Thorax (1961), **16**, 128.

EMPYEMA IN CHILDHOOD

BY

EUGENE HOFFMAN

From the Regional Thoracic Surgery Unit, Shotley Bridge, Newcastle upon Tyne, and Poole Hospital, Middlesbrough

(RECEIVED FOR PUBLICATION OCTOBER 25, 1960)

Sulphonamides and antibiotics have reduced the incidence of serious infections of the lungs and the pleura. Empyema in children has in the past few years usually proved to be staphylococcal in the majority of cases. In view of the increasing importance of staphylococcal infections I decided that it would be of interest to look up past cases of empyema in the paediatric age group and see how the clinical picture had changed. The cases reviewed include all the patients with empyema in this group who were admitted to the thoracic surgery unit at Shotley Bridge, which is the regional centre for Newcastle upon Tyne, between 1941 and 1958. All the cases were originally admitted to other hospitals in the region and then transferred to us for further treatment. These do not include many additional cases of empyema seen and treated by myself and my colleagues in other hospitals. Cases of empyema due to tuberculous infection and those following surgical procedures are not included.

In all there were 125 patients, aged from 2 months to 12 years. Seventy-one of these were boys and 54 were girls. On admission the children were divided into two groups; 112 were classified as having an acute empyema, the remaining 13 were in the chronic category. My criterion for an acute empyema was that it had occurred within eight weeks of the original illness, whereas in the chronic variety the primary illness had occurred at least five months before admission. This division of empyemata into acute and chronic on the basis of the time that had elapsed from the original illness is arbitrary. An untreated or inefficiently treated empyema may become chronic within two to three weeks from its origin.

Antibiotics and Admission Rate

Fig. 1 demonstrates two features: the two-yearly admissions of all children who had an empyema, and also the dates of the introduction of the commoner antibiotics into hospital practice. The numbers admitted have been split into two groups: infants up to the age of 2, and children aged from 2 to 12 years.

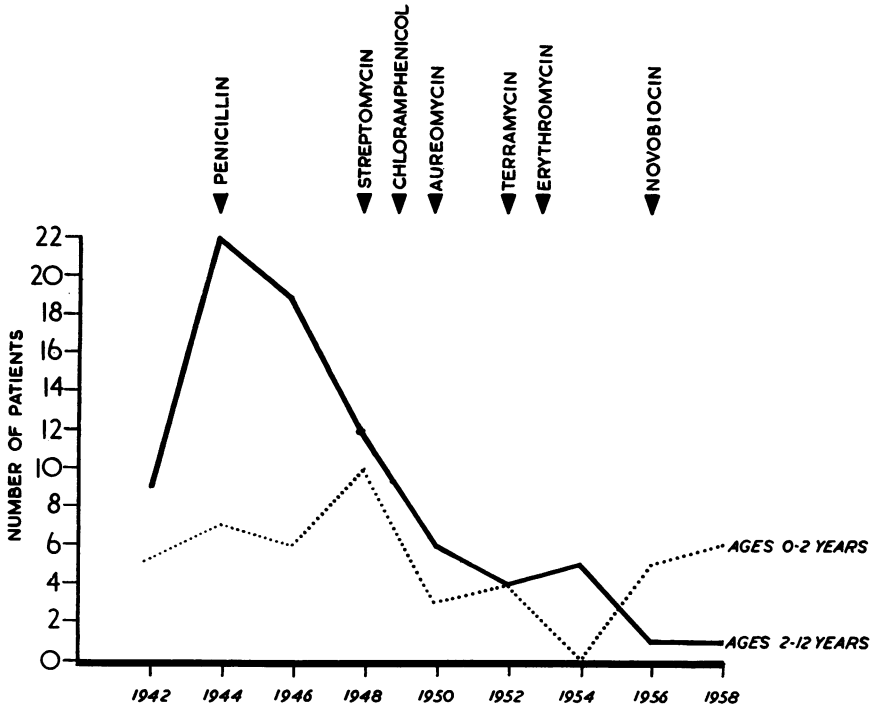
A sharp fall in the admission rate can be seen from 1944 to 1950. In 1944 penicillin was introduced and the years 1948 to 1950 saw the introduction of the commoner broad-spectrum antibiotics. Since 1950, up to the present, the admission rate has remained fairly steady. The graphs show that there has been a steady decline in the admissions of children over the age of 2 since 1944 up to the present. In the other group, that is, in infants under the age of 2, we see a different picture. At first there was a parallel decline until 1954; since then the rate of admissions in this age group has been increasing and now nearly equals the number seen in the pre- and early antibiotic era.

Fig. 2 provides an explanation for the different incidence in the admission rate in the two age groups. Pneumococcal empyema, which in the pre-antibiotic era was the cause of the majority of admissions, is hardly seen nowadays; the pneumococcus has been controlled and has remained sensitive to antibiotics, including penicillin. Since 1952 staphylococcal empyema is practically the only type we have had to deal with.

