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STAPHYLOCOCCUS AUREUS PNEUMONIA

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In the standard textbooks the staphylococcus is usually noted among other micro-organisms as a possible etiologic agent in the production of bronchopneumonia. A detailed description of the clinical picture of the disease associated with the presence of this organism in the lung has thus far failed to come to our attention. This is no doubt due in part to the relative rarity of this infection as encountered in civil practice, and possibly to the lack of careful study of the bacteriology of acute respiratory affections until but recently. How rarely *Staphylococcus aureus* infection of the lung occurs and how grave the prognosis is may best be stated by noting that in a series of about 800 cases of pneumonia, drawn from all classes of the population of New York City, only thirteen cases were treated at the hospital of the Rockefeller Institute under the direction of Dr. Rufus Cole, in a period of five years from 1913 to 1918, and of these, ten patients died. Some of these cases of bronchopneumonia were apparently secondary to local infections elsewhere in the body. Two seemed to be due to a primary infection of a finger and the scalp. One followed a severe attack of measles; another complicated a Type IV pneumococcus pneumonia. In most instances, however, it was impossible to find any antecedent infection, and the lungs appeared to be involved primarily.

During the present epidemic of influenza at Camp Jackson, S. C., which began about September 15 and continued for practically one month, a very unusual opportunity was afforded to study this infection in the medical clinic, under the direction of Major W. W. Herrick, chief of the medical service. In this period about 8,100 patients, chiefly soldiers, were admitted to the base hospital with an acute febrile condition accompanied by inflammatory changes of the upper respiratory passages and diagnosed influenza. The majority of these men after from three to five days of fever made a rapid and uneventful convalescence, returning to duty within a week or ten days. On the other hand, approximately 1,400 either continued to have fever and prostration, or after an afebrile period of from three to seven days began to show clinical evidence of inflammatory change in the deeper air passages of the lungs, and the condition was diagnosed as pneumonia, either broncho or lobar in

type. Many of these cases of pneumonia were relatively mild, only parts of one or two lobes being involved, usually the lower lobes and the dependent portions.

The examination of the sputum of these patients showed most frequently the presence of the pneumococcus, especially the strains designated as Type IV, less often *B. influenzae*, various types of streptococci, and various members of the gram-negative diplococcus group, usually *M. catarrhalis* or *M. flavus*. A certain number of cases, relatively few as compared with the total number of cases of pneumonia, but large when correlated with the total number of deaths, presented an entirely different picture. These patients were extremely prostrated almost from the onset of their infection. After being ill from three to four days with influenza, their condition became critical. They exhibited an unusual type of cyanosis. The cherry-red indigo-blue color was indeed very striking, though not pathognomonic of the infection to be described more fully, that associated with *Staphylococcus aureus*.

CLINICAL FEATURES OF THE DISEASE

The onset of *Staphylococcus aureus* pneumonia is almost always insidious and rarely accompanied by the chill and localized pain of a typical lobar pneumonia, though the course of the disease is extremely rapid. The facies, the anxious expression, and deep cyanosis suggest a grave prognosis from the onset, at a period when physical signs of pulmonary involvement are but scanty. Herpetic eruptions on the lips are scarcely ever noted, nor is delirium present except rarely. Usually the mind is clear almost to the end. Epistaxis is not uncommon. Occasionally pleuritic pain is complained of, but this is not usual. It is the picture of a general septicemia, so often seen in puerperal sepsis when the patient so little realizes the close proximity of death. Sweating is not a striking symptom of this type of infection, though near the end, the skin frequently becomes moist and later clammy. The fever on the whole is high, ranging between 104 and 106, with frequent remissions to 101. The pulse is relatively slow, at the onset under 100, and in only a few cases does it rise above 120 until just before death. The quality of the pulse, on the other hand, is usually poor, small, weak, and in many cases almost imperceptible. Respirations usually range between 24 and 36 and in some cases rise to 50 or 60 without much obvious discomfort. These patients rarely have the painful and labored breathing seen in pneumococcus infections.

Figure 1 illustrates the typical course of the disease in a patient who developed his infection in the hospital:

A white soldier, aged 22, and a native of Alabama, was admitted to the hospital, Sept. 6, 1918, about a week before the first cases of influenza began to appear in camp. He had

a moderately severe estivo-autumnal malaria and a chronic hookworm infection. Under treatment with quinin he had had no fever since September 10, and apparently was convalescing nicely. Although in a ward in which there were

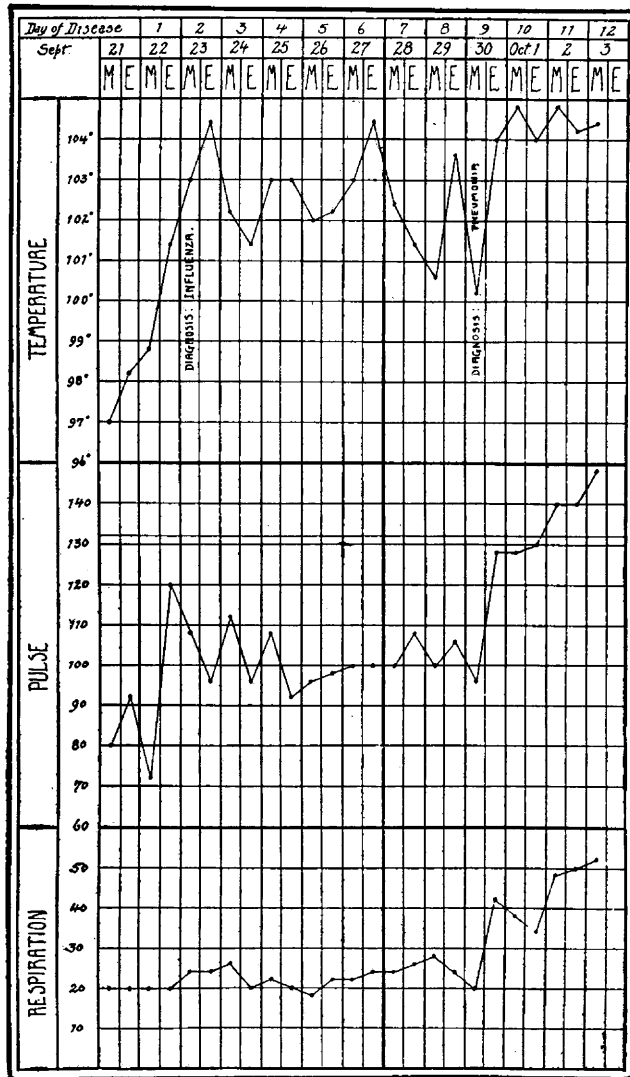


Fig. 1.—Temperature, pulse and respiration chart in a case of influenza and of bronchopneumonia of the right and left lower lobes that developed in a farmer from Alabama admitted to the hospital because of estivo-autumnal malaria. Blood count, October 3: white blood cells, 5,100; polymorphonuclears, 86 per cent.; lymphocytes, 13 per cent.; large mononuclears, 1 per cent.

no influenza patients, on the evening of September 22 he had fever and the following morning the symptoms of influenza. From that day on his temperature ranged between 101.4 and 104.4. His pulse and respirations were relatively slow until September 30, the ninth day of his illness, when signs of consolidation were noted over the right lower lobe of the lungs. From then on he rapidly became critically ill, having a pale color and a dark blue cyanosis, death following on the twelfth day of his disease.

