STAPHYLOCOCCAL PNEUMONIA

BY

AGNES R. MACGREGOR, M.B., F.R.C.P.E.

(From the Royal Hospital for Sick Children, Edinburgh, and the Department of Child Life and Health, Edinburgh University.)

That cases of pneumonia occur in which staphylococcus is the sole, or the predominating, infecting micro-organism is well known. Many of the reported cases have been associated with epidemics of influenza. Although generally less frequent than streptococcus haemolyticus and Pfeiffer's bacillus as a cause of pneumonia complicating influenza, staphylococcus aureus has been conspicuous in certain epidemics. Chickering and Park¹ described one of these and noted the very grave and often fatal character of the pneumonia when staphylococcus aureus played a leading role. In such cases it is to be supposed that the staphylococcus is a secondary invader, following upon the epidemic infection which has laid the respiratory tract open to attack. Apart from these occasional epidemics, staphylococcal pneumonia appears to be relatively uncommon. It may be questioned, therefore, whether staphylococcus ever causes pneumonia independently of other micro-organisms, and whether those cases in which it plays a dominant part have clinical or pathological features sufficiently distinctive to justify this condition being regarded as an entity, differing from other forms of broncho-pneumonia. Reimann², in a paper describing six cases, claims 'primary staphylococcic pneumonia' as a clinical and pathological entity. The facts now recorded from a series of ten fatal cases support this claim at least to the extent that they show this type of pneumonia to possess certain constant and distinctive features.

Case reports.

The ten cases were encountered in the pathological department of the Royal Edinburgh Hospital for Sick Children between August, 1935, and May, 1936. During that period there was no influenza epidemic of any serious proportions in the community, and in the hospital the incidence of pneumonia in general, though fairly high during the winter, was not unusual. But the occurrence of so many cases of staphylococcal infection of the lungs (other than pyaemic) within so comparatively short a time is without precedent in the records of the department.

For purposes of description the ten cases may be divided into two groups, according to the stage at which the pathological process was found at necropsy: (1) Four cases with sero-fibrinous pleural effusion, in which the early stages of the process in the lungs were shown; (2) six

cases with empyema or pyo-pneumothorax, in which the pathological process in the lungs had progressed to a later stage.

Group I. Case 1. A boy, aged seven weeks, was an under-weight, bottle-fed baby. The fatal illness was of four days' duration, with restlessness, slight fever (99.4° F.) and cough. On admission to hospital on the third day, physical signs indicated consolidation of the right lung.

POST-MORTEM EXAMINATION The right pleural cavity contained one ounce of thin turbid fluid and fibrinous exudate; there were numerous sub-pleural haemorrhages. The upper lobe of the right lung was completely consolidated, haemorrhagic and moist. The bronchi in this part contained much thick pus. The other lobes were not consolidated. There was no generalized bronchitis. The left lung and pleura were healthy.

BACTERIOLOGY. *Staphylococcus aureus* was obtained in pure culture, post-mortem, from lung, pleural fluid and blood.

Case 2 was that of a girl aged four months. She had had bronchitis two weeks before admission to hospital, but had made a good recovery. The fatal illness was of three days' duration and began with a cough, sneezing, nasal discharge and restlessness, followed by respiratory distress. When admitted to hospital on the third day the infant was cyanosed and very ill. Physical signs indicated consolidation in the left upper and right lower lobes. The temperature was 105.4° F.; the white blood cells numbered 31,000 per c.mm.

POST-MORTEM EXAMINATION. Both pleural cavities contained a quantity of slightly turbid serous fluid and fibrinous exudate; there were many sub-pleural haemorrhages. There were large well-defined areas of consolidation in the left upper and both lower lobes; all these were haemorrhagic, with yellow points of suppuration showing through the pleura, and blood-stained pus exuded from the cut surface. Other parts were not consolidated and there was no generalized bronchitis.

BACTERIOLOGY. *Staphylococcus aureus* was obtained in pure culture, post-mortem, from lung, pleural exudate and blood.

