EMPYEMA THORACIS IN INFANTS AND CHILDREN*

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Introduction

Although empyema thoracis was known to Hippocrates, there was no real advancement in treatment until the middle of the nineteenth century. Roe (1844) introduced repeated aspiration instead of simple incision by knife or cautery when the *necessitas* state had been reached. Intercostal drainage was soon to supersede this method (Goodfellow and de Morgan, 1859), which in turn gave way to rib resection, accredited to various persons, including Walter (1860) and Roser (1865). With improved technique the latter method gave better results and became the standard method of treatment. A setback was experienced in the war of 1914-18, when a change in the causal bacterium occurred. An alarming death rate was responsible for the formation of the Empyema Commission (1918), whose findings still form the basis of treatment to this day. With modified methods and improved technique mortality rates were soon reduced except in children, especially during the first two years of life. This feature is revealed in the many recorded series of cases of empyema occurring in children. Brown, J. P. (1923) reviewed 250 empyemata in children. The cases were admissions in the Children's Hospital, Philadelphia, from 1906-22. A general mortality rate following rib resection was 21.5 per cent., and after intercostal drainage was 40.3 per cent. The mortality in the first year of life was appalling.

The position was discussed at a British Medical Association Conference in London, 1925. Cameron and others emphasized that the early years of life carried a grave prognosis whenever empyema was diagnosed. Of fatal cases, many were shown to have synpneumonic empyemata. Additional serious lesions were frequently present, e.g. pericarditis and mastoiditis, and this feature was found to indicate a slender chance of survival. Strong support was given to the policy of aspiration in the case of synpneumonic empyema. No surgical interference was

recommended until the active pneumonic process had resolved.

Osman and Cameron (1925) reported the details of fifty-two empyemata in children, all under two years of age. No fewer than thirty-nine children died, and of the thirteen recoveries only one had a synpneumonic type of empyema. The mortality rates were: under 1 year, 66 per cent.; from 1 to 2 years, 50 per cent. Further facts were recorded by Spence, R. C. (1920). He had studied 204 cases of empyema in children under three years of age. The general mortality rate was 44.6 per cent. Sixty-four per cent. of children died in the first year, and 50 per cent. between 1 and 2 years of age. It was shown that the mortality rate decreased with increasing age. Similar findings were noted in the cases of Ladd and Cutler (1924), Farr and Levine (1928), Reinhoff and Davison (1928) and Heuer (1932).

C. R. Steinke (1935) reviewed the literature to date, and recorded 310 cases of his own. These cases were divided according to the different bacteriological groups, and the mortality figures showed that the pneumococcal cases carried the least mortality, while those due to the staphylococcus were most lethal.

Hochberg (1941) stressed the value of closed intercostal drainage in large seropurulent effusion, especially when aspiration had failed to relieve respiratory distress. He also pointed out the risk of infecting the chest wall by repeated aspiration, especially in staphylococcal cases. When reporting a series of 474 surgically treated cases of empyema, Lanman and Dimmler (1941) noted a reduced mortality with improved surgical technique. As the cases covered the period 1919-39, it is significant that they had noticed a marked reduction in the incidence of empyema since the use of sulphonamides in the treatment of pneumonia in 1938.

In the present paper cases of empyema are studied for two five-year periods, 1934-38 and 1940-44, and by comparison the effect of the sulphonamide groups of drugs upon the incidence of empyema is shown. With the relative increase in cases due

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to the staphylococcus aureus, an account of staphylococcal pneumonia and empyema is given. Since penicillin became available for general use in January, 1945, a new phase in the treatment of empyema caused by sensitive organisms has been opened. In section II of this paper the use of penicillin in staphylococcal and sulphonamide resistant pneumonia is discussed, and a collected series of twenty-one cases of empyema treated with penicillin reviewed, illustrating the improved prospects in the most critical age group, namely, in the first two years of life.

PART I

EFFECT OF SULPHONAMIDES ON THE INCIDENCE, MORTALITY RATES, AND BACTERIOLOGICAL FINDINGS IN EMPYEMA THORACIS OCCURRING IN INFANTS AND CHILDREN

The admissions of empyemata in children and infants have been studied for the period 1934-44 inclusive. These admissions (totalling 275) were to a large general hospital in the City of Birmingham, and represent all cases of post-pneumonic empyema without selection. Cases have been segregated in each year according to age, and according to the bacterial agent responsible. Mortality rates are also given. The period 1934-38 is taken as a five-year period in which sulphonamide drugs were not used in the treatment of acute pneumonia. The year 1939 is omitted, as in this year accurate details are lacking about the proportion of cases treated with and without sulphonamides. The period 1940-44 represents the five-year 'sulphonamide' period, which is compared with the 1934-38 period in order to assess the effects of sulphonamide drugs upon the incidence of empyema as a complication of acute pneumonia in children and infants.

The admissions of acute pneumonia to the hospital have been studied, and, when the same two periods are compared, it is found that the reduction in the admissions in the second five-year period is responsible only to a slight degree for the actual reduction in the numbers of empyemata. The most important factor is undoubtedly the sulphonamide therapy.

Appendix A includes yearly tables showing details of the numbers of empyemata at the various ages, with the bacteriological types. The yearly figures are then combined into two tables, one showing the whole age group covered, 0 to 14 years, and another the selected age group of 0 to 2 years, which is the most critical group when considered in regard to mortality rate.

Discussion of Tables

From a study of the tables in Appendix A it will be seen that although the admissions of acute pneumonia for the two five-year periods show a fall (from 2,067 to 1,686), by comparison the reduction of the empyema incidence is much more pronounced (from 192 to 63). A large part of this reduction is due to the effect of sulphonamide therapy upon the clinical course of acute pneumonia. The effect on the pneumococcal and streptococcal types is most striking, but the effect upon the staphylococcal cases is noticeable only in the group over two years of age. There appears to be little or no change either upon the incidence or mortality in the group 2 years of age and under.

The increased mortality rate in the sulphonamide cases is difficult to explain accurately. Some cases were extremely ill on admission, and it is probable that, of these, a number were inadequately treated with sulphonamides. The post-mortem examinations not infrequently revealed lesions other than empyemata. Pericarditis occurred in two cases, the empyema was bilateral in one case, meningitis occurred in one case, and congenital pyloric stenosis was present in another. Post-mortem examinations were not carried out on all fatal cases.

The effect upon the staphylococcal cases is shown to be fairly adequate control of the pneumonic process in the group 2 to 14 years. This effect is lacking in the under 2 years group, and this fact is of great importance, since now the incidence of staphylococcal empyema is at least as great, if not greater, than the pneumococcal types. In the cases 2 years and under a general mortality rate of some 64 per cent. exists, indicating that empyema in a child of 2 years of age is a serious condition, whatever the causal organisms.

Summary of Conclusions

A study of the tables in Appendix A shows the following results obtained over the period 1934-45:

1. Reduction in pneumococcal and streptococcal empyemata in children and infants.
2. Reduction of staphylococcal empyemata in children of 2 to 14 years; little or no effect either on the number of cases or mortality in the group 0 to 2 years.
3. Staphylococcal cases are at least as frequent, if not slightly more frequent, than pneumococcal cases in the group 0 to 2 years.
4. A general mortality rate in the 0 to 2 years group for all bacterial types is 64 per cent.

Staphylococcal Pneumonia and Empyema

Because of the increasing importance of pneumonia and empyema due to the *Staphylococcus aureus*, a review of these conditions is now included.