Clinical examination of the chest of the average case reveals a very atypical type of pneumonic involvement. Signs of congestion of both lower lobes are found frequently, though in the majority of cases a diffuse process in all the lobes may be present. At the onset, only slightly diminished resonance to percussion may be elicited, with diminished breath sounds and many coarse and fine moist râles. Fluoroscopic examination of the chest at this time reveals little or nothing. But rarely are there signs of pure consolidation of one or

more lobes, and then only late in the disease. Frequently there is an abundance of coarse moist râles heard throughout the chest. Rarely are pleural friction sounds elicited. In a very few cases a pleuropericardial rub may be heard. In one instance Major Herrick detected a true pericardial friction, on which sign, together with the roentgenographic evidence, the diagnosis of pericarditis was made, which was confirmed by the necropsy (Fig. 2).

Staphylococcus aureus pneumonia usually pursues a rapid course. Of the patients studied at Camp Jackson, twelve died between the first and fifth day, and seventy-three between the sixth and tenth day of the disease. In Table 1 the onset of the pneumonia was calculated from the onset of the first symptoms of influenza. It will be seen that the average length of the disease was not as long as that of ordinary primary

TABLE 1.—THE DURATION OF STAPHYLOCOCCUS AUREUS PNEUMONIA

Day of the Disease on Which Death Occurred	No. Cases	Per Cent.
1-5	12	7.8
6-10	73	47.7
11-15	41	26.7
16-20	15	9.8
21-25	7	4.5
26-30	2	1.3
31-35	1	0.6
36-40	2	1.3

lobar pneumonia. This fulminating character of the infection was likewise noted in the cases studied several years ago in New York.

LABORATORY FINDINGS OF THE DISEASE

The most characteristic feature of this type of pneumonia is the sputum. When typical, the sputum is friable, purulent material of a dirty salmon-pink resembling anchovy sauce or the contents of an overripe furuncle. Occasionally the sputum is hemorrhagic, at

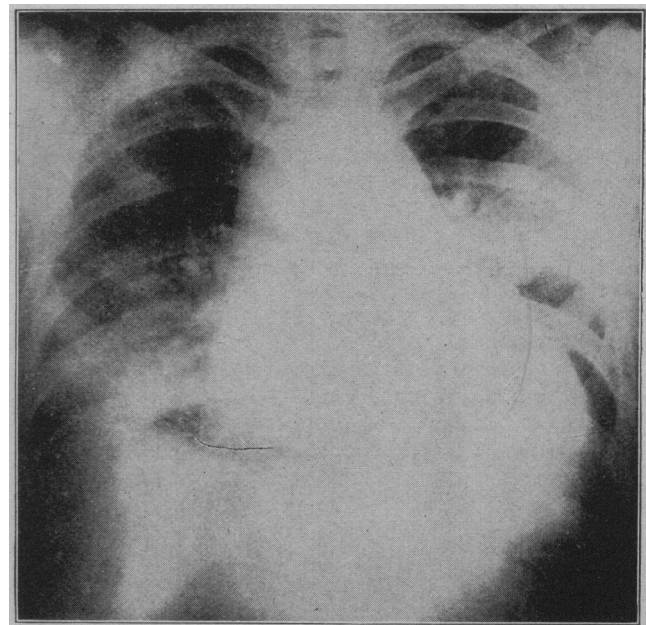


Fig. 2.—Diffuse bronchopneumonia and fibrinopurulent pericarditis; pure *Staphylococcus aureus* infection.

first suggesting an acute pulmonary hemorrhage; but on close inspection its purulent character can be distinguished. If smears of such sputum are made and stained according to Gram's method, one sees field after field of gram-positive group cocci and pus cells.

One can almost give a fatal prognosis when sputum as described above is obtained. Typical sputum, however, cannot always be procured; and frequently cases that ultimately result fatally produce only greenish yellow

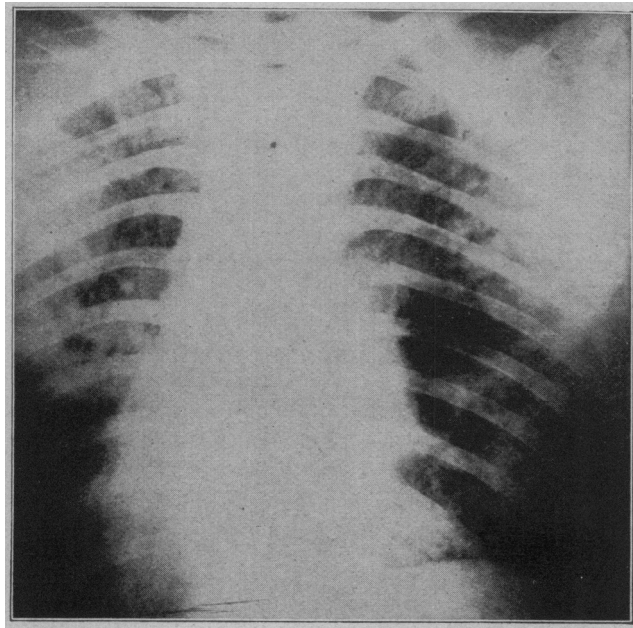


Fig. 3.—Diffuse bronchopneumonia; *Staphylococcus aureus* and hemolytic streptococcus recovered from the lung.

purulent material which on culture yields the staphylococcus as the predominant organism.

If sputum containing the staphylococcus is streaked on glucose-free blood agar plates, the colonies appear as opaque, round, shiny disks about 1 mm. in diameter surrounded by a wide zone of hemolysis after eighteen hours' incubation. On removal from the incubator, the colonies may appear white; but if the plates are allowed to remain a few hours in the day or sunlight, the yellow pigment appears.

In the routine examination of hundreds of specimens of sputum, *Staphylococcus aureus* is encountered frequently both from the throats of normal individuals and from those having a definite pneumococcus infection, but not usually as the predominating organism. It is impossible to say what proportion of those having pneumonic lesions and showing *Staphylococcus aureus* in the sputum are harboring the organisms in the alveoli of the lungs. A considerable number of individuals presenting these findings have recovered, but it is doubtful that many of them actually had a staphylococcus infection of the lungs when one considers the pathology of the disease. In many cases, in addition to the predominating *Staphylococcus aureus* in the sputum there were recovered various types of pneumococcus, *B. influenzae*, streptococcus and other organisms. The presence of these bacteria in association with the staphylococcus in the lung was confirmed in many instances in the postmortem examinations.

BLOOD CULTURES

During the height of the epidemic it was possible to make relatively few blood cultures, many of the laboratory staff themselves being ill, and technical difficulties with the culture medium made the possibility of obtaining bacterial growth uncertain. Two cases were reported as having positive cultures. At the Hospital

of the Rockefeller Institute, positive blood cultures were obtained in 53 per cent. of the cases of *Staphylococcus aureus* infection. Consequently it is evident that a bacteremia occurs with much greater frequency than with the hemolytic streptococcus infections of the lung, in which it is quite unusual to be able to demonstrate a bacteremia except just before death and then rarely. Only one patient having a positive culture has recovered, to our knowledge, so that the presence of a bacteremia is of very grave import.

PLEURAL FLUIDS

Few cases showed clinical evidence of accumulation of fluid in the chest or pericardium. When present, the fluid was slightly cloudy amber in color, sometimes with a tinge of blood, when discovered early in the disease. If later, frankly greenish-yellow pus may be obtained. Direct smears of the fluid stained by Gram's method show many pus cells and gram-positive group cocci. Many of the bacteria may be seen phagocyted. Cultures of the fluid on plain or blood agar show the typical colony of *Staphylococcus aureus*. The culture plates should be incubated for seventy-two hours before discarding, for frequently when present, the small, colorless, dewdrop-like colonies of *B. influenzae*, which are prone to develop as satellites about the large staphylococcus colony, may escape notice after eighteen hours' incubation, when they are only pinpoint in size and are seen only with a hand lens.

If, by chance, the chest is explored and no fluid is obtained, the needle penetrating solid or semiconsolidated lung tissue, the needle may be washed out by aspirating a little plain bouillon broth culture medium into the syringe and cultures made with the blood-tinged fluid. One can frequently recover *Staphylococcus aureus* in this manner, if it is present.

