DISEASES

OF THE

BRONCHI, LUNGS, AND PLEURA

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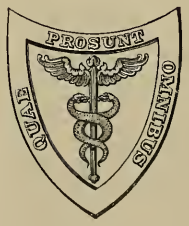

LEA & FEBIGER
PHILADELPHIA AND NEW YORK
1915

TO THE MEMORY

OF

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CRITICAL AND INSPIRING TEACHER WHO
THROUGH HIS SOUND KNOWLEDGE OF PATHOLOGIC ANATOMY
MADE LASTING CONTRIBUTIONS TO MEDICAL SCIENCE

PREFACE.

It is hoped that the following pages will fill the present need of a practical treatise on the diseases of the respiratory organs. The aim has been to present current knowledge, founded on the literature and the experience gained in the wards and pathologic laboratory of the Massachusetts General Hospital, in such form as to be of value to students and practitioners and also to provide a basis for further research. References are given to the most important original articles in order that the literature may be readily available to those who wish to go more fully into particular problems. Pulmonary tuberculosis is not considered under a separate heading, but special attention is given to conditions which simulate pulmonary tuberculosis and their differential diagnosis.

I am greatly indebted to Sir William Osler and Dr. Thomas McCrae and to the publishers, Messrs. Lea & Febiger, for the privilege of revising and including in this work the sections on the diseases of the pleura written for Osler and McCrae's *Modern Medicine*. It is a pleasure to acknowledge my share in the obligation of all students of respiratory diseases to the publications of Dr. Albert Fraenkel. My thanks are due to Dr. James Homer Wright for the use of pathologic material, to Dr. Walter J. Dodd for the *x*-ray plates, and to Mr. Lewis S. Brown for the photographs.

F. T. L.

Boston, Mass., 1915.

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SECTION I.

DISEASES OF THE BRONCHI.

CHAPTER I.

BRONCHOSTENOSIS.

Etiology.—The causes may be briefly summarized and for convenience divided into those affecting the large and medium-sized and the small bronchi.

A. **Stenosis of the Large and Medium-sized Bronchi.**—Partial or complete occlusion may be due to the following:

1. *Extrabronchial Causes.*—Compression from without may arise from aortic aneurysm, malignant disease of the lung, mediastinum, or esophagus, enlarged tracheobronchial lymph glands, pericardial effusion, dilatation of the left auricle, mediastinal abscess, or echinococcus disease. Bronchostenosis from dilatation of the left auricle is probably more common than is generally supposed. A slight degree of stenosis undetectable by ordinary methods may be recognized by bronchoscopic examination. Kahler[1] has reported 13 cases, in 11 of which the clinical diagnosis was mitral stenosis, 1 mitral insufficiency, and 1 aortic insufficiency. In one case Schrötter[2] noted narrowing of the bronchi from dislocation of the mediastinum in consequence of pneumohydrothorax. A discussion of these causes falls without the scope of this work.

2. *Diseases of the Bronchial Wall.*—In this group, benign and malignant tumors, syphilis, tuberculosis and scleroma may be mentioned and are described elsewhere. The lesions of leprosy, glanders, and variola may, in rare instances, give rise to bronchial occlusion. Brindel[3] reported the case of a man, aged sixty-four years, who was severely wounded in the neck thirty-four years before by a fragment of a shell. Thirteen years later a hard tumor appeared over the cicatrix and gradually increased to the size of the fist, with adhesion to the deeper parts and the trachea. Consequent disturbance of respiration led

[1] Monatsschr. f. Ohrenheilk., 1912, xlvi, 573.

[2] Klinik der Bronchoskopie, 1906, p. 265.

[3] Atrésie de la tracheé et des grosses bronches par néoformation sclérémateuse d'origine traumatique, Gaz. hebd. des sci. méd., 26 Fév., 1905.

to tracheotomy. Bronchoscopy showed diminution in the caliber of the trachea and bronchi. Histologic examination of the tumor showed cicatricial fibrous tissue.

3. *Intrabronchial Causes.*—In this class may be placed foreign bodies which gain entrance to the air passages by aspiration, or arise from within. They are considered under a separate heading. Devi[1] reports sudden bronchial obstruction from the accumulation of thick mucus during an attack of acute bronchial catarrh. Killian[2] found and removed, by lower tracheoscopy, tenacious secretion partly occluding the lower trachea and primary bronchi in a patient with laryngeal tuberculosis.

B. **Stenosis of the Smaller Bronchi**—Owing to the narrow lumen of the smaller passages, their proximity to the lung and the small area of pulmonary tissue supplied by individual branches, occlusion by compression from without, disease of the bronchial wall or foreign bodies fails to give rise to striking clinical features referable to the bronchi unless a large number of the smaller passages are simultaneously involved. In such conditions as widespread capillary bronchitis, bronchial asthma with spasm of the bronchioles, bronchitis fibrosa, and bronchitis and bronchiolitis obliterans, the obstruction to free entrance and exit of air may cause serious symptoms. These causes are considered elsewhere.

Pathology.—Sudden total occlusion, as by a foreign body, is followed by atelectasis and reduction in size of the part of the lung supplied by the occluded passage from absorption of air. Partial occlusion is more common, however, and is followed by diminished air content of the affected pulmonary territory. In early cases other lesions may be lacking, but if the occlusion persists for more than a few days, important changes occur, and for the most part as a result of stasis of secretion and infection by organisms always present and ready to set up inflammatory processes in the damaged region beyond the obstruction. Retained mucus is transformed into mucopurulent and purulent material. The infection extends to the pulmonary tissue, giving rise to bronchopneumonia, abscess, or gangrene. Bacterial invasion of the bronchial wall, the pressure of retained secretion, and disintegration of the supporting pulmonary tissue lead to the development of bronchiectasis. Chronic interstitial pneumonia and contraction of the pulmonary tissue follow the more acute inflammatory processes. Osler[3] speaks of the bronchiectasis and pulmonary suppuration following compression of a bronchus as aneurysmal phthisis. Extension to the pleura may cause fibrinous, serofibrinous, or purulent pleurisy. Pulmonary tuberculosis may develop. Its occurrence has been specially noted in connection with compression of the trachea

[1] Pester méd. Chir. Presse, 1884, xx, 115.
[2] Quoted from Schrötter, loc. cit., p. 265.
[3] Practice of Medicine, 1905, p. 856.

or bronchi from aortic aneurysm. Of 45 cases of aneurysm of the thoracic aorta reported by Fränkel,[1] in 4 there was chronic pulmonary inflammation and induration and in 3 other cases (about 7 per cent.) extensive tuberculosis with predominant infection of the left lung. In two of the three, considerable narrowing of the left primary bronchus was noted.

