A STUDY OF CULTURES FROM SPUTUM AND BLOOD IN LOBAR PNEUMONIA.*

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The researches of Weichselbaum proved that the pneumococcus was the etiological factor in the majority of the cases of lobar pneumonia which he investigated, and those cases in which the organism of Welch and Fraenkel could not be isolated were therefore considered of minor import. In this latter class of cases Friedländer's bacillus was usually thought to be the causative agent. Pearce (1) isolated the pneumococcus in all but three of the 125 cases that he reported (97 per cent.), and he believes that in these three it was present at some time in the course of the disease.

In 1905 Schottmüller (2) assigned a prominent rôle to *Streptococcus mucosus* as an etiological factor, and yet since that date lobar pneumonias of origin other than the pneumococcus have been but little considered. Lyall (3) in 1912 reported a series of forty-two cases of pneumonia in three of which he isolated a streptococcus from the blood.

From the widely varying results in the bacteriological examination of patients having pneumonia, the impression is created that some factors other than differences in technique must be responsible for the differences in the results. From the results of work carried on at the Laboratory of Clinical Pathology at Cornell, we concluded that the widely varying results are due to the fact that lobar pneumonia may be caused by a variety of organisms.

Since 1903 a yearly study of the sputa in respiratory tract infections has been made from patients of the Cornell Dispensary and the Second Division wards of Bellevue Hospital. A report of these cases by Hastings and Niles (4) includes sixty-six cases of lobar pneumonia, in forty-three of which the pneumococcus was not

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found. This study led to the conclusion that "lobar pneumonia may produce sputum free from pneumococci, and may undoubtedly be caused by organisms other than the pneumococcus." The present paper is a continuation of that report and deals with some cases of lobar pneumonia from the Second Division of Bellevue Hospital during 1911. The work, however, is amplified in that the sputum studies were controlled by blood cultures from most of the cases.

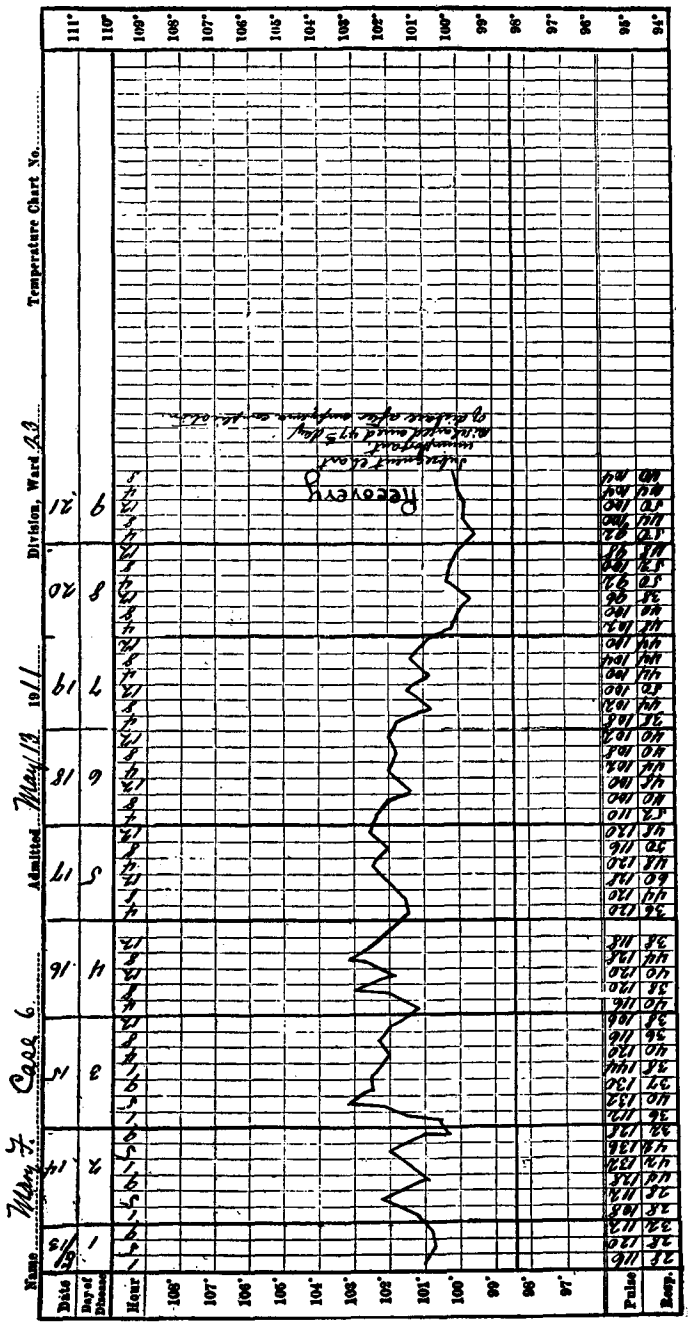
Niles and Meara (5) in 1911 reported two cases of lobar pneumonia, not caused by the pneumococcus, which are included in this series.