The *Staphylococcus aureus* has long been known as a secondary invading organism in influenza epidemics. Chickering and Park (1919) reported a series of 155 cases of this type. The mortality rate was appalling, and only two of the patients recovered. Of the 153 fatal cases, a frequent post-mortem finding was the occurrence of multiple abscesses in the pneumonic areas. Cultures revealed the *Staphylococcus aureus*.

The recognition of a primary staphylococcal pneumonia was largely due to the efforts of Reimann, H. A. (1933), who described six cases of primary staphylococcal pneumonia in children. Of two fatalities in this short series, one occurred in an infant. He stated that the clinical picture was suggested in pneumonia cases by the following features: (1) the severity of the illness, (2) the occurrence of rigors, (3) sweating, (4) a remittent septic temperature, and (5) a very high polymorphonuclear-leucocytosis. To these clinical observations is now added sulphonamide resistance, which also helps in the diagnosis. The examination of the sputum or lung puncture specimen may help in the diagnosis, but often the results are not conclusive. The difficulty of obtaining sputum from infants or children frequently renders the specimen of little value; and lung puncture is not without risk, particularly in staphylococcal cases. In adults, sputum examination is reliable and shows *Staphylococcus aureus* as the predominating organism. Reimann suggests that the *Staphylococcus aureus*, a normal inhabitant of the respiratory tract, becomes active when resistance is lowered by influenza, malnutrition, or some chronic disease, e.g. nephritis.

In most reported series of empyemata in children, it was the custom to record the number of cases due to the different bacteria responsible. Although cases of empyemata produced by the *Staphylococcus aureus* were often included, the significance of the relatively large numbers of such cases was not stressed until 1935.

Neuhof and Berck (1935) noted the high incidence of empyemata due to the *Staphylococcus aureus* in infants. The lesion, which often lead to pleural spread, was recognized as the sub-pleural abscess. This lesion was seen in many fatal cases. Smith, C. M. (1935), has described four cases of fulminating pneumonia in infants in a maternity block. All were due to the *Staphylococcus aureus* and were the probable result of a carrier state of *Staphylococcus aureus* amongst the staff and children.

MacGregor, A. R. (1936), in a detailed account of ten post-mortem examinations, supports the claim of Reimann that a true primary staphylococcal pneumonia does exist. Full reports of ten fatal cases of staphylococcal pneumonia are given. The cases occurred between August, 1935, and May, 1936. All cases were in children, the ages being

from sixteen days to three and a half years, and eight were children of under one year. In four cases sero-fibrinous pleurisy had occurred, culture revealing the presence of *Staphylococcus aureus*. Six cases had definite empyemata, and of these three showed pyopneumothorax. All cases showed the lung as the primary focus of staphylococcal infection. Mixed organisms were found only when broncho-pleural fistula had occurred. In these cases the *Staphylococcus aureus* was the predominating organism. Lesions were frequently related to one lobe of a lung. They were usually small, often surrounded by a haemorrhagic zone, and the centre of the area was red or yellow according to the duration of the lesion. In some cases liquefaction to pus had occurred. Sections of the affected area showed the bronchial route as the mode of entry, and the bronchus was often occluded in the pneumonic process. Adjacent bronchi showed inflammatory reaction, but this was not generalized in the remainder of the lungs. When the process passed to suppuration the result depended largely on the position of the pneumonic area. Rupture into the pleura was common, and in three cases a patent bronchus was also eroded, when a broncho-pleural fistula resulted. One of the cases was related to the inhalation of milk.

Since MacGregor's excellent report appeared there have been frequent references to the condition in the journals of children's diseases, and much attention has been given to this subject, in American journals in particular. Hochberg and Kramer (1939) reviewed 300 cases of empyemata in children and infants. In this series of cases thirty-three due to the *Staphylococcus aureus* were included. Thirteen deaths occurred in all (40 per cent. mortality), and cases two years and under numbered seventeen, with eight deaths, 47 per cent. mortality.

Amongst the 300 cases discussed, 255 are presented with full details of the causal organisms. These cases may be compared with those now presented which occur in the 1934-38 period (table 1), and a similarity of the relative frequency of staphylococcal cases is shown, although a lower mortality rate is present in the series of Hochberg and Kramer.

TABLE 1
COMPARISON BETWEEN HOCHBERG AND KRAMER'S AND CHAPLIN'S CASES

	0-15 years	Deaths	0-2 years	Deaths	% Incidence 0-15	0-2
Hochberg and Kramer	33	13	17	8	13	24
Mortality	40%		47%			
	0-14 years	Deaths	0-2 years	Deaths	% Incidence 0-14	0-2
A. E. Chaplin ..	23	11	14	9	12	20
Mortality	48%		64%			

In the same year Kanof, et al. (1939), reported a mixed series of primary and secondary staphylococcal empyemata. Twenty-five cases of primary empyemata were included in a total of thirty-seven. Sixteen of the primary cases occurred in the group one year and younger, with eleven deaths (70 per cent. mortality). Hochberg and Steiner (1940) showed the high incidence of staphylococcal cases in a report of the post-mortem findings on nineteen fatal cases of empyemata. All the patients were infants of three months age or less, and bacteriological data was included for twelve of this group: eight of the twelve were due to the *Staphylococcus aureus*.

In a research into post-mortem specimens, Gaspar (1941) found that in pneumonia in children at least 25 per cent. of cases were caused by the *Staphylococcus aureus*. Clemens, H. H., and Weens, H. S. (1942), pointed out that pyopneumothorax was a frequent complication in this particular type of empyema, and noted its occurrence in four out of six fatal cases reported.

Details of a single case of Staphylococcal pneumonia showing resistance to sulphonamide therapy was described by Genninger (1943). The development of empyema, a description of the fatal outcome of the case, and full details of post-mortem findings are given. The empyema was the sequel to the rupture of a sub-pleural abscess in the pneumonic area.

In a further series of surgically treated cases (primary and secondary in type), Ladd and Swan (1943) reported seventeen primary cases, all of one year and under, in which seven deaths occurred. (The seven fatal cases were aged four months or younger.)

A review of twenty-nine cases of staphylococcal empyema admitted to a babies' hospital from 1922 to 1942 was made by Riley (1944). Nine, with five deaths (55 per cent. mortality), occurred in the pre-sulphonamide era; between 1938 and 1942 there were twenty, with five deaths (25 per cent. mortality). In this series a relative increase in the occurrence of staphylococcal cases was noted in the sulphonamide era, this fact agreeing with the figures presented previously.

TABLE 2

SUMMARY OF FIVE SERIES OF CASES OF EMPYEMA

Authors	Cases	Deaths
Hochberg and Kramer, 1939 ..	33	13
Kanof, Kramer, and Carnes, 1939 ..	16	11
Clemens and Weens, 1942 ..	6	6
Ladd and Swan, 1943 ..	33	18
Riley, 1944 ..	29	10
Totals	117	58 (49.5%)

All the authors stress the seriousness of the condition, particularly when it occurs in children of two years and younger. In the first six months of life the prognosis is extremely poor. American observers have sought to link these facts with experimental findings. Kobak and Pilot (1931) have shown that newborn children fail to give positive reactions to intradermal injections of staphylococcal filtrate. A gradual increase in positive reactions was noted, until at one year 75 per cent. of children reacted.

It has also been noted that, although a high anti-haemolysin is present at birth, there is a rapid fall, with none detectable at the age of two months. A gradual rise in titre occurs from this period onwards (Bryce and Burnett, 1932). It is probable that these findings have some importance in determining the seriousness of the disease at the age group mentioned.

