STUDIES OF PNEUMONIA IN CHILDHOOD.

V. EMPYEMA.

BY

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CLINICAL CONSIDERATIONS.

Incidence. In our clinical series of 648 cases of pneumonia in children from birth to twelve years, analysed in the first of these studies¹, empyema occurred in 89, giving a frequency of 1 in 7. This approximates closely to the incidence of 1 in 8 in Spence's series of 204 cases of empyema from the Babies' Hospital, New York², and of 1 in 9 of Dunlop's 98 cases³. Our definition of empyema was the existence of pus or sero-purulent fluid in the pleura, even in small amount, determined either during life or after death: the same standard was adopted by Spence. In our cases, the incidence was lower in the earlier age periods and was appreciably higher in later childhood. Thus, in the periods from birth to two years and from two to five years, it was almost equal—1 in 10; while from five to twelve years, it was 1 in 5. There were 3 examples of well-marked pyo-pneumo-thorax in the series.

Mortality. For the total, the mortality was 40·5 per cent. For the age periods already given, it was as shown in Table 1.

TABLE 1. (CLINICAL).

Age period			Death rate
Birth to 2 years	...	...	75 per cent.
2 to 5 years	...	...	31·5 per cent.
5 to 12 years	...	...	8·5 per cent.

Sex. There were 53 boys and 36 girls in the group, figures which correspond closely to the 124 boys and 80 girls in Spence's series, and also to the general preponderance of boys over girls in our inclusive group of all types of pneumonia.

Site. The right pleura was involved in 35 and the left in 47 cases. The percentage of deaths was higher in the right-sided (16 deaths) than in the left-sided group (16 deaths). Of 7 bilateral cases, 3 recovered. In the great majority of cases, the empyema was basal. In 4 it was localized about the

middle of the parietal pleura : all these recovered, 3 after single or repeated aspiration without further drainage. A brief record of one of these cases follows :—

CASE I. Male, aged 8 years. Pneumonia 3 weeks before admission. Crisis after 2 weeks' acute illness, followed by relapse. On admission, percussion dullness limited to a considerable area in right axilla. X-ray photograph (Fig. 1) showed a large circular shadow on the right side, with luminous lung above and below. The first two explorations were negative ; a third in the 3rd interspace aspirated 5 ounces of thick pneumococcal pus. Steady uninterrupted convalescence followed. It is possible that this empyema was interlobar ; if so, it is the only example of an interlobar collection in the clinical series.

Type of pneumonia. The antecedent pneumonic illness was alveolar (lobar) in type in 45 cases, with 6 deaths : broncho-pneumonic in 13 cases, with 13 deaths : and undetermined in 31 cases, with 17 deaths.

Syn-pneumonic and meta-pneumonic empyema. In a study of 52 cases of empyema in children under 2 years of age, Cameron⁴ introduced this classification. The prognosis depends to a large extent on the presence or absence of active pneumonia at the time of development of the empyema, the high death-rate in syn-pneumonic empyema being due to the extent and severity of the underlying pneumonia. This difference in prognosis is most evident in the first two years, but in later years the death-rate in syn-pneumonic empyema is still appreciably higher than in the meta-pneumonic or residual type. It has been found possible to classify 86 of our 89 cases on this basis, and the results (Table II) generally confirm the value of the classification as a guide to prognosis.

TABLE II. (CLINICAL.)

Age period	Syn-pneumonic		Meta-pneumonic	
	Total	Deaths	Total	Deaths
Birth to 2 years	27	25	8	1
2 to 5 years	4	2	14	3
5 to 12 years	11	3	22	0
Total	42	30	44	4

Bacteriology. This was recorded in 70 of the 89 cases (Table III).

TABLE III. (CLINICAL.)

Micro-organism	Total	Deaths
Pneumococcus	53	18
Streptococcus	7	3
Staphylococcus	2	2
Mixed	8	6

FIG. 1. Radiograph of interlobar empyema (Case I).

PATHOLOGICAL STUDY.

Among the total of 244 post-mortem cases of pneumonia in children analysed in our first study, there were 69 of empyema, giving a frequency of almost 27 per cent.

Site and extent of empyema cavities. The right side only was affected in 25 cases; the left in 25; 19 were bilateral. In 27 empyemata, organized adhesions were absent and the whole sac was involved. In 33 instances, organized adhesions obliterated part of the pleural cavity and the pus was shut off in circumscribed pockets of varying size. In the remainder the empyema occupied the greater part of the pleural sac, but limited adhesions were present.

