, with pallor and a sub-normal temperature, are regarded as very suggestive of this disease in young infants.

Examination of the urine, which should be obtained with the aid of a test-tube in a male and by catheter in a female, will confirm the diagnosis. Treatment is along the usual lines. Abundant fluid, with alkalization of the urine, which may require the administration of as much as one drachm of sodium citrate in the first day or two, and $\frac{1}{8}$ gr. of sulphamezathine, four-hourly, will soon effect improvement.

The prognosis is very good. When relapse occurs, especially more than once, the possibility of a congenital abnormality of the tract causing stagnation of urine should be considered, and if possible eliminated, since malformations are a common cause of urinary tract infection in infants.

Congenital Syphilis

It is unusual for congenital syphilis to reveal itself in the first month of life. When it does the most common manifestation is snuffles with profuse sanguineo-purulent rhinorrhoea. Skin manifestations may be observed as early as the first few days, particularly scaly exfoliation of the skin of the soles and the appearance of reddish or milky macules which soon develop a bronze tint. Splenomegaly and hepatomegaly can be demonstrated in the more severe cases, but are usually missed until other manifestations appear. There is a variable degree of anaemia and it is often accompanied by erythroblastemia. Mucocutaneous lesions are uncommon in the first month. Roentgenography of the skeleton may show characteristic osteochondritis. It is usually present at birth, but may not be seen for several months. Chondroepiphysitis is the most common lesion, but periostitis is also frequently seen. The general condition of infants with manifest congenital syphilis in the first month is good, as a rule, but it may be indifferent or poor, and occasionally death may occur before any effective treatment can be given.

The placenta in congenital syphilis may not look remarkable on cursory examination, but in severe cases it has a pale pink colour, and an increased thickness and weight. Infarction in the form of multiple small infarcts, which may be missed on superficial examination, are a constant feature, but large infarcts are often found when intra-uterine death occurs. In erythroblastosis with hydrops foetalis or maceration the placenta is much larger and paler than in syphilis. Histologically thickening and clubbing of the villi, and

diminished vascularity with obliterating endarteritis and perivascular fibrosis are the principal features. The *spirochaeta pallida* may not be demonstrable in fresh placental tissue in which it is much more difficult to find than in macerated tissue.

The mother's Wassermann and Kahn tests are positive in a high proportion of cases, but may occasionally be negative. The infant's serological tests are unreliable in the first few months because of the immunological peculiarities of the newborn infant which have been discussed elsewhere.

TREATMENT. The introduction of penicillin has revolutionized and simplified treatment. The following is an outline of current therapeutic practice in the Department of Venereal Diseases, Edinburgh Royal Infirmary :

(1) The infant of a mother who has been treated in pregnancy and has a negative Wassermann reaction at parturition is given a course of 300,000 units of penicillin, receiving eight three-hourly injections of 5,000 units per day. Mother and child are examined at three-monthly intervals for the next two years and no failures have yet been encountered.

(2) The infant of a mother who has been treated in pregnancy and has a positive Wassermann reaction at parturition is given a course of 1,000,000 units of penicillin, receiving eight injections of 5,000 units on the first day of treatment, eight injections of 10,000 units on the second day and eight injections of 20,000 units on the third and subsequent days. A weekly injection of arsenic and bismuth for a period of ten weeks is also given to the infants in this category, as complete cure was not being obtained in all cases treated with penicillin alone.

(3) The infant of a mother who has not received any treatment is given a course of 2,000,000 units of penicillin along the lines detailed above. Also a course of arsenic and bismuth as recommended in category 2.

General Measures to Reduce the Incidence of Neonatal Infections

Improved social and hygienic standards and a strengthening of aseptic technique have steadily reduced the incidence of infection in the newborn, but much more could be done to safeguard infants from the risks of infection in the newborn period.

The following reforms would all contribute towards a further reduction in the incidence of neonatal infection :

(1) Improvement in the general health standard and physique of the people through the attainment of more universally satisfactory economic and social standards, particularly better housing conditions and nutrition.

(2) More universal and thorough supervision of the expectant mother, with special emphasis on an optimum diet.

(3) Much more widespread and attractive mothercraft teaching and propaganda through mothercraft clinics, films and publications. This should be directed particularly to women expecting their first child.