Symptoms and Signs.—The frequent coincident involvement of the trachea and primary bronchi in the conditions leading to bronchial stenosis makes it difficult or impossible in many instances to draw any sharp distinction between clinical features referable to one or the other, and the manifestations common to the various causes of *tracheobronchial stenosis* are first considered.

Gerhardt,[2] in his study of syphilitic tracheal stenosis, in which the important changes are often just above or at the bifurcation, noted three periods in the clinical picture, and these are also applicable with some modification to tracheobronchial stenosis from other causes. During the initial period of a gradually increasing obstruction there may be such *irritative symptoms* as cough with or without expectoration, a substernal tickling or uncomfortable sensation, weakening of the voice, and slight dyspnea on exertion. As the lumen of the involved passage diminishes, the first passes insensibly into the second stage, in which there is *persistent dyspnea* with the patient at rest, and this in turn into the third and final stage of *suffocation* and death. The different periods are often not clearly recognizable, and transient suffocative attacks, with cyanosis, severe dyspnea, and even unconsciousness for a time may appear early and recur at intervals throughout the disturbance. They may be due to catarrhal swelling of the mucous membrane about the site of a partial obstruction, to occlusion by secretion, or to acute cardiac dilatation. The strain upon the heart as a consequence of tracheobronchial obstruction is probably largely due to increase of pressure in the pulmonary circuit during forced expiration.

Hoarseness may be due to coincident disease of the larynx or recurrent laryngeal paralysis, but weakness of the voice may be observed quite independent of a disturbance of the larynx and may be ascribed to diminished volume of the air current in consequence of the trouble below.

The dyspnea of tracheobronchial obstruction is both inspiratory and expiratory. Predominant expiratory dyspnea is occasionally observed, and may be ascribed to the narrowing of the caliber of the trachea and bronchi and greater obstruction to the passage of air through an already partially occluded lumen during this phase of respiration. The head may be held forward with the chin approaching the chest, for the purpose of relaxing and widening the trachea. Immo-

[1] Spez. path. u. Ther. d. Lungenkrankheiten, 1904, p. 65.
[2] Deut. Arch. f. klin. Med., 1866-67, ii, 538.

bility of the larynx during respiration may be noted. These features may be contrasted with the predominant inspiratory dyspnea, tendency to hold the head backward, and greater amplitude of laryngeal excursion with laryngeal stenosis. The use of the accessory muscles of respiration, the inspiratory depression of the tissues at the root of the neck, the intercostal spaces, the epigastrium, and the lower parts of the chest in the region of the diaphragmatic attachment may also be noted. Inspiratory and expiratory or predominantly expiratory stridor may be heard. It is spoken of as "cornage" by the French, and is due to the passage of air through an obstructed tube.

On examination of the lungs, little or nothing of significance may be found early in the course of tracheobronchial obstruction, and before secondary inflammatory processes have arisen below the point of obstruction. The stridor may be of maximum intensity to one or the other side of the median line, as an indication of its point of origin; but it may be conducted along the trachea to the neck and heard best in this region when the site of obstruction is below. A considerable degree of obstruction may lead to inflation of the lung, hyperresonance, relative immobility, and abnormally low position of the pulmonary margin and other signs of emphysema.

With *unilateral bronchostenosis* the symptoms are the same, but less severe than with tracheobronchial obstruction. Complete sudden closure of a primary bronchus is followed by severe dyspnea and suffocative symptoms, which usually subside after a short time, and seldom terminate fatally unless complicated by other disturbances in the respiratory or circulatory system. Following the initial disturbance of sudden occlusion, or in the course of a gradually increasing partial obstruction, troublesome dyspnea may be present only on exertion. On examination, diminished respiratory excursion, resonance on percussion, and weakened breath sounds, voice, whisper, and tactile fremitus are found over the parts of the lung supplied by the occluded bronchus. Measurement may show some narrowing of the affected side. Stridor may be heard over the site of the obstruction. Signs of compensatory emphysema can be demonstrated over the unaffected lung.

Clinical manifestations arising in consequence of obstruction of individual bronchi become less striking and less typical, the more gradual the obstruction and the smaller the occluded passage. It not infrequently happens that bronchostenosis arising from disease of the bronchial wall or foreign bodies is masked by manifestations referable to secondary infection of the lung, or that bronchial obstruction due to compression from without is an inconspicuous and unheeded incident in the course of serious intrathoracic disease, the clinical features of which dominate the picture.

Diagnosis.—The differentiation between bronchostenosis arising from compression and that due to endobronchial causes is at times difficult or impossible. The extrabronchial causes comprise, for the

most part, disease which develops in or about the mediastinum or invades this region, as in the case of malignant disease by metastasis. They may give indication of their presence by dulness in the supracardiac region or over the vertebræ between the third and the ninth dorsal spines, and such signs of pressure upon other organs as dysphagia, inequality of the pupils or the pulses, variation in the blood-pressure in the two arms, "tracheal tug," recurrent laryngeal paralysis, engorgement of the vessels of the head and neck or one arm, and dilated superficial thoracic veins. A history of syphilis, attacks of pain like angina pectoris, pulsation of the dull area, systolic thrill and murmur, diastolic shock, and aortic regurgitation speak for aneurysm. Cachexia and enlarged cervical or axillary glands suggest malignant disease. Mediastinal involvement in a child with tuberculosis is likely to be due to enlarged and tuberculous glands. Examination with the *x*-rays is important, and may lead to the detection of extrabronchial disease, of which there is no indication on physical examination.

In the absence of indications, on physical and radioscopic examination, of an extrabronchial cause, foreign body or disease of the bronchial wall may be suspected. If there is a definite history of aspiration of a foreign body, followed by pulmonary symptoms and signs of unilateral bronchostenosis, the diagnosis is easily made, but it is important to remember, as is noted in the section on aspirated foreign bodies, that there may be nothing in the history or physical examination to indicate such a cause. Here also radioscopic examination may be helpful, but negative *x*-rays do not exclude a foreign body.

Bronchostenosis from syphilis may be suspected in a syphilitic subject after the exclusion of other causes. Scleroma and tuberculosis are uncommon, and there are usually other indications pointing to the diagnosis. Primary malignant disease of the bronchi is the most difficult of diagnosis.