TABLE 3

SUMMARY OF CASES UNDER TWO YEARS IN FOUR SERIES OF CASES OF EMPYEMA

Authors	Cases	Deaths	Age
Hochberg and Kramer, 1939.	17	8	0-2 years
Kanof, Kramer and Carnes, 1939.	16	11	0-1 year
Ladd and Swan, 1943	17	7	0-1 "
Riley, 1944 ..	22	8	0-1 "
Total	72	34 (47.2%)	

TABLE 4

STAPHYLOCOCCAL CASES IN THE PRESENT SERIES

Year	0-14 years	Deaths	0-2 years	Deaths
1934	5	2	3	2
1935	3	2	3	2
1936	4	2	2	1
1937	5	2	3	2
1938	6	3	3	2
Total	23	11	14	9
1939	2	1	2	1
1940	2	2	2	2
1941	5	3	4	3
1942	4	3	4	3
1943	4	2	4	2
1944	3	1	3	1
Total	18	11	17	11
Jan. 1945	2	2	2	2
Total Cases	45	25 (55.5%)	35	23 (64.5%)

Table 2 gives a summary of the above-mentioned series. The mortality (49.5 per cent.) is somewhat lower than the mortality rate in the series now presented, i.e., forty-five cases, twenty-five deaths, mortality 55.5 per cent.

In the present survey forty-five cases of staphylococcal empyemata are reviewed, these comprising all admissions of this type from 1934 to January, 1945, and they are included in the author's general list previously reviewed. These forty-five cases are the two groups of presulphonamide and sulphonamide cases. Thirty-five are cases under two years of age, and in this group twenty-three deaths occurred, a mortality of 64.5 per cent. This figure shows an increase when compared with the cases under two years of age in the previously mentioned series (table 3). Table 4 shows the details of the pre-penicillin staphylococcal cases in the present series.

PART II

USE OF PENICILLIN IN THE TREATMENT OF SULPHONAMIDE-RESISTANT PNEUMONIA, AND IN EMPHYEMA THORACIS DUE TO PENICILLIN-SENSITIVE ORGANISMS

With the discovery of penicillin by Fleming (1929), and its subsequent extraction by Chain, Florey, et al. (1940), at Oxford, an antibiotic became available for use in treatment of infections due to penicillin-sensitive organisms. Following the early clinical trials of Abrahams et al. (1941), and Florey and Florey (1943), the value of this new therapeutic agent was clearly established. Since empyemata following acute pneumonia are frequently produced by sensitive organisms, it is not surprising that penicillin has been used in the treatment of such cases. The staphylococcus, streptococcus, and pneumococcus are usually sensitive to penicillin, and hopes were held of its successful application in the treatment of empyemata due to these organisms. With the high mortality in the cases occurring in the first two years of life, and since the organism most commonly met at this period was the *Staphylococcus aureus*, it was felt that penicillin would play an important part in the treatment of such cases, particularly when this organism usually is sulphonamide-resistant.

In the days when penicillin was in short supply, cases that could be treated by local application were preferred to cases requiring systemic administration. Christie and Garrod (1944) mentioned sixteen cases of empyema in which one or two injections of 15-30,000 units of penicillin was all that was required to sterilize the pus in the pleural cavity. A marked reduction in the general toxicity was noticed. Butler, Perry and Valentine (1944) in a

paper on the treatment of acute empyema with penicillin, confirmed the belief of Christie and Garrod that sterilization of the pleural pus made a consequent reduction in general toxæmia of the patient. They found, in treating seventeen cases of acute empyema, that it was not possible to cure these patients by aspiration and penicillin instillation alone. Rib resection was required to evacuate a sterile abscess. The removal of fibrin was necessary to prevent thickened pleura and deformity of the chest wall. These facts were confirmed by Keefer et al. (1943), Bennett and Parkes (1944), Dawson and Holly (1944), Herrell (1944), and Bloomfield et al. (1944).

The prophylactic instillation of penicillin in chest injuries with hæmothorax was found by D'Abreu et al. (1944) to be of great value; frequently the sepsis was controlled with aspiration alone, and operation was avoided in some instances. Dawson and Holly (1944) included one case, an adult woman with an acute empyema due to the *Staphylococcus aureus*. She received intrapleural and systemic penicillin, and no surgical interference was necessary. Keefer et al. (1943) found it necessary to have a rib resection performed in seven out of nine cases treated with penicillin. They also found that penicillin could not be detected in the pleural cavity after large systemic doses had been administered.

Bennett and Parkes (1944) noted the excellent response of post-influenzal staphylococcal pneumonia to penicillin. The cure of an infant of ten months with a staphylococcal empyema by intrapleural and systemic penicillin was also included. This case had some residual thickened pleura, however. Some cases of staphylococcal pneumonia do respond to sulphonamides, as was shown by Michael (1942), who reported three recoveries in five cases of post-influenzal staphylococcal pneumonia when sulphadiazine was used. McBride (1944) reports the successful use of penicillin in two cases of staphylococcal pneumonia in infants. One child was four weeks old, the other five weeks, and both were desperately ill with pneumonia. No response was made to sulphonamides, but dramatic recoveries occurred when systemic penicillin was given.

The treatment of acute empyemata in children and infants presents an urgent problem. With such a high mortality due to all types of organisms it is not surprising that penicillin has been used extensively in treatment.

Gairdner (1944) reports a single case of pyopneumothorax due to *Staphylococcus aureus* in an infant. Pyæmia had followed intravenous infusion

of saline. This infant, although only four weeks old, recovered with intercostal drainage and heavy doses of sulphathiazole, and its recovery without penicillin is remarkable. Philips and Kramer (1945) reported five cases of empyema due to *Staphylococcus aureus* in infants of under one year of age. All cases received intrapleural and systemic penicillin, and only one death occurred. The fatal case was a child almost moribund on admission. Of the four cases which recovered, two were treated by aspiration alone, but the other two required surgical drainage to secure a good result, even though the pus had been sterilized.

Harris and Platou (1945) recorded a successfully treated case of pyopneumothorax in a premature baby twenty days old (a four-weeks premature Caesarian baby). When taken ill with pneumonia the response to both sulphadiazine and sulphamezathine was disappointing, and the child was gravely ill. After seven days' illness a pyopneumothorax was discovered, and the causal organism was the *Staphylococcus aureus*. Intrapleural penicillin (four occasions, 3,000 units) and systemic penicillin were sufficient to produce a complete recovery without surgical interference.

The difficulty experienced when aspiration is attempted as the sole method of interference is due to fibrin present in the pus blocking the lumen of the needle. The excessive fibrin production may be explained as a result of the experimental work of Dixon (1945). He discovered that although the *staphylococcus* normally produces two ferments, a coagulase and a fibrinolysin, in the presence of penicillin the second ferment is not liberated, although coagulase is still produced. Thus it is probable that a much slower absorption of fibrin occurs due to the absence of fibrinolysin.

Twenty-one Cases of Acute Empyema in Infants and Children Treated with Penicillin

The author has collected from three Birmingham hospitals a series of twenty-one children and infants with empyema; all received intrapleural penicillin therapy, and some were surgically drained as well. The causal organism in each case was duly tested for penicillin sensitivity, and all were found to be sensitive. One fatal case occurred, and at post-mortem examination the lung was expanded and normally aerated, and the surface of the lung was covered only by a thin layer of fibrin. Table 5 tabulates the cases according to age and bacteria responsible, and Appendix B gives details of cases.

This short series of cases further confirms the belief previously expressed, of the frequency of staphylococcal empyemata in the first two years of life. It is particularly significant that all cases under six months of age were due to this organism.

