that such foods can be purchased in adequate amounts for health by low income consumers."

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STAPHYLOCOCCAL PNEUMONIA IN CHILDHOOD

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THE purpose of this communication is to draw attention to the frequency of staphylococcal pneumonia in the young and to less well-recognized pathogenic potentialities of the staphylococcus. This will be illustrated by a description of the sudden and unexpected deaths of two infants in the nursery of a small rural hospital and by a summary of deaths from staphylococcal pneumonia in childhood occurring at Regina General Hospital.

CASE HISTORIES

At 1 a.m. on October 22, 1948, a nurse found two infants dead in their cots in the nursery of a small hospital. The nursery contained ten infants and had been inspected between three and four hours before when all the infants were considered to be normal. The family doctor had seen one of the infants seven hours before the incident and nothing untoward was noticed. One infant, baby girl M., was two days old. Her mother aged twenty-two was a primipara and had been three days in labour. The presentation was a frank breech but delivery was affected without instruments. The condition of mother and child was good and the infant was described as lusty. The other infant, baby girl F., was three days old. The mother, aged twenty-two, also a primipara, was a "lower instrument" delivery. The doctor described both mother and child as normal in all respects. Neither cyanosis nor respiratory embarrassment was ever noticed in the children. The infants had started breast feeding. Mrs. M. and Mrs. F. occupied a two-bed private room in the hospital. No septic condition could be found in either mother or in their attendants. Neither influenza nor the common cold were associated with the event.

AUTOPSY FINDINGS

Both infants were well nourished. The umbilical cords were healthy. There was deep cyanosis of the nail beds and lips. Blood was present in the mouth and nasal passages of baby M. There was no œdema or jaundice.

The structures of the mouth and neck were normal. The trachea and bronchi contained a thin film of mucus but nothing to indicate an inflammatory process. On pressing the lung a frothy fluid was forced into the bronchi; in the case of baby M. the fluid was blood-stained. The pleural membranes and cavities appeared normal. The lungs were fully expanded and sufficiently consolidated to retain their anatomical contours on removal. Section of the lungs showed a brownish, mottled surface and on pressure a moderate amount of frothy fluid was expressed. The lungs felt tougher than one usually encounters in the congested and œdematous lungs of infants dying from a wide variety of conditions. In the case of baby M. numerous dark blue (asphyxial) hæmorrhages were present in the thymus, mediastinal tissue, visceral pericardium, and throughout the lung substance. They varied from pinpoint to a few millimetres in diameter. In the lower lobe of the right lung there was gross confluent hæmorrhage. Snippets of lung tissue floated high in tap water.

The pericardia (apart from the hæmorrhages in baby M.) were normal, the auricles were distended. Other-

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wise, the hearts appeared normal. The great veins were dilated and full of dark blood.

Examination of the abdomen in each case revealed no abnormality except acute passive congestion which was marked in the liver. This organ was a dark plum colour and dark blood dripped freely from the cut surface.

The scalp tissues and calvaria appeared normal. In the case of baby F. small "birth" hæmorrhages were present in the tentorium cerebelli and, as a thin sub-arachnoid film, over both temporal lobes. Otherwise examination of the brains revealed no abnormality.

BACTERIOLOGY

Six swabs in all were taken of the frothy fluid in the bronchi and from the substance of the lungs. Culture on blood agar from all sources yielded a heavy pure growth of staphylococci. In each case the organism was heavily pigmented, strongly hæmolytic, and coagulase positive. Tests showed the organism to be insensitive to penicillin and to be as sensitive to streptomycin as the standard Oxford staphylococcus.

