PNEUMONIA IN NORTH-WEST LONDON, 1942–4:
I. BACTERIAL PNEUMONIAS*

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In a study of cases of primary pneumonia admitted to a large general hospital the findings will depend not only upon the prevalent infections in the area served but also upon the criteria of admission to hospital and the facilities for home treatment. Most published investigations of pneumonia until 1939 were confined to lobar pneumonia, the world literature dealing with which has been exhaustively reviewed by Heffron (1939). During and just before the war years, however, an increasing number of papers appeared concerning primary pneumonias due to other than the classical bacterial agents, and the conditions loosely termed " atypical " or " virus " pneumonia became widely recognized. There were many reasons for this, of which the most important were the improved prognosis for bacterial pneumonias afforded by modern chemotherapeutic agents, the increasing use of radiography, and the tendency for the early hospital treatment of relatively mild chest conditions among persons in the armed Forces. The great bulk of such investigations were made in the U.S.A., frequently on Services personnel, and they have been reviewed by Reimann (1947). The relative incidence of bacterial and non-bacterial agents in pneumonia among the general population in this country is far from certain. Even in two years in the U.S.A. estimates of the incidence of " viral " pneumonia ranged from 15 per cent of pneumonia admissions (Reimann and others, 1942) to 45 per cent (Goodrich and Bradford, 1942) and approximately 70 per cent (Reimann, 1943). It seems therefore to be of interest to present the results of a survey of primary pneumonia cases admitted to the Central Middlesex County Hospital during the period July, 1942, to April, 1944.

MATERIAL AND INVESTIGATIONS

The hospital is a large municipal general hospital. in North-West London, serving mainly a working-class area containing many factories of varying sizes which are mostly engaged upon light and moderately heavy engineering. For this reason the age distribution of the population (as evidenced by figures obtained for out-patient attendance for other diseases, such as peptic ulcer) approximated more closely to a normal peacetime distribution than in districts where a higher proportion of the age group 20 to 40 years would have been drafted into the armed Forces or into essential work elsewhere.

The criteria adopted for inclusion in the series were that the patient's age should lie between 12 and 70 years, that there should be radiographic evidence of consolidation at some stage, and that the consolidation should resolve during treatment. This last provision meant that cases of tuberculosis were excluded, except for two persons who had acute pneumonia superimposed on chronic pulmonary tuberculosis.

All patients were admitted into two wards set aside for non-tuberculous chest conditions. A full history was taken, with special note of any history of previous chest disease, of the social circumstances (including as much information as possible on nutrition, hours of work, and income), and of any sulphonamide drugs administered before admission. Radiographs of the chest were taken as soon as possible (94 per cent within 4 days of admission), and at weekly intervals thereafter while the patient was in hospital, or more frequently if indicated; at least one lateral view was included. During the follow-up period in the out-patient department radiographs were taken monthly until the condition had cleared or had become stationary. Sputum, when present, was obtained before treatment was begun, and in those cases which either did not respond to treatment or yielded no pathogenic organisms, subsequent samples were obtained, up to six in number. In each case one or more examinations were made of films stained for tubercle bacilli. Blood culture was done on admission, and in the first 150 cases was repeated on the two following days. Leucocyte counts were made in nearly all cases before sulphonamide treatment was started and were repeated if the patient's condition
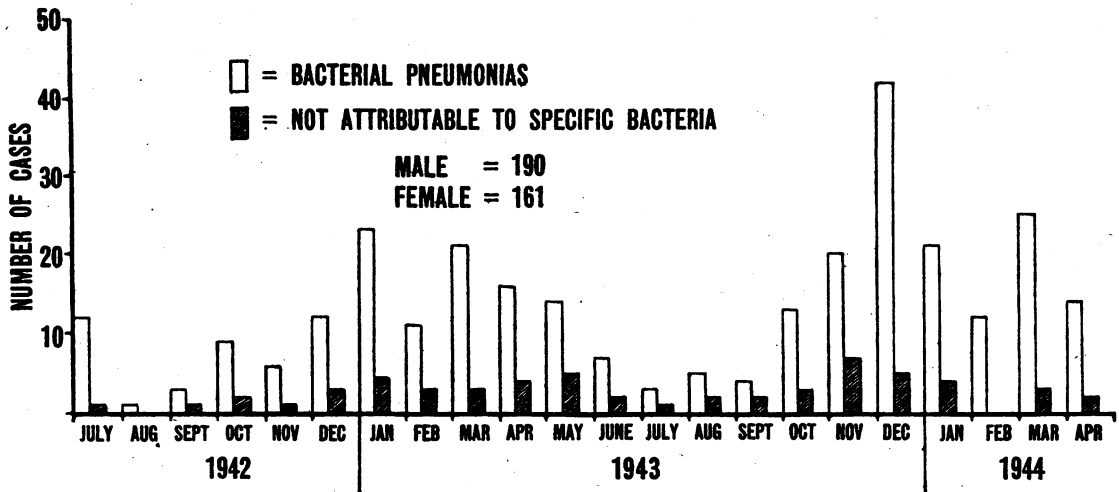
FIG. 1.—Monthly incidence of admissions for primary pneumonia, July, 1942, to April, 1944.