TABLE 5
THE PRESENT SERIES TABULATED ACCORDING TO AGE AND BACTERIA RESPONSIBLE

Age	No. of cases	Staph'l.	Pneumo'l.	Strept.
0-6 months ..	5	5	0	0
6-12 months ..	4	2	2	0
1-2 years ..	7	3	3	1
Over 2 years ..	5	2	3	0
Totals ..	21	12	8	1

MORTALITY RATE. From consideration of the five-year period of sulphonamide therapy, a general mortality figure of 60 per cent. was to be expected for the first two years of life, but in all the penicillin cases now presented only one fatality occurred (case 5). This patient was a child of four months of age who had its empyema treated by aspiration and penicillin instillation. The organism responsible was the *Staphylococcus aureus*. The case was complicated from the commencement by the presence of bilateral otitis media, and although the empyema was satisfactorily treated, the child developed bilateral mastoiditis and died from a severe gastro-enteritis. This terminal condition was not relieved either by operative interference to the mastoiditis, or by saline infusion. Post-mortem examination confirmed the clinical belief that the empyema had been treated adequately. The affected lung was re-aerated and was covered only by a thin fibrinous exudate. It could be claimed, therefore, that the empyema had been satisfactorily treated by penicillin, which had been given by the systemic route and by intrapleural injection.

CASES TREATED BY ASPIRATION ENTIRELY. In view of the reported difficulty experienced in securing complete resolution of an empyema by aspiration alone, it is significant that this method was successful in eight cases. One of these patients probably had a small interlobar collection of pus (case 17) and this case, while still in hospital, appears to be recovering satisfactorily. Case 21 had pus aspirated from the chest on one occasion only, and the empyema must have been small and localized. The other six cases (5, 6, 7, 8, 9, and 16), all had repeated aspiration of the pus in the pleural cavity and received both systemic and intrapleural penicillin. It is possibly significant that all except one of these latter six cases were under one year of age. This one case (case 8), although successfully treated by this method, had some thickening of the pleurae with a flattening of the corresponding side of the chest.

CASES NEEDING SURGICAL INTERFERENCE. In case 10, because of difficulty in deciding whether the

empyema had been completely dealt with, a rib resection was carried out; and, although no pus was discovered, a fair amount of free fibrin in a serous fluid was present, and also considerable thickening of the pleura. When the fibrin was removed, a short period of drainage was all that was necessary before the wound healed completely.

An example is presented by case 11, which illustrates the probable result of persistence with aspiration and penicillin instillation, although the size of the empyema remains stationary and the physical signs in the chest do not improve. Three weeks of such treatment had produced, in this particular case, marked flattening of the affected side of the chest and a scoliosis to the opposite side. The cause of this failure was revealed at operation. The chronic empyema, although sterile, contained one pint of pus and half a pint of fibrin, and both visceral and parietal pleurae were covered with a thick layer of fibrin. The empyema was treated by decortication and the cavity drained. The wound rapidly healed, but the deformity is still present, and the ultimate outlook remains uncertain. It is not unreasonable to assume that similar cases would need thoracoplasty to obliterate a cavity which the lung, because of the thickened pleura, is unable to expand and fill.

All the remaining patients were treated either by rib resection or intercostal drainage, after preliminary penicillin therapy had greatly improved their general condition. This treatment often resulted in the early sterilization of the pleural pus. Surgical drainage was usually followed by a speedy convalescence and rapid healing of the chest wound. Re-expansion of the lung was early and complete. Systemic penicillin given post-operatively appeared to help in producing an early cessation of discharge from the pleural cavity. This favourable result agrees with the experience of Roberts et al. (1945), who reported the necessity of surgical interference in the treatment of acute empyema in adults. Penicillin had failed to cure the empyema completely, and a sterile collection of pus had to be evacuated from the chest in most cases.

In twelve out of thirteen patients in the present series who received surgical treatment as well as penicillin therapy, details are available of the time taken for complete healing of the chest wound. (One case remains in hospital with a drainage tube still present.) The average time for complete healing was 5.5 weeks, which is an extremely satisfactory result.

Failure of aspiration alone to cure thirteen out of the twenty-one patients agrees with the experience of Butler et al. (1944), Keefer et al. (1943) and Roberts et al. (1945). The extremely low mortality rate in this series of cases confirms the hope expressed by Philips and Kramer (1945) of a marked improvement due to the application of penicillin therapy. Dosages of penicillin for the interpleural route, instead of from 10,000 to 30,000 units, should be

somewhat higher, according to the recommendations of Keefer et al. (1945).

RADIOGRAPHS. Eight radiographs, from three of the patients in this series, are reproduced. A case is illustrated from each of the two groups, i.e., aspiration alone, and aspiration followed by surgical drainage. Films at the commencement of treatment and at the end of treatment are shown to illustrate the good result in each type of case. In the surgically treated case an additional intermediate film is included, showing the drainage tube in situ. Three radiographs are included from case 11. The first illustrates the condition of the chest at the commencement of penicillin therapy, the second shows the failure of penicillin with aspiration to produce resolution of the empyema. Scoliosis and flattening of the chest have developed. The third film shows the improvement brought about by decortication of the empyema following resection of portions of two ribs. (See Plates VI and VII.)

BACTERIOLOGY. When the patients are reviewed with regard to the bacterium responsible, apart from the bacteriological examination of the pus, only slender clinical features help in differentiation of the cases. The onset of the empyema is not conclusive in suggesting a particular bacterium to be responsible, but the occurrence of an empyema within the first week of illness suggests the *Staphylococcus aureus* as the probable cause. This is illustrated by cases 7, 8, 9 and 14. When cases occurring in the first six months of life are studied, the staphylococcal cases predominate. In the series now under review, five cases under six months of age are included, and all were caused by this organism.

The presence of cyanosis and working alae nasi is common to all types of empyema.

It was noticed that the pus in staphylococcal cases was frequently blood-stained at the commencement, and this feature could be explained by the rupture of a sub-pleural abscess into the pleural cavity accompanied by a small amount of haemorrhage.

Resistance of the pneumonic state to sulphonamides does not necessarily mean that the staphylococcus is the causal organism, although that is often the case. In the series now presented, two cases showing marked resistance to sulphonamide subsequently developed pneumococcal empyemata (cases 18 and 19).

A feature common to all bacterial types in the twenty-one cases was the excellent response to penicillin therapy. Although a 60 per cent. mortality rate existed in the pre-penicillin era in cases two years of age and under, in the present series no fewer than sixteen fall within this age group, with only one fatality. In this fatal case the lung lesion and empyema had been cured, the cause of death being a fulminating gastro-enteritis following acute mastoiditis.

Conclusions

Penicillin plays an important part in the treatment of acute empyemata due to sensitive organisms. The penicillin is given by parenteral and intrapleural routes. Aspiration of the pleural pus, with instillation of an adequate dose of penicillin every two to three days, may produce complete resolution of the empyema in cases up to one year of age.

From one year onwards, success by this method is unlikely, unless the empyema is small. The aspirations are controlled by frequent radiographic examination; and, should the response of the case be slow, with possible development of a thickened pleura, surgical drainage is indicated. Similar interference is indicated when fibrin in the pus prevents adequate removal by aspiration. The intrapleural injection of penicillin should produce sterility of the pleural pus after one or two aspirations.

The rapid recovery with shortened convalescence is noted in both groups of cases, i.e., with or without surgical drainage.

Features which support the probable diagnosis of staphylococcal empyema include: (1) the onset of empyema within the first week of illness; (2) a patient less than six months of age; (3) resistance of the pneumonia to sulphonamides; (4) a blood-stained specimen of pus obtained on aspiration of the pleural cavity.