HISTOLOGY

Numerous sections of the lungs were examined. There was a complete absence of inflammatory change in the entire bronchial tree, which appeared healthy. The parenchyma showed gross capillary congestion, patchy partial collapse of alveoli, and a pink-staining (H and E sections) œdema fluid in many alveoli. Scattered fine hæmorrhage was also present. In occasional alveoli scanty "catarrhal" cells were present but fibrin and leucocytes were not evident and inspection of the blood in larger vessels did not reveal a leucocytosis. In every section from the lungs of baby F. one or two small foci of necrosis, just visible to the naked eye, were present. The foci showed no special relation to the bronchial system. Microscopic examination revealed a quiet necrosis of lung tissue where alveolar walls showed all stages from blurring of structure to complete disintegration, represented by a basophilic amorphous material containing nuclear debris and degenerate "catarrhal" cells. Sections stained for bacteria showed after prolonged search a few small clumps of Gram-positive cocci (the cultures yielding a heavy growth were made from expressed exudate in the bronchi and lung substance and thus sampled a large area of lung).

Sections of liver, spleen and kidney revealed no abnormality.

DISCUSSION

A major contribution to the pathology of pneumonia in infancy and childhood has been made by workers at the Royal Hospital for Sick Children, Glasgow, and frequent reference will be made to their work (Blacklock and Guthrie,[1] Guthrie and Montgomery[2]).

Toxicity and invasive properties of the staphylococcus.—The bacteriological examination which yielded a pure heavy growth of *Staph. aureus* identifies the cause of death in our two cases as a fulminating staphylococcal pneumonia. It should be emphasized that had the culture work not been done one could not, in baby M., have confidently identified the condition even as a bacterial pneumonia since congestion, patchy collapse and œdema are common findings in infants dying from a wide variety of conditions, although experience has shown that the pneumonic lung even in this early acute stage tends to be "tougher" than in other conditions: while the focal pulmonary necrosis (baby F.) would have presented an insoluble problem without the bacteriological findings. The examination also exemplifies properties of the staphylococcus not commonly appreciated. One usually associates with the staphylococcus a tissue response characterized by all the classical signs of inflammation and in particular with an abundant fibrinous exudate, while, with the decline of pyæmia, the toxic powers of the staphylococcus are commonly appreciated only in food poisoning. The present cases indicate a power to invade the respiratory tract equal to the most virulent pneumococcus in that no inflammatory change is present in the bronchial tree, while there has been rapid spread throughout the pulmonary parenchyma. A toxicity of high degree has also been exhibited in that the illness was fulminating and associated with pulmonary changes which, although universal, are associated with only the earliest reactions of inflammation, namely capillary congestion and serous exudate, and, in addition, foci of intense toxic action in the form of focal necrosis.

The Glasgow workers record fulminating cases with a similar pathology although the two cases described appear to be more rapid than any previous accounts which I have read. As will be seen later fulminating staphylococcal pneumonia is not uncommon in Regina and it is little wonder that a number of our cases have been medico-legal enquiries. The following case gives the more usual type of fulminating clinical course encountered in Regina.

The patient, a baby boy aged 2 months, was in good nutritional condition and was healthy apart from a slight nasal discharge. One evening he vomited a small amount of his feed but otherwise appeared well, was happy, and did not appear fevered. The mother saw him at 6.30 a.m., 7 a.m. and 8 a.m. the following morning when he appeared well and took his feed. At 9.30 a.m. he appeared normal but was noted to be sucking his hands. At 10 a.m. the mother noticed that he was cyanosed round the nose and mouth and was breathing rapidly. She rushed him to hospital. On admission the baby was deeply cyanosed, breathing rapidly, and moist râles were present throughout the chest. His temperature was 104° F. Some material was aspirated from the mouth; it appeared to be vomitus. The child went rapidly downhill and died four hours after admission. Postmortem findings (Dr. Colpitts) were identical with the two cases described with the addition that numerous clusters of staphylococci were present in sections of the lung.

Where the infant survives some days a pneumonia of more classical pathological type is encountered. The following case is illustrative of such a type.