(4) A general raising of obstetrical standards, with a reduction in the number of complicated and prolonged labours which often predispose to infection.

(5) A reversal of the trend towards confinement in maternity hospitals which, though sometimes of advantage to the mother, greatly enhances the possibility of the baby contracting an infection.

(6) More rigid precautions against introduction of infection to maternity units by adults. Nurses particularly should report the commencement of any infection such as a cold, diarrhoea or skin infection immediately, and be debarred from work in a maternity unit for as long as there is any danger of spreading infection.

(7) More enlightened up-to-date planning of maternity hospitals to diminish the risk of cross-infection among infants, by adopting a policy of dispersal, in small units of one to four beds, with their mothers, rather than crowding them into small nurseries as usually practised at the present time.

(8) Better teaching of medical students and post graduates and of nurses, midwives and health visitors in the physiology and care of the newborn, and particularly in the clinical features, epidemiology and prevention of infections.

(9) A more adequate establishment of experienced senior nursing staff and enough pupil nurses to ensure a high standard of nursing at all times.

(10) A reversal of the most regrettable decline in the incidence of breast feeding.

(11) The provision of greatly improved child welfare services in every locality, particularly a great increase in the number of well-trained health

visitors, who constitute the backbone of the service.

In the section on epidemiology of staphylococcal infections I have discussed the principal bacteriological and nursing measures which are necessary to minimize the incidence of staphylococcal infections in a maternity unit. These principles apply to the control of all forms of infection in the newborn. A detailed account of the measures necessary to prevent cross-infection in maternity hospitals has recently been written by Ludlam (1947) in his excellent publication on 'The Bacteriology and Epidemiology of Infections of Early Infancy.' The Medical Research Council publication (1944) on the 'Control of Cross Infection in Hospitals,' and the Department of Health for Scotland publication (1947) on 'Neonatal Deaths Due to Infection' contain much valuable information and advice about the control of infection in infancy and childhood.

BIBLIOGRAPHY

- BENIANS, T. H. C. (1943), *Brit. Med. J.*, **1**, 623.
 BUTLER, A. M., and TALBOT, N. B. (1944), *New. Engl. J. Med.*, **231**, 585, 621.
 CHAPMAN, G. H., LIEB, C. W., BERENS, C., and CURCIO, L. G. (1927), *J. Bact.*, **33**, 533.
 CRAIG, W. S. (1936), *Arch. Dis. Childh.*, **11**, 171.
 DARROW, D. C. (1946), *J. Pediat.*, **28**, 515.
 Department of Health for Scotland, Report of the Scientific Advisory Committee (1947), 'Neonatal Deaths Due to Infection.'
 GALE, E. F. (1944), *Lancet*, **1**, 567.
 GOVAN, C. D., and DARROW, D. C. (1946), *J. Pediat.*, **28**, 548.
 GREGG, N. M. (1942), *Trans. Ophth. Soc. Austral.*, **3**, 35.
 HENDERSON, J. L. (1943), *Brit. Med. J.*, **1**, 410.
 HENDERSON, J. L. (1947), *Practitioner*, **158**, 83.
 HENDERSON, J. L., and McADAM, I. W. J. (1946), *Lancet*, **1**, 922.
 KNOTT, F. A., and BLAICKLEY, J. B. (1944), *J. Obstet. Gynaec.*, **51**, 386.
 LIGHT, J. S., and HODES, H. L. (1943), *Am. J. Publ. Hlth.*, **33**, 1451.
 LUDLAM, G. B. (1947), Health Bulletin issued by the Chief Medical Officer of the Department of Health for Scotland, **5**, 40, 49, 79. 'Bacteriology and Epidemiology of Infections of Early Infancy.'
 LUDLAM, G. B., and HENDERSON, J. L. (1942), *Lancet*, **1**, 64.
 McCLURE, W. B. (1943), *J. Pediat.*, **22**, 60.
 MACGREGOR, A. R. (1939), *Arch. Dis. Childh.*, **14**, 323.
 MACGREGOR, A. R., and HENDERSON, J. L. (1943), *Arch. Dis. Childh.*, **18**, 186.
 Medical Research Council, War Memorandum No. 11 (1944), 'The Control of Cross Infection in Hospitals.'
 TODD, R. L. (1937), *Am. J. Hyg.*, **25**, 212.

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