Summary

1. In the introduction a general review of the literature on empyema thoracis is given. The problem of such cases in children and infants is stressed.

2. An analysis of 275 cases of empyemata in children and infants is made with regard to age, mortality, and bacteriological date. Two five-year periods, one of 'non-sulphonamide,' and the other of 'sulphonamide' therapy, are compared. The value of sulphonamides in the prevention of post-pneumonic empyemata is assessed. The resistance of staphylococcal cases to sulphonamide is shown.

3. Literature on staphylococcal pneumonia and empyema is reviewed with regard to incidence and mortality rates.

4. The use of penicillin in the treatment of sulphonamide-resistant pneumonia and in empyema due to sensitive organisms is reviewed.

5. A collected series of twenty-one cases of penicillin-treated empyemata in children and infants is presented. Good results are reported, with one fatal case in the whole series. The limitations of

treatment of acute empyema in children and infants by aspiration and penicillin alone are discussed. The need for surgical drainage in many cases is shown.

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REFERENCES

- Abrahams, E. P., et al. (1941). *Lancet*, **2**, 177.
 Bennett, T. I. and Parkes, T. (1944). *Ibid.*, **1**, 305.
 Bloomfield, A. L. et al. (1944). *J. Amer. med. Ass.* **124**, 627.
 Brown, H. P. (1923). *Ann. Surg.*, **77**, 401.
 Bryce, L. M. and Burnet, F. M. (1932). *J. Path. Bact.*, **35**, 183.
 Butler, E. C. B., Perry, K. M. A. and Valentine, F. C. O. (1944). *Brit. med. J.*, **2**, 171.
 Cameron, H. C., Souttar, H. S. et al. (1925). *Ibid.*, **3**, 331.
 Chain, E., Florey, H. W. et al. (1940). *Lancet*, **2**, 226.
 Chickering, H. T. and Park, J. H. (1919). *J. Amer. med. Ass.*, **72**, 617.
 Christie, R. V. and Garrod, L. P. (1944). *Brit. med. J.*, **1**, 513.
 Clemens, H. H. and Weens, H. S. (1942). *J. Pediat.*, **20**, 281.
 D'Abreu, et al. (1944). *Brit. J. Surg.*, **32**, 179.
 Dawson, M. H. and Holly, G. L. (1944). *J. Amer. med. Ass.*, **124**, 611.
 Dixon, K. (1945). *Brit. med. J.*, **1**, 514.
 Empyema Commission Report (1918). *J. Amer. med. Ass.*, **71**, 366.
 Farr, C. E. and Levine, M. I. (1928). *Surg. Gynec. Obstet.*, **46**, 79.
 Fleming, A. (1929). *Brit. J. exp. Path.*, **10**, 226.
 Florey, M. E. and Florey, H. W. (1943). *Lancet*, **1**, 387.
 Gairdner, P. (1944). *Brit. med. J.*, **1**, 44.
 Gaspar, I. A. (1941). *N.Y. St. J. Med.*, **41**, 834.
 Genninger, L. E. (1943). *Arch. Pediat.*, **60**, 419.
 Goodfellow, S. J. and De Morgan, C. (1859). *Med. Times Gaz.*, **1**, 659.
 Harris, E. S. and Platou, E. S. (1945). *Amer. J. Dis. Child.*, **70**, 226.
 Herrell, W. E. (1944). *J. Amer. med. Ass.*, **124**, 622.
 Heuer, G. J. (1932). *J. thorac. Surg.*, **1**, 461.
 Hippocrates, Genuine Works of. Trans. Adams. 1849. London.
 Hochberg, L. A. and Kramer, B. (1939). *Amer. J. Dis. Child.*, **57**, 1310.
 — and Steiner, M. (1940). *Arch. Pediat.*, **57**, 641.
 — (1941). *J. thorac. Surg.*, **10**, 354.
 Kanof, A., Kramer, B. and Carnes, M. (1939). *J. Pediat.*, **14**, 712.
 Keefer, C. S. et al. (1943). *J. Amer. med. Ass.*, **122**, 1217.
 — (1945). *Ibid.*, **128**, 1161.
 Kobak, A. J. and Pilot, I. (1931). *Proc. Soc. exp. Biol.*, **N.Y.**, **28**, 584.
 Ladd, W. and Cutler, G. D. (1924). *Surg. Gynec. Obstet.*, **39**, 429.
 — and Swan, H. (1943). *J. Pediat.*, **23**, 297.

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APPENDIX A
DETAILS OF CASES OF EMPHYEMA AT VARIOUS AGES

AGE (Years)	1934				1935				1936				1937				1938			
	Pneum.	Staph.	Deaths	Strap.	Pneum.	Deaths	Staph.	Deaths	Pneum.	Deaths	Strap.	Deaths	Pneum.	Deaths	Strap.	Deaths	Pneum.	Deaths	Staph.	Deaths
0-1	3	3	-	-	3	2	2	2	2	2	2	1	5	3	2	1	2	1	3	2
1-2	2	0	-	-	4	1	2	1	0	2	0	-	4	1	3	2	9	3	1	0
2-3	3	0	-	-	3	1	1	0	-	1	0	-	2	0	-	-	5	1	1	0
3-4	5	0	1	1*	3	0	-	-	2	0	1	0	2	2	-	-	2	0	-	-
4-5	4	0	-	-	2	0	1	0	-	3	0	1	2	0	-	-	4	0	1	0
5-6	6	0	-	-	2	0	1	0	-	3	0	-	2	0	-	-	5	1	1	0
6-7	3	1	-	-	3	0	-	-	-	-	1	0	1	0	-	-	4	0	-	-
7-8	2	0	-	-	2	0	-	-	-	1	0	-	1	0	-	-	1	0	1	0
8-9	1	0	1	0	1	0	-	-	1	0	-	1	1	0	-	-	1	0	1	1
9-10	1	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	0	-	-
10-11	-	-	1	0	1	0	-	-	-	-	-	-	1	0	-	-	1	0	-	-
11-12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
12-13	1	1	1	0	2	1	1	0	-	1	0	-	1	0	-	-	-	-	-	1
13-14	-	-	-	-	1	0	-	-	1	0	-	-	1	0	-	-	-	-	-	-
Total	31	5	4	1	5	2	28	5	8	3	2	2	18	4	7	2	22	6	4	5

Besides the above figures, the following cases of mixed organism, with no deaths, were reported: 1935, age 1-2 years, 1 case; age 11-12 years, 1 case; 1936, age 2-3 years, 1 case.