Primary Illness

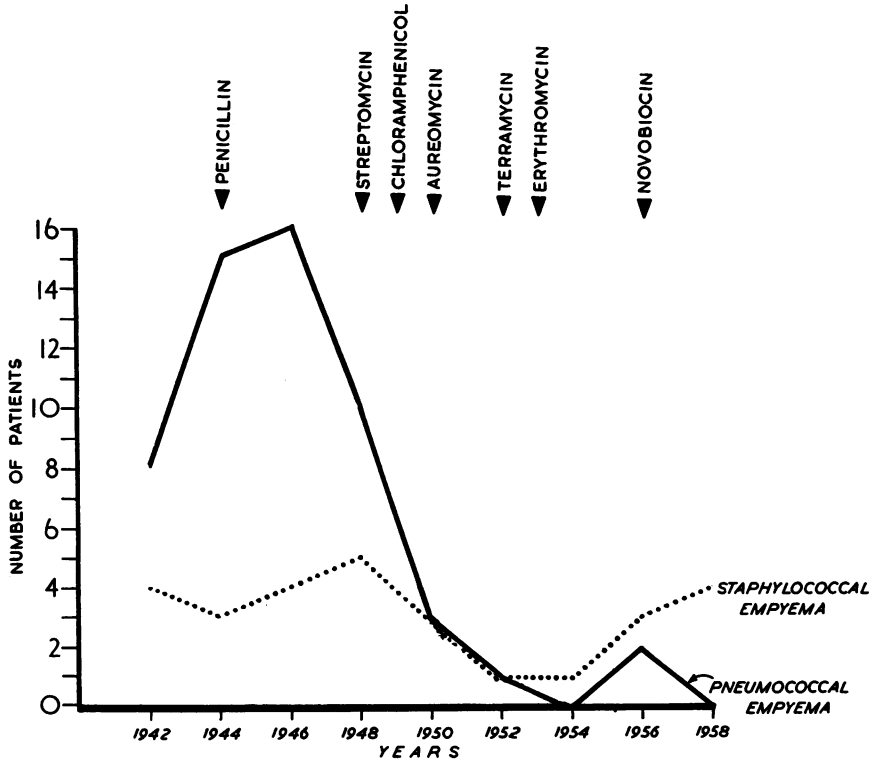
Respiratory infections are one of the major problems in paediatric practice. Primary bacterial pneumonia or pneumonia secondary to viral infections is, in our experience, the commonest cause of empyema. Seventy-six of our cases out of a total of 125 fell in this group. No attempt has been made to classify these pneumonias according to their anatomical distribution because, since the introduction of antibiotics, identification of the causative organism is of greater importance.

In Table I the primary illness giving rise to, and the various bacteria responsible for, the empyema are demonstrated.



YEARLY ADMISSIONS: Age groups 0-2 & 2-12years

FIG. 1



Relative incidence of pneumococcal & staphylococcal empyema up to the age of 12years.

FIG. 2

TABLE I
PRIMARY ILLNESS

	Pneumo-coccus	Staphylo-coccus	Strepto-coccus	*H. infl.*	*B. Friedl.*	Mixed	Sterile or Unknown	Total
Upper respiratory infection	8	9	1				1	19
Pneumonia	32	14	3	1		4	10	64
Secondary pneumonia: Measles			5			1	2	8
Secondary pneumonia: Whooping-cough	1	1	1					3
Secondary pneumonia: Scarlet fever	1							1
Bronchiectasis	1		1				1	3
Lung abscess	2							2
Subdiaphragmatic abscess						1		1
Tonsillectomy			1				2	3
Uncertain (fever, vomiting, chest or abdominal pain, loss of weight, listlessness, etc.)	9	4			1		7	21

The division into upper and lower respiratory tract infections has been made on the basis of the clinical findings of the physicians who first looked after these children. None of our patients in this series is related to the recent influenzal epidemics, but some may have started as viral infections that have paved the way fo. subsequent bacterial infection. Strangely enough, bronchiectasis and lung abscess only provided five cases, aspiration pneumonia following tonsillectomy three, and subdiaphragmatic abscess one. We were left with a group of 21 children with conditions of rather uncertain aetiology who presented with varying symptoms ranging from fever and vomiting to pain and loss of weight.

Our figures give no indication of the incidence of empyema following pneumonia. Benson and Penberthy (1941) reviewed 10,750 cases of pneumonia in infants and children over a period of 15 years and found an incidence of 5.2%. This survey took place in the pre-antibiotic era. More recently 1,043 cases of infants and children admitted to the Royal Victoria Infirmary and the Babies Hospital at Newcastle upon Tyne over the past 10 years with all types of pneumonia showed an incidence of 3% (Court, 1959).

BACTERIOLOGY

A review of the organisms that were cultured from the pleural pus showed that the pneumococcus was the commonest offender, accounting for 55 cases. *Staphylococcus pyogenes* was responsible for 28 and haemolytic streptococci for 12.

There was one case caused by *Haemophilus influenzae* and one by *Bacillus Friedlander* (Fig. 3). Mixed infections that totalled six were confined to the chronic empyema group. The last relatively large column (22 cases), with sterile or unknown bacteriology, may be partly accounted for by previous antibiotic therapy.