Important advances in methods of investigation have made it possible in many instances to resolve the difficulty of establishing the cause of bronchostenosis in doubtful cases. Laryngoscopy, tracheoscopy, and bronchoscopy, with suitable instruments in skilful hands, now permit earlier and more accurate diagnosis, and more especially in the case of foreign bodies and syphilis the institution of earlier and more successful treatment. A discussion of bronchoscopy will be found in the section on Foreign Bodies.

Prognosis and Treatment.—The prognosis depends on the cause of the occlusion. The outlook is grave in any case in which the obstruction cannot be removed. It is most unfavorable with malignant disease, only little better in aneurysm, and adds to the seriousness of tuberculous glands, pericardial effusion, dilated left auricle, and mediastinal abscess or echinococcus disease, the dangers of mechanical hindrance to respiration, cardiac strain, and pulmonary infection beyond the obstruction. If discovered early, syphilis offers considerable hope of relief. The prospect with foreign bodies grows increasingly bright

with advances in bronchoscopic removal, and even the chronic cases should not be regarded as hopeless. Further discussion of prognosis and treatment will be found in the separate sections.

1. TUMORS OF THE BRONCHI.

Benign Tumors.—These occur only in very rare instances. In Rokitansky's[1] case a submucous *lipoma* almost filled the lumen of the left primary bronchus. Seigert[2] at autopsy found a *papilloma* at the bifurcation of the trachea apparently filling the trachea and projecting into the right bronchus. Spiess[3] found a *polyp*, 4 cm. long and 1.5 cm. thick, taking its origin from the right bronchus just below the bifurcation. The right bronchus was completely and the left partially occluded. There were cough, severe dyspnea, and attacks of suffocation. The tumor was successfully removed by lower bronchoscopy. *Enchondromas* have been observed. Tumors containing cartilage may occur as flat, rounded, or nodular circumscribed growths, taking their origin from the larger or smaller bronchi. It is difficult to differentiate simple hyperplasia or enchondrosis and true enchondroma. A bean-shaped cartilaginous tumor occluding the lumen of a bronchus to the right middle lobe and leading to bronchial dilatation is described by Siegert.[4] Eicken[5] removed from the left primary bronchus by means of bronchoscopy a polypous mass containing islands of cartilage. In Blecher's[6] case there was found at autopsy a hard, spherical tumor, (ossified enchondrosis of a bronchial cartilage) the size of a hazelnut, in the left primary bronchus, beyond which the bronchi were dilated. Chiari[7] reported an intrabronchial tumor of a complicated structure (lipoma, chondroma, and adenoma).

Malignant Tumors.—The malignant tumors of the bronchi may spring from the primary bronchi or their larger or smaller divisions, and are usually cylindrical-celled carcinoma, less commonly flat-celled carcinoma. Extension by way of the lymph channels or direct continuity soon leads to malignant disease of the neighboring or more remote parts of the lung and peribronchial or other lymph glands. When the growth develops from the wall of the primary bronchus or one of its larger branches it soon leads to occlusion of the bronchial lumen, with bronchitis, bronchiectasis, abscess formation, and bronchopneumonia and interstitial pneumonia in the affected region. Although

[1] Lehrb. d. path. Anat., 1861, Band iii.
[2] Virchow's Arch., Band cxxix, p. 413.
[3] Münch. med. Woch., 4 Okt., 1910.
[4] Virchow's Arch., 1892, Band cxxix.
[5] Verhandl. d. Vereines süddeutsch., Laryngolog., 1907.
[6] Ueber die klinische Bedeutung d. Bronchialekchondrosen, Mitt. a. d. Grenzgeb. d. Med. u. Chir., 1910, xxi, 837.
[7] Prager méd. Woch , 1883, viii.

the question cannot yet be regarded as settled, it is probable that carcinoma of the lung almost invariably arises from the bronchi. The clinical features are predominantly pulmonary, and malignant tumors of the bronchi are therefore discussed under Tumors of the Lung.

2. SYPHILIS OF THE TRACHEA AND BRONCHI.

The initial sore of syphilis has not been observed in the trachea or bronchi. Such secondary lesions as catarrhal inflammation, hyperemic spots, and mucous patches have been noted in rare instances, but are of little clinical importance. Tertiary manifestations are found with diminishing frequency from above downward, occurring commonly in the uppermost parts of the tract, less often between pharynx and trachea, and only rarely in the trachea and bronchi.

Munk's[1] case seems to have been the first in which disease of the trachea and bronchi was ascribed to syphilis. In 1867, Gerhardt[2] reported 5 cases and summarized the clinical features. In 1878 Vierling[3] collected 46 cases, to which, in 1903, Conner[4] added 82. Conner's article is the most complete and careful study in the literature. Recently the number of reported cases has rapidly increased, owing to the greater frequency of diagnosis by means of bronchoscopy. Schrötter[5] was able to report in 1896 that 13 cases of tracheobronchial syphilis had come under his observation, from which the conclusion may be drawn that careful bronchoscopic investigation discloses more cases than would otherwise be found. Tracheal ulceration ascribed to syphilis was found in only 2 cases (Nos. 29 and 1196) among 3000 autopsies at the Massachusetts General Hospital.

Tracheobronchial manifestations may follow acquired or inherited syphilis, a variable interval elapsing between infection and the onset of symptoms. Of 31 cases of acquired syphilis in Conner's[6] series in which the interval was noted it averaged ten years, the extremes being nine months and forty-two years. In 10 cases of inherited syphilis the average age was ten years, the two oldest cases being nineteen and twenty years.

The upper or lower third of the trachea is most frequently involved, the region just above the bifurcation being a point of election. Combined lesions of the lower end of the trachea and the bronchi are common. In some cases one or both bronchi alone are involved. Bronchial branches of the third or fourth order are rarely if ever invaded. The frequency of syphilitic manifestations in the region of the tracheal bifurcation and the main bronchi may be ascribed to local irritation

[1] London Medical Gazette, 1841, p. 20.
[2] Deut. Arch. f. klin. Med., 1867, ii, 535.
[3] Ibid., vol. xxi, p. 325.
[4] Amer. Jour. Med. Sci., 1903, N. S., cxxvi.
[5] Klinik der Bronchoskopie, 1906, p. 342.
[6] Loc. cit.

of the tissue by dust particles in consequence of the division of the air current.

