SPIROCHETAL PULMONARY GANGRENE *

MAURICE FISHBERG, M.D., AND B. S. KLINE, M.D.
NEW YORK

Ever since Obermeier, in 1873, reported the presence of microorganisms of the genus spirocheta, or spirilla, in the blood of patients with relapsing fever, many diseases have been found to be caused by varieties of this species. The most important disease due to spirochetal infection is, of course, syphilis, to which etiologic relationship of the *Spirochaeta pallida* was demonstrated by Schaudinn and Hoffman in 1905. Castellani subsequently found that frambesia tropica, or yaws, was caused by the *Spirochaeta pertenuis*. The etiologic relationship of spirochetes to Vincent's angina, Weil's disease, rat bite fever and pyorrhea alveolaris has likewise been demonstrated.

It is, however, not so well known that certain pathologic processes in the bronchi and lungs are due to the activity of these microorganisms. Many years ago, Eichhorst stated that he found spirochetes in the sputum of some patients suffering from bronchitis. Bertarelli and Volpino observed *Spirochaeta buccalis* and *Spirochaeta pallida* in the sputum of patients affected with heart disease. These observations were not confirmed until Aldo Castellani¹ reported two cases of hemorrhagic bronchitis presenting symptoms simulating those of pulmonary tuberculosis, but no tubercle bacilli could be discovered in the sputum either microscopically or by animal inoculation. In these cases large numbers of spirochetes were found in the sputum. Although Castellani pointed out that similar organisms were also found in the saliva and the superficial scrapings of the gums of his patients, he was inclined to ascribe an etiologic relationship of the spirochetes to the pulmonary disease.

From a study of his cases Castellani arrived at the conclusion that, at least in Ceylon, there is a form of bronchial and pulmonary disease caused by spirochetes. To this disease he gave the name of bronchial spirochetosis.

These findings attracted attention and soon many other observers reported similar cases seen in the tropical world. Jackson, Phalen and Kilbourne² and Weston R. Chamberlain³ reported cases from the

* From the Montefiore Home and Hospital.

1. Castellani, A.: Note on a Peculiar Form of Hemoptysis with Presence of Numerous Spirochetes in the Expectoration, *Lancet* **1**:1384, 1906.

2. Phalen and Kilbourne: Report of the U. S. Army Board for the Study of Tropical Diseases made to the Surgeon-General, U. S. Army, Washington, D. C., June 30, 1909.

3. Chamberlain: The Occurrence in the Philippines of Associated Spirochetes and Fusiform Bacilli in Ulcers of the Throat (Vincent's Angina), of the Mouth and of the Skin, and in Lesions of the Lungs (Bronchial Spirochetosis), *Philippine J. Sc.* **6**:489, 1911.

Philippine Islands. J. A. Taylor⁴ observed several cases of "pneumonia" among the natives of Uganda in which the causative organisms appeared to be spirochetes. He also mentions one case occurring in a European living in Uganda. J. W. Scott Macfie⁵ reported cases observed at Accura, Gold Coast Colony, West Africa, and Frank S. Harper⁶ noted the condition of a cook living in Tomall, Northern Territories, Gold Coast, West Africa.

That the disease is not confined to tropical countries was made apparent when Ignatz Feldmann⁷ and K. Buday⁸ reported several cases observed in Hungary. Buday reported many cases of pulmonary gangrene in which a careful macroscopic and microscopic study was made. The spirochetes and fusiform bacilli were found in large numbers in the gangrenous pulmonary lesions.

During the Word War many causes of bronchial and pulmonary spirochetes were observed among the tropical troops brought to Western Europe. Likewise, in Europeans who had never been in the tropics, spirochetes were found in the sputum in certain cases of bronchitis and pneumonia, and of patients showing symptoms not unlike those of pulmonary tuberculosis. Thus, cases of spirochetosis bronchialis, hemorrhagic spirochetosis, etc., have been reported by G. Delamore,⁹ Dalimier,¹⁰ J. A. Thomson,¹¹ S. Fischera,¹² H. Violle,¹³ F. Barbary,¹⁴ P. Nolf,¹⁵ P. Spehl,¹⁶ and many others in France, Italy, England, Belgium, etc. G. A. Lurie,¹⁷ of Chicago, reported a case observed in a Greek lady residing in Uskub, Serbia. One of us observed in the A. E. F. Hospital Center, Bazoilles, Vosges, France, two cases in Americans (white) not unlike those reported by the authors mentioned. Smears from the gangrenous pulmonary areas made at necropsy showed innumerable mouth organisms, including spirochetes. One of

