

THE OCCURRENCE OF CARRIERS OF DISEASE-PRODUCING TYPES OF PNEUMOCOCCUS.

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In previous papers¹ we have discussed the varieties of pneumococcus responsible for the production of lobar pneumonia and the differences that exist between such organisms and those found in the mouths of healthy individuals. The pneumococci obtained from persons suffering from lobar pneumonia have been divided into four groups. We have pointed out that the first three groups are comprised of disease-producing races, and are responsible for about 75 per cent of all cases of lobar pneumonia. Approximately 25 per cent of cases of pneumonia are due to the fourth group. The pneumococci of this group cannot readily be distinguished from those dwelling in the normal human mouth. Disease caused by the highly parasitic types is usually much more severe than that occasioned by the strains which are indistinguishable from the sputum pneumococci. Inasmuch as the highly virulent forms are always associated with disease, and only occur in the mouths of healthy individuals under the special conditions which are reported in this paper, the evidence is strong that in the spread of lobar pneumonia the disease in a majority of instances is transmitted from one individual to another. Infectious diseases usually spread by immediate contact, through the intermediation of a temporary host, or by the agency of a healthy carrier. The importance of these modes of transmission varies with different diseases and in many instances more than one of these mechanisms may be involved. In all likelihood the healthy carrier may be a greater menace to the health of the community than the

¹ Dochez, A. R., and Gillespie, L. J., *Jour. Am. Med. Assn.*, 1913, lxi, 727. Dochez, A. R., and Avery, O. T., *Jour. Exper. Med.*, 1915, xxi, 114.

infected individual, largely because of failure to recognize the carrier condition. In the epidemiology of certain diseases, notably typhoid and epidemic cerebrospinal meningitis, the importance of the carrier state is well known because of the definite tracing of foci of disease to such a condition. The more readily a disease is transmitted from one individual to another, the greater becomes the number of instances at any one time, and consequently the more vigorous the search for the source of infection. The sporadic occurrence of lobar pneumonia, combined with the inability to distinguish disease-producing types of pneumococcus from those habitually living in normal mouths, has probably been responsible for the failure to establish a well defined epidemiology for this disease.

It is not our purpose in this paper to discuss the importance of immediate contact as a cause of the spread of pneumonia, for, although instances have occurred in which two closely associated individuals, such as husband and wife, have been infected within a short period with the same type of pneumococcus, cases of pneumonia usually develop at such wide intervals of space and time that direct contact relationships are obscured. Inasmuch as fully 75 per cent of all cases of lobar pneumonia are caused by peculiarly distinct races of pneumococci, not occurring in the normal mouth, then, as we have previously assumed, these instances of the disease must be due to contact infection, either direct or indirect, and some mechanism must exist by means of which the etiological agent is transmitted from one individual to another. In the present study we shall show that persons closely associated with individuals suffering from pneumonia in a large percentage of instances harbor in their mouths pneumococci of the same type as those causing the disease, that such organisms are not found in the mouths of normal individuals not exposed to pneumonia, and that the considerable period of time during which these organisms are carried may in part account for the sporadic occurrence of individual cases of pneumonia. An additional means of transmission exists in the fact that the recovered case also may carry the pneumococcus responsible for his disease during a relatively long period of time.

In the present paper are presented the studies of the pneumococci obtained from the mouths of persons associated with cases of pneumonia, of the type of pneumococcus encountered in the mouths of normal unexposed individuals, and of the period of time during which convalescents harbor the disease-producing organisms. For

TABLE I.

Incidence of Carrier Condition in Healthy Individuals in Contact with Lobar Pneumonia.

Case No.	Type of infecting pneumococcus.	Relationship of associates.	Type found in associates.	Duration of period of carrying.
2276	Type I	Wife	Type I	10 days+
2195	Type I	Husband	Type I	24 days.
2203	Type I	Wife	Type IV	
		Mother	Type IV	
2237	Type I	Nurse	Type I	Undetermined.
W	Type I	Wife	Type IV	
B	Type I	Wife	No pneumococcus	
		Daughter	Type IV	
2269	Type I	Wife	Type IV	
2286	Type II	Mother	Type IV	
		Father	Type IV	
2299	Type II	Sister	No pneumococcus	
2301	Type II	Wife	No pneumococcus	
2294	Type II	Wife	No pneumococcus	
2309	Type II	Mother	Type IV	
2314	Type II	Wife	Type II	Undetermined.
2335	Type II	Mother	No pneumococcus	
		Sister	No pneumococcus	
2326	Type II	Wife	No pneumococcus	
2330	Type II	Daughter	Type II	Undetermined.
2344	Type II	Sister	No pneumococcus	
1835	Type II	Wife	Type II	9 days+
2174	Type II	Son	Type IV	
2175	Type II	Mother	Type II	27 days+
		Sister	No pneumococcus	
		Nurse	Type II	Developed pneumonia, Type II.
2202	Type II	Mother	Type II	45 days.
2199	Type II	Husband	Type IV	
2298	Type II	Sister	Type IV	
2226	Type II	Wife	Type IV	
2245	Type II	Mother	Type IV	
		Brother	Type II	39 days+
2230	Type II	Wife	No pneumococcus	
2247	Type II	Daughter	Type II	Undetermined.
		Wife	No pneumococcus	
		Son	Type IV	
2266	Type II	Wife	No pneumococcus	
		Brother-in-law	No pneumococcus	
2270	Type II	Mother	Type II	7 days+
		Sister	No pneumococcus	
2265	Type II	Physician	Type II	21 days.