did not respond. The erythrocyte sedimentation rate was measured weekly on all patients by the Westergren method.

From February, 1943, onwards throat washings (in 20 per cent horse serum-saline) or early sputum samples were saved from each case. They were kept for not longer than one, or rarely two, days at 4° C. and were then stored at −70° C. until the diagnosis was settled and a decision could be made whether to discard the material or to use it for animal inoculation. Blood-serum samples were also saved from the majority of patients, one taken during the first four days after admission and the other during the week before discharge. These samples were stored sterile

at 4° C. and were used for testing for the presence of cold agglutinins or for complement fixation or virus neutralization tests.

During the period of investigation 351 cases of primary pneumonia were admitted to the pneumonia wards. Although we have no definite evidence on which to base our suggestion other than a map of the district showing where each case occurred, we consider that the patients admitted provided a fair sample and possibly even a majority of the cases of moderate and severe pneumonia occurring in the district. The monthly incidence is shown in Fig. 1, and the sex and age distribution in Figs. 2 and 3.
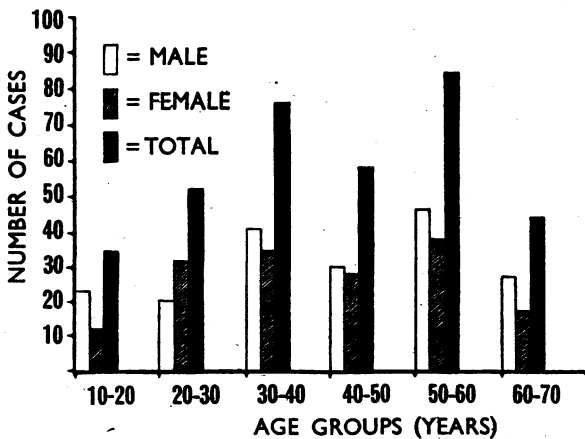

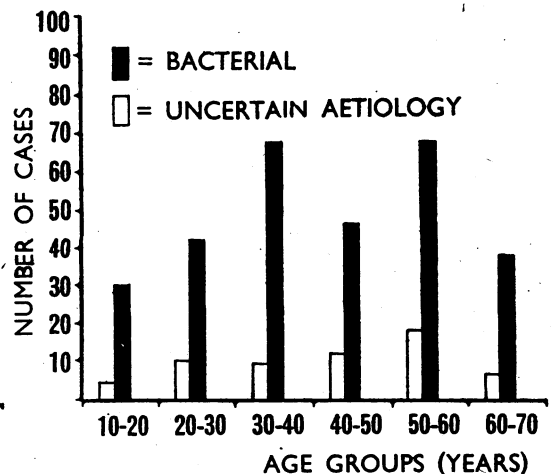FIG. 2.—Age and sex distribution of pneumonia cases, July, 1942, to April, 1944.

FIG. 3.—Age distribution of pneumonias due to bacteria and of uncertain aetiology.

Social conditions and previous chest disease.—A surprisingly high proportion of the patients had a history of previous severe chest illness. The findings are summarized in Table I. When the social

TABLE I

INCIDENCE OF PREVIOUS HISTORY OF SEVERE CHEST
ILLNESS IN 351 CASES OF PRIMARY PNEUMONIA

Classifi-cation	No.	Previous history of :		
		Pneu-monia %	Chronic bronchitis %	Pneumonia or chronic bronchitis %
Pneumococcal pneumonias	278	24	22	42
Other bacterial pneumonias	20	7	48	48
Pneumonias of uncertain aetiology ..	53	26	19	38

histories of the patients for whom sufficient details were available were correlated with the history of previous chest disease it was found that the incidence of previous chronic bronchitis and pneumonia was as shown in Table II.