In one case *Micrococcus catarrhalis* was isolated several times from the sputum, and one blood culture from this case gave a negative result. The case was admitted to the hospital and is described as being "evidently primarily an arthritis." The conclusion of Meara and Niles, that "it seems much more logical to attribute all of the phenomena to an acute pyogenic infection, which in this instance it would seem fair to assume was the *Micrococcus catarrhalis,*" is unwarranted. *Micrococcus catarrhalis* has never been isolated from the blood, and has never been known to cause a general pyogenic infection.

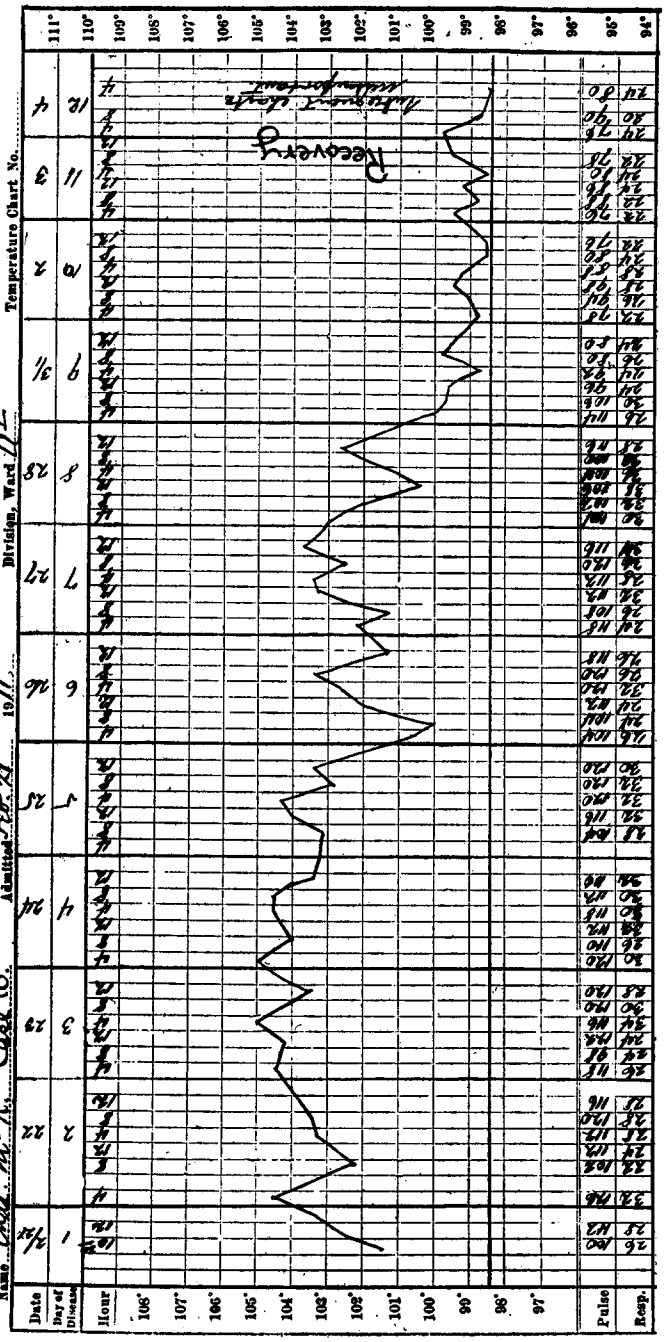
In the second case Meara and Niles reported obtaining *Bacillus coli communis* in pure culture from the sputum upon two examinations, and at the same time two negative blood cultures. These two cases are among the few reported in the literature in which cultures from the blood and from the sputum were taken at approximately the same time during the course of lobar pneumonia.