FIG. 2. Radiograph of right-sided empyema and collapsed right lung (Case III. See also Figs. 5 and 6). Note displacement of heart towards side of empyema.

Where organized adhesions are present, the pus may collect in several separate pockets in one pleural cavity. In 8 of our 33 cases two such independent collections were found; in one case there were three pockets separated from each other by firm fibrous adhesions.

The sites of the localized collections of pus may be of some interest. The most usual position was at the base (19 cases, of which 6 involved the diaphragmatic surface, most of the rest being posterior). In only one case was the pus entirely confined to the space between the inferior surface of the lung and the diaphragm. In 8 cases collections of pus were found in the region of the apex, 3 of them being situated on the medial aspect. In 3 cases the

pockets were on the mediastinal surface near the root; in 7, on the anterior surface; and in 6 on the posterior. In 2 cases interlobar collections were found, but in only one of these was the pus entirely imprisoned between the lobes.

Character of the empyema fluid. In the localized empyemata with fibrous adhesions, the fluid was usually of the nature of thick pus. Where adhesions were absent and the whole sac was involved, it was more usual to find thin pus or sero-purulent fluid, with masses of thick fibrin floating in it or adhering to the pleural surfaces. The amount of this thick fibrinous exudate was often very great.

Types of associated pneumonia. In 58 of the 69 cases, pneumonia of some kind was present in the lungs at the time of death: in 11 no pneumonia could be detected at autopsy. In 45 cases it was possible to determine the type of the pneumonia; in 13 this was not possible, because only remnants of pneumonia were present, and these cases were placed in a group termed 'unclassified.' Table IV shows the types of pneumonia in which empyema occurred, the number of cases of empyema associated with each type, and, for comparison, the total number of cases of each of these types in our whole series.

It will be noted that the incidence of empyema was somewhat higher relatively in alveolar than in broncho-pneumonia. But at the same time it is important to remark that almost exactly one-half of the empyemata in this series occurred in cases of broncho-pneumonia. We find it, therefore, impossible to agree with the view which has been expressed, that empyema seldom occurs in broncho-pneumonia. Our experience is that the great majority of fatal cases of empyema in children under two years of age complicate broncho-pneumonia (see Fig. 3, 4, 5 and 6).

TABLE IV. (POST-MORTEM.)

Type of pneumonia	Total	Empyema	Per cent. Empyema
Broncho-pneumonia	140	34	24
Alveolar (lobar) pneumonia	23	8	35
Septic (pyæmic) pneumonia	4	1	25
Chronic pneumonia (bronchiectasis)	5	2	40
Unclassified	17	13	70
No pneumonia	—	11	—

Age incidence. All the children were under 8 years of age; 47 were under two years. The largest number (31 cases) was found between the sixth and eighteenth months. The high incidence of fatal cases in the first two years is explained, as has already been stated, by the deadly character of the accompanying pneumonia during that age period.

FIG. 3. Same as Fig. 4. Right lung. Capillary bronchitis and acute broncho-pneumonia throughout, with confluence along medial border.

FIG. 4. Girl aged 1 year and 9 months (Case II). Left lung. Empyema of 3 weeks' duration. Organizing exudate over entire pleural surface; sub-pleural abscess (A) on diaphragmatic surface; broncho-pneumonia and collapse throughout lung.

FIG. 5. Girl aged 9 months (Case III). Right lung. Empyema of 5½ weeks' duration. Fibrous thickening of pleura on lateral surface; large sub-pleural abscess (A) about to rupture at base; deep-seated abscess (B) in lower lobe; almost complete collapse of lung.

FIG. 6. Same case as Fig. 5. Left lung. Acute broncho-pneumonia, especially in lower lobe. Well-marked acute vesicular emphysema. (The tri-lobed appearance of this lung is an artefact.)

Sex. There were 42 boys and 27 girls in this series.

Complications accompanying empyema. A fairly large proportion of the empyema cases showed other grave complications of pneumonia. The chief of these were pericarditis, peritonitis and meningitis. In 21 of the 69 cases of empyema, one or more of these three conditions occurred. Their frequency was :—Pericarditis, 16 ; peritonitis, 7 ; meningitis, 2. For comparison, the frequency of these complications in the 175 cases of pneumonia without empyema in our series was :—pericarditis, 2 ; peritonitis, 3 ; meningitis, 4. These figures show that in this series both pericarditis and peritonitis occurred much more frequently in cases of empyema than in pneumonia without empyema, but that this was not the case with meningitis. Pericarditis was present in 23·2 per cent. of the cases of empyema, compared with 1·1 per cent. of the cases of pneumonia without empyema ; the corresponding figures for peritonitis were 10·1 per cent. compared with 1·7 per cent. ; while for meningitis they were 3 per cent. compared with 2·2 per cent.