TABLE II

INCIDENCE OF PREVIOUS CHRONIC BRONCHITIS AND
PNEUMONIA CLASSIFIED ACCORDING TO PATIENTS'
SOCIAL HISTORY

Social history	No. of patients %	Previous history of:	
		Pneumonia %	Chronic bronchitis %
Good	60	22	10
Moderate ..	153	18	30
Bad	80	35	26

These figures raise problems lying outside the scope of this paper. As judged by length of stay in hospital, however, patients with a bad social history did not take much longer (20.8 days average) to become fit for discharge or convalescence than the patients in the series as a whole (18.9 days average).

Duration of illness and treatment before admission.—The average duration of symptoms before admission in the 298 cases of bacterial pneumonia was 4.05 days, and in the 53 cases of pneumonia of uncertain aetiology 6.2 days. In the whole series only 14.5 per cent had received sulphonamide drugs before admission, and of these more than half had received less than 10 g. Thus it

appears that during the period of investigation the general practitioners in the district tended to send established cases of pneumonia to hospital without attempting to treat them at home, and some support is afforded for our contention that we observed a representative sample of patients with this disease.

Routine treatment after admission.—The only treatment given to every patient, in addition to the skilled and practised nursing made possible by the existence of pneumonia wards, was the administration by mouth of sulphonamide drugs together with at least six pints of fluid each day. Twenty-seven per cent received sulphapyridine, the standard course being 24 g. in four days; 20 per cent received sulphathiazole or sulphadiazine, 34 g. during four days; and 49 per cent received sulphamezathine, 28 g. during four days. Blood-level estimations on 56 patients selected at random during their course showed that the dosage used was sufficient to maintain blood levels of the unconjugated drugs greater than 5.0 mg. per 100 ml. or over. There were five cases of drug rash, and none of haematuria attributable to sulphonamides administered in hospital. The temperature responses to the various sulphonamides are summarized in Table III.

TABLE III

INCIDENCE OF DEFERVESCENCE WITHIN FOUR DAYS OF
STARTING TREATMENT WITH VARIOUS SULPHONAMIDES

Drug	No. treated	Percentage of patients whose temperature was normal within four days of starting treatment:	
		All cases %	Pneumo-coccal cases only %
Sulphapyridine	96	59	67
Sulphadiazine Sulphathiazole }	72	53	60
Sulphamezathine	174	54	62

By the seventh day of treatment the temperature had returned to normal in 83 per cent of those cases considered to be due to pneumococci (see below). These figures do not by themselves indicate more than the relative therapeutic effectiveness of the drugs used, since there is no control group. The average duration of symptoms before admission was four days in the pneumococcal group. Davies and others (1935) cite 36 patients with type I pneumococcal pneumonia who received no treatment and of whom 21 were afebrile by the

ninth day of their disease. Such rapid recovery rates are actually faster than the average for treated patients in this series.

AETIOLOGICAL CLASSIFICATION

Except in such cases as provide unequivocal proof of invasion by a particular type of organism, such as a positive blood culture, the assignment of cases into aetiological categories is a matter for combined clinical, radiological, and bacteriological judgment. We describe below the classifications which were reached retrospectively, together with an analysis of some of the more interesting points which emerged. Since considerable weight is in all cases attached to the interpretation of sputum findings, these are discussed at some length. The results of attempts to obtain evidence of virus infection by serological and animal inoculation methods will be presented in a later paper in which are discussed pneumonias not attributable to specific bacterial infection.

The interpretation of sputum findings.—It is only after due consideration of many factors that a particular organism isolated from the sputum of a pneumonia patient can be considered to be the cause of the disease. Some persons, particularly young ones, are unable to produce sputum, even though they are suffering from clinically typical lobar pneumonia. There were sixteen such in our series (22 per cent of those cases diagnosed as pneumococcal pneumonia without isolation of the organism), and there would certainly have been more if it had been possible rigidly to exclude samples consisting of saliva only. Pneumococci do not survive well in sputum at room temperature, and it is important that bacteriological examination should be begun with as little delay as possible. All our sputum samples were plated out on the same day as they were obtained from the patient, and it was made a rule that whenever possible sputum samples should be checked by a physician or by the ward sister before being sent to the laboratory, in order that they should pass as being representative. The first suitable samples were sent for examination, and subsequent samples only if none of the usual pathogenic organisms had been isolated or if response to treatment was poor.