4. Taylor: Bronchial Spirochetosis in Uganda, with Pneumonic Symptoms, *Ann. Trop. M. & Hyg.* **8**:13, 1914.

5. Macfie: Bronchial Spirochetosis, *J. Trop. M. & Hyg.* **18**:63, 1915.

6. Harper: Bronchial Spirochetosis, *J. Trop. M. & Hyg.* **17**:194, 1914.

7. Feldmann: Beitrag zu den durch *Bacillus fusiformis* und *Spirillum dentium* herforgerufenen Infektionen mit besonderer Berücksichtigung der Eiterungen, *Wiener. klin. Wchnschr.* **19**:695, 1906.

8. Buday: Histologische Untersuchungen über die Entstehungsweise der Lungengangrän, *Beitr. z. path. Anat. u. z. allg. Path.* **48**:700, 1910.

9. Delamore: *Bull. et mem. Soc. méd. d. hôp. de Par.* **43**:526, 1919.

10. Dalimier: *Presse méd.* **27**:124, 1919.

11. Thomson: Pulmonary Spirochetosis, *Brit. M. J.* **2**:775, 1919.

12. Fischera: *Riforma med.* **34**:384, 1918.

13. Violle: *Bull. de l'Acad. de méd., Par.* **79**:429, 1918.

14. Barbary: *Bull. de l'Acad. de méd., Par.* **79**:461, 1918.

15. Nolf and Spehl: *Arch. méd. Belges* **71**:1, 1918.

16. Nolf, P.: Fetid Spirillar Bronchitis and Pulmonary Gangrene, *Arch. Int. Med.* **25**:429 (April) 1920.

17. Lurie, G. A.: Note on Castellani's Broncho-Spirochetosis, *J. Trop. Med. & Hyg.* **18**:269, 1915.

these patients had marked dental caries, and smears from the material in the cavities likewise showed many mouth organisms including spirochetes.

It is noteworthy that even before these reports were made, J. H. Rothwell¹⁸ reported two cases of "bronchial Vincent's angina" with symptoms and signs simulating pneumonia, but in which the sputum was found to be full of spirillae and fusiform bacilli.

More recently Ralph R. Mellon¹⁹ reported a series of cases of whooping cough, pneumonia and empyema from Rochester, N. Y., in

Fig. 1.—Right lung: Extensive bronchopneumonia with gangrenous ulceration in right lower lobe.

which fusiform bacilli were discovered in the sputum. A. N. Sinclair²⁰ also found in the Philippine Islands numerous cases of pulmonary hemorrhage of tuberculous origin, in which Vincent's spirochetes, or fusiform bacilli were discovered in the sputum. It is his opinion that the presence of fusiform bacilli predisposes to hemoptysis

18. Rothwell: Bronchial Vincent's Angina, *J. A. M. A.* **54**:1867 (June 4) 1910.

19. Mellon: A Clinical and Bacteriological Study of Fusiform Bacillus Infection, *New York State J. M.* **20**:187, 1920.

20. Sinclair: Vincent's Spirochetes and Hemorrhage in Pulmonary Tuberculosis, *Am. Rev. Tuberc.* **4**:201, 1920.

in tuberculous individuals, and that hemorrhage only rarely occurs in incipient cases unless they are present.

The following case of pneumonia with gangrenous ulceration, apparently caused by spirochetes, observed at the Montefiore Hospital, is believed to be the first reported in New York:

REPORT OF CASE

M. S. (No. 027757), aged 33, native of Russia, six years in the United States; tailor; admitted April 19, 1920, as a case of pulmonary tuberculosis.

Symptoms on admission: Fever, reaching 105 F., of a continuous type; severe, incessant cough, copious expectoration of foul smelling, greenish mate-

Fig. 2.—Pneumonia with associated gangrenous ulceration. Low power.

rial, at times bloody; dyspnea, cyanosis, prostration. The mental state of the patient precluded obtaining a clear cut and reliable history of the case, but combining the data elicited from him with those given by his friends who visited him at the hospital, we find that his family and personal past history present no conditions which may have had any bearing on his present state. He had been married for eight years, had two children, both alive and well, and had worked at his trade, tailoring, without interruption due to illness, till March 15, 1919, when he began to cough and expectorate. This cough, however, was at the beginning so slight, that he believed it to be due to excessive smoking and he paid little attention to it.