Pathology.—Three principal pathologic lesions, representing the evolution of the syphilitic process, may be recognized singly or combined in the same or different cases. (1) *Gummata* occur as circumscribed or diffuse, single or multiple, large or small reddish masses, projecting into and encroaching on the lumen of the trachea or bronchi. They may be rounded or irregular and hard or soft. In some instances, fibrinous or purulent exudate or ulceration is seen on the surface. (2) *Ulcers* may be single or multiple, discrete or confluent, large or small and superficial or deep, irregular or circular in outline, and with a thick or thin and at times undermined margin. The loss of substance may be confined to the mucosa or submucosa, or include the fibrocartilaginous layer, with erosion and destruction of cartilage, fragments of which may be expectorated. Cicatrization may or may not accompany the destructive changes. Perforation of the trachea or bronchi and extension to neighboring tissues may occur. Mediastinal abscess and perforation of the esophagus have been observed. The opening of a bloodvessel may be followed by fatal hemorrhage. Circumscribed or diffuse (3) *scars* develop as a result of the syphilitic process. Endotracheal or endobronchial increase of connective tissue leads to the production of cicatrices of variable shape and extent, always tending to narrow and at times even obliterating the lumen of the affected passage. Band-like, annular or membranous strictures may be found. Gerhardt[1] likened the resulting appearance of the trachea to that of a rope-ladder. Fibrous peritracheitis or peribronchitis may involve adjacent structures, especially the recurrent laryngeal nerves. Associated enlargement of the tracheobronchial glands may cause compression stenosis. Tracheal or bronchial dilatation may be found above and below an obstruction.

Old or recent syphilis of the mouth, nose, pharynx, or larynx may be present. Bronchiectasis below the obstruction is not uncommon, and may be ascribed to the stenosis, weakening of the bronchial wall and the adjoining pulmonary tissue from syphilis or other disease. Lobar or bronchopneumonia may complicate the process. Coexistent pulmonary tuberculosis is occasionally observed. Emphysema is not infrequent.

Symptoms and Signs.—An initial stage of irritation, followed in turn by permanent stenosis, and finally by suffocative attacks, as noted by Gerhardt,[2] may be recognized in many cases. Cough is commonly the earliest symptom and is at first dry, but later accompanied by mucoid, mucopurulent or purulent, and occasionally blood-streaked sputum. Elastic tissue may be found in the sputum. Hemoptysis, when it occurs, is a prominent symptom in about half of the

[1] Loc. cit. [2] Loc. cit.

cases. Of 16 cases in which it was noted it was of minor importance in 9 ([1] to [9]) and fatal in 7 ([10] to [16]).

In 3 ([10], [11], [13]) of the 7 fatal cases the bleeding was preceded by hemorrhage. An autopsy was performed on 6 and disclosed ulceration of the trachea and bronchi with perforation of the pulmonary artery in 3 ([14] to [16]) and the aorta ([11]), branches of the bronchial artery ([12]), and the superior vena cava ([13]) in 1 each. Hemorrhage may be the first striking symptom, as in 1 of the Massachusetts General Hospital cases reported by Gannett.[17] The patient, a man, aged thirty-seven years, had coughed without expectoration for three years. He had an abundant hemoptysis three days before entrance. Death occurred two days after admission from a recurrence of the bleeding and at autopsy (No. 1196) it was found that a large branch of the pulmonary artery had ruptured into the right primary bronchus through a cicatrix involving the wall of the bronchus and the artery. Other cicatrices were found in the trachea and the left primary bronchus. Interstitial orchitis with the findings in the trachea and bronchi suggested syphilis as a cause.

Symptoms of tracheobronchial stenosis are seldom absent. Persistent or paroxysmal dyspnea is the most constant and conspicuous manifestation, and may be ascribed to the obstruction to respiration and consequent cardiac insufficiency.

Suffocative attacks may follow exertion or occur at night. They are probably due to acute failure of an already overtaxed heart. During the paroxysm, orthopnea, cyanosis, inspiratory or both inspiratory and expiratory dyspnea and stridor; relative immobility of the larynx; inspiratory retraction of the tissues at the root of the neck, the lower intercostal spaces, and the epigastrium; diminished respiratory motion and feeble vesicular murmur, weak pulse, and even unconsciousness may be noted. On auscultation the stridor may be of maximum intensity over the site of the obstruction. In Prengrueber's[18] case, a suffocative attack, after running up stairs, was the first symptom.

[1] Hanzel, Wein. klin. Woch., 1898, xi, 955.
[2] Parrain, Thèse, Bordeaux, 1894, No. 89. Quoted from Conner.
[3] Chiari, Schrötter's case, Monatschr. f. Ohrenh., 1881, xv, 196.
[4] Lancereux, Ann. des mal. d'Or., 1882, p. 117.
[5] Gairdner, Glasgow Med. Jour., 1890, xxxiii, 463.
[6] Silcock, Trans. Path. Soc., London, 1886, xxxvii, 115.
[7] Wright, New York Med. Jour., 1891, liii, 672.
[8] Wright, ibid.
[9] Norton, Trans. Path. Soc., London, 1872, xxiii, 44.
[10] Sokolowsky, Berl. klin. Woch., 1889, xxvi, 209.
[11] Barnays, St. Louis Med. and Surg. Jour., 1880, xxxix, 250.
[12] Watson, New York Jour. of Med., 1843, i, 57.
[13] Turner, Trans. Path. Soc., London, 1886, xxxvii, 117.
[14] Gerhardt, Deut. Arch. f. klin. Med., 1867, ii, 541.
[15] Kelly, Trans. Path. Soc., London, January 2, 1872, p. 45.
[16] Gannett, Boston Med. and Surg. Jour., July 21, 1904.
[17] Loc. cit.
[18] Algérie Médicale, 1870: also Rey. Syphilis trachéale, Paris, 1874, quoted from Conner, loc. cit.

and was followed by many similar attacks, during which the patient was for many hours unconscious, with barely perceptible pulse, while in the intervals she was quite well. In 11 of the cases collected by Conner[1] the patient died in a suffocative attack. In Wadsack's[2] 2 cases a sudden and fatal attack of suffocation terminated a period of comparative health. Pain of a dull character and usually referred to the substernal region is at times observed. Dysphagia and aphonia may also be noted.

Unilateral bronchostenosis may be indicated by diminished respiratory motion, breathing, voice, whisper, and tactile fremitus on the affected side.