BACTERIOLOGY

Methods.—Throughout the main investigation we relied upon plating of the purulent sputum on blood agar plates. After twenty-four hours' incubation at 37° C. typical colonies were picked off and subcultured on to blood agar, and the organisms were identified by colony form, morphology, and by suitable special tests. Suspected pneumococci (several colonies from each plate) were subcultured in serum broth and after four to six hours' incubation examined for type by the Neufeld method (using Lederle typing sera); if not found typable they were tested for bile solubility and for inulin fermentation before being reported as " pneumococci " (not types I to XXXIII). In about half such cases mouse passage was performed and attempts to type were repeated. No selective media were used to facilitate isolation of haemolytic streptococci or *H. influenzae,* and in many cases the latter may have escaped detection, though present. The use of blood agar plates only, omitting routine inoculation of sputa into mice, is open to criticism on the grounds that pneumococci present in small numbers in sputum are often detected only after mouse inoculation. Being at the time mainly interested in the relative number of different organisms, as a guide to which was the infective agent, we acted on the assumption that an organism which was causing acute disease would grow predominantly or at least copiously. This assumption is not strictly justified, since examination of sputum films stained by Gram's method often reveals more organisms resembling *H. influenzae* than appear on culture, and strictly anaerobic organisms do not grow at all. Furthermore, when in the earlier part of the investigation direct typing of pneumococci was attempted regularly, they were occasionally revealed in very scanty numbers by the capsule swelling reaction and yet were not isolated at all on culture. As a test of the self-consistency of direct plating technique, a number of sputa were plated out independently by five persons, and the distribution of colonies showed good agreement from one person to another.

Results.—" Rusty " sputa or a clear history of such sputa were obtained in hospital from less than 20 per cent of all the patients studied, the highest percentage being 20 per cent of those with pneumococcal pneumonias (types I to VIII) and 21 per cent of those with pneumonia due to other known pathogenic organisms. Nevertheless copious growth of pneumococci was obtained from many sputum samples which contained no blood, and with few exceptions the types of pneumococci isolated corresponded with those isolated subsequently from blood or pus. Other samples grew only moderate numbers of scanty colonies of pneumococci; and many samples grew none, although the patients from whom they were obtained had clinically typical pneumococcal lobar pneumonia. There were ten occasions on which pneumococci were isolated from blood or pus and yet were not found in the sputum. In 45 patients pneumococci were cultured from the first samples of sputum, but were absent from subsequent samples obtained after therapy had continued for three days. On the other hand, in eleven cases pneumococci were cultured from the second

TABLE IV

DISTRIBUTION OF PNEUMOCOCCAL TYPES ISOLATED FROM PNEUMONIA PATIENTS: (A) BY CULTURE ONLY FROM JULY, 1942, TO APRIL, 1944; (B) BY CULTURE AND MOUSE INOCULATION FROM JULY TO OCTOBER, 1944

Type	All pneumonia patients July, 1942, to April, 1944	Pneumonia patients, July, 1944, to October, 1944: Total isolated by all methods	Isolated by mouse inoculation only
I ..	58 (29%)	11	1
II ..	20 (10%)	4	2
III ..	31 (16%)	6	6
IV ..	3	2	1
V ..	9	10	3
VI ..	1	1	1
VII ..	10	2	
VIII ..	13	3	
IX ..	1	1	
X			
XI ..			
XII ..	2	1	1
XIII ..	1	1	
XIV ..	2	1	1
XV ..	1	3	1
XVI ..	2		
XVII ..	2		
XVIII ..	3		
XIX ..	1	1	
XX ..	4		
XXI ..	1		
XXII ..			
XXIII ..	3	2	1
XXIV ..		1	
XXV ..	5		
XXVII			
XXVIII			
XXIX ..	1		
XXXI ..			
XXXII ..			
XXXIII..	2	1	
Not I–XXXIII	20	2	
Total ..	196	53	18

sample (after three days) only, and in twelve cases from the third sample (after seven days) only.