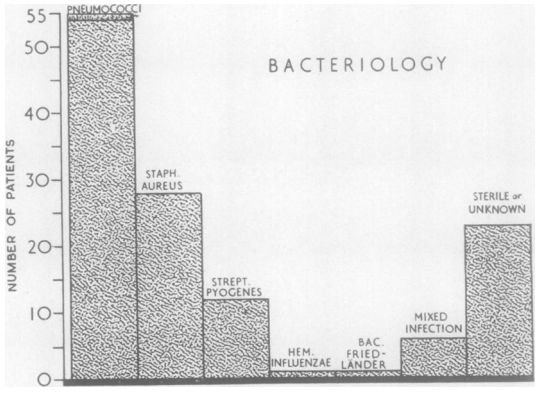


FIG. 3

Fig. 4 shows the relative incidence of the three main causative organisms in the various age groups. Over the age of 1 year the pneumococcus was responsible for the greatest number of cases

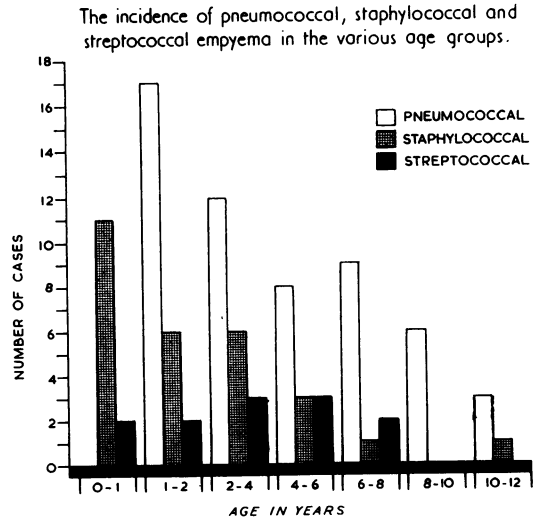


FIG. 4

TABLE II
PRIMARY STAPHYLOCOCCAL PNEUMONIA AND ITS COMPLICATIONS IN INFANTS UNDER THE AGE OF 2

	Period	No. of Cases	Mortality	Pneumothorax	Empyema	Pneumatocoele
Kanof *et al.* (1953) ..	1953	30		15 (38%)	23 (57%)	10 (25%)
Disney *et al.* (1956) ..	1953–1954	29 (37·3% of all pneum.)	4 (14%)	7 (24%)		9 (31%)
Wallman *et al.* (1955) ..	1952–1955	44	10 (23%)	11 (25%)	14 (32%)	29 (66%)
Pryles (1958)	1955–1957	24 (0–42/12)	9 (37·5%)	8 (33%)	11 (45·8%)	4 (16·6%)

in this series, streptococcal empyemata were fairly evenly divided in all age groups, but the greatest number of staphylococcal empyemata occurred in children under the age of 2 years ; 17 out of a total of 28 came into this category. There were 11 cases in babies under 1 year of age. For all practical purposes, an empyema occurring in the first 12 months of life is likely to be of staphylococcal origin. This is of importance in selecting which antibiotic shall be used before culture and sensitivity tests are available. In our experience both the pneumococcal and streptococcal empyemata tended to follow similar well-known patterns.

STAPHYLOCOCCAL EMPYEMA

Staphylococcal pneumonia is a suppurative bronchopneumonia with abscess formation. A summary of some of the recent publications describing complications of staphylococcal pneumonia in infants is shown in Table II. Pneumothorax occurred in 25 to 33% and pneumatocoeles in 16 to 66%. These two complications may be described as diagnostic of the disease. Of our 28 cases of staphylococcal empyema, seven presented as tension pyopneumothoraces. Three further cases are not included in this group because the pus was sterile. This complication can manifest itself at any stage of the disease, either during the acute phase or later during convalescence. Eight of our 10 cases were observed during the acute stage of the illness. The remaining two presented as late complications due to the rupture of residual cysts two and two and a half months respectively following the original pneumonia. As a point of interest, six out of the last seven children admitted with staphylococcal empyemata presented with a tension pyopneumothorax. This may be coincidence or may indicate a changing pattern in the clinical picture of the disease. Fig. 5 demonstrates the incidence of complications in our cases of staphylococcal empyema.

Pneumatocoeles, or lung cysts, were present radiologically in five cases. These cysts owe their origin to lung distension rather than to lung destruction. This is borne out by the fact that they usually disappear without leaving permanent lung damage and do not require special treatment. The patients should be followed up because of the rare complications of rupture, infection, or distension of the cyst. This danger is demonstrated by the following two cases.

