

PNEUMOCOCCIC INFECTIONS IN FAMILIES¹

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The development of multiple cases of pneumococcic pneumonia in a family within a short period of time is an infrequent occurrence. When information can be obtained from studies of family outbreaks it is helpful in understanding the epidemiology of pneumococcic infections. In this paper we wish to present an analysis of a series of thirty-three families in which two or more members were ill of pneumococcic infections. In the paper which follows (1) we have recorded bacteriological and immunological studies on all the members of five families of this series.

From the records of patients in whom the type of pneumococcus was determined at The Boston City Hospital during the past fifteen years we have found thirty-three family or contact groups in which two or more individuals were ill within a period of forty-five days. In every instance at least one member of the group had pneumonia. The clinical diagnosis, based on history and physical examination, was confirmed by roentgenogram, lumbar puncture, thoracentesis, or other laboratory procedures. The essential clinical and laboratory data of each case are summarized in Table I.

All the studies reported were made at The Boston City Hospital with two exceptions. One child (Number 23) was admitted to The Children's Hospital. The second patient (Number 16) was cared for at home by one of the district physicians of The Boston Dispensary, and the sputum of this patient was typed in the bacteriological laboratory of the Massachusetts Department of Public Health. We are indebted to the physicians of these two institutions for providing us with abstracts of the case histories.

At the outset certain difficulties were encountered. Only rarely was any attention paid in the

routine history-taking to inquiry into possible contacts with other cases of pneumonia. Moreover, if mention were made of other cases in the family it was frequent that only one member of the family was admitted to the hospital and the others were cared for at home by the family physician whose facilities for bacteriological study obviously were not comparable to those of a well equipped hospital. Occasionally, cases of pneumonia have developed on the wards in patients admitted for conditions other than respiratory infections. For the past several years, for example, an average of two internes of The Boston City Hospital have been ill of pneumonia each year. In many of these instances contact infection has been suspected but since no careful investigation was made at the time, we have excluded all material other than that adequately studied bacteriologically. We present the circumstances under which the material for this study was obtained in order to emphasize the fact that our data do not warrant any conclusions regarding the incidence of multiple cases of pneumococcic infections in families or in contact groups.

In addition to the cases occurring among members of family households we have included two instances of ward contact infection which came under our observation. In the first instance (Number 19) a sister and a brother were ill of lobar pneumonia and bacteremia due to a Type V pneumococcus. A third patient, who was ambulant in the room with the brother, developed a pneumococcus Type V lobar pneumonia, with bacteremia, about twenty-six hours after the initial exposure to the brother. The pneumococcic infection was fatal in all three patients. The ambulant patient had been admitted to the hospital for insulin regulation of diabetes mellitus but otherwise was well. Even though strict vigilance was employed, it was proven that he pillaged beyond the limits of his calculated diet and ac-

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quired his greatest spoils from the trays of other patients too ill to partake completely of their diets. With the apparent occurrence of contact infection observed on this medical ward an investigation was begun for other possible carriers of pneumococcus Type V and forthwith throat cultures were made on all the patients, nurses, and orderlies who had been in contact with either of the two male patients ill of Type V pneumonia. Cultures of the throat of seven patients in the same room, four nurses, and two orderlies failed to yield pneumococcus Type V.

The second instance outside a family group was that of an interne and a patient (Number 21) both of whom, within a period of six days, were ill of a Type VII pneumococcus pneumonia. The patient was admitted on the second day of a lobar pneumonia and a pneumococcus Type VII was isolated from her sputum. The physician, who incidentally had just begun his service, examined the patient, obtained the sputum for typing, and administered specific serum therapy. On the third day after the initial exposure he became ill of an upper respiratory tract infection, and three days