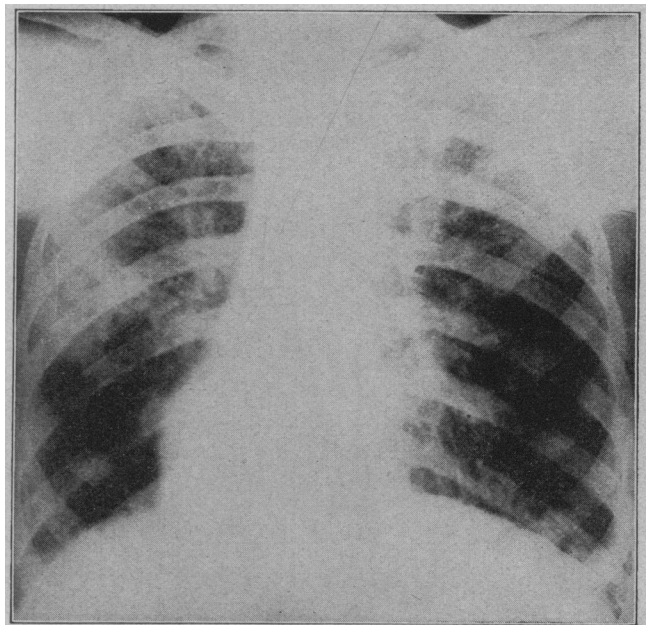


Fig. 4.—Diffuse bronchopneumonia; *Staphylococcus aureus* and *B. influenzae* recovered from the lung.

BLOOD EXAMINATIONS

Under the direction of Major M. A. Barber, chief of the laboratory of the base hospital, leukocyte determinations were made of a considerable number of cases of *Staphylococcus aureus* pneumonia.

Table 2 shows the white blood cell estimations of cases grouped according to the results obtained from the postmortem cultures. It is obvious that the majority of the figures are quite unlike those obtained

It is possible that the cause of the primary epidemic infection, whatever it may be, depresses the hematopoietic system to such a degree that it is unable to react normally to infection by bacteria, which is usually accompanied by a leukocytosis. This, in turn, may offer an explanation for the production of pathologic lesions in the lungs by the bacteria that are commonly found in the nose and throat of healthy individuals and which are to be considered as secondary invaders.

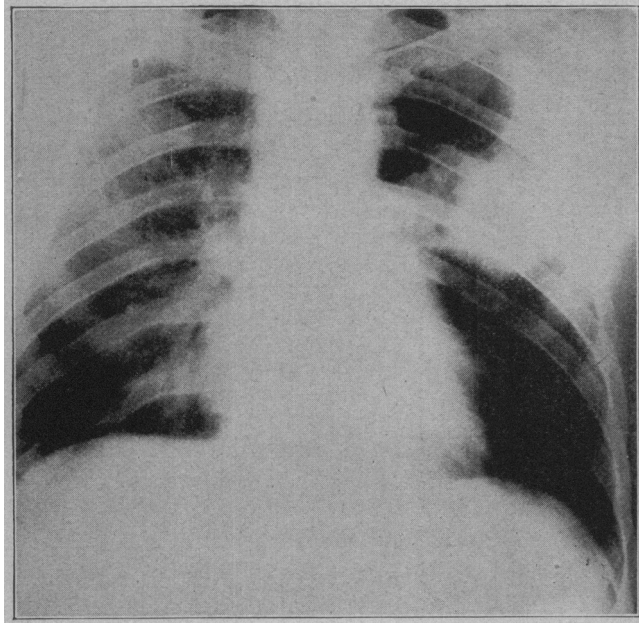


Fig. 5.—Diffuse and confluent bronchopneumonia with abscess formation; *Staphylococcus aureus* and pneumococcus Type IV recovered from the lung.

The examination of the urine has shown nothing characteristic of *Staphylococcus aureus* infection, though no special investigation was made of the urine in these cases. A trace of albumin and a few granular casts are frequently seen, as in most acute febrile conditions. Apparently the disease is of so brief a duration that the formation of abscesses in the kidneys rarely takes place.

ROENTGEN EXAMINATIONS¹

Brief mention has been made of the lack of definite localized shadows in the lungs on fluoroscopic examination early in the disease. Figures 3 and 4 are illustrative of the diffuse involvement of the lungs as shown by roentgenograms. In many instances the diffuse mottling of the whole lung suggests the lesion associated with miliary tuberculosis. In other instances, as in Figures 5 and 6, small multiple areas of consolidation can be demonstrated. Occasionally whole lobes are involved, there being a confluent bronchopneumonia present or a pneumococcus lobar type of lesion with a *Staphylococcus aureus* infection superimposed. The roentgen ray has been of great value as an aid in the diagnosis of the chest complications of this disease, namely, empyema and pericarditis (Figs. 2 and 7).

in ordinary lobar pneumonia. Both the patients dying of pure *Staphylococcus aureus* infection and those having a mixed infection with *B. influenzae*, pneumococcus or hemolytic streptococcus, show in many

TABLE 2.—BLOOD EXAMINATIONS

— <i>Staphylococcus Aureus</i> —		— <i>S. Aureus</i> and <i>B. Influenzae</i> —	
Number of Leukocytes	Polymorphonuclears, per Cent.	Number of Leukocytes	Polymorphonuclears, per Cent.
2,800	46	4,400	65
2,900	57	4,400	83
3,100	53	6,700	87
3,100	84	8,000	76
3,900	52	8,000	76
4,100	80	8,500	70
4,300	84	27,300	89
4,400	86	31,800	82
4,500	66		
4,500	59	<i>S. Aureus</i> and <i>Pneumococcus</i> Type I	
5,000	75	5,600	62
5,000	67		
5,100	86	<i>S. Aureus</i> and <i>Pneumococcus</i> Type II	
5,500	53	3,300	77
28,600	83	6,700	86
6,300	76	13,000	78
6,900	84		
11,000	94	<i>S. Aureus</i> and <i>Pneumococcus</i> Type III	
7,000	81	5,500	64
8,000	72	12,900	93
8,400	74		
9,200	76	<i>S. Aureus</i> and <i>Pneumococcus</i> Type IV	
9,600	87	4,800	84
10,300	83	7,700	77
10,400	85	9,600	69
11,000	76	10,100	58
11,400	93	11,600	92
13,400	86	12,900	69
15,600	90	38,000	Meningitis 90
21,000	Recovered 84		
24,000	83	<i>S. Aureus</i> and Nonhemolytic <i>Streptococcus</i>	
28,400	89	4,000	75
28,600	Pericarditis 90	5,000	69
35,500	Empyema 86	8,500	89
54,000	Pericarditis 95		

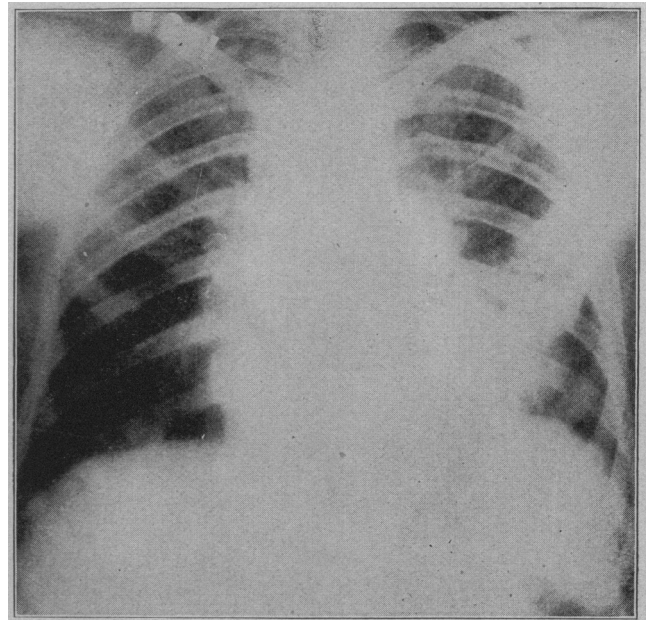


Fig. 6.—Diffuse and confluent bronchopneumonia; *Staphylococcus aureus* and *B. influenzae* recovered from the lung.

instances a leukopenia. The majority are about normal; a few show a moderate leukocytosis. Many of those having an increased number of white blood cells had localized complications, as empyema or pericarditis, as noted in the table.