A 19-day-old baby was admitted ; he had a right-sided staphylococcal pneumonia. After 17 days' treatment with penicillin and streptomycin he was discharged home. His radiograph showed residual cysts at the right base: four weeks later he had to be readmitted because of a tension pneumothorax. He was critically ill and only insertion of an intercostal tube saved his life. He was transferred to us for further treatment. A large cyst was still

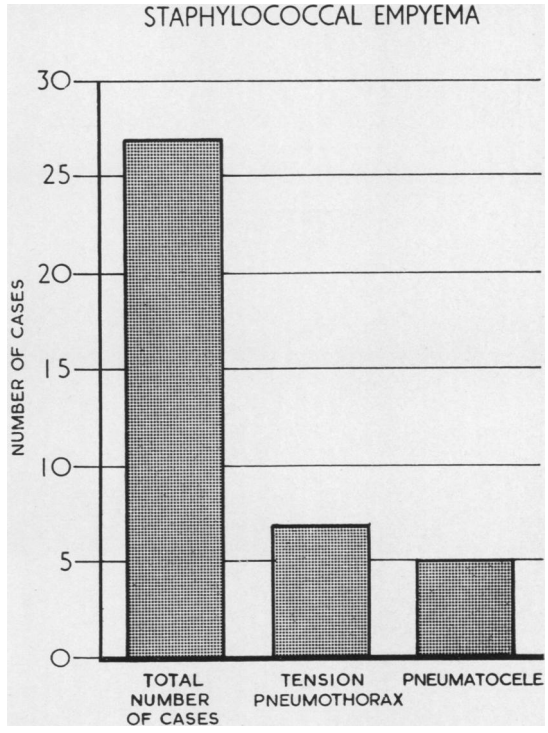


FIG. 5

visible at the right base, and it was decided to explore the chest. (This was the only patient in our series of acute staphylococcal empyemata who had a thoracotomy.) At operation a large cyst was removed from the lower lobe ; the pneumothorax was the result of the rupture of two cysts in the upper lobe ; small bronchiolar leaks were visible and oversewn. Convalescence was uneventful. Bronchographic examination, carried out two years later, showed a normal bronchial tree.

The next case demonstrates infection as a late complication in a pneumatocoele that had eventually to be treated surgically (Fig. 6a).

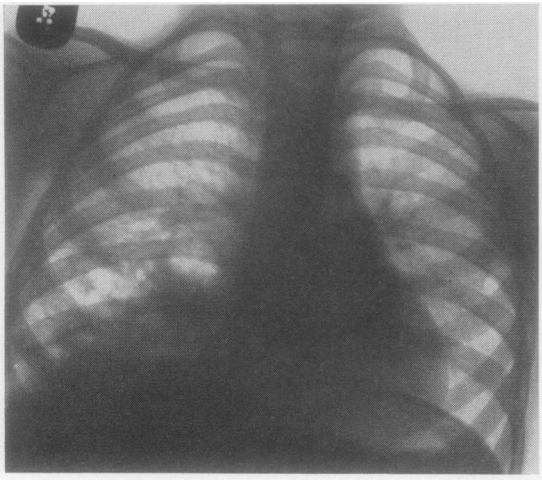


FIG. 6a

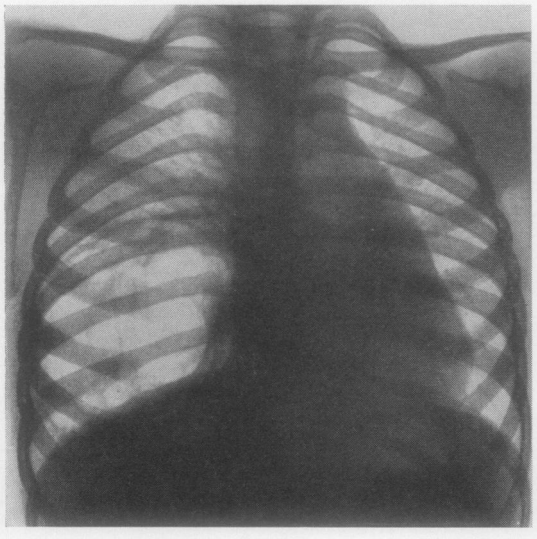


FIG. 6b

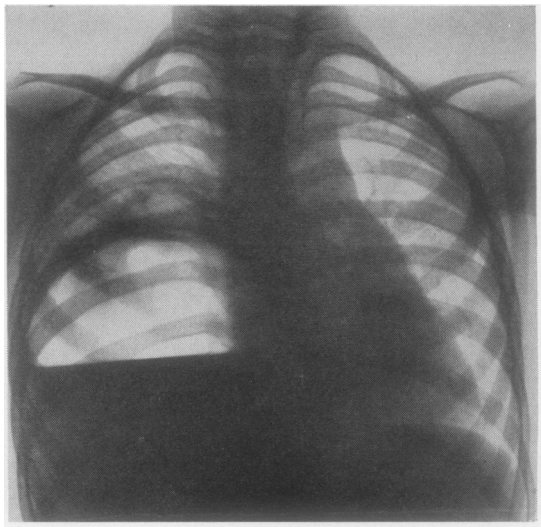


FIG. 6c

The patient, a 3-year-old boy, was originally admitted with a staphylococcal pneumonia at the right base. Ten months later a large cyst was still visible at the right base (Fig. 6b). After a further three months a radiograph (Fig. 6c) showed that a fluid level had developed in the cyst. He was readmitted, and pus was aspirated from the cyst and proved to be sterile. A bronchogram showed the cyst in the lower lobe which was destroyed. A tube had been inserted because initially he was thought to have an empyema. Due to the persistence of a large bronchopleural fistula a right lower lobectomy was eventually carried out. The child made an uneventful recovery and his radiograph four years later was satisfactory.