During the first week of April, he was suddenly seized with vomiting, followed by fever and prostration. A physician who examined him at that time informed him that "weak lungs" were responsible for his trouble and advised a trip to the mountains. The severity of the disease prevented his leaving the city. The frequent chills, high fever and sweats became very marked and

he was referred to the Montefiore Hospital with a diagnosis of acute progressive pulmonary tuberculosis.

On admission it was felt that we were dealing with a case of gangrene of the lungs. The foul, sharp, penetrating odor of the breath and expectoration pointed in this direction; the high fever, the sweats and the prostration gave support to this provisional diagnosis. Physical exploration of the chest revealed a suspended area of flatness in the middle of the right side of the chest; this flatness was most marked over the lower two-thirds of the inter-scapular space. On auscultation the breath sounds were found feeble, hardly audible over the flat area, while over the upper lobe of the right lung, medium sized, moist râles were heard; over the right base, in the axillary space, a soft friction sound was made out. There were also signs of fluid in the left pleural cavity, flatness, feeble breath sounds, abolition of vocal fremitus, dulness

Fig. 3.—Smear from gums (Fontana stain), high power. Spirochetes and other organisms.

in Traube's space, etc. These signs elicited on physical examination of the chest suggested either an interlobar empyema which had broken through a bronchus, a pulmonary abscess which may thus have originated, or gangrene of the right lung. A roentgenogram confirmed the findings of physical exploration. A large, somewhat round, shadow, occupying the middle third of the right lung, was disclosed. The rest of the lung showed evidences of hyperaeration.

Of the laboratory findings, the following are of interest: Blood—hemoglobin, 70 per cent.; leukocytes, 21,000; lymphocytes, 18 per cent.; polymorphonuclears, 80 per cent. Wassermann reaction (blood) negative; urea N = 13.7 per 100 c.c.; creatinin, 4.3 per 100 c.c. Urine: acid; sp. gr. 1.022; slight amount of indican; no albumin; no sugar;

Ehrlich's diazo reaction negative; no casts; no tubercle bacilli. Repeated search also failed to disclose tubercle bacilli in the sputum.

Correlating the history with the physical and roentgenographic signs it appeared that the process was not an interlobar empyema. There was no history of an acute onset with pain in the chest, fever, etc., nor has the temperature declined sufficiently to indicate that empyema broke through a bronchus and was being drained. The fetid odor of the expectoration also spoke against an interlobar abscess; there was no history of an acute pulmonary disease such as pneumonia, preceding it. As soon as the patient began to expectorate, the sputum

Fig. 4.—Gangrenous lung (Fontana stain), high power. Spirochetes and other organisms.

had the sharp penetrating odor characteristic of gangrene. A foreign body in a bronchus was thought of, but the history, symptomatology and the roentgenogram spoke against it.

The history, symptomatology, physical and roentgenographic signs, combined with the laboratory findings, were thus all against a diagnosis of tuberculosis. As has already been stated, an interlobar empyema was also excluded. The slow onset, the absence of a history of acute pulmonary disease, or operation on the tonsils, etc., also spoke against pulmonary abscess. Furthermore, the expectorated material had the intensely penetrating odor characteristic of gangrene of the lung.

The sputum was then again sent to the laboratory with a request that a careful search be made for spirochetes. With the Fontana

stain, the presence of fusiform bacilli and spirochetes was readily demonstrated. Inasmuch as these organisms are very often found on the gums of healthy individuals, and especially the gums of those who suffer from pyorrhea alveolaris, the sputum was carefully washed, and it was found to contain numerous spirochetes. The material scraped from the gums was then examined and many spirochetes, of the morphology of *Spirocheta microdentium* and *S. macrodentium* were found; some had the morphology of the *Spirochaeta bronchialis* of Castellani. A few had an appearance not unlike that of *Spirochaeta pallida*.

Fig. 5.—Smear from gangrenous lung (Fontana stain), high power. Spirochetes and other organisms.