Fig. 1

Syphilitic narrowing of the trachea, beginning 2 cm. above the bifurcation. Left bronchus almost closed. Right bronchus much narrowed. (Wadsack.)

Diagnosis.—Tracheobronchial syphilis may be suspected when there is a history of the disease and such symptoms as cough, dyspnea, bloody sputum, or frank hemoptysis in the absence of other obvious cause. Manifestation of late syphilis elsewhere, especially in the upper parts of the respiratory tract, failure to react to tuberculin, a positive Wassermann test, and symptoms of tracheobronchial stenosis are important additional evidence. Foreign bodies in the air passages,

[1] Loc. cit.

[2] Zwei plötzliche Todesfälle infolge syphilitischer Bronchostenose, Charité Annalen, 1905, xxix, 211.

tumors developing from the wall, and compression from without are most likely to offer difficulty of differentiation. Examination with the *x*-ray will be of assistance in reaching a decision. Direct inspection by tracheoscopy or bronchoscopy may demonstrate ulceration and scarring of the trachea and bronchi. Such lesions are seldom due to other causes than syphilis, but neither the macroscopic nor the microscopic appearances can be regarded as establishing the diagnosis. Syphilis and tuberculosis cannot thus be distinguished, and only the demonstration of the spirochæta of syphilis is conclusive. In doubtful cases, therefore, the investigation of a small piece of excised tissue will be helpful.

Prognosis.—Thus far the mortality has been high. In Vierling's[1] 46 cases death occurred in 39. In Conner's[2] 82 cases there were 58 deaths, giving a mortality of 76 per cent. in the two series. Pneumonia, a suffocative attack, hemorrhage from perforation of a large bloodvessel, exhaustion, or cardiac failure are the most common causes. The possibility of diagnosis by tracheoscopy and bronchoscopy during the early gummatous or ulcerative stage of the infection, and while treatment may still be effective, may be expected to favorably influence the chances of recovery. Tracheobronchial stenosis from firm, unyielding, and irremediable cicatrices is very unfavorable. The outlook is less hopeful the deeper down in the tract the syphilitic process occurs. The prognosis is worse with bronchial than with tracheal syphilis.

Treatment.—Chief reliance should be placed on salvarsan and mercury. The earlier the treatment is begun the better the chances of success. In 3 cases reported by Kehler,[3] in which the diagnosis was made by bronchoscopy before the disease had advanced beyond the stage of gummata or superficial ulceration, cure was accomplished with little resulting stenosis. By bronchoscopic examination Halle[4] saw gummata of the trachea disappear in fourteen days after the administration of 0.6 gram of salvarsan. Mechanical dilatation of a stricture has occasionally given relief, but is not unattended with danger. In the case reported by Seifert,[5] cicatricial stenosis of the trachea and left main bronchus was almost completely relieved after ten weeks of almost daily dilatation of the obstruction.

3. TUBERCULOSIS OF THE BRONCHI.

The trachea and bronchi are occasionally the site of tuberculous invasion as a result of *secondary* infection from the lungs or bronchial glands. Single or multiple ulcers with consecutive contraction and

[1] Loc. cit.
[2] Loc. cit.
[3] Wiener klin. Woch., 1909, li, 2902 and 2963.
[4] Berl. klin. Woch., January 2, 1911.
[5] Münch. med. Woch., 1895, xlii, 719.

stenosis of the trachea or bronchi may result. The infrequency of the disease in the trachea and bronchi may be ascribed to the rapidity with which infected material is expelled by cough, the absence of folds and depressions in which such material may lodge, the protection which a thin layer of mucus affords to the walls of the air passages, and the expulsion of small particles by ciliary motion. With rare exceptions only, tracheobronchial tuberculosis is an inconspicuous incident in the course of graver pulmonary manifestations of the disease.

Primary tuberculosis of the trachea or bronchi has been established in only a few cases. In 1901 Gidionsen[1] reported the case of a woman, aged forty-one years, in whom death followed hemoptysis. At autopsy dilated and varicose veins were found in the trachea, and on the posterior wall just above the bifurcation an elongated ulcer about the size of a pfennig piece. The lungs were free from tuberculosis. Although the ulceration was ascribed to tuberculosis and the microscopic sections submitted to Weigert, yet syphilis cannot be regarded as adequately excluded in view of the well-known difficulty of differentiating the two conditions from the histologic picture. In 1904 Hedinger[2] reported the case of a woman, aged twenty-nine years, whose clinical history could not be obtained, but in whom at autopsy multiple ulcers of the lower part of the trachea and the bronchi were found. The lumina of both primary bronchi were much narrowed. The histologic picture was typical of tuberculosis, but no tubercle bacilli could be found. No other evidence of tuberculosis was found in the body. In this case also the proof of the tuberculous nature of the disease is incomplete. In Hansemann's[3] patient, a woman, aged seventy-three years, thorough search of the body failed to reveal tuberculous lesions elsewhere than in the trachea, where ulceration extended above to the larynx and below to beyond the bifurcation. The tuberculous nature of the ulceration was first recognized microscopically by the finding of bacilli. Schmorl[4] reported 2 cases of primary tuberculosis of the trachea and large bronchi. In the first, a boy, aged eighteen years, who died of typhoid, an unulcerated tubercle half the size of a pin's head was found in the left principal bronchus. In the second, a child, aged eight years, a group of three tubercles larger than millet-seeds was found in the trachea.

4. SCLEROMA.

This is the same disturbance which is spoken of in the nose as rhinoscleroma. It is probably identical with Gerhardt's[5] chorditis

[1] Münch. med. Woch., 1901, No. 42.
[2] Verhandl. d. path. Gesellsch., 1904, vii, 83.
[3] Ibid., p. 88.
[4] Ibid., p. 88.
[5] Deut. Arch. f. klin. Med., xi, 583.

vocalis hypertrophica inferior in the larynx and Stoerk's[1] chronic blennorrhea of the nose, larynx, and trachea. It is seldom observed in this country, and is apparently most common in Europe among the poorer classes in and about Cracow, where Pieniàžek has had the opportunity of studying many cases. In 1905 his assistant, Nowotny[2] reported on 42 cases in which tracheobronchial stenosis was due to scleroma. The cause is unknown. The disease usually begins in the nose and thence slowly extends into the nasopharynx, larynx, and trachea. In rare instances the trachea is primarily involved, as in one of Nowotny's cases. Extension into the primary and even the secondary bronchi is occasionally observed. The lesions first appear as reddish infiltrations, resembling granulation tissue, involving parts or the whole of the tract, with catarrh of the surface, the formation of dried masses of secretion, and subsequent transformation into connective tissue, with little tendency to the production of ulceration. Great thickening and deformity of the wall and narrowing of the lumen may result. According to Nowotny the thickening and flattening of the carina tracheæ is typical and unlike that seen in any other disease. Stenosis of a bronchus may be followed by the development of bronchiectasis beyond the point of obstruction. The symptoms are such as are seen in tracheobronchial stenosis from other causes. The disease may last for many years and is incurable, but in rare instances spontaneous healing takes place. Treatment consists in the removal of infiltrations by curettage, the rupture of membranous bands, and the dilatation of strictures with the assistance of tracheoscopy or bronchoscopy.