*Summary.*TABLE I.—*Concluded.*

Type of pneumococcus.	No. of cases.	Positive contacts.	Per cent.
Type I.....	8	3	37.5
Type II.....	24	10	41.7
Total.....	32	13	40.6

Approximate duration of carrier state 23 days.

the sake of clearness, an explanation of our classification of pneumococci is given. The organisms have been placed into four groups, numbered from I to IV. Groups I, II, and III are found only in association with disease and are distinctly parasitic in type. Members of Groups I, II, and III are recognized by their immune reactions which are identical within the respective group. Group IV consists of a heterogeneous series of strains which are not related antigenically, and which cause a minority of cases of pneumonia, and from which the pneumococcus occurring in the normal mouth is indistinguishable. In the Tables I to IV the pneumococci studied are classified according to this numerical grouping.

TABLE II.

Type of Pneumococcus Isolated from Sputum of Normal Individuals.

Pneumococcus.	Incidence.	Per cent.
Contacts { Type I	3	2.6
{ Type II	8	7.0
Type IV	55	48.6
No pneumococcus	47	41.6
Total	113	
Pneumococcus present	66	58.4
Pneumococcus absent	47	41.6

TABLE III.

Type of Pneumococcus Isolated from Individuals with Lobar Pneumonia.

Pneumococcus.	No. of cases.	Per cent.
Type I	78	34.97
Type II	75	33.63
Type III	22	9.86
Type IV	48	21.52
Total No. of cases	223	

TABLE IV.

Persistence of Disease-Producing Type of Pneumococcus during Convalescence.

Case No.	Type of pneumococcus during height of disease.	Type of pneumococcus after recovery.
1654	Type I	60 days, Type I. 65 days, Type IV.
1751	Type I	59 days, streptococcus. 73 days, streptococcus.
1775	Type I	30 days, Type IV.
1867	Type I	90 days, Type I.
1828	Type I	33 days, Type IV.
1792	Type I	30 days, Type IV.
2167	Type I	12 days, Type IV.
2168	Type I	45 days, Type I.
2191	Type I	15 days, Type IV.
2195	Type I	28 days, Type I. 49 days, no pneumococcus.
2203	Type I	12 days, no pneumococcus.
2237	Type I	13 days, Type I.
W	Type I	15 days, Type I. 23 days, Type IV.
B	Type I	14 days, no pneumococcus.
2250	Type I	10 days, Type I.
2269	Type I	13 days, no pneumococcus.
2284	Type I	15 days, Type I. 29 days, no pneumococcus.
2267	Type I	15 days, no pneumococcus.
2276	Type I	15 days, Type I.
1679	Type II	30 days, streptococcus. 48 days, Type IV. 108 days, Type IV.
1753	Type II	60 days, Type IV.
1763	Type II	34 days, streptococcus. 40 days, Type IV.
1761	Type II	47 days, streptococcus. 78 days, Type IV.
1825	Type II	53 days, Type II.
1786	Type II	20 days, Type IV. 25 days, Type IV.
1820	Type II	30 days, Type II.
1827	Type II	14 days, Type IV.
1880	Type II	63 days, Type II.
1950	Type II	21 days, Type IV.
1969	Type II	24 days, Type IV.
2174	Type II	15 days, streptococcus.
2175	Type II	17 days, no pneumococcus.
2212	Type II	12 days, Type II. 17 days, no pneumococcus.

TABLE IV.—*Concluded.*

Case No.	Type of pneumococcus during height of disease.	Type of pneumococcus after recovery.
2202	Type II	37 days, Type II. 43 days, Type IV.
2199	Type II	32 days, no pneumococcus.
2226	Type II	29 days, Type II.
2245	Type II	16 days, Type IV.
2266	Type II	15 days, Type II.
2270	Type II	37 days, Type II.
2286	Type II	10 days, Type II. 25 days, no pneumococcus.
2292	Type II	29 days, Type IV.
2296	Type II	19 days, no pneumococcus.
1743	Type III	13 days, Type III. 73 days, Type IV.
2185	Type III	16 days, Type III. 34 days, no pneumococcus.
2249	Type III	14 days, Type III.