COMPLICATIONS

Complications occurred in 26 of our 125 cases. The suppurative process may spread locally or become disseminated by the blood stream (Table III).

Bilateral empyema occurred in four cases. Infection spread through the chest wall (empyema necessitans) in four cases. The diaphragm, oesophagus, and pericardium are usually resistant to the spread of infection from an empyema. In one of our cases the infection spread into the pericardium, causing a suppurative pericarditis. This occurred in a boy aged 18 months who was admitted with a pneumococcal empyema in 1943. After intercostal drainage he was progressing satisfactorily when on the 10th day he developed clinical signs of cardiac tamponade. An open pericardiostomy had to be carried out following which he made a satisfactory recovery.

TABLE III
COMPLICATIONS

	Acute Empyema				Chronic Empyema	Total
	Pneumococcal	Staphylococcal	Streptococcal	Unknown		
Bilateral empyema	1	1	1		1	4
Empyema necessitans	1	1			2	4
Suppurative pericarditis	1					1
Septicaemia (multiple abscesses, splenomegaly, etc.)	4	1			1	6
Meningitis and cerebral abscess	1				1	2
Bronchiectasis		1			3	4
Osteomyelitis Ribs		4				4
Osteomyelitis Spine		1				1
Deaths	2	1		1	1	5

Spread of infection by the blood stream gave rise to transient septicaemia and pyaemia in six cases and to cerebral abscess and meningitis in two.

A long-standing bronchopleural fistula occurring in a chronic empyema may in my opinion lead to lung damage. This happened in four of our cases and these children were left with residual bronchiectasis.

Another complication that necessitated readmission at a later date was osteomyelitis of the ribs which occurred in four cases. In these patients the bony radiological changes were not evident during their stay in hospital. These children presented with chronic discharging sinuses and were readmitted at intervals varying from four months to four years after their original illness. Removal of sequestra and of the adjoining ribs led to complete clearing of the infection.

There were five deaths in our series and these will be discussed later.

CHRONIC EMPYEMA

There were 13 patients in our series who were admitted with an established chronic empyema. A chronic empyema develops from an acute empyema when lung expansion and space obliteration have become stationary due to underlying lung disease or to inadequate treatment of an acute pleural infection. They were evenly distributed in all age groups: five of them were boys and eight of them girls. The last of these patients was admitted in 1951 and we have not seen a case since. All these children were left with persisting signs and symptoms such as breathlessness, productive cough, listlessness, chest wall and spinal deformities, finger clubbing, toxaemia, and amyloidosis following a previous attack of pneumonia. The bacteriology was variable and often mixed.

The most frequent cause of chronic empyema was failure to recognize the condition. This occurred in nine of the 13 cases. The remaining four were due to unsatisfactory drainage.

The treatment of some of the patients did not differ from that of acute empyema. Aspiration sufficed in one and seven responded satisfactorily to tube drainage alone or with rib resection. Four cases had major surgery. Pleurectomy would nowadays be the treatment of choice in most cases of chronic empyema.

TREATMENT

The use and choice of antibiotic have become of primary importance in treatment and particularly of staphylococcal empyema, because this usually occurs during the acute stage of the pneumonia. Antibiotics have changed the incidence and clinical course of empyema, but they have brought fresh problems, the most important of which is the development of an increasing number of resistant strains of the staphylococci to each new antibiotic in turn. The resistance of the staphylococci varies from place to place and is lower in the general population than in hospitals.

Fig. 7 demonstrates the sensitivity to some of the antibiotics of the three commonest bacteria cultured from the pleural pus of 37 of our patients from 1944 to 1958. Until 1947 all bacteria remained sensitive to penicillin. In 1948 the first case of a penicillin-resistant staphylococcal strain emerged and this patient died from an uncontrollable septicaemia. This case occurred before the introduction of the broad-spectrum antibiotics. The first staphylococcal strain resistant to streptomycin appeared in 1950 and to the tetracyclines in 1956. In one of our cases the staphylococcus was sensitive to penicillin as recently as 1958. In this series we have not come across any strains that were resistant either to chloromycetin or to erythromycin, although resistance to these antibiotics is becoming more frequent.