Towards the end of the investigation isolation of pneumococci was attempted by a variety of cul-

ture methods in order to gauge in how many cases they would have been missed by our routine technique. One hundred successive sputa were taken from cases comparable with those included in the main investigation, and each sputum was cultured on blood agar plates aerobically, anaerobically, and in 10 per cent carbon-dioxide. Each was also injected intraperitoneally into a white mouse, which was killed (whether sick or not) after eighteen hours for culture of peritoneal contents and heart blood on blood agar plates and in serum broth. The results agree fairly closely with those given in the protocols of the report of U.S. Commission on Acute Respiratory Diseases (Dingle and others, 1944). Aerobic culture alone yielded thirty-six out of a hundred positive, whereas a combination of all methods yielded fifty-six out of a hundred positive for pneumococci. By other experiments it was shown that sulphonamides, which were present in sputa in concentrations comparable with those in the blood stream, did not interfere with the isolation of pneumococci.

It seems safe to conclude that in our investigation the number of cases in which pneumococci were isolated could have been increased by a third if suitable methods had been used. Table IV shows the incidence of pneumococcal types in the whole series. It will be observed that those which emerged by mouse inoculation only were mostly lower-numbered types which, except for type III, are not commonly found in healthy persons and are therefore likely to have played a pathogenic role.

The findings for other organisms in the sputum are given in Table V. Only those are included which are commonly accepted as respiratory pathogens. H. influenzae, which does not appear in the Table, was the predominant organism in from 5 to 10 per cent of sputa in all classes of case, except for the group of higher-type pneumococcal pneumonias in which it predominated in 20 per cent. The frequency with which it was found would certainly have been much greater if selective media had been used, since from 25 to 80 per cent of persons in normal populations have

TABLE V

CORRELATION BETWEEN BACTERIOLOGY OF SPUTUM AND PRESUMED AETIOLOGY IN 351 CASES OF PNEUMONIA

	Pneumococcus	Staph. aureus	Strep. haemolyticus	Bact. friedlanderi
Pneumococcal pneumonias	199 (72%)	15 (5%)	21 (7.5%)	2 (0.7%)
Non-pneumococcal proved bacterial pneumonias	3 (18%)	6 (37%) all causative	2 (12%) all causative	3 (19%) causative in two
Pneumonias of uncertain aetiology	7 (12%)	11 (21%)	1 (2%)	0 (0%)

been shown to harbour *H. influenzae* in the nasopharynx (Ministry of Health Report, 1939).

The only other points for comment are the rarity in this series of finding Friedländer's bacillus, and the relative rarity of *Staphylococcus aureus*, both of which organisms are easily isolated in mixed cultures and are not likely to have been greatly overlooked. Although the numbers are too small for generalization, it is notable that in two out of five of the cases in which *Bact. friedlanderi* was found, and in a fifth of those with *Staphylococcus aureus*, these organisms were the cause of the pneumonia. The carrier rate of *Bact. friedlanderi* has been found to vary in healthy populations from less than 1 per cent to 3 per cent (Ministry of Health Report, 1939).

The significance of pneumococci in small numbers.—The significance of pneumococci, or any other organisms, which are isolated in small numbers only, or which are recovered only after mouse inoculation, is difficult to determine. The carrier rate for pneumococci in the general population is high (15 to 40 per cent), though the lower-numbered types, except type III, are rare. Under ordinary hospital conditions there is a considerable element of chance in their isolation. Furthermore, organisms recovered through a bronchoscope from the bronchial mouths do not always correspond with those in the sputum (Neuhof and Thomas, 1945). " Rusty " sputum, loaded with pneumococci, was obtained from our patients after admission in only one case of pneumonia out of five. In unmodified " classical " pneumonia, pneumococci are usually plentiful in the sputum around the time of the crisis, but when the course is altered by chemotherapy they may apparently remain scanty throughout. It seems probable that when clinical and radiological evidence points to pneumococcal lobar pneumonia, the finding of pneumococci (of the lower-numbered types at any rate) should be regarded as significant, even in small numbers only. If this view is correct, then to the numbers of pneumococci isolated must be added a further 35 per cent, which would have been found if mouse inoculation had been performed as a routine. These would suffice to account for the 77 cases (28 per cent) of lobar pneumonia from whose sputa no pneumococci were isolated.