Case 3 was that of a boy aged three-and-a-half years. He had always been healthy. The fatal illness was of eight hours' duration. He appeared to be quite well in the morning. At noon he asked to be put to bed. He became obviously ill during the afternoon; vomited blood at 6 p.m. and again an hour later; and died at 8 p.m. on the way to hospital.

POST-MORTEM EXAMINATION. Both pleural sacs contained one ounce of slightly turbid blood-stained fluid and fibrinous exudate; there were many sub-pleural haemorrhages. The left lower lobe and the base of the right lower lobe were consolidated and very haemorrhagic. There was no pneumonia elsewhere, and no generalized bronchitis. The pharynx and larynx were inflamed.

BACTERIOLOGY. *Staphylococcus aureus* was obtained in pure culture from lung and pleural exudate. Blood culture yielded a pure growth of pneumococcus Type II. All cultures were made post-mortem.

Case 4 was that of a girl aged sixteen days, born prematurely by one-and-a-half months and illegitimate. She was feeble and would not take the breast; she was fed with breast milk from a bottle. The fatal illness was of about twenty hours' duration. She refused feeds and was pale and collapsed; blood came from the nose and a black motion was passed. She was moribund when admitted to hospital.

POST-MORTEM EXAMINATION. The right pleural cavity was full of blood-stained serous fluid; copious sub-pleural haemorrhage made the whole serous membrane crimson. There was a small patch of consolidation at the apex of the right upper lobe, sharply defined, haemorrhagic. The rest of the right lung was collapsed. The left pleural sac and lung were healthy. There was no generalized bronchitis. The upper respiratory passages were not inflamed. The ileum contained altered blood.

BACTERIOLOGY. *Staphylococcus aureus* was obtained in pure culture, post-mortem, from the right lung, pleural exudate and blood.

The macroscopic characters of these four cases were so similar and so unlike other types of pneumonia that each one, after the first, was recognized at necropsy and tentatively diagnosed as staphylococcal pneumonia before any bacteriological investigation had been carried out. In each there was a pleural effusion of sero-fibrinous fluid, slightly turbid or

FIG. 1. Case 3. A bronchus with early suppuration destroying the wall, surrounded by haemorrhagic consolidation (x 60)

blood-stained, with numerous sub-pleural haemorrhages. Each had one or more areas of massive consolidation, sharply defined, intensely haemorrhagic, with a soft, moist surface on section which suggested the early onset of suppuration. In each there was an absence of generalized bronchitis and of scattered small patches of consolidation such as are found in the usual forms of broncho-pneumonia. In no case was any focus of infection found to which the pneumonia might have been secondary, nor were there any pyaemic lesions. The other organs showed the usual toxic changes, which were always severe.

The microscopic characters of these four cases were so similar that separate description is unnecessary. The consolidation was due to a combination of haemorrhage and inflammatory exudation. The haemorrhage affected both the alveoli and the coarse stroma. The exudate was

cellular in alveoli and bronchi, with heavy deposits of fibrin in the interlobular septa. Even in the earliest cases there was a strong tendency to suppuration, which might develop anywhere, but especially in the bronchi (see fig. 1), where the walls were destroyed and adjacent alveoli were involved; and in interlobular septa and perivascular stroma, where it spread along, and out from, the lymph vessels. Throughout the affected parts there were extraordinary numbers of staphylococci in large clumps (see fig. 2). Other parts of the lungs showed no pathological changes except some congestion and oedema.

Group II. Case 5 was that of a boy aged ten weeks. He was a feeble baby and had been losing weight; there had been an umbilical discharge. The fatal illness was of ten days' duration and began with a sudden rise of temperature to 103.4° F. and consolidation in the left lung. On the day before death 40 c.c. of pus was removed from the left pleural cavity.