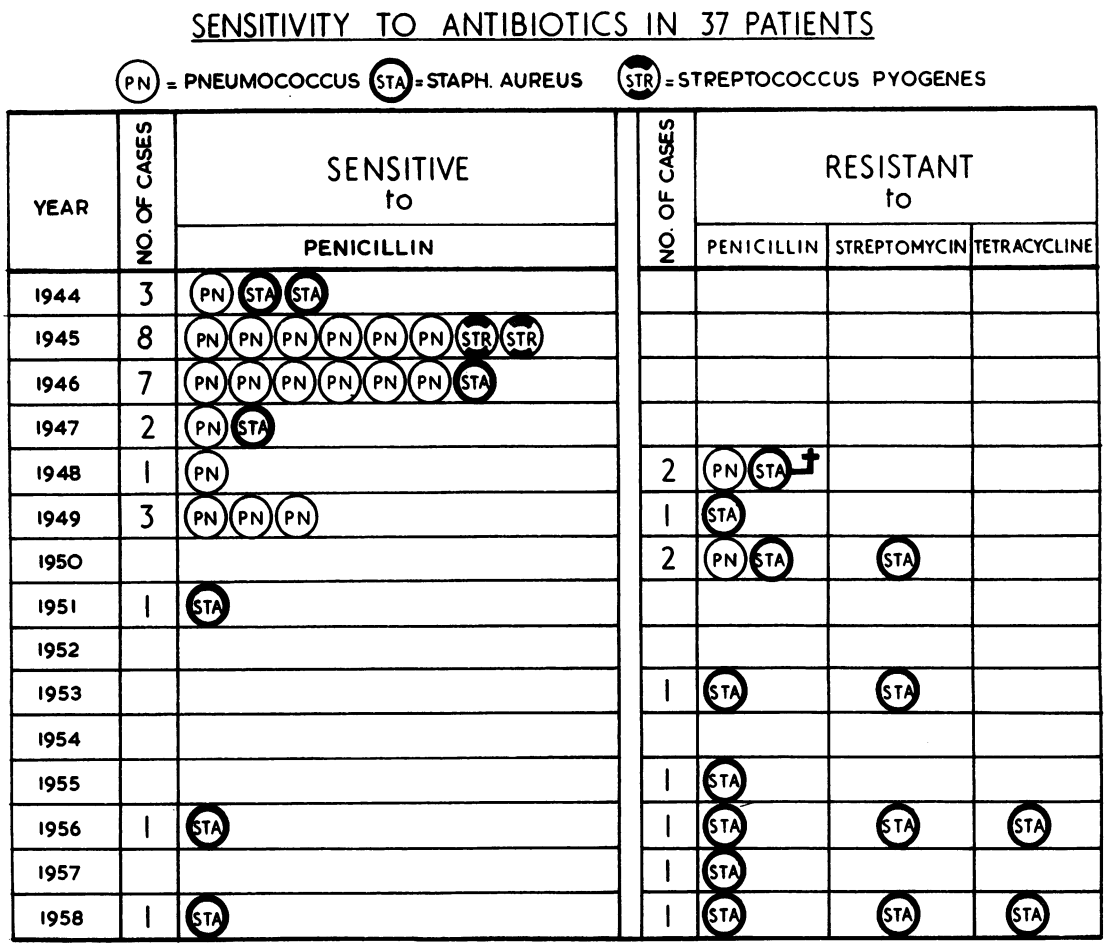


FIG. 7

The correct choice of antibiotic in the first instance in a young child suffering from a severe chest infection is not always easy. From previous considerations I think it is wisest to assume that a child below the age of 1 presenting with a pneumonia and/or empyema has a staphylococcal infection and should be treated accordingly until proved otherwise. It is my routine in the first 48 hours after admission, and until the sensitivity tests are available, to start treatment with penicillin in older children or cases of mild infection, and with chloromycetin or erythromycin in infants and the more severe cases.

In addition to the antibiotic therapy mentioned above, early and complete drainage of the empyema and re-expansion of the underlying lung are essential. The various methods that have been used to achieve this over the past 18 years are shown in Fig. 8. Aspiration alone or in combination with the instillation of antibiotics into the pleural cavity has its place in the treatment of empyema, especially in smaller effusions. This method has been successful in curing a considerable number of our cases. But in many patients admitted to this centre aspiration had been persisted with for too long and has resulted in some patients developing a chronic empyema. I believe that, if complete evacuation of all the pus is not obtained after two or three attempts, aspiration should not be persisted with and other methods of drainage should be adopted.

Repeated aspirations are an important preliminary to a planned pleurectomy. We have tried the intrapleural instillation of proteolytic enzymes in cases where the pus was thick, but with little success.