The present report comprises thirty-two cases in which blood cultures and sputum cultures were taken. A growth occurred in eleven of the blood cultures (34 per cent.). Of the eleven positive cases, the pneumococcus was found in nine and *Streptococcus hemolysans* in two. In all the cases in which the pneumococcus was isolated from the blood, it was isolated also from the sputum, and in the two cases showing streptococcemia the streptococcus was isolated from the sputum.

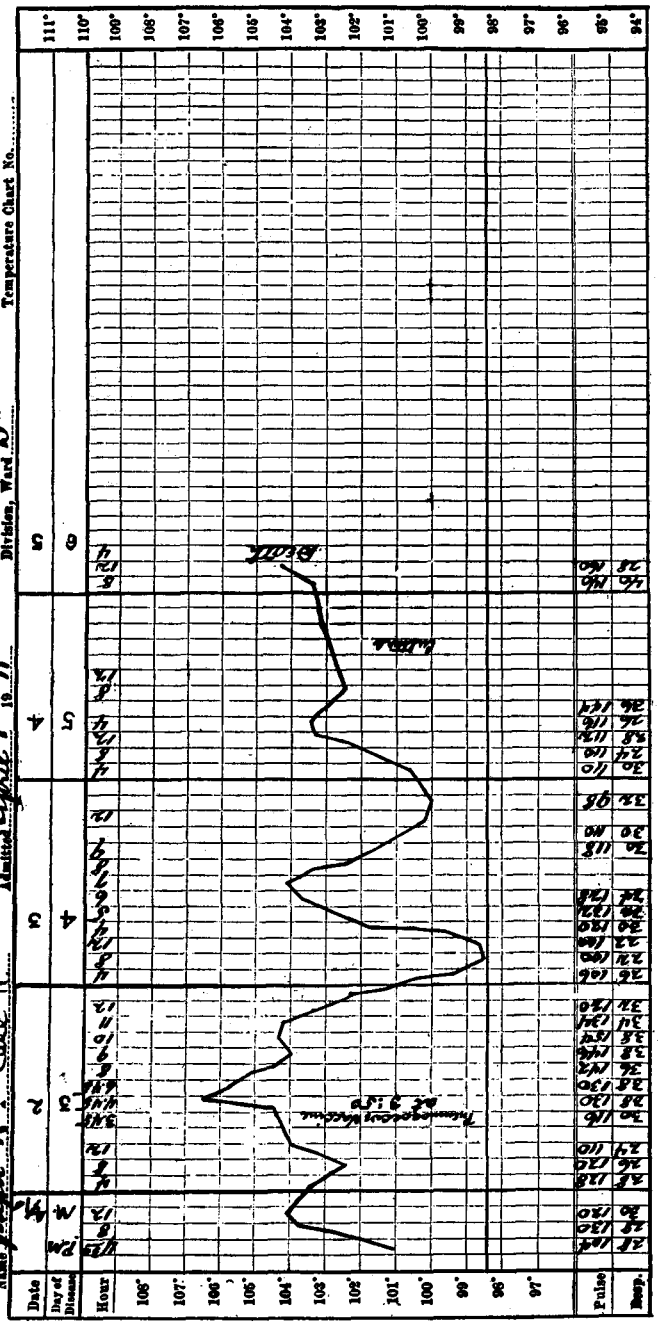
For the blood cultures the usual routine was followed. The blood was drawn into sterile Ewing tubes, and immediately poured