5. ASPIRATED FOREIGN BODIES.

A number of valuable monographs have appeared dealing with the aspiration of foreign bodies into the air passages. In 1854 Gross[3] collected nearly 50 cases. In 1893 Preobraschensky[4] analyzed 763 cases, to which, in 1902, Pohl[5] added 312. These publications deal with the aspiration of foreign bodies into all parts of the air passages, while their lodgement in the bronchi only concerns us here. Recently interest in this subject has centred principally in the rapid advances made in diagnosis and treatment through the use of the bronchoscope. In 1907 Gottstein[6] collected 137 cases reported to April 1, 1906, in which the bronchoscope had been used. His discussion is full and

[1] Klinik d. Krankh. d. Kehlkopfes, etc., Stuttgart, 1880, p. 161.

[2] Arch. f. Laryngolog. u. Rhinolog., 1905, xvii.

[3] A Practical Treatise on Foreign Bodies in the Air Passages, Philadelphia, Blanchard & Lea, 1854.

[4] Ueber Fremdkörper in den Athmungswegen, Wiener Klinik, 1893, xix.

[5] Ueber Fremdkörper im Kehlkopf, in der Luftröhre und in den Bronchien, Inaug. Diss., Breslau, 1902.

[6] Ueber die Diagnose und Therapie der Fremdkörper in den unteren Luftwegen mit besonderer Berücksichtigung der Bronchoskopie und Radioskopie, Mitt. a. d. Grenzg. d. Med. u. Chir., 1907, 3 Suppl.

complete. In 1909 Eicken[1] increased the number to 303. Brünings'[2] bronchoscope is the instrument most commonly used.

Etiology.—Foreign bodies which gain entrance to the air passages are of endless variety, but consist for the most part of small articles commonly placed in the mouth.

Aspiration usually takes place during an unexpected, forced inspiration, such as may accompany a sudden impulse to cough, laugh, or cry, a fright, or a blow on the back. It may also occur while the patient is asleep, intoxicated, partially or completely unconscious from narcosis or other cause. Bones, beans, needles, and hollow bodies are the most frequent invaders, and more than half the cases occur in children under five.

The mechanism of ready entrance and difficult exit of foreign bodies has been compared to that of a penny savings-box, but is somewhat more complicated. Entrance into and lodgement in the air passages are facilitated by gravity and inspiratory widening of the glottis and the bronchial tubes. The chances of spontaneous expulsion are diminished by expiratory narrowing of the passages and reflex spasmodic closure of the glottis, so that expiratory efforts are relatively ineffectual, and, even if successful, exit through the glottis may not be possible. Partial absorption of air below an occluding body and an increase of pressure above it, during spasmodic attacks of cough with the glottis closed at the beginning of expiration, may more firmly fix it in position. If released and unexpelled there is danger of reimpaction, which, owing to the diminished inspiratory current into a previously involved territory, is likely to take place into another bronchus, with the danger of immediate suffocation.

The conditions differ according to the character of the foreign body. Beans capable of swelling are likely to completely occlude the bronchus, and are difficult to extract, hence most dangerous. Rough bodies of an irregular shape, such as pieces of bone, are likely to be held in place. Hollow bodies may permit the passage of air, but make expulsive efforts ineffectual. Needles become quickly fixed, but allow air to pass readily to and fro and cause less severe initial symptoms. The larger the foreign body and the smaller the child the greater the danger of suffocation.

The bronchi leading to the lower lobes are usually invaded, and the right side in about 80 per cent. of the cases. The likelihood of right-sided invasion increases with the youth of the patient. The greater aspiratory force of the right lung, the more vertical course and larger size of the right primary bronchus serve to explain the greater frequency of lodgement on the right.

Pathology.—Bacteria invariably accompany aspirated foreign bodies, and are largely responsible for the pathologic changes. Much depends

[1] Die directe Laryngo-Tracheo-Bronchoskopie, Deut. Klinik, vol. xii.
[2] Deut. med. Woch., 16 Mai, 1912.

on the interval which elapses after the aspiration. Within the first few hours, unless death occurs from suffocation, the local changes are limited to erosion and simple inflammatory swelling of the mucous membrane. Such lesions are quickly repaired following successful removal. At times, however, grave inflammatory processes develop with astonishing rapidity, and in rare instances pneumonia may follow within twenty-four hours. If the foreign body remains impacted, purulent bronchitis, ulceration of the bronchial wall, extension of inflammation to the peribronchial and neighboring pulmonary tissue usually occur. Complete bronchial occlusion is followed by absorption of air and atelectasis in the involved territory, and, whether partial or complete, infection soon leads to multiple or confluent areas of bronchopneumonia and to bronchiectasis. Disintegration of tissue, weakening or ulceration of the bronchial wall, and the accumulation of purulent secretion below the obstruction usually reopen the occluded passage, and may even partially dislodge or extrude the foreign body. By extension, aspiration, or metastasis, acute or subacute bronchopneumonia is likely to arise in nearby or remote parts of the same or the other lung. Chronic interstitial pneumonia, multiple areas of abscess, gangrene and bronchiectasis are likely to follow. In rare instances, tuberculosis or actinomycosis develops. The foreign body may be discharged through the chest wall. Fibrinous, serofibrinous, or purulent pleurisy and pneumothorax are occasionally observed. These chronic and permanently damaging processes may be avoided by immediate removal or spontaneous expulsion of the foreign body.

Symptoms.—These may be divided into primary and secondary manifestations, between which a period of comparative latency may intervene.