The usual symptomatic treatment apparently had no effect on the progress of the disease. The fever remained high, between 103 and 104 F.; cerebral symptoms made their appearance and the prostration remained severe. The foul odor of the expectoration and the weakness of the patient increased. Reports have shown that in some cases of abscess and gangrene of the lung, artificial pneumothorax has proven of value, though in the experience of one of us, it has never been a success in this class of cases. On entering the right pleural cavity with the pneumothorax needle May 5 we found excellent negative pressure with respiratory oscillations and allowed 400 c.c. of air to enter. The intrapleural pressure remained minus 10 after the initial inflation.

No improvement was noted in the general condition of the patient after the pneumothorax was induced. The fever remained high, the prostration continued, and the weakness increased. May 6, the cerebral symptoms became accentuated, the patient died at 4:30, manifesting intense dyspnea and cyanosis.

For special reasons a complete necropsy could not be made; only the thoracic and abdominal viscera were removed for examination.

The lungs showed extensive coalescing lobular and bronchopneumonia of both upper lobes and the right middle lobe. In the right lower lobe, associated with the consolidated lung, there was extensive gangrenous ulceration, the ulcerated areas varying in size from several millimeters to a cavity 4 cm. in diameter.

Microscopically, the picture was that of extensive lobular and bronchopneumonic exudation with numerous areas of necrosis and gangrene. With Fontana and MacCallum stains, spirochetes and fusiform bacilli were observed in large numbers in the necrotic and gangrenous areas. The following is an abstract of the necropsy protocol:

NECROPSY PROTOCOL

The larynx and upper part of the trachea were not removed. The lower portion of the trachea and right bronchus show an intensely injected, swollen mucosa. In the lumen, there is a considerable amount of mucopurulent material. In the left pleural sac, several hundred c.c. of thin, blood tinged fluid were found.

Lungs: All lobes much more voluminous than usual. The upper lobes cushiony, soggy; middle and lower lobes soggy, solid. The pleura is thickened over the upper lobes and over the posterior portions of the lower lobes. There are sheetlike, fibrous tags in these areas. There is some fibrinous exudate over the lateral and median portions of both lower lobes. Glands at the hilum enlarged, pulpy, edematous, injected, pigmented. On section of the upper lobes, a moist, dark red surface presents. The tissue is apparently congested and edematous. There is no definite consolidation. There is a considerable amount of thin fluid in the air sacs. The bronchial branches show an injected, swollen mucosa, overlaid by blood tinged, mucopurulent material. Right middle lobe on section, shows extensive consolidation, the patches small, several millimeters to one centimeter in diameter, almost adjoining one another throughout the lobe. These areas are soft, yellowish, almost purulent. They are, however, considerably more coherent than abscesses. Both lower lobes on section show extensive, patchy consolidation, the patches almost adjoining each other throughout the lobes. This is especially true in the posterior portions. The patches in these lobes also vary in size from several millimeters to one centimeter. They vary in color from reddish yellow to dark green. The latter color is especially marked in the right lower lobe. In addition, many of the dark green, consolidated patches show central ulceration. The cavities vary in size from a few millimeters to four centimeters in diameter. The large cavity is present in the upper anterior portion of the right lower lobe, well below and median to the apical portion. There is no sharp reaction zone about the cavities. They are all surrounded by greenish, consolidated lung. Within the cavities, there is thin, greenish, necrotic material. The ulceration in the left lower lobe is much less advanced than in the right lower. The bronchial tree throughout, shows beginning calcification of the cartilages. The mucosa is swollen, injected, overlaid by mucopurulent material. In places, espe-

cially in the right lower lobe, the mucosa has a greenish tint. The lungs have an intense, penetrating, disagreeable odor.

Smears from the yellow and green consolidated areas and cavities show innumerable, gram-negative spirillae and spirochetes resembling *Spirochaeta microdentium*, *S. macrodentium* and *S. refringens*, the latter present in small numbers. Throughout the smears there are also innumerable gram-negative bacilli. Some of these are small, resembling *Bacillus influenzae*; others are larger. Some of the larger gram-negative bacilli have a safety-pin appearance, resembling colon bacilli. In addition, there are a large number of rounded, gram-negative cocci and some diplococci. In the smears the following gram-positive organisms were noted: innumerable diphtheroids, many rounded cocci, rounded and lancet shaped diplococci, scattered small chains of rounded cocci, also scattered, straight and curved, beaded bacilli with tapering ends about the size of gas bacilli and somewhat smaller.