Age	1934			1935			1936			1937			1938		
	Total Cases	Deaths	%	Total Cases	Deaths	%	Total Cases	Deaths	%	Total Cases	Deaths	%	Total Cases	Deaths	%
0-14	40	8	20.0	41	10	24.4	30	8	26.6	33	12	36.4	48	12	25.0
2-20	8	5	62.5	16	8	50.0	11	7	63.6	17	10	58.8	18	9	50.0
All	3	2	66.6	3	2	66.6	2	1	50.0	3	2	66.6	3	2	66.6
0-2 Staph.															
A.P.	462			359			321			429			496		
E.		8.65%			11.4%			9.3%			7.7%			9.6%	

APPENDIX A (continued)

AGE (years)	1939				1940				1941				1942				1943				1944			
	Pneum.	Deaths	Staph.	Deaths	Pneum.	Deaths	Staph.	Deaths	Pneum.	Deaths	Staph.	Deaths	Pneum.	Deaths	Staph.	Deaths	Pneum.	Deaths	Staph.	Deaths	Pneum.	Deaths	Staph.	Deaths
0-1	1	0	-	-	1	1	1	1	2	1	1	1	1	1	-	4	3	1	1	1	1	1	1	3
1-2	1	0	1	0	1	0	1	1	1	0	-	1	4	2	-	-	2	1	-	1	-	-	-	-
2-3	3	0	-	-	-	1	0	-	-	-	-	1	3	3	-	-	1	0	-	-	-	2	1	-
3-4	4	0	1	0	-	-	-	-	3	0	-	-	2	0	-	-	1	0	-	-	-	-	-	-
4-5	3	1	-	-	-	-	-	-	1	0	-	-	-	-	-	-	1	0	-	-	-	-	-	-
5-6	2	0	-	-	-	-	-	-	-	-	-	-	1	0	-	-	-	-	-	-	-	-	-	-
6-7	1	1	-	-	-	-	-	-	-	-	-	-	1	0	-	-	1	0	-	-	-	-	-	-
7-8	-	-	-	-	-	-	1	0	-	-	-	-	1	0	-	-	-	-	-	-	1	0	-	-
8-10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	0	-	-
10-12	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
12-14	1	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	16	2	2	0	2	1	5	2	1	0	2	2	13	6	1	0	4	3	7	2	0	0	4	2

One fatal case of mixed organism occurred in 1943 in the age group 13-14. One non-fatal case of mixed organism occurred in 1944 in the age group 2-3 years.

AGE	1939			1940			1941			1942			1943			1944		
	Total Cases	Deaths	%	Total Cases	Deaths	%	Total Cases	Deaths	%	Total Cases	Deaths	%	Total Cases	Deaths	%	Total Cases	Deaths	%
0-14	20	3	15.0	8	4	50.0	14	6	42.8	18	9	50.0	12	5	41.7	11	4	36.3
0-2	5	1	20.0	5	4	80.0	8	5	62.5	9	6	66.6	7	4	57.1	5	3	60.0
All	2	1	50.0	2	2	100.0	4	3	75.0	4	3	75.0	4	2	50.0	3	1	33.3
Staph.																		
A.P.	347			320			400			328			372			266		
E.	5.6%			2.5%			3.5%			5.5%			3.23%			4.1%		

A.P. = Cases of acute pneumonia.

E. = Incidence of empyema.

* = + few streptococci.

APPENDIX A (continued)

SUMMARY OF ALL CASES, 1934-45

Year	Pneumo- coccal		Strepto- coccal		Staphylo- coccal		Mixed organisms		Totals	
	Cases	Deaths	Cases	Deaths	Cases	Deaths	Cases	Deaths	Cases	Deaths
1934	31	5	4	1	5	2	-	-	40	8
1935	28	5	8	3	3	2	2	0	41	10
1936	18	4	7	2	4	2	1	0	30	8
1937	22	6	6	4	5	2	-	-	33	12
1938	34	6	8	3	6	3	-	-	48	12
Total	133	26	33	13	23	11	3	0	192	50
Mor- tality	19.5%		39.4%		48.0%		-		26.0%	
1939	16	2	2	0	2	1	-	-	20	3
1940	5	2	1	0	2	2	-	-	8	4
1941	8	2	1	1	5	3	-	-	14	6
1942	13	6	1	0	4	3	-	-	18	9
1943	7	2	-	-	4	2	1	1	12	5
1944	3	1	3	2	3	1	2	0	11	4
Total	36	13	6	3	18	11	3	1	63	28
Mor- tality	36.1%		50.0%		61.1%		33.3%		44.4%	

Total cases = 275.

% Incidence

Period	Pneumo- coccal	Strepto- coccal	Staphylo- coccal	Mixed organisms
1934-8	69.2	17.2	12.0	1.6
1940-4	57.1	9.5	28.6	4.8

SUMMARY OF CASES UNDER TWO YEARS, 1934-45

Year	Pneumo- coccal		Strepto- coccal		Staphylo- coccal		Mixed organisms		Totals	
	Cases	Deaths	Cases	Deaths	Cases	Deaths	Cases	Deaths	Cases	Deaths
1934	5	3	0	0	3	2	-	-	8	5
1935	8	3	4	3	3	2	1	0	16	8
1936	7	4	2	2	2	1	-	-	11	7
1937	9	4	5	4	3	2	-	-	17	10
1938	11	4	4	3	3	2	-	-	18	9
Total	40	18	15	12	14	9	1	0	70	39
Mor- tality	45.0%		80.0%		64.3%		-		55.7%	
1939	2	0	1	0	2	1	-	-	5	1
1940	3	2	-	-	2	2	-	-	5	4
1941	3	1	1	1	4	3	-	-	8	5
1942	5	3	-	-	4	3	-	-	9	6
1943	3	2	-	-	4	2	-	-	7	5
1944	1	1	1	1	3	1	-	-	5	3
Total	15	9	2	2	17	11	-	-	34	23
Mor- tality	60.0%		100.0%		64.7%		-		67.6%	

Total cases = 109

% Incidence

Period	Pneumo- coccal	Strepto- coccal	Staphylo- coccal	Mixed organisms
1934-8	57.1	21.4	20.0	1.5
1940-4	44.1	5.9	50.0	-

EMPHYEMA INCIDENCE RATES

Year	Acute pneumonia	Emphyemata	% Incidence	Year	Acute pneumonia	Emphyemata	% Incidence
1934	462	40	8.65	1939	347	20	5.8
1935	359	41	11.4	1940	320	8	2.4
1936	321	30	9.3	1941	400	14	3.25
1937	429	33	7.7	1942	328	18	5.5
1938	496	48	9.6	1943	372	12	3.23
				1944	266	11	4.1
Total	2,067	192	9.3	Total	1,686	63	3.7

(References continued from page 34)

- Lanman, T. H. and Dimmler, C. L. (1941). *Amer. J. Surg.*, 54, 29.
- McBryde, A. (1944). *Amer. J. Dis. Child.*, 68, 271.
- MacGregor, A. R. (1936). *Arch. Dis. Child.*, 11, 195.
- Michael, M. (1942). *J. Amer. med. Ass.*, 118, 869.
- Neuhof, H. and Berck, M. (1935). *Arch. Surg.*, 30, 543.
- Osman, A. A. and Cameron, H. C. (1925). *Lancet*, 1, 1297.
- Philips, B. and Kramer, B. (1945). *J. Pediat.*, 26, 481.
- Reimann, H. A. (1933). *J. Amer. med. Ass.*, 101, 514.
- Reinhoff, W. F. and Davison, W. C. (1928). *Arch. Surg.*, 17, 676.
- Riley, C. M. (1944). *J. Pediat.*, 24, 577.
- Roberts, J. E. et al. (1945). *Lancet*, 1, 40.
- Roe, H. E. (1844). *Ibid.*, 1, 197.
- Roser, W. (1865). *Arch. Heilk.*, 6, 33.
- Smith, C. M. (1935). *Lancet*, 1, 1204.
- Spence, R. C. (1920). *Amer. J. Dis. Child.*, 20, 545.
- Steinke, C. R. (1935). *Ann. Surg.*, 101, 617.
- Walter, A. G. (1860). *Brit. med. J.*, 1, 48.

APPENDIX B.