COMPLICATIONS

In this series of cases the complications have been relatively rare. This has been due largely to the high

1. The roentgen examinations, plates, and photographs were made under the direction of Lieut. G. A. Finney, M. C., U. S. Army, of Kansas, in charge of the roentgen laboratory, base hospital, Camp Jackson, S. C.

immediate mortality, the disease running a brief course, death intervening in about ten days and in some cases as early as the fifth day. Only three patients have had discoverable empyema. One of these patients, who

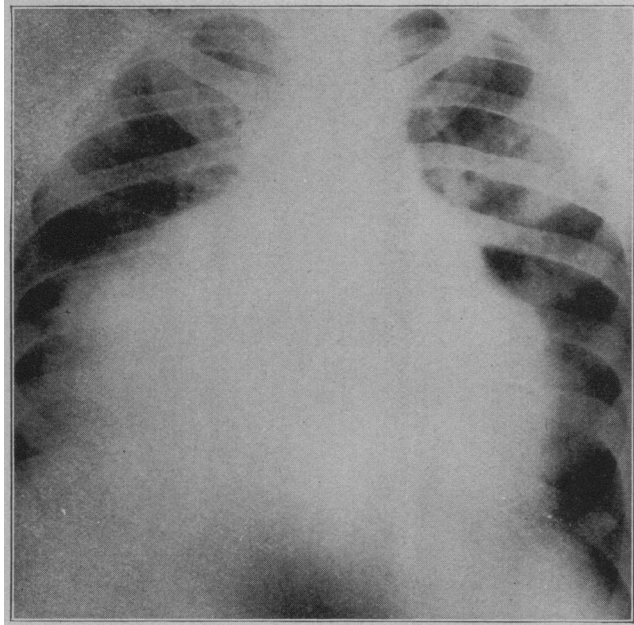


Fig. 7.—Localized suppurative pleuritis; pure culture of *Staphylococcus aureus* obtained from pus.

had a bacteremia early in the course of the disease, died on the ninth day with a diffuse process in the lungs and a left suppurative pleuritis. The second patient, in addition to a double empyema, had suppurative pericarditis and a bilateral otitis media, and died on the thirty-second day of the disease. The third case was quite unusual, and the patient is convalescing nicely. A large pocket of pus developed in the right chest in the angle between the mediastinum and the diaphragm (Fig. 7). This abscess was drained by resecting a portion of the fifth rib in the anterior axillary line.

Other complications have been few in number. Seven patients had acute otitis media. One patient had a staphylococcus meningitis. Nine patients had signs of meningeal irritation, but examination of the spinal fluids proved them to be normal. One patient developed a *Staphylococcus aureus* pericarditis. The pericardium, both parietal and visceral layers, were covered with a thick, shaggy coat of fibrin. A small amount of purulent fluid was found in the pericardial sac (Fig. 2).

Subcutaneous emphysema, a complication rarely seen in primary lobar pneumonia, was encountered six times in the total series of about 1,400 cases of pneumonia. In two of these cases *Staphylococcus aureus* was isolated from the lung. The emphysema has been very extensive, involving the head, neck and trunk. In one case the eyelids were completely closed. It apparently embarrassed the respirations but little.

One patient had a complicating suppurative parotitis from which the staphylococcus was cultivated. Several patients had multiple furuncles.

PATHOLOGY

Of the necropsy examinations made during this epidemic by Capts. Paul Wegeforth and W. H. Norton,

in fourteen cases it has been possible to cultivate *Staphylococcus aureus* directly from the lung tissue, either as the sole organism or in association with other micro-organisms, as shown in Table 3.

From this material an unusual opportunity has been presented to study the lesions associated with the presence of *Staphylococcus aureus* in the lung tissue. The lungs on gross inspection are not usually so voluminous as those seen in the hemolytic streptococcus infections, nor do they have the same shotty feeling on palpation. Usually the dependent portions of the lungs, the lower lobes or very frequently the posterior portions of all the lobes being the dependent parts with the body in the horizontal position, are involved.

TABLE 3.—LUNG CULTURES IN FOURTEEN CASES

	No. of Cases
<i>Staphylococcus aureus</i>	7
<i>Staphylococcus aureus</i> and <i>B. influenzae</i>	1
<i>Staphylococcus aureus</i> and pneumococcus Type I.....	1
<i>Staphylococcus aureus</i> and pneumococcus Type II.....	1
<i>Staphylococcus aureus</i> and pneumococcus Type III.....	1
<i>Staphylococcus aureus</i> and pneumococcus Type IV.....	1
<i>Staphylococcus aureus</i> and <i>Streptococcus hemolyticus</i>	1

There may or may not be any pleural exudate. A fibrinous exudate is much less commonly found than in lobar pneumonia. The surface of the affected portions of the lung is deep purplish blue. If one examines the pleura carefully, one can usually see, in addition to showers of petechiae, small yellowish white spots, pinhead in size, situated just beneath the pleura, which prove to be minute abscesses. The cut surface of the lung may be intensely hemorrhagic, resembling the cut surface of the spleen if the course of the disease has been of brief duration, or it may have the appearance of a confluent bronchopneumonia. One does not see, however, small bronchioles standing up above the cut surface and surrounded by a zone of

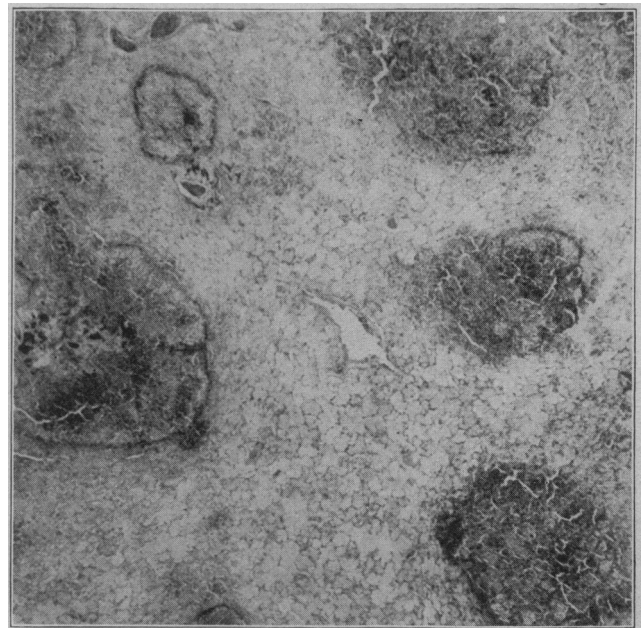


Fig. 8.—Section of lung tissue, ×13, showing abscesses; case from Hospital of the Rockefeller Institute. The photomicrographs were prepared under the direction of Mr. Louis Schmidt, Department of Illustration, Rockefeller Institute for Medical Research, New York.

dark red infiltrated tissue as in the bronchopneumonias following measles, which is the lesion most frequently associated with the hemolytic streptococcus. On the contrary, one usually finds innumerable small abscesses

ranging in size from 1 to 10 mm. in diameter. If the process is a very early one, these minute white spots may not be even broken down. If they are of longer duration, many small abscesses may have become con-