FIG. 2. Case 4. Masses of staphylococci among haemorrhagic and purulent exudate (x 55)

POST-MORTEM EXAMINATION. The left pleural sac showed organized adhesions anteriorly, and posteriorly contained a large quantity of pus. There was a small area of suppuration in the left lung near the base of the lower lobe, from which pus was discharging into the pleural cavity. The rest of the left lung was collapsed. There was no generalized bronchitis. The right lung and pleura were healthy.

BACTERIOLOGY. *Staphylococcus aureus* was obtained in pure culture from the pleural pus during life.

Case 6 was that of a boy aged one year. The fatal illness was of three days' duration, with fever (105° F.), cough, dyspnoea and blood-stained discharge from the nose. He was moribund when admitted to hospital.

POST-MORTEM EXAMINATION. The right pleural cavity contained thin pus and fibrino-purulent exudate. At the anterior border of the right upper lobe a consolidated area of about two cubic inches contained many

ramifying abscesses, several of which had burst through the pleura. The rest of the right lung was collapsed. The left lung and pleura were healthy. The pharynx and tonsils were inflamed.

BACTERIOLOGY. A strongly haemolytic strain of staphylococcus albus was obtained in pure culture from pleural pus removed just before death.

Case 7 was that of a girl aged four months. The fatal illness was of thirty-six hours' duration, but was preceded by a slight cold and cough for a few days. She became pale and collapsed, with respiratory distress and fever (103° F.).

POST-MORTEM EXAMINATION. The right pleural cavity contained a large amount of thin pus and air. A consolidated area of about three-quarters of a cubic inch at the base of the right lower lobe was riddled with ramifying abscesses, one of which had burst through the pleura. The rest of the right lung was collapsed. The left lung and pleura were healthy. There was early fibrinous pericarditis.

BACTERIOLOGY. Staphylococcus aureus was obtained in pure culture, post-mortem, from the pleural pus, but in direct films other organisms also were present, notably streptococci and Gram-negative diplococci of the Neisseria group.

Case 8 was that of a boy aged four months. The fatal illness was of five days' duration, with dyspnoea, cyanosis and fever (104.2° F.). The white blood cells numbered 26,000 per c.mm.

POST-MORTEM EXAMINATION. The left pleural cavity contained a large quantity of thin pus, fibrino-purulent exudate and air. A consolidated area at the base of the left lower lobe was riddled with ramifying abscesses, one of which had burst through the pleura. The rest of the left lung was collapsed. There was broncho-pneumonia without sup-puration at the base of the right lung.

BACTERIOLOGY. Staphylococcus aureus and pneumococcus were obtained from the pleural pus during life.

Case 9 was that of a boy aged six months. The fatal illness was of twenty-five days' duration, with pallor, panting, cough and sweating. During a feed (cows' milk) he had choked and from that moment there was increasing respiratory distress. He was treated at home, where he developed pneumonia in the left lung. On the fourteenth day he became worse, and on the eighteenth day he was admitted to hospital with an empyema. Skiagrams showed a pyo-pneumothorax, and fifty cc. of pus and air were evacuated from the left pleural cavity. Staphylococcal antitoxin (B.W. & Co.) was given, ten cc. by the intravenous and ten cc. by the intramuscular route over forty-eight hours, with temporary improvement. Death followed a sudden collapse.

POST-MORTEM EXAMINATION. The left pleural cavity was mostly obliterated by fibrous adhesions, among which were several pockets of thick pus. The antero-inferior portion of the left upper lobe was riddled with ramifying abscesses, several of which had burst through the pleura. The rest of the left lung was collapsed. The right lung and pleura were healthy.

BACTERIOLOGY. Staphylococcus aureus was obtained in pure culture from the pleural pus and blood during life and from the left lung after death,

Case 10 was that of a boy aged seven months. The fatal illness was of two weeks' duration, but had been preceded by measles and bronchitis from which he had never fully recovered. The symptoms of acute illness were cough, dyspnoea and cyanosis. When admitted to hospital, two days before death, his temperature was 101.8° F., and signs of fluid were present at the right base. Forty-five cc. of pus were evacuated from the right pleural cavity.