The delivery was normal and the child (weight 8 lbs. 6 oz.) and mother showed no abnormality. Progress was normal until the third day when the early morning temperature of the infant was noted to be 102° F. but she took her feeds well. By 3 p.m. the baby was cyanosed and the temperature was 103° F. She was isolated and given continuous oxygen, and penicillin (10,000 units in her feeds). On the 4th day the temperature was 102.3° F. and feeds were partly regurgitated. Mucus in the throat became troublesome and the child coughed and choked while drinking. Despite the fact that she took her feeds well she went progressively downhill and breathlessness increased (respirations, 80). She died on the fifth day.

Post-mortem examination (Dr. Marion Gilmour) revealed a massive generalized bronchopneumonia from which a heavy pure growth of *Staph. aureus* (coagulase positive) was obtained with similar bacterial sensitivities to the cases previously described. Histological examination showed bronchioles inflamed and plugged with an acute fibrinous inflammatory exudate and similar changes in contiguous air sacs, some going on to softening. Abundant staphylococci were seen in sections. The liver showed a massive patchy necrosis. The nuclei of the affected cells showed complete lysis and cell bodies were bloated and indistinct. Since there was no collapse of the organ and no jaundice this was deemed to be a recent terminal event and was not encountered in any other case. All other children in the nursery at the time remained well.

Incidence of staphylococcal pneumonia in childhood.—All recent work confirms that the staphylococcus is a major pathogen in primary pneumonia in infancy and childhood. This is strikingly borne out by an analysis of the cases of pneumonia in children up to 12 years of age coming to post-mortem examination in the period 1939 to 1948. Cases of aspiration of feed or vomitus have been excluded.

REGINA GENERAL HOSPITAL

Cases of pneumonia in the newborn, infancy and childhood coming to post-mortem in the period 1939 to 1948.

1. *Primary staphylococcal pneumonia*:
   - Number of cases 24
   - First month of life 10
   - Second to third month 7
   - Fourth to twelfth month 5
   - Over one year (14 months and 6 years) .. 2

In 16 cases isolation of *Staph. aureus* from the lungs was in pure culture.

In 8 cases lung culture yielded a mixed growth of *Staph. aureus* and one or more of the following organisms not generally considered to be primary pathogens: coliform bacilli, alpha and gamma streptococci, diphtheroids. In only one were staphylococci described as scanty in culture.

2. ***Staphylococcal pneumonia associated with another condition.***—Acute nephritis, one case; age, 7 weeks. Whooping cough, one case; age, 5 weeks. Staphylococcal eczematous lesion of leg, one case; age, 3 weeks.

3. *Primary pneumonia associated with another possible pathogen in addition to staphylococcus aureus.*—(*a*) With beta hæmolytic streptococcus, one case; age, 15 days; cellulitis of chest wall present. (*b*) With pneumococcus; one case; age, 4 years.

4. *Primary pneumonia other than staphylococcal.*—Beta hæmolytic streptococcus, one case; age, 15 days. Pneumococcus, one case; age, 4 weeks.

5. *Cases believed to be primary pneumonia mainly in the newborn where lung culture yielded doubtful results.*—In seven cases a pure or mixed growth of some of the following was obtained: coliform bacilli, alpha and gamma streptococci, unidentified Gram-positive and Gram-negative bacilli.

6. *Cases believed to be primary pneumonia but not cultured.*—Nine cases fell into this group. Only one was over the age of one year. A consideration of the history and pathological findings in four cases, all infants, suggested that they were fulminating staphylococcal pneumonias.

7. *Additional observations in staphylococcal pneumonia.*—Prematurity was only recorded in two cases in the newborn. Empyema was recorded in three cases, one of which was in the neonatal period. In three cases purulent tracheo-bronchitis was described as the predominant lesion. While abscess was recorded in a few, it was not analyzed since there was no agreed standard as to what constitutes an abscess and peri-bronchiolar softening of tissues, which one could include under abscess, was not infrequent in cases surviving more than three days.

8. *Length of clinical illness.*—The majority of the cases of staphylococcal pneumonia had a history from hours to three days and exceptionally to five days. The following were the only cases in the whole series of the pneumonias which had a clinical history of seven days or more.