Fig. 9.—Section of lung tissue, $\times 13$, showing abscesses; case from Hospital of the Rockefeller Institute.

fluent, having softened and become filled with thick, greenish yellow pus. Nine of the fourteen cases examined postmortem revealed these small abscesses. Of the cases not showing abscess formation, three were very early, the patients dying on the fourth, sixth and seventh days from the onset of the primary epidemic infection. The sections of these cases showed intense red cell congestion with rupture of the alveolar walls and exudation of serum and red cells into the alveoli. Another case, in which the patient died on the eleventh day without abscess formation, was complicated by suppurative pericarditis (Fig. 2). In the last case there was a mixed infection with *B. influenzae*, in which process *Staphylococcus aureus* apparently played a minor rôle. Direct smears of the abscesses show pus cells and many gram-positive group cocci. The majority of the abscesses tend to be situated at the periphery of the lung near the pleura, though the whole lung may be involved. The propensity of *Staphylococcus aureus* to form multiple small abscesses in the lung appears to be characteristic of this organism, for the type of lesion shown in Figures 8 and 9 from the case treated at the Hospital of the Rockefeller Institute in 1915 is similar to that illustrated in Figure 10. In the institute case there was no history of any antecedent infection.

Figures 8, 9 and 10 show the circumscribed abscesses found scattered through congested lung tissue. There is at first marked engorgement of the alveolar walls with exudation into the alveoli of serum, a small amount of fibrin, and leukocytes and plasma cells containing blood pigment. There is apparently a very rapid coalescence of alveoli with the resultant formation of small, circumscribed abscesses filled with degenerated pus cells and bacteria (Figs. 10 and 11). In some instances there is an attempt to limit the process by the formation of new connective tissue. In other

instances there is so rapid a solution of tissue that this reaction is scarcely evident. Figure 12 shows the lesion rapidly extending out into unaffected alveolar tissue.

Lord,² in describing the pathology of the broncho-pneumonia following influenza, states that not infrequently small abscesses in the lungs have been found, but no mention has been made of the presence of *Staphylococcus aureus*. In our experience it seems probable that while not every case having a *Staphylococcus aureus* secondary infection in the lung may show abscess formation, the occurrence of innumerable small abscesses of the lung predicates that micro-organism, excepting, of course, multiple tuberculous abscesses of the lung, which even grossly present a different pathologic picture.

Three necropsies revealed the presence of a suppurative pleuritis. In one case the pus was localized in the lower part of the left pleural cavity. In another there were collections of pus in both pleural cavities. One of the pockets, situated in the upper part of the left anterior chest, communicated with the pericardial cavity. The latter was the seat of a fibrinopurulent pericarditis.

In this series there were four cases of pericarditis. In one the necropsy disclosed no evidence of infection of the pleural cavities. The heart was covered with a thick layer of shaggy fibrinous material. An acute vegetative endocarditis of the mitral valves was demonstrated in one instance.

Suppuration of the left parotid gland occurred once. In no case did necropsy reveal any abscesses of the kidney, lesions which are frequently seen in *Staphylococcus aureus* pyemia. One abscess in the spleen was discovered.

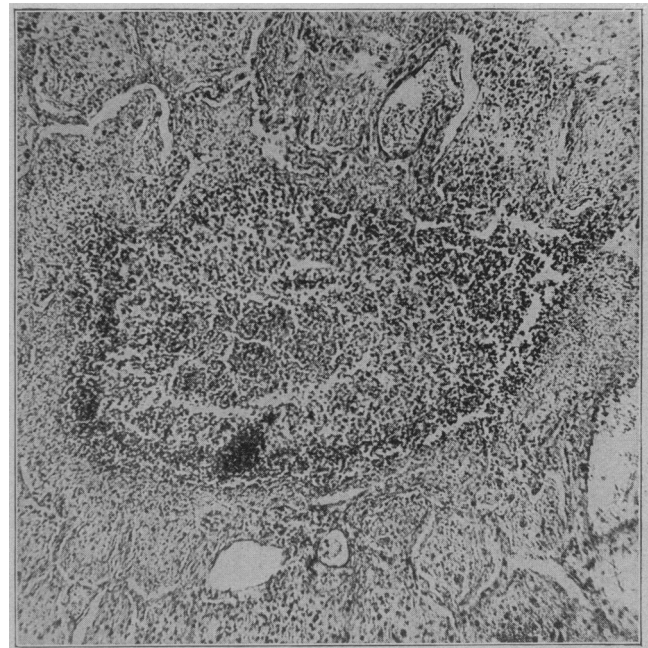


Fig. 10.—Section of lung tissue, \times about 90, showing abscess; from base hospital, Camp Jackson, S. C.

A postmortem examination of one of the two cases presenting signs of subcutaneous emphysema was made. It was impossible to discover the pathway of the escape of air from the lungs. The mediastinal

2. Lord, in Osler: System of Medicine.

tissue was filled with bubbles of air. Along the lappet of the inferior edge of the right upper lobe, the visceral pleura was distended with large bubbles of air varying in size from 1 to 10 mm. in diameter.

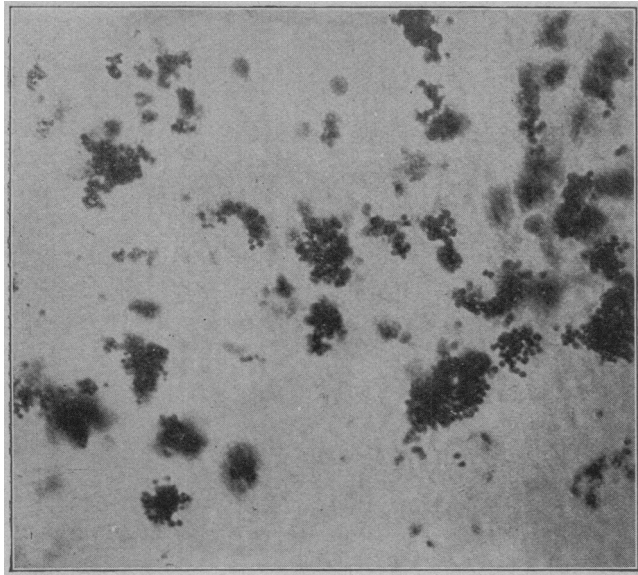


Fig. 11.—Section through a miliary abscess, $\times 1,000$, stained for bacteria, showing group cocci, morphologically staphylococci.

The multiple foci of infection especially numerous in the periphery of the lung, together with the occasional occurrence of metastatic abscesses in other parts