TABLE I
Pneumococcic infections in contact and family groups †

Group number	Relationship	Age	U.R.I.	Pneumococcic infection					Interval between pneumococic infections	Bacteriology			
				Onset	Admission	Discharge	Diagnosis	Result		Sputum	Blood	Throat swab	Other source
1	Mother Son	34	0	Jan. 16	Jan. 21	Feb. 3	Lobar	R	0	I	0	I	
		2	0	Jan. 16	Jan. 21	Jan. 28	U.R.I.	R					
2	Brother Brother	20	Jan. 25	Feb. 20	Feb. 21	Mar. 29	Lobar	R	17	I	0		
		11	Feb. 1	Feb. 3	Feb. 12	Mar. 1	Lobar	R					
3	Sister Sister	10	0	Nov. 25	Nov. 27	Dec. 14	Lobar	R	1	I	0		
		15	0	Nov. 26	Nov. 27	Dec. 14	Lobar	R					
4	Father Son	68	0	Mar. 19	Mar. 20	Mar. 23	Lobar	D	10	I	I		
		38	Mar. 27	Mar. 29	Mar. 30	Apr. 24	Lobar	R					
5	Son Mother	13	0	Mar. 4	Mar. 11	Apr. 2	Lobar	R	5	I	0		
		45	Mar. 5	Mar. 9	Mar. 11	Mar. 20	Lobar	R					
6	Mother Son	35	Dec. 23	Dec. 30	Jan. 1	Jan. 25	Lobar	R	6(731)	I	0		
		14	0	Feb. 1	Feb. 4	Mar. 1	Lobar	R					
7	Father Son	50	Oct. 1	Oct. 2	Oct. 3	Nov. 3	Lobar	R	4(736)	I	I		P.F. = I
		54	?	Nov. 7	Nov. 28	Jan. 1	Emp.	R					
8	Husband Wife	62	0	Mar. 6	Mar. 11	Mar. 18	Lobar	D	7	I	I		
		44	0	Mar. 13	Mar. 17	Mar. 25	Lobar	D					
9	Son Mother	16	?	Apr. 13	Apr. 17	May 2	Lobar	R	13	I	0		
		41	Feb. 28	Apr. 26	May 1	May 21	Lobar	R					
10	Son Father	17	Jan. 30	Jan. 31	Feb. 2	Feb. 15	Lobar	R	14(730)	I	0		
		38	0	Mar. 2	Mar. 4	Mar. 20	Lobar	R					
11	Sister Sister	23	Dec. 31	Jan. 6	Jan. 13	Feb. 24	Lobar	R	0	I	0		P.F. = I
		21	?	Jan. 6	Jan. 9	Mar. 18	Lobar-Emp.	R					
12	Son Father	19	0	Apr. 5	Apr. 8	May 4	Lobar	R	7	I, VI	0		
		42	Apr. 11	Apr. 12	Apr. 16	May 20	Lobar	R					
13	Sister Sister	6	Jan. 4	Jan. 8	Jan. 11	Apr. 21	Emp.	R	1				P.F. = I P.F. = I
		4	Jan. 4	Jan. 9	Jan. 15	Apr. 21	Emp.	R					
14	Daughter Mother	5	Dec. 8	Dec. 10	Dec. 24	Mar. 4	Emp.	R	10				P.F. = I P.F. = I
		31	Dec. 10	Dec. 20	Feb. 2	Feb. 21	Emp.	R					
15	Wife Husband	48	Oct. 12	Oct. 19	Oct. 20	Nov. 26	Lobar	R	5	II	II	II	S.F. = II
		56	?	Oct. 24	Oct. 25	Oct. 27	Menin.	D					
16	Brother Brother *	18	0	Feb. 1	Feb. 3	Feb. 23	Lobar	R	10	II	0		
		13	Feb. 5	Feb. 11	Feb. 11	Feb. 23	Lobar	R					
17	Son Daughter Father Daughter	15	Dec. 17	Dec. 25	Dec. 28	Jan. 10	Lobar	R	0	II	0	II	
		13	Dec. 23	Dec. 25	Dec. 29	Jan. 10	Lobar	R					
		48	Dec. 22	Dec. 26	Dec. 29	Jan. 21	Lobar	R					
		11	Dec. 19	Dec. 28	Dec. 29	Jan. 14	Lobar	R					
18	Sister Brother	54	0	Feb. 2	Feb. 8	Feb. 10	Lobar	D	0	V	V		
		29	Feb. 4	Feb. 2	Feb. 11	Feb. 12	Broncho	D					
19	Sister Brother Ward contact	58	?	?	Jan. 12	Jan. 17	Lobar- Menin.	D	3	V	0	II	S.F. = V
		53	Jan. 12	Jan. 15	Jan. 18	Jan. 25	Lobar	D					
		36	0	Jan. 22	Jan. 22	Jan. 27	Lobar	D	1	V	V		

TABLE I (continued)