PNEUMONIAS SURVIVING SEVEN DAYS OR LONGER

Age	*Duration*	*Organism*	*Associated conditions*
2 weeks	7 days	*Staph. aureus*	Empyema and abscess
3 weeks	13 days	*Staph. aureus*	Staphylococcal eczema of legs
5 weeks	10 days	*Staph. aureus*	Whooping cough
18 mths.	12 days	Culture—negative for pathogens	
13 mths.	14 days	No bacteriology done	Subacute bronchitis
6 yrs.	10 days	Sterile at autopsy	Empyema (treated with antibiotics)
6 yrs.	17 days	*Staph. aureus*	Muco-purulent tracheo-bronchitis

Thus of a series of 47 cases dying from pneumonia, 27 are staphylococcal, 2 are mixed staphylococcal and pneumococcal or streptococcal, while only one is pneumococcal and one streptococcal. In the remainder it is doubtful if the pathogen was isolated or no culture was done. It is only recently that coagulase tests have been done and while this and many other points could be brought up to limit the value of those figures there are, however, some undoubted conclusions.

1. In southern Saskatchewan the only bacterial pneumonia commonly causing death in the young is staphylococcal.

2. In the newborn the condition is usually rapidly fatal.

3. Generally in older children the illness is of longer duration.

4. Mortality from the condition declines sharply after the first year.

Our pathological findings are in agreement with Guthrie and Montgomery that the type of lung lesion depends on the duration of the disease and not on the age of the child. Thus, while survival in the newborn for more than three days was rare, in those cases which survived one found typical inflammatory reaction going on to suppurative softening. In the only newborn where the illness lasted seven days empyema was present.

There is general agreement that the condition is becoming more common. Thus the workers at the Royal Hospital for Sick Children, Glasgow, record only 3 primary staphylococcal pneumonias in the period 1926 to 1935 in a series of 2,300 consecutive autopsies, while they record 55 cases in the period 1936 to 1945 in a series of 2,877 consecutive autopsies. They also record an increasing incidence of staphylococcal empyema secondary to primary pneumonia. While the Regina records do not go so far back they award a striking preponderance to the staphylococcus as a lung invader in infancy.

Epidemiology of primary staphylococcal pneumonia in childhood. — Guthrie and Montgomery show in their bacteriological investigations that staphylococcal pneumonia is a bronchogenic infection and they record a much higher incidence of staphylococci in nasal swabs from sick infants in a nursery epidemic of staphylococcal pneumonia, than in a control series of premature infants. In Guthrie's investigation of a small epidemic where 16 babies died of staphylococcal pneumonia there was mild clinical influenza and small premature infants were the principal victims. Prematurity has not been an obvious feature of the fatal cases in Regina and of the cases with which I am personally acquainted influenza has not appeared to be a factor.

The disease occurs in epidemic and sporadic forms and in both it is primarily a disease of children. It is noteworthy that in the last World War outbreaks in troops of staphylococcal pharyngitis, sometimes membranous, were encountered but pneumonia was rarely, if ever, encountered. Attempts to trace the origin of the staphylococcus (mastitis in mothers, skin infection, nasal and skin carriers, feeds) have generally been unsuccessful (Smith,[3] Guthrie and Montgomery[2]). In Regina the cases have generally been sporadic, with occasionally two or three cases occurring close together. While nothing is definitely known to account for the alteration in the bacteriology of primary pneumonia in the young it may be that the sulfa-drugs have played a part in eliminating the pneumococcus and the streptococcus. The experience in Saskatchewan is consistent with the common opinion that the staphylococcus is potentiated by passage especially in hospital communities and that the newborn is specially susceptible to the staphylococcus. It is noteworthy that the two most rapidly fatal cases encountered here are in the youngest babies (two and three days old).