TABLE 4.—SUMMARY OF POSTMORTEM LUNG CULTURES

	Number
Staphylococcus aureus	92
Staphylococcus aureus and pneumococcus Type II.....	5
Staphylococcus aureus and pneumococcus Type III.....	4
Staphylococcus aureus and pneumococcus Type IV.....	16
Staphylococcus aureus and B. influenzae.....	17
Staphylococcus aureus and nonhemolytic streptococcus.....	3
Staphylococcus aureus and Streptococcus hemolyticus.....	5
Staphylococcus aureus and Streptococcus viridans.....	2
Staphylococcus aureus and M. flavus.....	1
Staphylococcus aureus and diphtheroid bacillus.....	1
Staphylococcus aureus and B. coli.....	1
Staphylococcus aureus, B. influenzae and pneumococcus Type II.....	1
Staphylococcus aureus, B. influenzae and pneumococcus Type III.....	1
Staphylococcus aureus, B. influenzae and pneumococcus Type IV.....	1
Staphylococcus aureus, pneumococcus Type III and B. coli.....	1
Staphylococcus aureus, B. influenzae and Streptococcus hemolyticus.....	1
Staphylococcus aureus, B. influenzae and Streptococcus viridans.....	1
Pneumococcus Type I.....	6
Pneumococcus Type II.....	16
Pneumococcus Type III.....	29
Pneumococcus Type IV.....	41
Pneumococcus Type I and Streptococcus hemolyticus.....	1
Pneumococcus Type I and B. influenzae.....	1
Pneumococcus Type II and B. influenzae.....	3
Pneumococcus Type III and B. influenzae.....	7
Pneumococcus Type IV and B. influenzae.....	2
Pneumococcus Type IV and diphtheroid bacillus.....	1
Pneumococcus Type IV and M. flavus.....	1
Pneumococcus, type undetermined.....	2
B. influenzae.....	19
B. influenzae and nonhemolytic streptococcus.....	2
B. influenzae and Streptococcus hemolyticus.....	2
B. influenzae and a gram-negative diplococcus.....	1
Streptococcus hemolyticus.....	6
Streptococcus hemolyticus and hemorrhagic septicemia bacillus group.....	1
Nonhemolytic streptococcus.....	7
Streptococcus viridans.....	2
Streptococcus hemolyticus and M. flavus.....	1
Micrococcus flavus.....	1
Meningococcus, Strain 10.....	1
A gram-negative diplococcus, culturally meningococcus.....	1
Hemorrhagic septicemia bacillus group.....	1
Acute and chronic disseminated tuberculosis.....	1
Total number of cases cultivated.....	312
Staphylococcus aureus, alone or associated with other organisms.....	153

of the body, suggest that the condition is disseminated by the blood stream. The absence of abscesses in the liver and kidneys, however, does not support this

theory. It is possible that the nonproductive, harassing cough that frequently accompanies the early stage of this epidemic infection was responsible for the dispersion of micro-organisms from the nose and throat into the deeper respiratory passages.

POSTMORTEM CULTURES

On account of the crowded condition of the morgue, it became impossible to hold many postmortem examinations. Consequently an attempt was made to learn more of the bacterial infection of the lungs of the fatal cases by exploring the lungs postmortem with an ordinary chest exploring needle and syringe. The syringes and needles were sterilized by boiling and the skin by the application of tincture of iodine. The needle was thrust into the lung tissue and aspiration continued until about 1 c.c. of bloody fluid was obtained. This fluid was then cultivated on glucose-free blood agar plates and slants and in plain broth, and in many cases direct smears of the lung juice were made. These smears checked closely with the cultures. Table 4 details the results of these postmortem cultures. The organisms recovered in this way were found as well in the sputa, blood cultures, and empyema fluids. The number of mixed infections of the lung is surprising. But Cole and MacCallum,³ in a study of the bacteriology of cases of bronchopneumonia following measles last winter at San Antonio, Texas, obtained similar results.

The occurrence of *Staphylococcus aureus* in the lungs in the fatal cases is quite striking, 49 per cent. of the 312 cases cultivated showing this organism present either alone, ninety-two cases, or in association with the influenza bacillus, twenty-two cases, the pneumococcus, twenty-nine cases, or various streptococci,

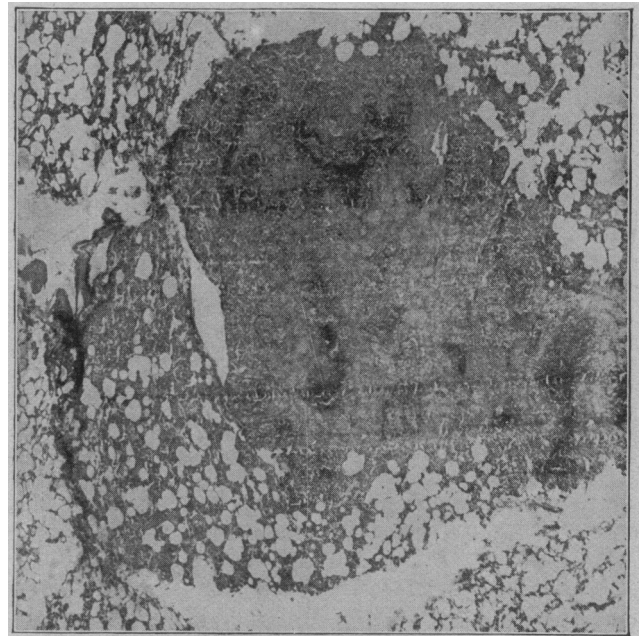


Fig. 12.—Section of lung tissue, showing a type of rapidly spreading lesion.

twelve cases. In many instances, death was early predicted from the appearance of the sputum alone, and the postmortem cultures verified the information obtained from the sputum examination.

3. Cole, R., and MacCallum, W. G.: Pneumonia at a Base Hospital, J. A. M. A. 70: 1146 (April 20) 1918.

The ninety-four cases showing the pneumococcus alone in the lungs were clinically more like typical lobar pneumonia, often showing extensive consolidation and pure bronchial breathing.

It is to be remarked that the organism found so frequently last winter associated with the bronchopneumonia following the epidemic of measles in the Army camps, the hemolytic streptococcus, was rarely encountered either in the sputum or in material from the lung.

On several of the plates, colonies of bacteria conforming to the characteristics of the meningococcus were found. Unfortunately, in only one case did these colonies grow on subcultures, and in this instance the organism agglutinated with Strain 10 meningococcus antiserum furnished by the Rockefeller Institute. This

plague bacillus. Once before this organism was encountered in a fulminating case of bronchopneumonia treated at the Rockefeller Institute Hospital. Here again, it was found associated with *Staphylococcus aureus*.

EPIDEMIOLOGY

Pneumonia associated with *Staphylococcus aureus* occurred in almost every organization at Camp Jackson (Fig. 13). In general, where the total incidence of pneumonia was high there was a correspondingly larger number of *Staphylococcus aureus* infections.

In the First, Second and Third regiments, Field Artillery Replacement Depot, with a total strength of 6,820 men, there developed 178 cases of pneumonia, in which fourteen were found to be harboring *Staphy-*