These facts may have some bearing on the question of the channel by which the infection spreads to these various secondary sites. In the case of meningitis there can be little doubt that the usual route by which the infection reaches the meninges is the blood stream. In the case of pericarditis and peritonitis there is a possibility of a more local spread, probably by lymphatics ; but the view that these also are results of a blood-spread infection is widely favoured. The figures just presented would seem to support the view that pericarditis and peritonitis may be often—perhaps most often—the result of spread of infection by the more direct route, and not of a blood infection. It is always dangerous to draw conclusions from small numbers of cases, and it must be admitted that there is a greater probability of blood infection in cases of pneumonia complicated by empyema, because they are on the average more severe and prolonged, and run a greater risk of the development of a secondary septicæmia. Yet if all these three conditions were alike caused by blood infection, it might be expected that the incidence of all three would be similarly affected by the occurrence of empyema.

Suppuration in the lungs. Suppuration or necrosis in the lungs was found in 26 of the 69 cases of empyema (37·7 per cent.). Seventeen of these were cases of broncho-pneumonia, while only one was alveolar (lobar) pneumonia. Exactly one-half of the cases of broncho-pneumonia with empyema showed suppuration or septic necrosis in the lungs. In a few instances where suppuration was present, it could be shown at autopsy that an abscess or abscesses in the lung had burst into the pleural sac, and had thus, in all likelihood, caused the empyema. In several other instances abscesses, as yet unruptured, projected immediately beneath a stretched, infected and sometimes necrotic pleural membrane (Figs. 4 and 5). Sometimes the abscesses were deep-seated, and had no apparent connection with the empyema.

In the 175 cases of pneumonia without empyema, suppuration or necrosis was found in 21 (12 per cent.). From this it would appear that these changes in the lungs are distinctly more common in cases of empyema than in pneumonia without that complication. While in some instances it is fairly obvious that

the suppuration in the lung is the direct cause of the empyema, in others it is no easy task to determine which of the two conditions arose first. For while it is evident that suppuration in the lung renders empyema more likely, it is probable that the converse is true also, that the presence of an empyema increases the risk of suppuration in the lung. The reason for this is as follows. Suppuration in the lungs in cases of the kind being considered is usually in the form either of bronchial abscesses or of septic infarcts (Fig. 9). Brief mention of this was made in the third of these studies⁵, when it was pointed out that bronchial abscesses are the result of suppuration starting in the bronchial walls and peribronchial lymphatics; and septic infarcts the result of thrombosis of blood vessels due to involvement of their walls in a suppurative inflammation

FIG. 7. Suppuration in perivascular lymphatics. Boy aged 4 weeks (Case IV). (A) Artery. (L) Lymphatics distended with pus.

FIG. 8. Same case as Fig. 4. To show the amount of pleural thickening after a period of not more than 3 weeks. (A) Fibrino-cellular exudate. (B) Thickened pleura with exudate in process of organization. (C) Lung.

spreading along the perivascular lymphatics (Fig. 7). It is probable that the impairment of circulation of blood and lymph, and the restricted movement of the lung in the presence of an empyema, favour the development and spread of this suppurative lymphangitis, with its grave effects upon the lung.

Fibrosis of the pleura and lung. A certain amount of fibrous thickening of the pleura is probably inevitable in most cases of empyema which survive long enough to allow it to occur. Even when the pus has been successfully evacuated, a quantity of thick fibrino-purulent exudate often remains adhering to the pleural surfaces. Organization of this is bound to lead to the formation of new fibrous tissue, and probably to the production of adhesions (Fig. 10).

It is remarkable with what rapidity a fairly thick layer of new fibrous tissue may form beneath an inflammatory exudate. Even after two or three weeks its amount may be quite considerable (Fig. 8).