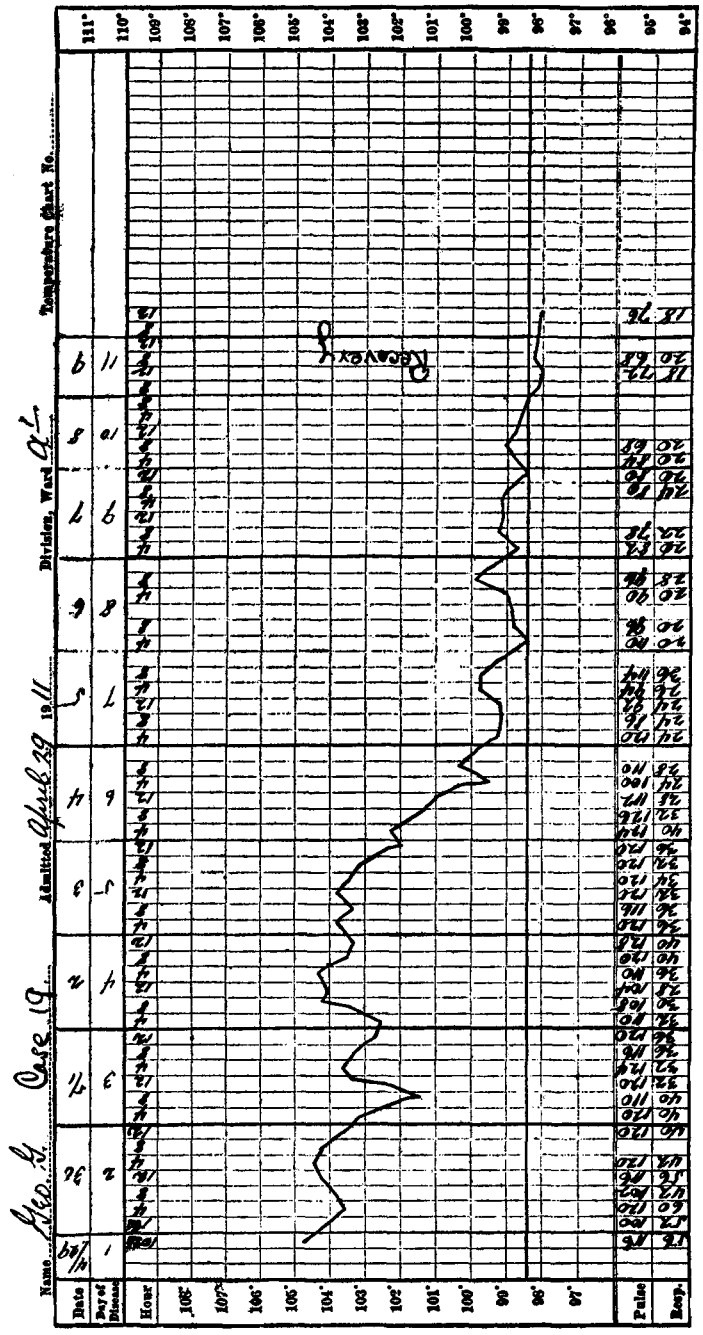
TEXT-FIG. 1. From a typical case with pneumococci in both the blood and the sputum.



TEXT-FIG 2. From a streptococcus case. The history, physical examination, and course of the case were typical of lobar pneumonia as it is ordinarily seen. *Streptococcus hemolysans* was found in the blood and the sputum.



TEXT-FIG. 3. From a streptococcus case. The history, physical examination, and course of the case were typical of lobar pneumonia as it is ordinarily seen. *Streptococcus hemolysans* was found in the blood and the sputum.



TEXT-FIG. 4. From a typical case with pneumococci in the sputum. The blood was negative.

TABLE I.

Case No.	Blood culture.			Sputum culture.	Remarks.
	Medium.	Dilution.	Result.		
1	Bouillon	1:50	+	Pneumococcus	Fatal case.
		1:75	+Pneumococcus		
	Agar plates		+		
2	Bouillon	1:25	+	Pneumococcus	
		1:50	+Pneumococcus		
		1:75	+		Fatal case.
	Agar plates		+		
3	Bouillon	1:25	+Pneumococcus	Pneumococcus	Fatal case.
		1:75	+		
4	Bouillon	1:25	+	Pneumococcus	Recovered.
		1:50	+Pneumococcus		
	North's medium plates		+		
5	Bouillon	1:25	+	Pneumococcus	Fatal case.
		1:50	+Pneumococcus		
	Agar plates		+		
6	Bouillon	1:25	+	Pneumococcus	Sputum not rusty. Patient recovered (text-figure 1).
		1:50	+		
		1:75	+Pneumococcus		
	Agar plates		+		
7	Bouillon	1:25	+	Pneumococcus	Fatal case.
		1:50	+Pneumococcus		
	North's medium plates		+		
8	Bouillon		+Pneumococcus	Pneumococcus	Recovered.
	Agar		+		
9	Bouillon		+Pneumococcus	Pneumococcus	Recovered.
	Agar		+		
10	Bouillon	1:50	+	*Streptococcus hemolysans (longus)*	*S. hemolysans (longus)* also in blood. Patient syphilitic. Typical lobar pneumonia clinically. Recovered (text-figure 2).
		1:75	+Streptococcus		
	Agar plates		+		