In the above four tables are given the main facts upon which we base our assumption that in the majority of cases lobar pneumonia is a disease the continued wide-spread incidence of which is dependent upon communication of infection from one individual to another. Table I establishes beyond doubt the existence of healthy carriers of the disease-producing types of pneumococcus. The study of the carrier state was limited to the investigation of infection with pneumococcus Types I and II because of the relative ease with which these organisms can be distinguished from other types of pneumococcus. Out of a total of thirty-two cases studied, at least one carrier of infection among the patient's associates was found in thirteen instances, 40.6 per cent. Types I and II show approximately the same percentage incidence of the carrier condition, and in every instance the pneumococcus isolated corresponds in type with that of the infected individual. The approximate duration of the carrier state has been twenty-three days, which is probably somewhat shorter than would be found had it been possible to retain under observation all carriers until the disease-producing type of pneumococcus had disappeared from the mouth

flora. Study of Table I shows that positive carriers are more commonly observed among females than among males, a fact that is probably accounted for by the more frequent service of the former in a nursing capacity, thus entailing more intimate association with the sick.

Tables II, III, and IV develop somewhat further, points brought out in a previous communication. In Table II is shown the incidence of pneumococcus in the mouth flora of normal individuals and the classification of such pneumococci. All normal individuals studied are given in this table, whether in contact with cases of lobar pneumonia or not. Pneumococcus was found in 58.4 per cent of all instances and was absent in 41.6 per cent. Of the cases in which pneumococcus has been found, 48.6 per cent of the organisms have been of the sputum type and 9.6 per cent have been of the disease-producing type. All the latter have occurred in individuals intimately associated with cases of lobar pneumonia, and their presence is dependent upon this association. Determination of contact carriers of pneumococci belonging to Group III, *Pneumococcus mucosus*, presents certain difficulties. Only recently have we been able to obtain an immune serum effective against organisms of this group. Further development of the study of the mucous group is showing that certain organisms resembling in their cultural reactions *Pneumococcus mucosus*, are, in reality, mucous types of streptococcus. The latter varieties are frequently found in normal sputum, and have led to some confusion. With the working out of the serological reactions of the true *Pneumococcus mucosus*, evidence is accumulating that this organism is as strictly pathogenic in type, and has quite as specific immunological characteristics as pneumococci belonging to Groups I and II.

For comparison with the statistics given in Table II, which illustrates the prevalence of the mouth type of pneumococcus in normal individuals, Table III is added to show the percentage incidence of the fixed types of pneumococci observed in individuals suffering from lobar pneumonia. In this table the highly pathogenic types are dominant, being responsible for 77.2 per cent of all infections studied. This fact is convincing evidence that specific types of

pneumococci are mainly responsible for the production of lobar pneumonia. The dominance of these organisms in disease is in striking contrast to the high percentage incidence of the sputum type of pneumococcus in the mouth flora of normal individuals.

Table IV shows the length of time during which recovered cases of pneumonia harbor the organism responsible for their disease. The period of carrying is measured from the date of onset of the pneumonia. The shortest time in which the disease-producing pneumococcus has disappeared from the mouth has been twelve days, and the longest duration of carrying has been ninety days. These results show that pathogenic types of pneumococcus persist in the mouths of individuals recovering from lobar pneumonia for a variable period of time. Because of wide intervals between observations, the average duration of this condition can only be approximately determined, and has been found to be about twenty-eight days.

The studies detailed in this paper show that there are two sources of danger in the spread of pneumococcus infection. One lies in the occurrence of healthy carriers of disease-producing pneumococci among individuals associated with cases of pneumonia, and the other in the fact that patients recovering from the disease harbor the responsible organism for a considerable length of time. The actual tracing of cases of pneumonia to examples of the carrier state is difficult, but even the small amount of effort that has so far been devoted to this side of the study has brought to light an occasional suggestive fact.

SUMMARY.

Lobar pneumonia in 75 per cent of instances is due to specific types of pneumococci possessed of a high degree of pathogenicity. Although pneumococci occur in the mouths of 60 per cent of normal individuals, such organisms are readily distinguishable from the highly parasitic types of pneumococcus responsible for the severe forms of lobar pneumonia, a convincing proof that infection in this disease is, in the majority of instances, not autogenic in nature, but is derived from some extraneous source. In a high percentage of instances healthy persons intimately associated with

cases of lobar pneumonia harbor the disease-producing types of pneumococcus. In every such instance the pneumococcus isolated has corresponded in type with that of the infected individual. Convalescents from pneumonia carry for a considerable length of time the type of pneumococcus with which they have been infected. The existence of the carrier state among healthy persons and among those recently recovered from pneumonia establishes a basis for understanding the mechanism by means of which lobar pneumonia spreads and maintains its high incidence from year to year.