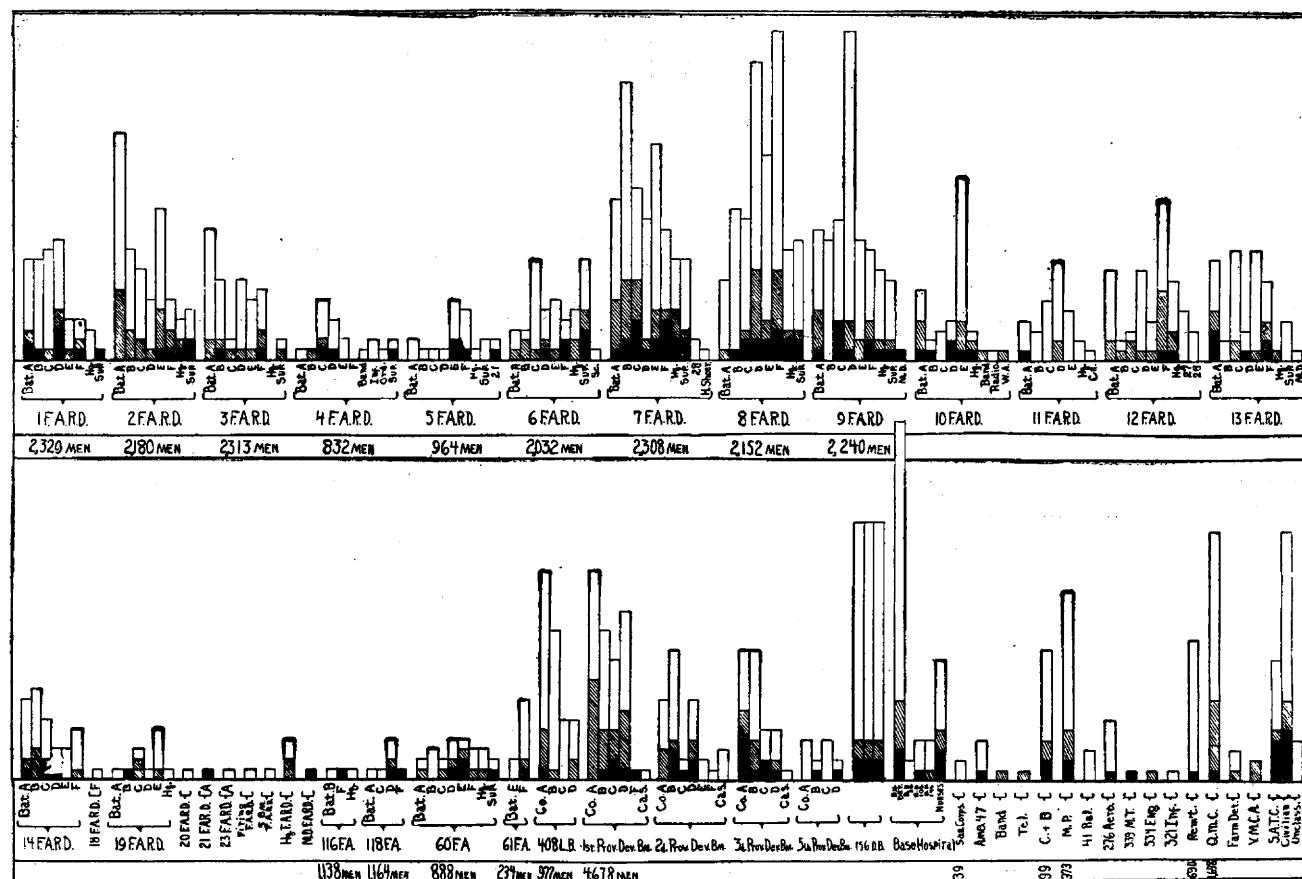


Fig. 13.—Incidence of pneumonia in military organizations at Camp Jackson, Sept. 15 to Nov. 1, 1918; outline, total cases of pneumonia; one square represents one case; black, *Staphylococcus aureus* deaths; shaded, deaths associated with other organisms.

patient died without exhibiting any symptoms of meningitis that could be detected clinically. The presence of these organisms in the lungs, and the occurrence of several cases of meningococcus meningitis complications in this series of cases, opens up a new aspect to the ever increasing knowledge of the activities of the meningococcus in the human body.

In two cases, organisms conforming culturally and morphologically to bacilli of the hemorrhagic septicaemia group were encountered. The colonies were moist and grew readily on blood agar. They appeared as gram-negative oval coccobacilli frequently showing bipolar staining. Some of the slides were examined by Major M. A. Barber, who has had a field experience with the bacillus of plague, and he observed the

lococcus aureus in the lung, a percentage incidence of 7.8. In the Seventh, Eighth and Ninth regiments, F. A. D. R., organizations having a smaller quota, 6,700 men, there were 380 cases of pneumonia, in forty-three, or 11.3 per cent., of which, staphylococci were harbored in the lung.

In the base hospital organizations there occurred fifty-eight cases of pneumonia, of which seven, or 12 per cent., were associated with *Staphylococcus aureus*.

The higher incidence of pneumonia in the Seventh, Eighth and Ninth regiments may possibly be explained by the fact that these regiments were composed of men who were recent arrivals in camp and in the midst of their period of intensive training.

Last winter in the mortality statistics of the post-

largely due to the hemolytic streptococcus, certain Southern states suffered in comparison with the Northern states.

In this camp the incidence of the virulent *Staphylococcus aureus* pneumonia was greater among the men from New York and Ohio, 15 and 18.5 per cent., respectively, than among the men from Florida, 12.5 per cent., North Carolina, 9 per cent., and South Carolina, 12 per cent. Here again the men from Ohio and New York were among the more recent arrivals.

South Carolina furnished ten *Staphylococcus aureus* pneumonias, or 7.1 per cent. of the 139 pneumonias among the negroes. These men were from one regiment of the F. A. R. D. and from labor battalions, and had been in camp for some time.

caffein and whisky were also used. Hypodermoclysis or infusions of physiologic sodium chlorid solution were administered in the event of the patient's not being able to take fluids by mouth. In a few cases, infusions of 25 per cent. glucose in physiologic sodium chlorid solution, in 250 c.c. amounts, were given once or twice a day. Practically no amelioration of the patient's condition followed the use of these therapeutic measures.

In the treatment of the complications, the one patient having a localized suppurative pleurisy was drained by a thoracotomy and costectomy and the Carrel-Dakin after-treatment instituted with excellent results. The other two patients died with complicating pericarditis and endocarditis.