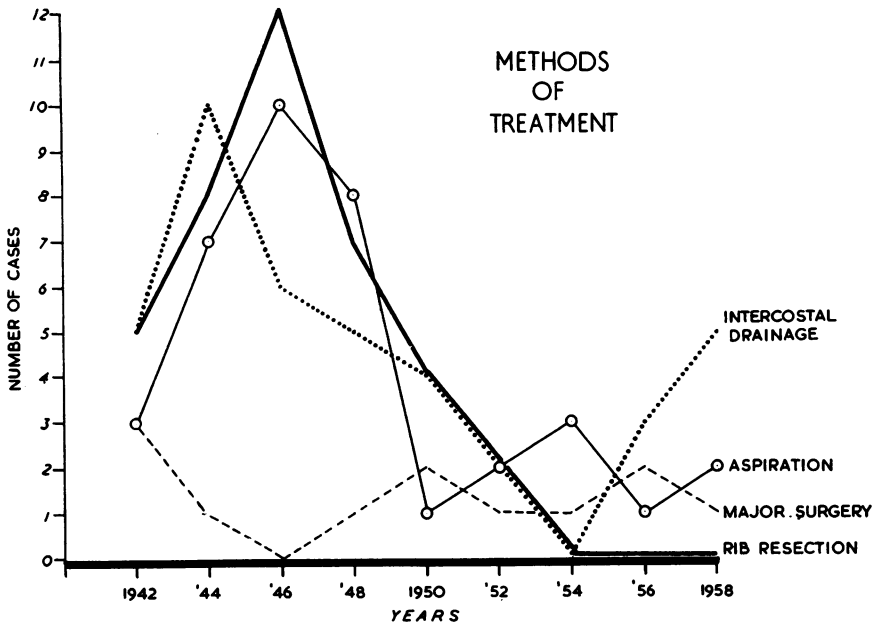


FIG. 8

Intercostal drainage has been used frequently in the past and since 1954 is again coming to the fore and is the treatment of choice in small children. This is the treatment I adopt in all cases of staphylococcal pyopneumothorax or empyema.

Rib resection, which was used principally in pneumococcal empyema in order to remove fibrin and necrotic debris, has not been used since 1954.

Only a small number of our patients came to major surgery. The procedures carried out were pleurectomies, unroofing operations, and in one instance a pneumonectomy. The operation of pleurectomy is one of the advances in the treatment of empyema and in older children and adults is being used nowadays more frequently in both acute and chronic cases that, in the past, would have been treated by rib resection or tube drainage.

PROGNOSIS

Bronchographic examination is the most reliable method of assessing the outcome of an empyema and the degree of residual lung damage. Bronchograms were carried out in 56 of our patients. Forty-five of these were done before the patient was discharged from hospital, and the remaining 11 patients were readmitted for bronchography some years later (Table IV).

Infants below the age of 2 and children from 2 to 12 years have been assessed separately. The group has been split into two subgroups, namely, acute and chronic empyema. The acute cases have been further subdivided according to their bacteriology.

An analysis of these bronchograms showed that 41 patients had a normal bronchial tree, eight had minimal to moderate bronchial dilatations, and in

TABLE IV
RESULTS OF BRONCHOGRAPHY AFTER EMPYEMA IN 56 PATIENTS

	Acute Empyema								Chronic Empyema		Total
	Pneumococcal		Staphylococcal		Streptococcal		Unknown				
	Below 2	2–12	Below 2	2–12	Below 2	2–12	Below 2	2–12	Below 2	2–12	
Normal	3	13	9	4		3		5		4	41
Minimal to moderate segmental dilatations	1	1	1	2		2		0		1	8
Gross bronchiectasis	0	1	0	1		1		1		3	7*

*In three bronchiectasis was the cause of empyema.

only seven were there changes of severe bronchiectasis. The least lung damage occurred in the pneumococcal and staphylococcal cases. The streptococcus was responsible for a somewhat greater degree of lung damage and finally chronic empyema caused the highest incidence of bronchial complications.

The number of normal bronchograms was high. In view of the increasing incidence of staphylococcal pneumonia and its suppurative and necrotizing pathology I was prompted to follow up our cases of staphylococcal empyema that had occurred in infants below the age of 2, and to assess, if any, the degree of residual lung damage. I readmitted 10 patients for bronchography who came into this category. Of these 10, nine had normal bronchograms and only one showed moderate bronchial dilatations. The following case demonstrates the above findings.

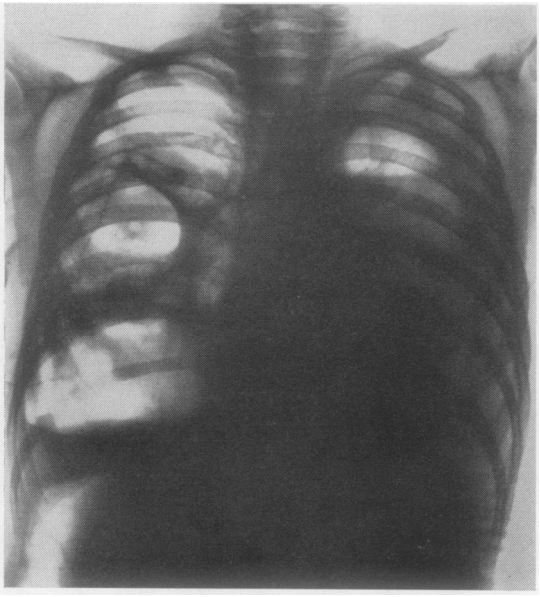


FIG. 9

A boy aged 2 was admitted in 1953 with bilateral staphylococcal empyemata and tension pneumothoraces (Fig. 9). Repeated intubations on alternate sides had to be carried out, after which he eventually made a good recovery confirmed by bronchography seven years later.