Fig. 6.—Section of gangrenous lung (MacCallum stain), high power. Fusiform bacilli and other organisms.

Microscopic Sections: Section 1 shows on gross inspection a number of circumscribed areas from one to several millimeters in diameter with pink periphery and bluish center. Alveoli in general apparently filled. Under low power, the circumscribed areas mentioned above are seen to be composed of a zone of necrotic pink stained lung tissue and exudate, the central portions bluish, consisting of masses of organisms. There are many of these necrotic areas in the section; in places they adjoin one another; in places they are discrete and vary in size from that of a glomerulus to several millimeters in diameter. In addition to these areas, the alveoli throughout the section in general are filled with exudate composed of swollen alveolar cells and amorphous pink stained material and a few wandering cells. The alveolar walls, in general, show swollen epithelial cells with blood vessels moderately engorged. In places, the alveoli are filled in great part by red blood cells. Portions of the pleura in the section are swollen, distended by amorphous

pink stained material, red blood cells and scattered wandering cells. There is a small amount of fibrin present. In places there is definite beginning organization of the exudate.

Section 4 shows in addition to circumscribed necrotic areas with masses of blue stained organisms, the adjoining alveoli filled with pus cells and mononuclear cells, the nuclei of the majority of these being deeply stained (pyknotic). External to the alveoli filled with pus cells, are alveoli filled with large mononuclear cells, some containing blood pigment, some pus cells, some red blood cells and some amorphous pink stained material. The pulmonary vessels throughout are engorged. In this section there are numerous groups of alveoli filled with exudate rich in polymorphonuclears; in places there is definite necrosis of the exudate. In places there are circumscribed masses of blue stained organisms. There are scattered bronchial branches filled with necrotic exudate containing blue stained organisms, the epithelium of these bronchial branches is almost homogeneously pink stained, the nuclei being barely visible. Throughout all coats of bronchial branches the blood vessels are engorged. There is apparently considerable thickening due to the presence of granulation tissue. In places, in the section the alveoli contain in great part amorphous pink stained material (serum) and scattered, desquamated cells. In places, the exudate is present in the peribronchial alveoli, in places the exudate is apparently lobular in distribution and varies in proportion of serum, large phagocytic mononuclear cells, pus cells and red blood cells. In places, there is definite organization of the exudate; in other places there is necrosis and ulceration associated with blue stained masses of organisms.

Section 5 shows a wall of a large cavity composed of amorphous pink stained necrotic material in the innermost zone, external to which there is granulation tissue composed of numerous engorged capillaries and fairly densely layered connective tissue cells. In places, the connective tissue cells are loosely connected. In places, there are numerous plasma cells in the granulation tissue. External to this zone there are numerous, somewhat collapsed alveoli filled with exudate, varying in character, as described above. In this section also there are fair sized bronchial branches with greatly thickened walls, due to granulation tissue.

Sections of the lung stained by Fontana method show in the necrotic areas a considerable number of spirochetes resembling *Spirochaeta macrodentium* and *S. microdentium*. With this stain, innumerable other organisms are observed in the necrotic and consolidated portions. Sections stained by MacCallum's stain show in the consolidated and necrotic areas innumerable gram-positive organisms including gram-positive bacilli, some of these having the morphology of diphtheroids; gram-negative bacilli, some having the morphology of influenza bacilli, also gram-positive and gram-negative cocci. There are also many large slightly curved gram-positive bacilli, not unlike the fusiform bacilli of Vincent's angina. The spirochetes are poorly stained by this method. With this stain the predominant organism is the somewhat gram-positive bacillus.

DISCUSSION

The presence of numerous spirochetes in the gangrenous portions of the lung in the case reported, suggests their etiologic relationship to the lesion. It is probable that the spirochetes responsible for the gangrene in this case are of the type Castellani calls *Spirochaeta bronchialis*. While, of course, there are present in the lesions numerous mouth organisms, the overwhelming number of the spirochetes, as well as the study of their location in the diseased area, and the cellular reaction to their presence, compels the conclusion that the predominantly gangrenous lesions are to be directly attributed to the spirochetes.