Immediately following the aspiration, severe symptoms due to irritation and suffocation may be observed. There are paroxysmal cough, spasm of the glottis, inspiratory and expiratory dyspnea, a sense of suffocation and cyanosis. The severe cough and dyspnea gradually diminish in intensity and commonly last only a few hours, but may unexpectedly recur at intervals. Persistence of dyspnea without cough usually indicates that the foreign body has become fixed. Hoarseness may be present if the vocal cords have been injured or if the body is situated in their neighborhood. A sense of irritation in the sternal region or deep in the chest is common, but actual pain is infrequent, although it may occasionally be observed with sharp or pointed bodies, and is then usually thoracic, in rare instances it is abdominal. Sputum is absent or scanty and at times blood-tinged. If the body is large or movable, paroxysms of cough and dyspnea may be of extreme severity, with suffocation, strangling, vomiting, convulsions, attacks of unconsciousness, or death. A fatal termination immediately after the aspiration is, however, fortunately uncommon.

After the subsidence of the initial symptoms, if the foreign body remains impacted, a period of comparative relief usually follows, and

the patient may be troubled only by occasional slight cough and dyspnea on exertion. This interval of partial or complete relief often leads to a false sense of security, but is followed usually within a few days by secondary manifestation of pulmonary infection. Cough, more or less abundant, purulent and foul-smelling sputum, fever, and such other symptoms as are common with bronchitis, bronchial and pulmonary suppuration ensue, and continue for an indefinite period. The chronic stage may last weeks, months, or years, and when death occurs it is usually due to sepsis.

In Neumeyer's[1] case the extraction of a bone twenty-four hours after aspiration did not prevent pneumonia, which proved fatal in the next twenty-four hours. In one of Gottstein's[2] cases pneumonia developed in forty-eight hours after aspiration of a needle.

The initial symptoms may be insignificant, overlooked, misinterpreted or forgotten, and the foreign body remain unrecognized as the cause of an apparent simple bronchitis, bronchopneumonia, bronchiectasis, abscess, gangrene, or empyema. In Carpenter's[3] patient, such insignificant symptoms followed the aspiration of four artificial teeth that the patient thought they had passed in the stool, but they were found at autopsy thirteen years later in the pus of an empyema. Leyden[4] reported two unsuspected instances in physicians, one of whom had symptoms suggestive of chronic tuberculosis, which was found at autopsy to be due to an aspirated bone. The other was an invalid from severe cough and gangrenous, putrid sputum, the cause of which was uncertain until in a severe paroxysm of cough a shirt-button was expelled.

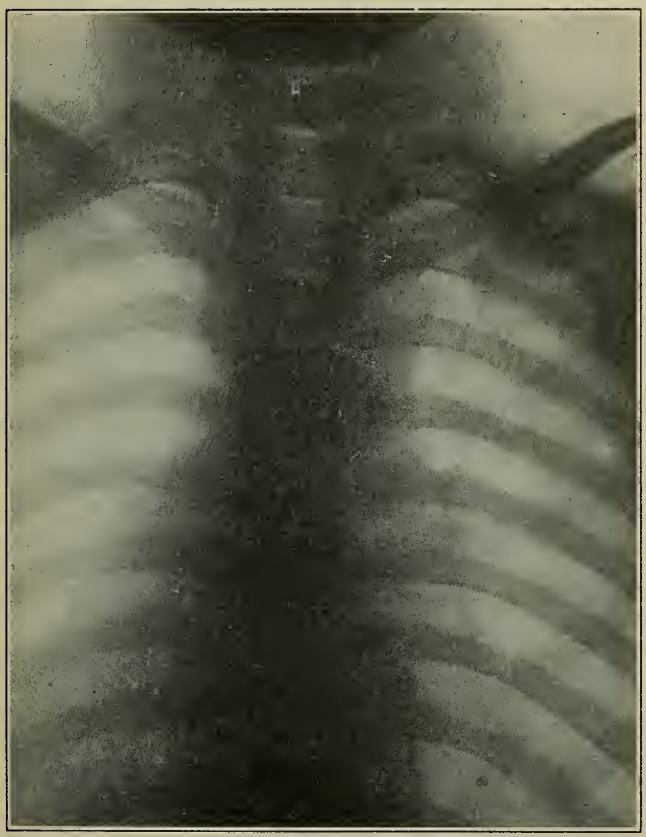
In rare instances a body too large for impaction in the bronchi is aspirated through the glottis, and may then remain free and mobile in the air passages, or it may happen that a body expelled from the bronchus is too swollen for reimpaction and likewise remains free. Such mobile dancing bodies may oscillate back and forth between the glottis and the bifurcation of the trachea, causing paroxysms of cough of extreme severity and attacks of suffocation. Lodgement of toy whistles in the air passages may result in squeaks or whistling sounds with inspiration or expiration. In Andrew's[5] case the aspiration of a toy squeaker was followed by a short, shrill inspiratory whistling sound.

Signs.—In cases in which the lodgement is in the larynx or trachea, examination of the lungs is usually negative. Invasion of the principal bronchi or their branches commonly gives important indications. Total occlusion of a principal bronchus causes markedly diminished respiratory motion, diminished or absent diaphragm shadow (Litten's phenomenon), breath sounds, voice, whisper, and tactile fremitus on the affected side. The percussion note is unchanged or at times tympanitic in quality. Percussion of the pulmonary margin during forced

[1] Münch. med. Woch., 1904, 38 and 39, case 6.
[2] Loc. cit.
[3] Guy's Hosp. Rep., 1842, vii, 353.
[4] Deut. med. Woch., 1903, V. B, p. 34.
[5] Lancet, 1903, i, 1296.

inspiration and expiration shows absence of mobility. Fever is absent. Obstruction of a branch of the principal bronchus may be indicated by similar signs limited to the involved territory. If the occlusion is partial the signs are correspondingly less marked, and if the object is small and allows free passage of air to and fro, nothing may be found except perhaps slight limitation of motion on forced breathing from reflex irritation on the affected side. In some cases, sibilant or sonorous sounds may be heard, of maximum intensity over the site of the partial obstruction.

Fig. 2



Stick pin in bronchus. (Gottstein.)