Group number	Relationship	Age	U.R.I.	Pneumococic infection					Interval between pneumococic infections	Bacteriology					
				Onset	Admission	Discharge	Diagnosis	Result		Sputum	Blood	Throat swab	Other source		
20	Son	18	Feb. 18	Feb. 23	Feb. 21	Mar. 3	Lobar	R	22(728)	V	0	V XXII XXII XXII	Ear = XXII		
	Father	38	Feb. 20	Feb. 25	Feb. 26	Mar. 6	Lobar	R		2	V			0	
	Daughter	6	0	Mar. 28	Mar. 28	Mar. 28	? Broncho	R		4				0	
	Daughter	5	Mar. 18	Mar. 24	Mar. 25	Apr. 6	Lobar	R		4				0	
	Son	3	0	Mar. 28	Mar. 28	Apr. 8	Broncho	R		4				0	
	Daughter	2	0	Mar. 28	Mar. 28	Apr. 8	? Broncho	R		4				0	
	Daughter	9	0	Mar. 17	Mar. 17	Mar. 29	Tonsillitis	R						0	S.H. XXII 0
	Son	1½ mos.	0	Apr. 1	Apr. 2	Apr. 9	U.R.I.	R							
	21	Patient	29	Nov. 10	Nov. 22	Nov. 26	Dec. 8	Lobar		R	6			VII	0
Physician	26	Nov. 29	Dec. 2	Dec. 3	Dec. 14	Broncho	R	VII, H.I.	0						
22	Husband	45	0	Mar. 9	Mar. 12	Mar. 22	Lobar	R	30(743)	XII	0				
	Wife	32	?	Apr. 21	Apr. 23	May 15	Lobar	R		XII	0				
23	Son **	2½	Nov. 5	Nov. 12	Nov. 18	Nov. 21	Lobar	R	6	XIV	0	XIV			
	Father	44	Nov. 14	Nov. 18	Nov. 18	Nov. 21	Lobar	D		XIV	0				
24	Father	41	0	Dec. 27	Dec. 30	Jan. 23	Lobar	R	5	II, Gr. IV	0				
	Son	12	0	Jan. 2	Jan. 6	Jan. 22	Lobar	R		Gr. IV	0				
25	Father	29	0	Jan. 17	Jan. 21	Feb. 17	Broncho	R	2	III	0				
	Mother	28	0	Jan. 19	Jan. 21	Feb. 17	Broncho	R		Gr. IV, H.I.	0				
	Daughter	19 mos.	0	Jan. 19	Jan. 21	Jan. 29	U.R.I.	R		Gr. IV, H.I.	0				
26	Father	38	0	Jan. 8	Jan. 9	Jan. 31	Lobar	R	11(734)	I	0				
	Son	12	0	Feb. 11	Feb. 14	Feb. 26	Lobar	R		II	0				
27	Wife	72	?	?	?	June 10	Broncho	R	?	III	0				
	Husband	78	0	Apr. 14	Apr. 21	Apr. 28	Lobar	D		Gr. IV	0				
28	Brother	32	0	Feb. 13	Feb. 20	Apr. 8	Lobar	R	8	I	0	VIII			
	Brother	36	0	Feb. 21	Feb. 24	Feb. 25	Lobar	D		VIII	0				
29	Grandson ***	6	Dec. 20	Dec. 29	Jan. 5	Jan. 21	Lobar	R	2	VIII	0	XIV			
	Grandmother	60	Dec. 28	Dec. 31	Jan. 11	Jan. 14	Lobar	R		XIV	0				
	Grandfather	58	?	Jan. 6	Jan. 11	Jan. 14	Lobar	D		XIV	0				
30	Husband	38	?	Apr. 9	Apr. 16	Apr. 18	Broncho	D	6	Gr. IV	0				
	Wife	36	Apr. 9	Apr. 15	Apr. 16	May 13	Broncho	R		Gr. IV	0				
31	Mother	49	0	Apr. 13	Apr. 19	May 3	Broncho	R	0	Gr. IV	0				
	Daughter	18	0	Apr. 13	Apr. 19	May 4	Broncho	R		Gr. IV	0				
32	Wife	29	0	Jan. 15	Jan. 17	Jan. 27	Broncho	R	1	Gr. IV, H.I.	0				
	Husband	29	0	Jan. 16	Jan. 17	Jan. 30	Broncho	R		Gr. IV, H.I.	0				
33	Son	16	0	Feb. 21	Feb. 24	Mar. 16	Lobar	R	7(730)	Gr. IV	0				
	Father	44	Mar. 19	Mar. 23	Mar. 26	Apr. 5	Lobar	R		Gr. IV	0				

† Abbreviations:

- U.R.I., Upper respiratory infection.
- Emp., Empyema.
- O.M.A., Acute otitis media.
- Menin., Meningitis.
- Pn., Pneumococcus (type in Roman numeral).
- Gr. IV, Pneumococcus Group IV.