MORTALITY

The most important factor regarding mortality is the patient's age. The highest mortality is in children under the age of 1 year.

Benson and Penberthy (1941) reviewed the death rate of 551 cases of empyema in childhood. These cases were of mixed bacteriology, the majority being pneumococcal, and the series covered the years 1926–41, i.e., in the pre-antibiotic era, and revealed a mortality of 8.2%. They observed that the mortality rate from pneumonia and from empyema was very similar.

The mortality from staphylococcal empyema has always been higher, but this is not necessarily a sign of greater virulence, as it can be explained by the younger age group in which this type of empyema occurs. Forbes (1946) collected from the literature 1,867 cases of staphylococcal empyema described by various authors from 1913 to 1943 and found that the average mortality was 38.7% for children of all ages, 40.7% for children under the age of 1, and 51.3% for infants below 6 months of age. In the pre-antibiotic era the mortality from staphylococcal pneumonia, which is the main cause of death in staphylococcal empyema, was very high, particularly during infancy. More recent studies reported a lower mortality. Wallman, Godfrey, and Watson (1955) encountered 10 (23%) deaths in 44 cases of primary staphylococcal pneumonia. Sabiston, Hopkins, Cooke, and Bennett (1959) reported only five (8%) deaths in 60 patients with primary staphylococcal pneumonia. In secondary staphylococcal pneumonias due to the chronic debilitating diseases the mortality is of course high. In our series there were five deaths. Three of these were due to septicaemia and pyaemia and the last two to causes not directly due to the empyema.

The first case was that of an infant of 5 months who was admitted in 1948 with a staphylococcal empyema. The staphylococcus proved to be resistant to penicillin. The second case was a child of 18 months who was admitted in 1942 with a pneumococcal empyema. He was treated with sulphonamides and tube drainage. A pure growth of a haemolytic streptococcus was cultured from the empyema fluid. A necropsy showed extensive bilateral bronchiectasis and the empyema was secondary to this condition. The third death occurred in a girl aged 8, who was admitted in 1941 with bilateral empyema. Necropsy showed multiple staphylococcal abscesses in the brain, liver, and spleen ; the empyemata seemed to have arisen by extension of the infection in the subphrenic spaces. The fourth case, a boy aged 8, died from an allergic reaction immediately after injection of a local anaesthetic (a mixture of procaine and decicaine) before rib resection. The

last case, a boy aged 10, died for reasons unknown during a post-operative bronchoscopy. The bronchoscopy was being carried out after a lobectomy for bronchiectasis and was in no way related to the empyema which had cleared up some months previously.

Conclusions and Summary

All children up to the age of 12 who were admitted to the Newcastle upon Tyne Regional Chest Surgery Centre at Shotley Bridge between the years 1941 and 1958 have been reviewed in order to assess the changing clinical pattern, if any, of this disease. One hundred and twenty-five children were included; 112 of them had an acute and 13 a chronic empyema. The various clinical aspects that were considered included the influence of antibiotics on the admission rate, the primary illness giving rise to the empyema, and the bacteriology and its relation to the clinical course and treatment. Methods of treatment, with special reference to the choice of antibiotics and various surgical procedures, have been discussed.

In pre-antibiotic days the pneumococcus was the commonest cause of empyema in childhood, but in recent years the pattern has changed and staphylococcal empyema in infants was the principal type seen. In 1959, and to date in 1960, this pattern has been maintained.

Bronchographic examinations were carried out in order to determine the degree of lung damage in 56 patients. These demonstrated that very little or no lung damage resulted from pneumococcal and staphylococcal infections. Streptococcal empyema proved to be more destructive, and finally chronic empyema was associated with the highest incidence of bronchial damage.

Our experience indicates that the prognosis of staphylococcal empyema in infancy is good and the child is likely to recover without permanent lung damage, but the final prognosis depends on the response of the staphylococcal pneumonia to antibiotics.

I am grateful to my colleagues at the Thoracic Surgery Unit, Shotley Bridge, for allowing me to include their cases, to Dr. N. L. K. Robson for his help in the preparation of this paper, and to Mr. D. P. Hammersley for drawing the diagrams.

References

Benson, C. D., and Penberthy, G. C. (1941). *Ann. Surg.*, **113**, 1082.
Court, S. D. M. (1959). Personal communication.
Disney, M. E., Wolff, J., and Wood, B. S. B. (1956). *Lancet*, **1**, 767.
Forbes, G. B. (1946). *J. Pediat.*, **29**, 45.
Kanof, A., Epstein, B., Kramer, B., and Mauss, I. (1953). *Pediatrics*, **11**, 385.
Pryles, C. V. (1958). Ibid., **21**, 609.
Sabiston, D. C., Hopkins, E. H., Cooke, R. E., and Bennett, I. L. (1959). *J. thorac. cardiovasc. Surg.*, **38**, 421.
Wallman, I. S., Godfrey, R. C., and Watson, J. R. H. (1955). *Brit. med. J.*, **2**, 1423.