POST-MORTEM EXAMINATION. The right pleural cavity contained a large amount of pus and fibrino-purulent exudate. An area of about one cubic inch, just below the apex of the right upper lobe, was consolidated and contained ramifying abscesses, one of which had burst through the pleura. The rest of the right lung was collapsed. The left lung and pleura were healthy. The pharynx was inflamed.

FIG. 3. Case 10. Multiple abscesses in an area of haemorrhagic consolidation (x 7)

BACTERIOLOGY. *Staphylococcus aureus* and *B. influenzae*, the former predominating, were found in the pleural pus during life. After death, *staphylococcus aureus* was obtained in pure culture from the right lung, and *streptococcus haemolyticus* from the blood.

The remarkable similarity of the pathological findings in these six cases cannot fail to be noted. Every case had a unilateral empyema; in three cases there was a pyo-pneumothorax. In every case suppuration had developed in the corresponding lung in a localized area which was never very large and often quite small. Within the affected area in every case multiple ramifying abscesses had formed, one or more of which had burst through the pleura. In all except case 8 there was an absence of generalized bronchitis and of consolidation in either lung apart from the single area involved in suppuration. Case 8, in which there was a mixed infection, showed broncho-pneumonia in the base of the other lung.

The microscopic characters were almost identical in the six cases. In all but one the abscesses were of an acute type, without evidence of any organization. The exception was case 5, in which some of the cavities had a lining membrane of recent granulation tissue. In many instances some of the cavities were bounded in part by fragments of bronchial wall, or had a traceable connection with bronchi. Sometimes suppuration had originated in lymph vessels in the interlobular septa. Although acute, the abscesses were usually fairly sharply defined. The lung substance between them was collapsed or consolidated, and only occasionally showed spreading necrosis and suppuration. (see fig. 3 and 4.)

FIG. 4. Case 5. Well defined abscess cavities separated by collapsed lung substance (x 5)

It is obvious that these six cases illustrate a further stage of the pathological process seen in its earlier stage in cases 1 to 4. Both groups show the same localization of the lung lesion to certain well-defined areas, and the same absence of generalized bronchitis and of the disseminated patches of consolidation so constantly found in broncho-pneumonia due to other organisms. The incipient suppuration arising especially, though not only, in the bronchi, which was noted in the cases of group I, had developed in those of group II into a series of ramifying abscess cavities, rupture of which through the pleura had produced empyema. When this happens, if the almost inevitable broncho-pleural fistula communicates with a bronchus which still contains air, pyo-pneumothorax will result, as in cases 7, 8 and 9.

Bacteriological summary.

In nine of the ten cases staphylococcus aureus was isolated, and in one case staphylococcus albus. In six cases no evidence was obtained from the bacteriological investigation that any micro-organisms other than staphylococcus played any part. In cases 7, 8 and 10, although staphylococcus predominated, other organisms accompanied it in the lung or pleural exudate, viz., streptococcus and a coccus of the Neisseria group in case 7, pneumococcus in case 8, and B. influenzae in case 10, in which there was also a haemolytic streptococcus in the blood. In Cases 7 and 10 there was a definite history of a respiratory infection preceding the onset of the fatal illness. In case 8, while no such history was obtained, in addition to the characteristic staphylococcal lesion, there was, in the other lung, an acute broncho-pneumonia without suppuration, which may have been due to the pneumococcus. In these three cases, therefore, it is likely that the staphylococcal infection was superimposed on a previous respiratory infection of another type. In case 3, that rather extraordinary case of a previously healthy boy who died within eight hours of the onset of symptoms, while as far as could be ascertained staphylococcus aureus was responsible for the pulmonary condition, there was a coincident pneumococcal septicaemia. It is difficult to explain how this double infection may have arisen, but clearly it was a peculiarly deadly combination.

Discussion.