GROUP I: PNEUMOCOCCAL PNEUMONIA

Of the total of 350 cases studied, 278 fall into this group. Patients were allocated to this group after careful study of such factors as the finding of pneumococci in the sputum ; the character and

onset of the symptoms ; clinical and radiographic evidence of lobar consolidation ; a raised leucocyte count ; a satisfactory fall in temperature as a result of treatment ; and reasonably rapid clearing of the radiographic changes.

The frequencies with which certain features were observed in the 278 cases were as shown in Table VI. These cases were sufficiently characteristic

TABLE VI

FREQUENCY OF CERTAIN SYMPTOMS IN 278 CASES OF PNEUMOCOCCAL PNEUMONIA

Symptoms	%
Onset with sudden rigors and chest pain　　..	54
Physical signs of consolidation: one lobe　..	70
two lobes　..	26
more than two lobes　..	4
Radiographic appearance of homogeneous lobar consolidation (with or without collapse)　..	69
Radiographic appearance of patchy scattered consolidation (mainly lobar) ..　　..　　..	31
Isolation of pneumococci from sputum:	
types I to VIII isolated　..　　..　　..	54
higher types isolated　..　　..　　..	17
pneumococci not isolated ..　　..　　..	29
Leucocyte count higher than 12,000 per c.mm. on admission　..　　..　　..　　..　　..	74
Fall of temperature to 98.4° F. within 7 days of commencing treatment (excluding deaths) ..	91
Radiographic clearance within one month　..	77
within two months　..	93

to justify their separation from the other groups discussed below, although not every one satisfied all the criteria.

The disease was, on the whole, more severe in those patients infected with pneumococci of types I, II, and III than in those infected with higher types or from whom no pneumococci were recovered, but the clinical course and incidence of complications were not sufficiently different to justify separate treatment. The age incidence is, however, of some interest (Table VII), since it bears

TABLE VII

AGE INCIDENCE OF CASES OF PNEUMOCOCCAL PNEUMONIA

Type	Average age
I ..　　..　　..　　..　　..	38
II ..　　..　　..　　..　　..	39
III ..　　..　　..　　..　　..	52
VIII and higher　..　　..　　..	44
Pneumococci not isolated　..	33

out the observation of earlier studies (Heffron, 1939) that type III infections tend to occur mainly in elderly people. Types I and II infection did

not show the predominant incidence in young persons in the prime of life which was expected.

Response to treatment.—The response to routine treatment with sulphonamides was satisfactory in more than 90 per cent of patients, the average time between onset of the disease and defervescence being 10.3 days (omitting patients who developed empyemata or who died, it was nine days). The average duration of symptoms before admission was four days and the duration of pyrexia in hospital was correspondingly less, being five days under treatment. Seventy-seven per cent of patients had no residual radiographic changes at the end of one month. Fifty-eight per cent were discharged within two weeks, and a further 34 per cent within four weeks of admission—the great majority going to convalescent homes for at least two weeks before becoming out-patients for follow-up.

Complications.—These are set out in Table VIII. The treatment of empyema in these cases has been discussed in detail elsewhere (Fatti and others, 1946), and will not be further discussed here.

The importance of *sterile pleural effusion* as a cause of persistence of pyrexia and of a raised erythrocyte sedimentation rate was shown by the observation that in nearly half these cases the temperature did not settle for ten to fourteen days, and in one-third the erythrocyte sedimentation rate was more than 20 mm. per hour by the Westergren

TABLE VIII

INCIDENCE OF COMPLICATIONS IN 278 CASES OF PNEUMOCOCCAL PNEUMONIA

Complications	No. of cases	Incidence, %
Sterile pleural effusion:		
less than 5 oz.	10 } 15	5
more than 5 oz.	5	
Empyema	11	4
Pyaemic abscesses ..	4	2
Abscess of lung	2	1
Extension during treat-ment	15	5
Blood culture positive after admission ..	14	5
Jaundice	6	2
Cardiac—pericarditis ..	4 } 5	2
endocarditis ..	1	
Venous thrombosis ..	6	2
Death	15	5
Meningitis	0	0

method after twenty-eight days. Tuberculosis, however, was excluded by the rapid resolution observed radiologically, and the effusions were presumably either due to pleural irritation by the underlying pneumonia, or would actually have been empyemata had they not been sterilized by chemotherapy at the time of development.