Case No.	Blood culture.			Sputum culture.	Remarks.
	Medium.	Dilution.	Result.		
11	Bouillon	1:25	+	*Streptococcus hemolysans (longus)*	Blood cultures and sputum both showed the streptococcus. Sputum rusty and viscid. Patient died (text-figure 3).
		1:50	+		
		1:75	+Streptococcus		
	North's medium plates		+		
12	Bouillon	1:50	−	Pneumococcus	Two blood cultures negative. Pneumococci in sputum both times. Fatal case.
		1:75	−		
	Agar plates		−		
13	Bouillon	1:25	−	Pneumococcus	Subsequent empyema. Three blood cultures negative. Recovered.
		1:50	−		
		1:75	−		
	Agar plates		−		
14	Bouillon	1:25	−	Pneumococcus	Patient alcoholic. Recovered.
		1:50	−		
	Agar plates		−		
	North's medium plates		−		
15	Bouillon	1:25	−	Pneumococcus	Massive pneumonia. Recovered.
		1:50	−		
		1:75	−		
	Agar plates		−		
	North's medium plates		−		
16	Bouillon	1:50	−	Pneumococcus	Sputum not blood-tinged. Recovered.
		1:75	−		
	North's medium plates		−		
17	Bouillon	1:25	−	Pneumococcus	Alcoholic. Fatal case.
		1:50	−		
	Agar plates		−		
18	Bouillon	1:25	−	Pneumococcus	Recovered.
		1:50	−		
	Agar plates		−		
19	Bouillon	1:25	−	Pneumococcus	Recovered (text-figure 4).
		1:50	−		
	North's medium plates		−		
20	Bouillon		−	Pneumococcus	Recovered.
	Agar		−		
21	Bouillon	1:50	−	*Bacillus coli communis*	Subsequent suppurative pleurisy. *B. coli communis* in exudate. Fatal case.
		1:75	−		
	Agar plates		−		

Case No.	Blood culture.			Sputum culture.	Remarks.
	Medium.	Dilution.	Result.		
22	Bouillon		—	*Micrococcus catarrhalis*	Acute arthritis. Tonsillitis. Lobar pneumonia. Recovered. One culture.
	Glycerin agar		—		
	Plain agar		—		
23	Bouillon		—	*Bacillus coli communis*	Two blood cultures negative. Recovered.
	Glycerin agar		—		
	Plain agar		—		
24	Bouillon		—	Streptococcus and staphylococcus	Recovered.
	Agar		—		
25	Bouillon	1:50	—	No pneumococcus	Recovered. Many staphylococci in sputum.
		1:75	—		
	Agar plates		—		
26	Bouillon	1:25	—		Patient quite toxic. Unidentified Gram positive chromogenic organism predominant in sputum. Recovered.
		1:50	—	No pneumococcus	
		1:75	—		
	Agar plates		—		
27	Bouillon	1:25	—	No pneumococcus	Few streptococci in sputum with many staphylococci. Patient alcoholic. Recovered.
		1:50	—		
	North's medium plates		—		
28	Bouillon	1:20	—		*B. influenzæ* isolated. Patient alcoholic. Recovered.
		1:50	—	No pneumococcus	
	Agar plates		—		
29	Bouillon	1:25	—	No pneumococcus	Subsequent empyema. Unidentified Gram negative bacillus in sputum. Recovered.
		1:50	—		
	Agar plates		—		
30	Bouillon	1:25	—		
		1:50	—	No pneumococcus	
		1:75	—		Fatal case.
	Agar plates		—		
31	Bouillon	1:25	—		Very toxic and delirious. Developed acute mastoiditis. Recovered. Two blood cultures, both negative.
		1:50	—	No pneumococcus	
		1:75	—		
	Agar plates		—		
32	Bouillon	1:25	—		
		1:50	—	No pneumococcus	Recovered.
	North's medium plates		—		

into flasks of broth in dilutions of 1 : 25 to 1 : 75. Blood agar plates were also made in varying dilutions, 1 : 3 to 1 : 12. No special media, such as that suggested by Wiens (6), were used, as in our experience growth took place as readily on the ordinary as on the special media. Strouse and Clough (7) in their reported series of cases seem to have had a similar experience. In all our positive cases growth occurred in both the liquid and solid media.

The sputa reported in this series were clean specimens, *i. e.,* free from varied bacterial and fungoid growth, buccal cells, and foreign particles. This is easily determined from a smear. The sputa were collected and washed after the method of Kitasato (8). After being washed, the selected portion of sputum was streaked upon plates of North's medium and upon blood agar, and from these colonies were later transferred to suitable media for differentiation. Three smears from each sputum were made. One was stained with methylene-blue, and showed at a glance whether the specimens were clean. The second was stained by Gram's method, and the third by Hiss's method for capsules. In no case were pneumococci recovered in culture where they were not seen in the smear preparations; and conversely, they were always procured in culture when present in smears.