It is reasonably certain that the pathological process in the lungs in these ten cases was the result of a primary infection of the respiratory tract, and not of a haematogenous infection from a distant septic focus. In only one case was any antecedent septic focus known to exist (the umbilicus in case 5), and even there no connection was established. Study of the pathological anatomy of the lung lesion leaves little doubt that it is the result of infection which reaches the lung via the bronchi. The intimate relation of many of the abscesses to bronchi, and the severe purulent inflammation of the bronchial walls, even in the earliest cases, together with the absence of septic thrombosis of the pulmonary arteries, are features which almost prove the bronchial and disprove the vascular route. Anatomically the lesions are unlike those of pyaemic infection.

In four cases there was reason to suppose that an antecedent respiratory infection may have predisposed the lungs to attack by staphylococci. In the other six cases, although an antecedent or coincident infection by other organisms cannot be altogether ruled out, there was no evidence that staphylococcus was not alone responsible. In one

case (case 9) there was a strong suggestion in the history that the illness may have been initiated by the baby aspirating milk into the lung. Although there was no suggestive history in any other case, aspiration of food is a possibility, especially in cases 1 and 4, these patients having been feeble, premature babies who did not suck well. Milk often contains staphylococci, and it was noted by Johnson and Meyer³ that staphylococcal pneumonia in newborn infants might be caused by aspiration of food. But it is probably unnecessary always to seek the cause in any such accidental introduction of staphylococci into the lungs. As with other organisms more commonly associated with respiratory infection, their invasion of the lungs may depend upon predisposition or lowered resistance in the host, or upon their own exalted virulence. The occurrence of so many of these cases in this hospital within a relatively short period possibly indicates a phase of increased virulence among staphylococci. No statistical proof can be produced in support of this suggestion, but surgeons and pathologists working in the same city endorse the opinion that there has been in recent months an increased prevalence of other staphylococcal diseases.

Whether or not the staphylococcus was accompanied by other organisms, in this series of cases the resulting lesions had constant, distinctive and easily recognized characters, quite unlike those of other forms of pneumonia. It is clear that it was the staphylococcal infection which determined the characteristic form of the lesion. It may therefore be claimed that staphylococcal pneumonia (whether 'primary' or not in the sense that the staphylococcus is the first or only bacterial invader) is a definite pathological entity.

Summary.

Ten cases of staphylococcal pneumonia in children are described. Four cases represent the earlier stages, with serous pleural effusion; six the later stage, with empyema.

The children's ages ranged from sixteen days to three-and-a-half years, but eight were under one year.

In nine cases staphylococcus aureus was isolated; in one case staphylococcus albus.

In six cases, as far as bacteriological investigation showed, staphylococcus was the only infecting micro-organism. In four cases there was a mixed infection.

At the earlier stages staphylococcal pneumonia is characterized by massive consolidation of one or more localized areas of one or both lungs, without generalized bronchitis. Haemorrhage and early onset of suppuration are constant features. Suppuration especially attacks the bronchi and lymph vessels.

At the later stage the affected part breaks down into a group of ramifying abscess cavities, one or more of which may burst through the pleura. This gives rise to empyema or pyo-pneumothorax.

The pathological anatomy indicates that infection reaches the lungs via the bronchi. Aspiration of food is a possible cause in some cases, especially in weakly infants.

Staphylococcal pneumonia is an entity presenting distinctive pathological characters.

Thanks are due to Professor Charles McNeil, Dr. Lewis Thatcher and Dr. J. McNair Murray for permission to publish these cases, and for the use of the clinical records of patients in their wards.

REFERENCES.

1. Chickering, H. T., and Park, J. H., *J. Am. Med. Assoc.*, Chicago, 1919, LXXII, 617.
2. Reimann, H. A., *ibid.* 1933, CI, 514.
3. Johnson, W. C., and Meyer, J. R., *Am. J. Obst. Gyn.*, St. Louis, 1925, IX, 151.