Case No.	Age in years	Sex	Relevant history	Condition on admission	Day of onset of empyema	Organism *	Treatment
1	1 $\frac{1}{2}$	F	Ill for 7 days with cough and dyspnoea; worse for 1 day.	Well nourished; febrile, grunting respiration; impairment note, Rt. base, ? pneumonia.	14	Staphylococcus C + P.S.	Sulphonamides (resistant); aspiration and intrapleural penicillin; systemic penicillin and surgical drainage.
2	1	F	Ill for 2 days with cough and dyspnoea.	Well nourished; ill; grunting respiration; febrile; impaired note Rt. base; ? pneumonia.	8	Staphylococcus C + P.S.	Sulphonamides, good response; the empyema developed and was treated by aspiration and instillation of penicillin and, later, surgical drainage.
3	1 $\frac{3}{4}$	F	Cough and febrile for 3 days.	Well nourished; febrile; marked dyspnoea; impaired note; ? bronchial breath sounds; Rt. upper lobe.	16	Staphylococcus C + P.S.	Initial response to sulphonamides; relapse and empyema developed; aspiration and instillation of penicillin, then rib resection.
4	1 $\frac{4}{5}$	M	Cough, dyspnoea 1 day.	Well nourished; ? pneumonia right base.	10	Staphylococcus C + P.S.	Sulphonamide and penicillin—resistant pneumonia; empyema developed; initial aspiration and instillation of penicillin; rib resection (large empyema).
5	$\frac{4}{5}$	F	Cold for 1 week; febrile; wheezy chest; off feeds; otitis media (bilateral) 12 days before onset of present illness.	Fairly well nourished; febrile; acute upper respiratory infection and bilateral otitis media.	23	Staphylococcus C + P.S.	Initial sulphonamide therapy, no response; developed extensive sulphonamide-resistant pneumonia (right base); empyema treated by aspiration and by instillation and systemic penicillin.
6	$\frac{10}{12}$	F	Ill for 9 days with cough, feverish over similar period.	Fairly well nourished; febrile; signs of fluid at Rt. base; aspiration—pus +.	10	Staphylococcus C + aureus P.S.	Aspiration of pus with instillation of 20,000 × 5 systemic penicillin.
7	$\frac{1}{12}$	M	Cough 3-4 days; attacks of cyanosis.	Poorly nourished; extremely ill; dull at Rt. base, ? fluid; aspiration—pus +.	5	Staphylococcus C + aureus P.S.	Repeated aspiration of pus with intrapleural penicillin 20,000 × 5; systemic penicillin; sulphadiazine.
8	2 $\frac{1}{12}$	M	Tiredness for 4 days with pain in back; cough and dyspnoea for 1 day.	Fairly well nourished; febrile; grunting respiration; poor movement, left chest; dull left base, ? fluid; aspiration—pus +.	5	Staphylococcus C + aureus P.S.	Repeated aspiration of pus (9 times) and instillation intrapleural penicillin; systemic penicillin and sulphadiazine by mouth.
9	$\frac{6}{12}$	F	Cold for 3 days; vomiting all feeds.	Pale, wasted; cough; febrile; dullness and distant breath sounds, left base; ? pneumonia.	5	Staphylococcus C + aureus P.S.	Repeated aspiration of pus; penicillin instilled × 4; sulphadiazine by mouth.
10	2	M	Pneumonia; swinging temperature; pus aspirated from chest before admission (10th day).	Pale, toxic, febrile; dull and absent breath sounds, left chest; ? fluid; aspiration—pus +.	10	Pneumococcus P.S.	Repeated aspiration and instillation of penicillin; initial response to systemic penicillin, but relapsed with more fluid; resection and drainage for relapse; sulphadiazine and systemic penicillin given.
11	9	F	Ill for 9 days; tired and had shivering attacks; pain in left chest 3 days; cough for 2 days.	Pale, toxic, febrile; dull left base; ? fluid present.	9	Pneumococcus P.S.	Repeated aspiration of chest and intrapleural penicillin, 50,000 × 5; failure of resolution resulted in surgical interference.
12	7	M	Cough for 4 days; listless off food; no pain.	Fairly well nourished; febrile; dull right base distant breath sounds; ? pneumonia.	30	Pneumococcus P.S.	Sulphadiazine by mouth; no response of temperature or signs in chest; finally developed pus on 30th day of illness; aspiration and instillation of penicillin followed by rib resection.
13	1 $\frac{1}{12}$	F	Cough, swelling, and ulceration of gums for 1 week.	Fairly well nourished; ulcers in mouth; febrile; no signs of consolidation in chest.	4	B. Haemolytic Streptococci P.S.	After satisfactory treatment to mouth, and acute febrile illness had begun with signs in chest, right upper lobe, sulphadiazine was given; fluid developed 4th day; aspiration—pus; intrapleural penicillin × 2, followed by intercostal drainage.
14	$\frac{8}{12}$	M	Cough; feverish for 1 day; difficult breathing and off food 1 day.	Fairly well nourished; alae nasi +; febrile; no signs of consolidation.	4	Staphylococcus C + aureus P.S.	Signs of pneumonia, right base; sulphonamides given; no response; ? fluid right base, pus +; intrapleural penicillin × 5; sulphamezathine by mouth.

APPENDIX B.

Progress.	Radiograph	Features of case	Result
Relapse after rib resection, ? due to inadequate course of penicillin (systemic).	1: Pneumonia, right base. 2: Fluid right base. 3: Resolution proceeding. 4: Chest clear.	Sulphonamide-resistant pneumonia; satisfactory resolution of empyema; relapse due to too short post-operative course of penicillin.	Good: chest wound healed soundly.
Post-operative relapse due to inadequate course of penicillin (systemic).	1: Pneumonia, right base. 2: ? Fluid right base. 3: Resolving. 4: Chest almost clear. 5: Resolution complete.	Empyema developed after response to sulphonamides; post-operative relapse responded to systemic penicillin.	Good: chest wound healed soundly.
Good response to surgical drainage; although child improved with aspiration, no headway was made against size of empyema.	1: Shadow, apex right lung, ? pneumonia. 2: Opacity, right base, ? Fluid. 3: Resolution proceeding. 4: Chest clear.	Good response to penicillin; rapid resolution of empyema and early healing of chest wound.	Good: chest wound healed soundly.
Rapid response to penicillin instillation and finally rib resection. Early healing of chest.	1: Pneumonia, right middle lobe. 2: Extension to right lower lobe. 3: ? Fluid right base. 4: Resolution complete.	Empyema developed after sulphonamides and penicillin; rapid resolution of empyema after rib resection.	Good: rapid resolution and healing.
Empyema resolved satisfactorily; otitis showed no improvement; developed diarrhoea and vomiting and bilateral mastoiditis; no response to mastoidectomy.	Repeated x-rays showed gradual resolution of empyema before development of diarrhoea and vomiting.	Satisfactory treatment of empyema by aspiration alone; death from diarrhoea and vomiting and bilateral mastoiditis.	Although child died, necropsy revealed no pneumonia and complete resolution of empyema.
Gradual resolution of empyema with aspiration alone.	1: Fluid, right base. 2: Chest clearing. 3: Chest clear.	Satisfactory response of empyema without resection.	Good; no operation.
Rapid reduction of general toxicity of child; satisfactory resolution of empyema without surgical drainage.	1: Fluid, right base. 2: Chest clearing. 3: Chest clear.	Rapid initial reduction in general toxicity; satisfactory resolution with aspiration alone.	Good; no operation.
The empyema was large and resolved only with difficulty without operation; chest remained flattened, and some thickening of pleura was present.	1: Fluid, left chest. 2: Less fluid present. 3: Some residual thickening of pleura.	Empyema was large and responded with difficulty to aspiration alone; illness was somewhat prolonged, and some residual thickening of pleura remained.	Fair; some thickened pleura when discharged home.
Response to aspiration and instillation of penicillin; no systemic penicillin; sulphadiazine by mouth.	1: Fluid, left base. 2: Less fluid. 3: Chest almost clear.	Response to local penicillin and sulphadiazine; no operation or systemic penicillin.	Good: no operation.
Initial response to aspiration alone; relapsed with increase in size of empyema; rib resection performed; fibrin and serous fluid; not a true empyema; rapid healing following operation.	1: Fluid, left chest. 2: Less fluid. 3: Marked increase in fluid. 4: After operation chest clearing. 5: Chest almost clear.	Failure to respond to aspiration alone; rapid healing following surgical drainage.	Good after surgical drainage.
After initial response the empyema remained stationary; the chest became flattened, and scoliosis resulted.	1: Fluid, left chest. 2: Some reduction in extent of fluid. 3: More fluid. 4: Scoliosis and flattening of chest, with thickened pleura. 5: Rapid clearing after operation.	Failure of response to aspiration alone; early development of thickened pleura with flattening of chest and scoliosis; rapid healing following decortication of chronic empyema.	Fair: earlier operative interference may have prevented scoliosis and flattening of chest.
Sulphonamide-resistant pneumonia; late development of empyema; good response to penicillin; rapid recovery after rib resection.	1: Pneumonia, right base. 2: No change (repeated). 3: Fluid, right base. 4: Chest clearing.	Late development of empyema (large size) after sulphonamide-resistant pneumonia.	Good: healed after resection and drainage.
Developed pneumonia in hospital ? secondary to ulcerated mouth; rapid response after penicillin and intercostal drainage; relapse after 6 weeks, but resolved speedily on discharge of a superficial abscess in intercostal scar.	1: Satisfactory drainage of empyema. 2: Chest clearing. 3: Chest clear.	Response of empyema to aspiration and instillation of penicillin followed by intercostal drainage; no systemic penicillin given.	Good following intercostal drainage.
After repeated aspirations (5) the empyema did not appear to be resolving; intercostal drainage.	1: Pneumonia right base. 2: ? fluid, right base. 3: Chest clearing. 4: Chest clear.	Good result after aspiration and instillation of penicillin followed by intercostal drainage.	Good following intercostal drainage.