In cases of longer standing, especially when the lung has remained for some time in a partly collapsed condition, there may be extensive fibrosis of the lung itself. The beginning of this may be found a few weeks after the onset of empyema, in the form of fibrous tissue proliferation in the interlobular septa, commencing at their junction with the pleura and spreading inward (Fig. 11); and also in the walls of alveoli immediately beneath the pleura or

FIG. 9. Boy aged 1 year and 2 months (Case V). Right lung. Empyema of 3 weeks' duration. Organizing exudate in pleura over lower lobe; partial collapse of lung at base; multiple areas of infarction (A) and of pneumonic consolidation in upper lobe.

adjacent to thickened septa. In more advanced cases this chronic interstitial pneumonia may lead to an almost complete obliteration of the air-containing lung tissue. Interlobular septa, enormously broadened by the growth of new fibrous tissue in them, pass in from a greatly thickened pleura and divide the lung substance into widely separated lobules, in which the alveoli are more or less completely collapsed and show a variable amount of fibrous thickening of their walls. Fibrosis of the alveolar walls is, however, sometimes less striking than might be expected. The constant outstanding feature of pleurogenic fibrosis of the lung would appear to be the immense thickening of the septa which, together with the thickened pleura, effectively prevents the normal expansion of the lung.

ABSTRACTS OF CASES ILLUSTRATED.

CASE II (Fig. 3, 4 and 8). *Left-sided empyema, complicating acute broncho pneumonia.* Female, aged 1 year and 9 months. Died 3 weeks after onset of illness, and 3 days after admission to hospital. Pus (pneumococcal) removed by syringe from left pleura on day before and day after admission. On *post-mortem* examination, large quantity of thick yellow pus in left pleural sac; whole pleura covered with thick fibrino-purulent exudate with exception of medial surface where loose adhesions were present. Left lung collapsed and airless; several small abscesses in lower lobe, one immediately under pleura and in relation to empyema cavity. Right pleura healthy. Right lung emphysematous, with recent acute broncho-pneumonia; strip of consolidation along medial border. Tracheo-bronchial glands swollen and soft. *Microscopically*, degree of organization and formation of young fibrous tissue in left visceral pleura surprisingly

FIG. 10. Pleura from empyema of about 10 week's duration. Girl aged 1 year and 5 months (Case VI). To show thickening of pleura with well-formed vascular fibrous tissue.

FIG. 11. To illustrate pleurogenic fibrosis. Empyema said to be of 6 weeks' duration. Boy aged 1 year and 8 months (Case VII). (A) Pleura with increase of fibrous tissue. (B) Thickened interlobular septa. (C) Collapsed lung.

advanced for an inflammation of 3 weeks' duration; marked bronchitis in left lung, suppurative in lower lobe; several small abscesses of bronchial origin in infero-medial portion; combination of collapse and consolidation in lung substance.

CASE III, (Fig. 2, 5 and 6). *Right-sided empyema, complicating broncho-pneumonia.* Female, aged 9 months. Died some 5½ weeks after onset of illness and 10 days after admission to hospital. Pus (pneumococcal) removed by syringe on two occasions while in hospital. X-ray photograph (Fig. 2), taken on day before death, of considerable interest because of displacement of heart to affected side. On *post-mortem* examination, more than half a pint of greenish-yellow pus in large pocket on lateral aspect of right lung; remainder of pleural sac obliterated by recently organized adhesions. Right lung collapsed and compressed against mediastinal tissues; projecting sub-pleural abscess on infero-medial aspect; smaller abscess in substance of lower lobe. Left pleura healthy. Left lung very markedly emphysematous, almost completely over-lapping

heart; bronchitis and small areas of broncho-pneumonia present, especially in lower lobe. *Microscopically*, great thickening of right pleura in relation to empyema cavity seen to be due mainly to well-advanced organization. Bronchi throughout right lung inflamed, with thick cellular walls denuded of lining epithelium; abscess in substance of lower lobe, referred to above, obviously of bronchial origin; solid condition of right lung due largely to collapse, but very definite broncho-pneumonic element also evident.

The displacement of the heart to the affected side in this case, illustrated in the X-ray photograph, must be ascribed, in part at any rate, to the push of the markedly emphysematous functioning left lung. There is no question of its being the result of traction by a fibrosed right lung, as the illness was too short to allow of the necessary degree of fibrosis, and, in any case, microscopic examination effectually rules out the possibility. It is of interest in connection with the recent observations of Tallermann and Jupe⁸.

CASE IV, (Fig. 7). *Fulminating pneumonia, of septic type, with early empyema*. Boy, aged one month; twin; full-time; breast-fed. Illness said to have been of only 36 hours' duration; convulsions the most prominent feature. On *post-mortem* examination, about an ounce of turbid blood-stained fluid in right pleura. Right lower lobe solid and of a deep red colour, with certain areas in process of undergoing softening. Left pleura inflamed in patches but without any fluid content. Left lower lobe less completely consolidated than right, but also hæmorrhagic and the site of breaking-down pneumonic areas. *Microscopically*, essential condition seen to be broncho-pneumonia of a very acute septic type, but consolidation contributed to by hæmorrhage and necrosis; suppurative lymphangitis a prominent feature.