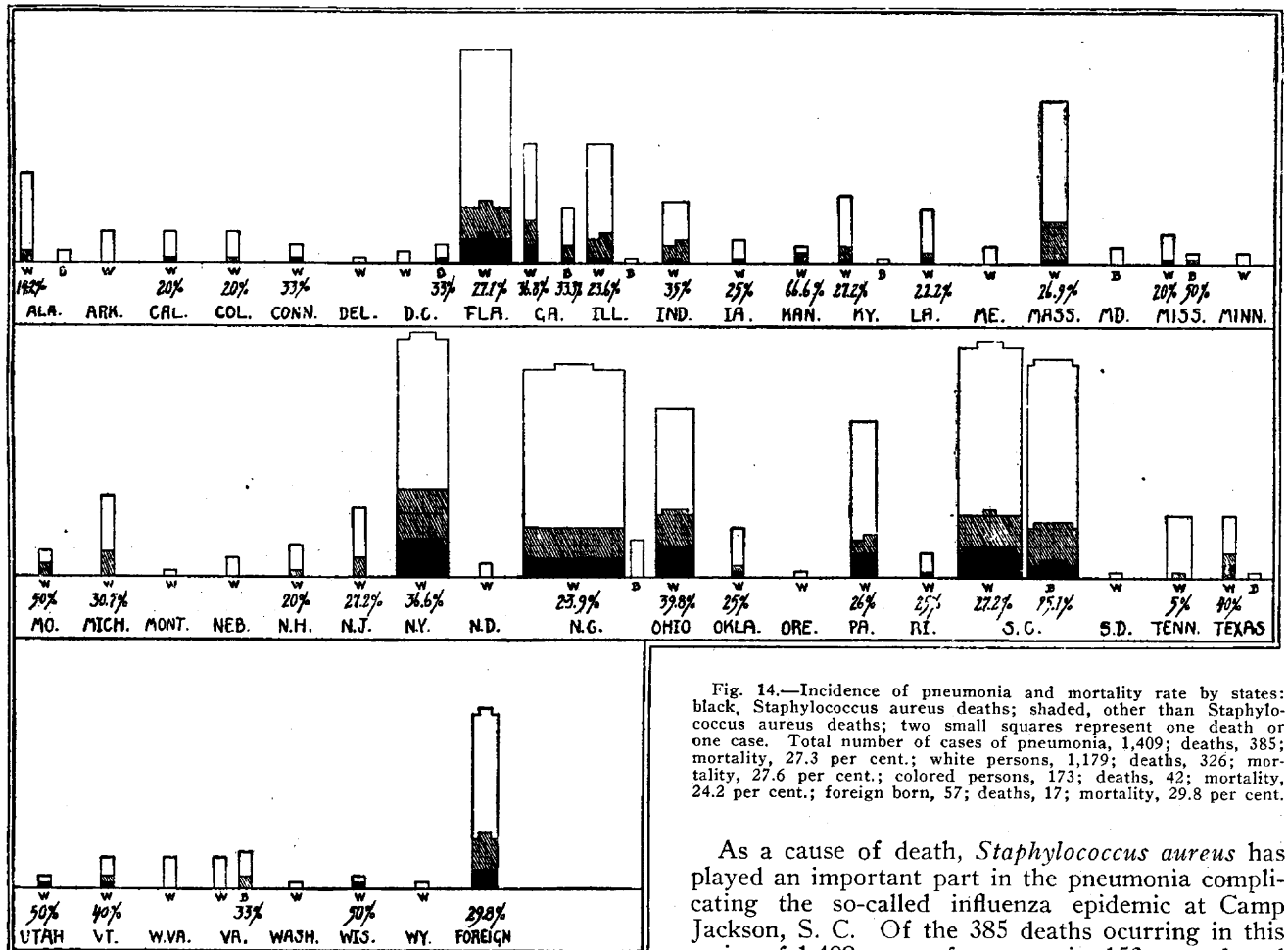


Fig. 14.—Incidence of pneumonia and mortality rate by states: black, *Staphylococcus aureus* deaths; shaded, other than *Staphylococcus aureus* deaths; two small squares represent one death or one case. Total number of cases of pneumonia, 1,409; deaths, 385; mortality, 27.3 per cent.; white persons, 1,179; deaths, 326; mortality, 27.6 per cent.; colored persons, 173; deaths, 42; mortality, 24.2 per cent.; foreign born, 57; deaths, 17; mortality, 29.8 per cent.

TREATMENT

The treatment of *Staphylococcus aureus* infection of the lung is extremely ineffectual. Apparently unless the lesions become localized, as happened in two of the cases at the Hospital of the Rockefeller Institute, or there is a localized empyema, the outlook for recovery is extremely bad. The soldiers treated at Camp Jackson were put to bed as soon as possible after they became ill. They were not allowed to get out of bed or to sit up. Very little catharsis was given, dependence being placed on a daily morning enema of soapsuds to keep the bowels open.

As a routine for pneumonia, tincture of digitalis was given in 2 c.c. doses every four hours up to 20 c.c., and continued further if indicated. Camphor in oil,

As a cause of death, *Staphylococcus aureus* has played an important part in the pneumonia complicating the so-called influenza epidemic at Camp Jackson, S. C. Of the 385 deaths occurring in this series of 1,409 cases of pneumonia, 153 were found to be associated with *Staphylococcus aureus* in the lung. As cultures from the lung were obtained from only 312 of the 385 individuals who died, it is reasonable to suppose that this number does not represent the total mortality due to this micro-organism.

The striking features of the disease are the peculiar cherry-red indigo-blue cyanosis, the fulminating course, the lack of definite signs of consolidation of the lungs, the dirty salmon-pink purulent sputum, and usually a leukopenia.

Pathologically, if the disease is of long enough duration, it is characterized by innumerable abscesses in the lungs.

The prognosis is always grave, though a few patients occasionally survive. Only two patients in this series have recovered.

From the standpoint of our present knowledge, it would seem probable that the particular *Staphylococcus aureus* found in the lungs of these cases was no other than that found often in the mouth secretions of healthy persons. However, the depression of the individual's defensive mechanism by the primary epidemic infection was sufficient to enable these organisms subsequently to produce widespread pulmonary lesions. This, in turn, explains the occurrence of the infection in almost every organization in Camp Jackson and a higher incidence of the infection among the more recent arrivals in camp, irrespective of the states from which they came.

EARLY SUTURING OF WOUNDS OF THE FACE

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The practice of suturing wounds of the body at an early date after injury is at present arousing an active interest among surgeons. The procedure is achieving

the wounds, the amount of involvement of adjacent structures, and the degree of sepsis that has developed.

The vascularity of the facial tissues unquestionably promotes rapid healing and an early reduction or dis-

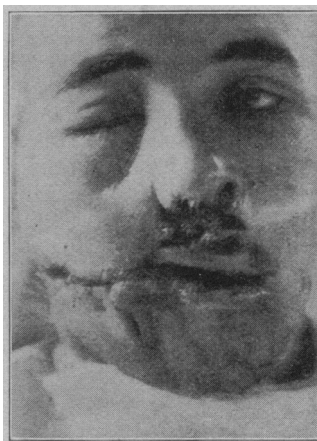


Fig. 3 (Case 2).—Result of operation at a casualty clearing station, June 25, 1917.

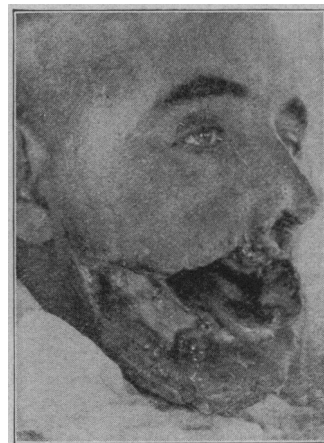


Fig. 4 (Case 2).—Appearance of patient, June 28.



Fig. 1 (Case 1).—Appearance of patient, Aug. 27, 1917, after wound had been closed at a casualty clearing station.

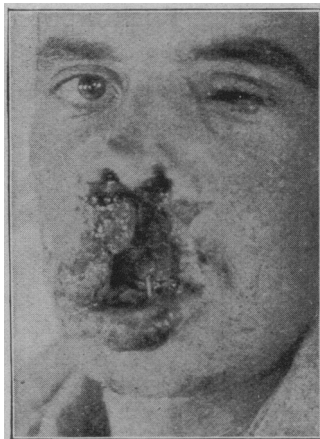


Fig. 2 (Case 1).—Septic condition of tissues and failure of sutures, September 7.

appearance of inflammation; yet the advantage is partly offset by these conditions:

The majority of wounds communicate with the nasal or oral cavities, from which they cannot be isolated, and they are therefore easily and persistently reinfected.

Serious injuries are always associated with a comminution of the bone tissue, the displacement of which exaggerates the size of the wound, favors the inflammation, and facilitates the spread of sepsis.

Liberal excision of the soft tissues, which is an essential feature in the technic of primary suturing of wounds in other parts of the body, is obviously impracticable on the face.

PRIMARY SUTURING

Primary suturing of wounds of the face has been practiced frequently at casualty clearing stations, but the results, as observed at many base hospitals, would lead to the belief that the procedure is totally unsatis-

increased success, undoubtedly because of a better knowledge of the exact nature of war injuries, of a better surgical technic involved, and of a proper use of antiseptics.

If early suturing can be accomplished, the benefits are obvious: the healing process is materially shortened, many unsightly scars are avoided, and the patient undergoes a briefer period of convalescence.

There has always been a considerable divergence of opinion in regard to the most suitable time for the closure of facial wounds. Some surgeons have recommended early suturing on the grounds that undue contraction of the tissues was forestalled by bringing the lacerated borders together and that subsequent elaborate plastic operations were to a great extent evaded. Others favored late suturing at a time when the wounds were clean, asserting that suppuration and inflammation were greater hindrances than contraction of the tissues to a successful cosmetic effect. A critical analysis of the two opposing views points to the fact that both methods must be followed to obtain a minimum amount of facial disfigurement. The determining factors are the location and severity of



Fig. 5 (Case 3).—Appearance of patient, Sept. 23, 1917, after suturing of wounds at a casualty clearing station.

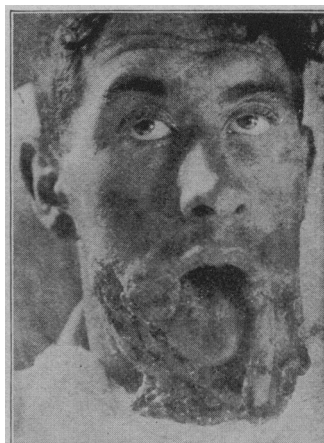


Fig. 6 (Case 3).—Resulting condition, September 27.

factory and would continue to be so, unless modifications in technic and a careful selection of suitable cases were made. Only in mild and superficial cases has healing taken place, and when the damage to the