APPENDIX B—continued.

Case No.	Age in years	Sex	Relevant history	Condition on admission	Day of onset of empyema	Organism *	Treatment *
15	1 $\frac{1}{2}$	M	Ill for 3 weeks; cough and occasional vomiting.	Pale, poorly nourished; poor movement, left chest; dull ? fluid; aspiration—pus.	Present on admission to hospital.	Pneumococcus P.S.	Repeated aspiration of pus and instillation of penicillin (4); rib resection.
16	1 $\frac{0}{8}$	M	Ill 5 days; cough; vomiting; off feeds.	Pale; fat; alae nasi +; no consolidation; ? acute bronchitis.	9	Staphylococcus C + aureus P.S.	Pneumonia developed (right lower lobe); no response to sulphonamides; aspiration and instillation of penicillin.
17	1 $\frac{1}{2}$	M	Ill for 3 weeks; cough and occasional vomiting; worse for 3 days; now off feeds.	Fairly well nourished; toxic; febrile; ? pneumonia, right upper lobe.	Doubtful	Pneumococcus P.S.	No true response to sulphonamides; penicillin given systemically and into ? interlobar empyema.
18	8 $\frac{1}{2}$	M	Ill 1 week; fretful; coryza and cough.	Poorly nourished; dyspnoea +; cyanosed and febrile; dull left base; bronchial breath sounds; ? pneumonia.	11	Pneumococcus P.S.	No response to sulphonamides; systemic penicillin; aspiration and intrapleural penicillin $\times$ 3, and then rib resection.
19	3 $\frac{1}{2}$	F	Ill for 3 weeks with cold and cough; worse for 2 days.	Pale, spare; toxic; febrile; dull left lower lobe; bronchial breath sounds; ? pneumonia.	? 32	Pneumococcus P.S.	Good response to sulphonamide; relapse after 5 days—fluid found left chest; intrapleural penicillin $\times$ 2; large empyema—drainage by rib resection.
20	8 $\frac{1}{2}$	M	Ill 4 weeks; cough; dyspnoea 3-4 days.	Fairly well nourished, forward for age; febrile; dull left base; flattening; absent breath sounds; aspiration—pus +.	Present on admission.	Pneumococcus P.S.	After initial intrapleural penicillin, rib resection performed; systemic penicillin.
21	8	M	Ill for 1 week; cough and cold; pain in right chest for 2 days.	Well nourished; flushed, febrile; dull to percussion right lower lobe; absent breath sounds; ? fluid; aspiration—nil.	9	Staphylococcus C + aureus P.S.	Penicillin systemically and sulphamezathine by mouth; one intrapleural injection of penicillin.

* P.S. = Penicillin-Sensitive.

APPENDIX B—continued.

Progress	Radiograph	Features of case	Result
After repeated aspiration the size of the empyema appeared to be increasing; rib resection.	1: Fluid, left chest. 2: ? Increase in fluid. 3: Drainage proceeding. 4: Chest clear.	No immediate response to repeated aspiration and instillation of penicillin; rib resection performed; no sulphonamides or systemic penicillin given.	Good after rib resection.
Resolution of empyema by aspiration alone; systemic penicillin given; Intrapleural $\times$ 2.	1: Fluid, right chest. 2: Chest clearing. 3: Chest clear.	Satisfactory response of small empyema to aspiration alone.	Good: no operation necessary.
No true response to sulphonamides or penicillin; when child improved clinically still had signs in chest.	1: Opacity, right upper lobe, ? pneumonia. 2: Opacity still I.S.Q. 3: Chest I.S.Q. 4: Chest I.S.Q.	Although clinical improvement occurred, signs in chest persisted.	Fair: no operation.
No response to sulphonamides; developed empyema after penicillin therapy; no headway with aspiration; resection followed by rapid resolution.	1: Pneumonia left base. 2: Increased density; ? fluid. 3: Resolution proceeding. 4: Chest clearing.	Empyema developed after sulphonamide and penicillin; rapid resolution after resection preceded by penicillin (intrapleural).	Good with rib resection.
Development of empyema after response of pneumonia to sulphonamide; rapid resolution after intercostal drainage.	1: Pneumonia, left base. 2: ? Fluid, left base. 3: Resolution proceeding. 4: Resolution proceeding.	Rapid response to rib resection after preliminary intrapleural penicillin; no sulphonamides or systemic penicillin given after development of empyema.	Good with rib resection.
Difficulty was experienced in aspirating empyema, ? due to fibrin; rib resection performed—good result.	1: Fluid, left chest. 2: Resolution proceeding. 3: Resolution proceeding.	Good response to rib resection and systemic penicillin.	Good with rib resection.
Pus aspirated once only from chest; response to systemic penicillin good.	1: Opacity, right chest ? fluid. 2: Some clearing of chest. 3: Resolution proceeding. 4: Chest clear.	Good response to systemic penicillin and sulphonamide; small empyema response to one aspiration and instillation of penicillin.	Good; aspiration only (small empyema).

C + = Coagulase-Positive.

(a)—Case 3, before penicillin therapy.

(b)—Case 3, immediate post-operative state.

(c)—Case 3, final radiograph.

(d)—Case 6, before penicillin therapy.

(e)—Case 6, final radiograph after aspiration only.

EMPYEMA THORACIS BY ALFRED E. CHAPLIN

(a)—Case 11, before penicillin therapy.

(b)—Case 11, after penicillin without resolution.

(c)—Case 11, after surgical drainage.

PLATE VII