Deaths.—The overall death rate of 5 per cent for pneumococcal pneumonia among working-class

TABLE IX

ANALYSIS OF DEATHS FROM PNEUMOCOCCAL PNEUMONIA

		No. of patients	No. of deaths
Age-group (years)	10–20	30	1 (rheumatic mitral stenosis)
	20–30	40	0
	30–40	66	0
	40–50	44	1
	50–60	61	7 (1 pulmonary infarct)
	60–70	37	6
Duration of illness before admission	1–3 days	120	5
	3–6 days	101	4
	more than 6 days	57	6
Number of lobes involved ..	one	193	3
	two	73	6
	more than two	12	6
Pneumococcal type involved ..	I	3	1 patient, convalescent from clinically typical pneumococcal pneumonia though pneumococci could not be isolated from the sputum, died of pulmonary embolism
	III	8	
	VIII	1	
	XXIX	1	
	XXX	1	

patients aged 12 to 70 years is fairly satisfactory for days before penicillin, and due credit must be given to the nursing staff as well as to chemotherapy. Certain relevant points are analysed in Table IX. Eight out of the fifteen patients who died had a history of previous pneumonia or chronic bronchitis, which is not a significantly higher proportion than obtained in the group of pneumonias as a whole. The analysis of the deaths does, however, show that death was in the main associated with massive infection in elderly patients who had been ill for several days before admission. More than half the deaths were due to type III pneumococcus, although this type was isolated in only 16 per cent of all pneumococcal pneumonias. These findings agree with American series, but not wholly with those in the large series of Anderson and his colleagues in Glasgow (1938–42), where type II pneumococci caused twice as many deaths as any other type, although in their patients also type III infections carried the highest fatality rate (26 per cent) in cases of all ages.

Delayed resolution.—In view of the not infrequent diagnosis of delayed resolution as a cause of persistent ill-health following an acute pneumonia, those cases in which radiographic changes were present for more than two months after admission were analysed. The results are given in Table X. They show clearly that the diagnosis of " delayed resolution " would have been justified in less than 10 per cent of cases with prolonged illness.

GROUP II: PRIMARY PNEUMONIA DUE TO OTHER BACTERIA THAN PNEUMOCOCCI

This group, though small, was quite distinct. Classification was made by isolation of organisms from body fluids during life or at autopsy, or by repeated isolation as a predominant growth from

TABLE X

COMPLICATIONS FOUND IN CASES SHOWING PERSISTENT RADIOGRAPHIC CHANGES TWO MONTHS AFTER ADMISSION

Type of case	Number
No complication detected	2
Empyema	15
Pyaemic abscesses or lung abscess	4
Sterile effusion with spread of pneumonia ..	4
Venous thrombosis	2
Total	27

the sputum. Although there were only twenty cases in the group, there were among them five deaths, and the average stay in hospital was 23.5 days—more than twice as long as the pneumococcal pneumonias. Nearly all the patients were gravely ill, and nearly all developed complications. The infecting organisms and more important complications are set out in Table XI.

Haemolytic streptococci.—The origin of pneumonia due to haemolytic streptococci was generally different from that due to pneumococci. In two cases the streptococcal infection supervened upon old bronchiectasis. In three it followed a quinsy or acute tonsillitis. The mechanism in such cases was presumably that a small subpleural embolic abscess ruptured into the pleural cavity with resultant empyema, for haemolytic streptococci were no longer recoverable from the throat of two of these patients when the empyema developed. The treatment was along the same lines as for patients with pneumococcal infections. Although at first very ill, these patients did well.

Staphylococcus aureus. — The staphylococcal pneumonias, on the contrary, did very badly. Only one patient had the benefit of systemic treatment with penicillin, and had she not had it the mortality

TABLE XI

INFECTING ORGANISMS AND COMPLICATIONS IN TWENTY CASES OF PNEUMONIA DUE TO BACTERIA OTHER THAN PNEUMOCOCCI

	Cases	Cardiac (endocarditis and myocarditis)	Empyema	Lung abscess	Pyaemia	Sterile effusion	Death
Haem. strep.	9	—	4	—	1	—	—
Staph. aureus	7	2	3	4*	—	1	4
B. friedlanderi	2	—	—	1	—	—	1
Anaerobes mixed	1	—	1	—	—	—	—
Veillonella parvula ..	1	—	1	—	—	—	—

* One case had empyema as well.

rate would almost certainly have been five out of seven. The radiographic appearances showed multiple small areas of consolidation with or without cavitation, and in the four patients who died autopsy disclosed multiple lung abscesses from which *Staphylococcus aureus* was isolated in pure culture or associated with pneumococcus type III. One patient had auricular flutter, which did not respond to quinidine, and at autopsy her myocardium was found to contain numerous tiny staphylococcal abscesses.