CASE V, (Fig. 9). *Right-sided empyema, complicating pneumonia with septic infarction*. Male, aged 1 year and 2 months. Died 3½ weeks after onset of illness and 12 days after admission to hospital. Clinically, regarded as case of lobar pneumonia, at first of right upper and later of left lower lobe. Cerebral symptoms prominent. Empyema (pneumococcal) detected on right side 6 days after admission, i.e., 2½ weeks after beginning of illness; treated by repeated aspiration. On *post-mortem* examination, not much pus, but very thick fibrino-purulent exudate in lower part of right pleural sac. Right upper lobe extensively consolidated, as a result partly of pneumonia and partly of necrosis; several independent areas of latter, some of them becoming purulent. Small abscesses also present in middle lobe. Mixture of pneumonia and collapse in infero-lateral part of right lower lobe. Left pleura acutely inflamed over lower lobe: no free fluid. Large patch of pneumonia of alveolar type in left lower lobe. *Microscopically*, commencing organization of copious pleural exudate on right side; type of pneumonia in right upper lobe difficult of definition, as septic infarction so widespread. Necrosis regarded as having developed in pneumonic lung as a result of infection of vessel walls from perivascular tissues, and consequent thrombosis.

CASE VI, (Fig. 10). *Long-standing left-sided empyema*. Female, aged 1 year and a half. Illness of about 11 weeks' duration. Main incidence of pneumonia said to be at first in right lung, later in left. Admitted 3 weeks after onset of symptoms, with left-sided empyema (pneumococcal). Treated by repeated aspiration and then by drainage through cannula inserted between ribs. Progress fairly satisfactory for some weeks. Severe constitutional symptoms and jaundice before death. On *post-mortem* examination, left pleural sac largely obliterated by dense organized adhesions; drainage opening communicating with relatively small unobliterated pocket; abscess in chest wall in relation to drainage opening. Left lung much collapsed; remnants of broncho-pneumonic process in substance; bronchi slightly dilated and filled with pus. Recent acute pleurisy with effusion on right side. Small scattered patches of consolidation and softening in right lung, more suggestive of blood-borne than air-passaged infection. Profound toxic changes in organs, especially liver. Death regarded as result of terminal septicæmia.

CASE VII (Fig. 11). *Left-sided empyema: original pneumonia probably broncho-pneumonia*. Male, aged 1 year and 8 months. Died after an illness which, so far as could be ascertained, lasted about 6 weeks. Admitted 3 weeks after onset. Empyema suspected but not discovered till a week later; aspirated on two occasions and then drained by rib-resection. Cavity not large and drainage apparently complete. Constitutional disturbance continued, however, and death occurred about a week after operation. On *post-mortem* examination, left pleural sac obliterated by dense fibrous adhesions except at point of drainage, where small empty cavity

remained. Left lung partially collapsed, but not pneumonic. Right pleura acutely inflamed. No pneumonia obvious in right lung. Early acute pericarditis and peritonitis. Pronounced toxic changes in organs. *Microscopically*, right pleura greatly thickened by well-organized fibrous tissue: interlobular septa in relation to pleura also markedly thickened. Intervening lung substance collapsed. Surprising degree of fibrosis in pleura and stroma of lung, for inflammation of 6 weeks' duration. Death, as in last case, due to septicaemia.

SUMMARY.

A short survey of 89 clinical and 69 post-mortem cases of empyema in children is presented. Figures are given showing age incidence, mortality, associated types of pneumonia, and frequency and situation of localised collections of pus. The association of empyema with lung abscess, pulmonary fibrosis, and certain other complications is briefly discussed.

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ACKNOWLEDGMENTS.

In connection with this series of studies of pneumonia and its complications in childhood, we wish to express our indebtedness to:—The Committee of the Laboratory of the Royal College of Physicians, Edinburgh; Lieut.-Col. A. G. McKendrick, superintendent of the Laboratory; the late Dr. J. W. Dawson and Lieut.-Col. W. F. Harvey, in whose department most of the technical work was carried out; Mr. T. D. Hamilton, who prepared the very beautiful large sections with which we worked, and who was also responsible for the photographs; Dr. Norman Carmichael and Dr. Lewis Thatcher, for permission to refer to and illustrate certain of their cases; Professor J. Lorrain Smith, for his sympathetic interest and helpful and suggestive criticisms; the Carnegie Trust for a grant to one of us; and the very kind friend, who prefers to remain anonymous, whose generosity has defrayed the expenses of this research.