The pneumococci and different streptococci isolated were referred to the laboratory for further study and for the purposes of this study were classified according to Schottmüller, except for slight modifications. The variations noted by those who have made particular studies of similar organisms were also investigated. The classification is as follows:

Streptococcus pyogenes (*longus et erysipelatis*).
Streptococcus hemolysans (*longus sue brevis,* Schottmüller).
Streptococcus mitior (*viridans, tenuis*) (*longus sue brevis,* Schottmüller).
Pneumococcus (Welch and Fraenkel).
Streptococcus mucosus (Perkins and Howard, and Schottmüller).
Micrococcus zymogenes (Hastings and Macallum).
Enterococcus (Thiercelin),—probably a *Streptococcus mucosus.*

In addition to the usual blood, glucose, and special media, such as North's and nutrose media, the following carbohydrate media were utilized.

Monosaccharids
- Hexoses
  - Dextrose
  - Levulose
  - Galactose

Disaccharids
- Saccharose
- Lactose
- Maltose

Polysaccharids
- Dextrin
- Inulin

Alcohols
- Mannite
- Dulcite

Our blood cultures show a low percentage (30.3 per cent.) of positive results for pneumococcus, which is in harmony with the results of Schottmüller, who obtained 23 per cent. of positive cultures out of 209 cases, and with those of Cole (9), who obtained 30 per cent. of positive cultures from thirty cases. These figures differ widely from those of other workers, notably Prochaska (10), who reported 100 per cent. of positive cultures out of forty cases, Rosenow (11), who obtained 91 per cent. out of 145 cases, and Kinsey (12), who reported 76 per cent. positive out of 25 cases. Kinsey seemed to think that the degree of dilution of the blood was a most important factor. We did not think that the dilution was so important, and our own work and that of others (Strouse and Clough (7)), who mention their dilutions, confirmed our opinion.

Our cases are summarized in table I.

SUMMARY.

In the thirty-two unselected cases studied, cultures were taken from both the blood and the sputum, and in five of these more than one blood culture was taken.

In one case the culture was taken from the blood only, and in this instance the pneumococcus was found. This case will be considered only with reference to the incidence of the pneumococci in blood cultures in lobar pneumonia.

The results in the thirty-two cases in which cultures were made both from the blood and the sputum are as follows:

1. In eleven cases the blood and sputum cultures were positive.

(*a*) In nine cases the pneumococcus was isolated, and five of these patients died.

(*b*) In two cases, instead of the pneumococcus, *Streptococcus hemolysans* (*longus*) was found. One of these patients died.

2. In twenty-one cases the blood cultures were negative, and in eighteen of these the sputum cultures were positive and in three negative. In these three the only result recorded was the absence of the pneumococcus.

(*a*) In nine cases the pneumococcus was isolated. Two of these patients died.

(*b*) In twelve cases no pneumococcus was found. Two of these patients died.

Of the patients in which no pneumococcus was found, in two cases *Bacillus coli* was isolated; in one case *Micrococcus catarrhalis;* in one case a staphylococcus (type not stated); in two cases staphylococcus and streptococcus; in one case *Bacillus influenzæ;* in one case *Bacillus fluorescens non-liquefaciens;* in one case an unidentified Gram positive chromogenic organism, probably saprophytic; and in three cases there are no recorded results except that the pneumococcus was absent.

In the total of thirty-three blood cultures, the pneumococcus was found in ten cases (30.3 per cent.), and six of the patients died. During the years 1910 to 1912 sputum cultures were taken from forty-four cases of pneumonia, of which twenty-four showed pneumococci (54 per cent.), and twenty showed no pneumococci (45 per cent.).

CONCLUSIONS.

1. Typical cases of lobar pneumonia, in which no pneumococci are to be found either in the blood or sputum, probably exist more frequently than is generally supposed.

2. These cases are not to be distinguished from the pneumococcus group except by blood and sputum cultures.

3. *Streptococcus hemolysans* (*longus*) is an organism which may give rise to such a case. In this connection it is of interest to note that Schottmüller (13) isolated *Streptococcus mucosus capsulatus* from the blood in a case of croupous pneumonia.

There is probably no prognostic value in the bacteriological findings in lobar pneumonia, but from a series of thirty-two cases we believe no definite opinion can be drawn.

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