* Treated at home by Boston Dispensary District Physician.

** Treated at Children's Hospital, Boston.

*** Treated by family physician.

- H.I., Hemophilus influenzae.
- S.H., Streptococcus hemolyticus.
- S.F., Spinal fluid.
- P.F., Pleural fluid.
- R, Recovered.
- D, Died.

thereafter, or six days after his first contact, he had physical signs and x-ray evidence of broncho-pneumonia. A pneumococcus Type VII was obtained from his sputum. The wards to which this physician was assigned had at that time no other case of pneumonia due to a Type VII pneumococcus.

The relationship between the original and subsequent contact cases is shown in Table I. Group IV pneumococci were responsible for the infec-

tion in each of the eight patients of four families. These cases occurred prior to the subdivision of Group IV pneumococci by Cooper et al. (2, 3) and are included in our series only for the sake of completeness. Obviously, no analysis can be made of Group IV pneumococcus cases since the individual patients may or may not have been infected with the same type pneumococcus.

The remaining twenty-nine cases are readily divided into, 1—those in which the infections were

caused by the same type pneumococcus, and 2—those in which the infecting pneumococci were of heterologous types. The distribution of the cases according to the type pneumococcus is shown in Table II. Twenty-three groups, comprising

TABLE II

Type distribution of family and contact cases of pneumococcal infections

Type	Number of groups	Number of patients
I.....	14	28
II.....	3	8
V*.....	3	12
VII.....	1	2
XII.....	1	2
XIV.....	1	2
Homologous.....	23	54
Heterologous.....	6	14
Group IV.....	4	8
Total.....	33	76

* One family includes a double epidemic involving 3 patients with Pn. V and 4 patients with Pn. XXII (1).

fifty-four individual patients, were ill of pneumococcal infections due to organisms of homologous types, comprising seventy-nine per cent of the cases. In one family (Number 20), included among those of homologous type, there was a double epidemic, the organisms being pneumococci Types V and XXII. This family was studied in detail, bacteriologically and immunologically, and is considered fully in the paper that follows (1).

While in a large majority of the families pneumococci Types I and II accounted for the infections, it is significant that in seven instances pneumococci formerly classified as Group IV were specifically identified in the several members ill of pneumococcal disease. In three families pneumococcus Type V was isolated, and pneumococci Types VII, XII, XIV, and XXII were responsible for the infection each in one family group.

In the individual groups of cases infected with homologous pneumococcus types, the data indicate that when due allowance is made for differences in age, the disease had common features suggesting a similar virulence of infection beyond the presence of the same pneumococcus type. Thus the results of the blood cultures usually corresponded among the relatives, or both members of the same family developed empyema, or the ter-

mination was the same in each patient of the individual group.

The pneumococcal lesions were not always in the lungs. In each family group, however, at least one member had a lobar pneumonia but within the family group the pneumonia was not always of the lobar type, as seen in Numbers 18 and 20 where pneumococcus Type V caused a lobar pneumonia in one patient and a bronchopneumonia in the relative. Numbers 20 and 21 further illustrate that pneumococci Types XXII and VII respectively can produce a lobar pneumonia in one member of a family and a bronchopneumonia in other patients. Extra-pulmonary lesions, namely meningitis (Number 15) and acute otitis media (Number 20), can also be attributed to the pneumococcus of the same type that caused pneumonia within the family group. Upper respiratory infections in contacts who did not develop pneumonia, but from whom a pneumococcus of the same type was isolated from their nasopharynx as from the relative with pneumonia, are presented in Numbers 1 and 20.

In the six groups of patients infected with pneumococci of heterologous types, only one family (Number 26) exhibited both a distinct type difference and satisfactory evidence of contact. In this family, the father had a pneumococcus Type I lobar pneumonia, and the son later developed a pneumococcus Type II lobar pneumonia. Two families are included in which the exposures may have been of less intimate character than in the other instances presented. Number 28 consisted of two brothers, both chronic alcoholic addicts, who developed lobar pneumonia, due to pneumococci Types I and VIII respectively, within an interval of eight days. While the brothers lived in the same house, the extent of their contact with each other was not certain. In Number 29, the grandson was attended three or four hours each day by his grandmother who subsequently developed a Type VIII pneumococcus lobar pneumonia. The grandfather had had no exposure to the child for several weeks and his only contact with his wife, after the onset of her illness, occurred following her admission to the hospital. Seven days after the development of pneumonia in the grandmother, the grandfather contracted a pneumococcus Type XIV pneumonia,

with bacteremia. Of the three remaining groups of cases, two are concerned with Type III and Group IV pneumococci, the etiological significance of which may frequently be in doubt (4, 5) and was not definitely proved in these cases; and in the third family both members had Group IV pneumococci and one had Type II in addition.