PROBLEMS OF TREATMENT

Treatment is rightly presented as a problem. The majority of the cases in infants here coming to autopsy have been fulminating and the rapid course does not suggest any hopeful treatment. However, awareness of the problem should alert the clinician to suspect the condition as it arises in the newborn and in children hospitalized for other complaints. Guthrie and Montgomery advocate for children up to a month, as treatment and prophylactically in an epidemic, the giving of penicillin in feeds (10,000 unit tablets dissolved in each feed). Over the age of a month they advocate penicillin by injection. They record that since penicillin sensitivity tests have been carried out, the organisms have proved sensitive to penicillin. Our recent experience is the opposite. The organisms are resistant to penicillin but as sensitive as the Oxford staphylococcus to streptomycin. This is in keeping with the general trend of infection by the staphylococcus towards a preponderance of resistant strains. Thus Barber and Dowzenko[4] record the following proportion of penicillin-resistant strains in staphylococcal infection in the same hospital: 1946, 14.1%; 1947, 38%; 1948, 59%.

While our organisms have been sensitive to streptomycin the drug has the disadvantage that it cannot be given by mouth for systemic action. Indeed there may be positive danger in giving it by mouth in the presence of staphylo-

coccal infection since, if the organisms enter the alimentary tract they find good conditions for multiplication by the reduction of bacterial competition, as the coliform flora may be reduced to the point of sterility. Accordingly a fatal staphylococcal enteritis may ensue as recorded by Kramer.[5]

Gastro-enteritis in relation to staphylococcal pneumonia.—Over the last fifteen years reports have been coming in from all parts of the world of mysterious epidemics in infants in institutions with a case mortality as high as 47% (Cooper[6]) and as high as 89% during the war in Germany (Brehme[7]). Virologists, bacteriologists and epidemiologists have all been baffled. While in many outbreaks there has been diarrhœa, in others the condition has been described as "toxæmia" and the infants have refused food, perhaps vomited, lost weight and showed rapid dehydration. While accepting the mysterious nature of the condition steps should be taken to exclude staphylococcal infection, where, as is evidenced by the cases described, failure to carry out simple bacteriological investigation can easily render a simple problem equally baffling.

SUMMARY

1. Cases of fulminating staphylococcal pneumonia in infants are described.

2. Attention is drawn to (*a*) the highly invasive and toxic potentialities of the staphylococcus; (*b*) the increasing incidence of staphylococcal pneumonia in infancy and childhood.

3. Records over the last ten years show that in Regina the staphylococcus is the only organism commonly producing fatal pneumonia in infancy and childhood.

4. Recently the organisms encountered in southern Saskatchewan have been resistant to penicillin and sensitive to streptomycin.

It will be interesting to see how long streptomycin-sensitivity holds.

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NON-PARALYTIC POLIOMYELITIS*

(Some Observations on Differential Diagnosis)

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THE diagnosis of virus diseases is usually made by clinical methods alone, because laboratory tests are not as readily available as are investigations for bacterial infections. This applies particularly to poliomyelitis, where the only test of value involves inoculation of monkeys.

Little difficulty is likely to arise in the diagnosis of cases showing frank paralysis, but the problem in the much commoner non-paralytic form is different, for the virus can cause a variety of manifestations. These range from a transient fever with no evidence of nervous involvement, to a severe meningeal irritation with fever, neck stiffness, and increase of cells in the cerebrospinal fluid, lasting from 48 hours to several days. The clinical appearances of non-paralytic poliomyelitis are not specific and many bacterial and viral agents can produce similar symptoms and signs. As regards virus infections, we must consider in differential diagnosis diseases such as encephalitis or lymphocytic meningitis.

For example, *equine encephalomyelitis,* mainly of the Western type, affected man in the Prairie Provinces in 1941 and 1947.[5, 11, 16, 17] *St. Louis encephalitis* is widespread in the United States, but does not appear to have been reported in Canada. The difficulty of establishing a diagnosis by clinical methods between these two illnesses and poliomyelitis, particularly in abortive forms, has been stressed.[1, 4, 6, 8, 18, 19] An additional complication is that epidemics of these diseases have occurred at the same time in Manitoba, Minnesota, and California.[12, 18, 19] Ac-

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