It is worth noting, in view of the reported association between fatal staphylococcal pneumonia and preceding influenza infection (Finland and others, 1942), that only one of our patients in this group (which is admittedly very small) had a history of recent influenza-like disease. The others who died all had long histories of chronic bronchitis.

B. friedlanderi.—One case, who had a relatively mild infection, recovered (while receiving sulphamezathine). The other had a very severe infection, with much blood-stained sputum and marked cavitation of the lungs. He went downhill despite massive doses of sulphadiazine, and died with generalized oedema. At autopsy it was found that the acute infection was superimposed on a chronic tuberculous cavity.

Anaerobic infections.—Both patients with anaerobic infections had developed empyema following quinsies, and both were shown by iodized oil injection to have broncho-pleural fistulae. Their condition was therefore most probably due to rupture of a subpleural embolic abscess.

The identification of *Veillonella parvula* was kindly made by Dr. Herta Schwabacher. The organism was repeatedly isolated from the empyema fluid, sometimes in pure culture, but more often associated with a micro-aerophilic streptococcus.

Incidence of sulphonamide-fast strains of pneumococci.—The sulphonamide sensitivity of strains of pneumococci was tested by the ditch-plate method described in the Medical Research Council War Memorandum No. 10 (1945), and sensitivity was tested against the particular sulphonamide drug which the patient was receiving and usually against one other (sulphathiazole) as well. Several strains were tested at a time in order that sensitive strains should act as controls for the " insensitive " strains.

Tests were made as a routine on forty consecutive strains of pneumococci after primary isolation from sputa. Apart from these, tests were confined to pneumococci isolated from empyemata, or at autopsy, or from the sputum of patients who were

not responding to therapy clinically and in whose sputum pneumococci were persisting. The results are given in Table XII.

TABLE XII

TESTS OF SULPHONAMIDE-SENSITIVITY OF PNEUMOCOCCI

	No. of strains examined	Sensitive	"Insensitive"*
Routine sputa from patients responding satisfactorily	40	38	2
Sputa from clinically resistant cases	5	0	5
Empyemata	6	3	3†
Autopsies	8	5	3

* "Insensitive" is, of course, a relative term only. The initial concentrations of sulphonamide in the ditch were 25 or 50 mg. per 100 ml.
† A strain of haemolytic streptococcus is included.

Although this is not a large series, it suffices to show that complications and failure to respond satisfactorily were associated with a much higher incidence of " insensitive " strains that was present in the routine sputa. In general, though not always, the " insensitive " strains were obtained from patients who had had a prolonged or repeated course of sulphonamides. It is not possible to state whether the complications occurred because the pneumococcus became resistant early, or whether the resistance developed because treatment was prolonged owing to the complications. Both may be true. It is interesting in this connexion to note that Siegel and Julianelle (1945) found that in a colony of children treated prophylactically with sulphadiazine the great majority of strains of pneumococci isolated were more or less drug-fast. Hamburger and others (1943), however, reported a series of 171 pneumonia patients none of whose pneumococci were sulphonamide-resistant on primary isolation. After from four to twenty days of treatment only four strains showed increased resistance when tested for growth in liquid media containing varying concentrations of sulphonamides. This discrepancy in the findings may be real, or it may lie partly in the different methods used to assess resistance, since the ditch-plate method tends (rather erratically) to magnify differences in sensitivity over certain ranges of inhibitor concentration.

SUMMARY

In a series of 351 cases of primary pneumonia admitted to a municipal general hospital during the period July, 1942, to April, 1944, the disease was

attributed to pneumococci in 278 and to other pathogenic bacteria in twenty cases.

The recovery and complication rates in the bacterial pneumonias are discussed.

Data are presented on the interpretation of sputum findings and on the incidence of sulphonamide-resistant strains.

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