In six instances (Numbers 6, 7, 10, 22, 26, and 33) there was difficulty in deciding what should be considered the correct interval of time between the original and the subsequent contact case, inasmuch as there was the question of double exposure. As shown, a patient was admitted to the hospital with a pneumococcic infection, was discharged after a necessary period of convalescence and, following his return home, a second case developed. Because the exact time of the acquisition of the infecting pneumococcus is indeterminate it is impossible to do more than indicate the double exposure. It has been shown (6-10) that either a patient ill of pneumonia or a contact may be a carrier of the causative pneumococcus for as long as six to twelve months. Regardless of which time is taken as the correct period, it is seen that the longest interval between contact cases was forty-three days (Number 22). In the greatest number of groups the onset of the pneumococcic infections was separated by an interval of fourteen days or less, and in three families the onset of the pneumonia was on the same day, strongly suggesting a common source of infection.

DISCUSSION

The conception of the dissemination of pneumococci producing disease has undergone considerable change in the last quarter of a century. Before the subdivision of pneumococci into types many investigators assumed that pneumococcic infections were of autogenous nature, based on the finding of pneumococci in the mouths of normal, healthy individuals. In order for disease to develop it was supposed that the resistance of the individual was lowered, or that the virulence of the pneumococcus was increased, or that some combination of the two occurred. Serious doubt was cast on this concept by Dochez and Avery (11, 12) who demonstrated that such an occurrence could account for only a small proportion

of the total number of cases of pneumonia since eighty per cent were due to pneumococci Types I, II, and III, whereas it was rare to isolate pneumococci Types I and II from the sputum of normal individuals. Moreover, they noted when a normal individual harbored Types I, II, or III pneumococci in his sputum, the individual had been in contact with a case of pneumonia and the type corresponded to that with which the patient with pneumonia was infected. Their general conclusion was, therefore, that the spread of pneumonia was the result of direct or indirect contact with a previous case.

Further investigation into the epidemiology of pneumococcic pneumonia has been directed along three main lines, 1—a study of pneumococcus carriers among those exposed to cases of pneumonia and in control series of healthy individuals in the population at large (6-25), 2—investigation of the family groups in which a case or multiple cases of pneumonia have developed (7, 19, 26, 27, 28, 29), and 3—observations on the bacteriology of epidemics of pneumonia (30-35). These studies are obviously of an overlapping nature, and many papers have included all phases. All the reports have emphasized the marked increase in the carrier rate in the group of individuals exposed to cases of pneumonia, and especially is this true in the cases of pneumococci Types I and II infections. Some of the investigators have also succeeded in demonstrating, in family contacts of cases of lobar pneumonia, instances of infections other than lobar pneumonia but due to the same type of pneumococcus.

The present paper adds thirty-three instances of multiple family or contact cases of pneumococcic infections in which the evidence strongly indicates that the subsequent infections were the result of exposure to a previous case or to a common source. It seems highly significant that twenty-three groups, or seventy-nine per cent of the cases, exclusive of those due to pneumococci Group IV, were infected with pneumococci of homologous types, and that over half of these cases were caused by a pneumococcus Type I or Type II. The further classification of pneumococci formerly included in Group IV (2, 3) has made possible the correlation of infections due to these types, which might previously have been

considered to be normal mouth organisms. More adequate bacteriological and immunological studies of cases infected with various pneumococcal types now permit of a more definite evaluation of the disease-producing agent in these cases (4, 5). There are presented here instances of multiple cases of pneumonia and other infections with types other than I and II.

SUMMARY

Thirty-three groups of multiple cases of pneumococcal infections are reported in which the evidence indicates that they were the result of contact with an antecedent case. With the exception of two instances, the infections occurred in families. Twenty-three groups included fifty-four individuals ill of pneumococcal infections of homologous types. The majority of contact infections occurred in less than fourteen days after exposure and were of similar severity. While the causative organisms were most frequently the Type I and II pneumococci, a significant proportion of the instances of multiple cases of pneumonia were due to type-specific pneumococci formerly classified in Group IV. Instances of empyema, primary meningitis, acute otitis media, simple upper respiratory tract infections, and bronchopneumonia were encountered in which the causative pneumococcus was of the same type as that which gave rise to uncomplicated lobar pneumonia in other members of the family.

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