X-ray Examination.—This is an important method, and may be indispensable in doubtful or difficult cases. It is specially useful in determining the presence and position of metallic bodies. Of 156 cases collected by Eicken[1] metallic bodies were thus demonstrated in all but

[1] Zeit. f. Ohrenheilk. u. f. d. Krank. d. Luftwege, Band lxv, Heft 2 u. 3, p. 103.

five. It is less valuable for the demonstration of bone and ivory substances, a positive result being obtained among 40 such cases in only 4, in all of which the body was of considerable size, and so fortunately placed as to appear as a shadow in an intercostal space. Even when the foreign body itself cannot be demonstrated, evidence of considerable value may still be obtained. A shadow from changes in the pulmonary tissue about the body may be noted. The intercostal spaces may be narrowed and the diaphragm elevated on the affected side in consequence of pulmonary retraction. Dislocation of the mediastinum toward the involved region may be observed. Radiographs should be taken with the breath held in full inspiration. Fluoroscopic examination may show limited respiratory excursion of the chest wall and the diaphragm and with a hard cough expiratory dislocation of the mediastinum toward the involved lung. A body in the esophagus may be indicated by a median position and motion on swallowing, but not with respiration. Lateral position and mobility with respiration suggest lodgement in the lung. With the *x*-ray plate on the back the size of the projected shadow is more nearly that of the foreign body if it lies in the esophagus, relatively larger if more anteriorly placed in a bronchus. Stereoscopic plates may assist in the localization.

Diagnosis.—This is easily made if there is a definite history of aspiration, the immediate occurrence of paroxysmal cough and dyspnea, and signs of partial or complete occlusion of a bronchus. It is important to know the size, shape, and kind of foreign body, and it is well, if possible, to obtain another article of the same sort. In children and in adults when the aspiration occurs during partial or complete unconsciousness there may be nothing in the history to suggest a foreign body. In such cases, and in those in which the initial symptoms are slight, atypical, or absent, the diagnosis is difficult. Foreign bodies should be suspected in all cases in which there is circumscribed bronchopneumonia, bronchiectasis, abscess or gangrene of uncertain origin, and especially when the right lower lobe is involved.

Not infrequently with children, and at times with adults, the patient is said to have "swallowed something" or "choked." If the body is lodged in the esophagus there is likely to be increase of saliva, and difficulty and pain on swallowing solid food, but no cough or dyspnea. Paroxysmal cough and dyspnea, absence of pain and ability to swallow, suggest aspiration into the air passages. Examination with the *x*-ray may assist in the differentiation. In rare instances an attack of spasmodic laryngitis, laryngeal diphtheria, whooping cough, or asthma may be mistaken for aspiration of a foreign body.

A foreign body lodged in the esophagus may perforate the wall and lead to pulmonary symptoms. It may then be difficult to determine whether the foreign body is in the esophagus or the air passages. A history of dysphagia and the absence of initial pulmonary symptoms are of importance in the differentiation. In the case of A. C. (No. 192, 934), who swallowed a chicken bone, there was constant pain on

swallowing. He began to cough three days after the accident, and in the following six weeks had fever and abundant, foul-smelling, purulent sputum containing elastic tissue. There was dulness on percussion and a shadow by *x*-ray examination (Chapter XVI, Fig. 44) at the root of the right lung. The bone was successfully extracted from the esophagus. The patient died five months later of pulmonary tuberculosis.

Spontaneous expulsion of a fragment of bone is not an assurance of absence of other fragments. In long-standing cases persistence of paroxysmal cough and signs of atelectasis should lead to the suspicion that a foreign body may still be present. In the case of L. K., aged sixty-six years, seen with Drs. A. Coolidge and H. P. Mosher, May 1, 1914, there was a history of aspiration of a chicken bone nine months before. Severe paroxysmal cough and one to three ounces of mucopurulent sputum persisted in spite of the expulsion of a small piece of bone thirteen weeks after the accident Examination showed involvement of the root of the right lung and partial atelectasis of the right lower lobe. A second fragment of bone, about 1 cm. long and 0.6 cm. in greatest diameter, was removed by bronchoscopy from one of the branches of the right primary bronchus on May 16 by Drs. Coolidge and Mosher. The patient developed a left hemiplegia during the operation. On the third day after operation he coughed up a third fragment of bone, about 0.6 cm. long, sharp and pointed at one extremity and irregularly club-shaped at the other, the greatest diameter reaching 0.2 cm. Cough and expectoration rapidly subsided. On June 4 the expectoration amounted to only three or four small masses of mucopus a day. The hemiplegia persisted.

Of great importance in diagnosis is the use of the bronchoscope. Among 137 cases collected to April 1, 1906, by Gottstein[1] a diagnosis was successfully made by this means in 121 (88.3 per cent.). The failure to establish the diagnosis in 16 (11.6 per cent.) cases may be largely ascribed to faulty technique early in the use of this method.

Prognosis.—Recovery seldom occurs unless the foreign body is spontaneously expelled or extracted. Encapsulation and freedom from symptoms with the body remaining only rarely occurs.

Spontaneous expulsion occurs in a not inconsiderable number of cases, but the expectation of relief by this means cannot be estimated with sufficient accuracy in individual cases to justify delay in treatment. Large, soft bodies of organic material, such as meat or fruit, cause death unless immediately expelled or extracted. Smaller particles may quickly undergo disintegration, and may be successfully expectorated. Of other substances, according to Gottstein,[2] rough, jagged bodies, such as bone, and smooth, flat, or smooth, round and even pointed bodies, are expelled in about one-third of the cases, while those which swell by imbibition, such as beans, and also hollow bodies

[1] Loc. cit. [2] Loc. cit.

in only about 11 to 12 per cent. Much depends on the interval which elapses between aspiration and removal. Although expulsion not infrequently follows in the course of secondary pulmonary suppuration, it usually fails to relieve the chronic inflammatory changes which slowly progress and commonly lead to a fatal termination. In most cases in which complete relief follows the expulsion the foreign body has been fixed in the upper part of the air passage and not in the bronchi.

Progress in the development and use of the bronchoscope has greatly increased the prospect of successful removal and avoidance of dangerous secondary infection.

Of 114 cases collected by Gottstein,[1] in which the diagnosis of the presence of a foreign body was established by the bronchoscope, bronchoscopic extraction was completely successful in 96 (84 per cent.). Of 113 cases in which the outcome was known, 97 (86 per cent.) were "cured," 9 died in spite of the removal, and 7 died without the foreign body having been removed.

Of 231 cases[2] collected by Eicken,[3] 177 were completely and 29 partially relieved, while the attempt was unsuccessful in 25 cases.

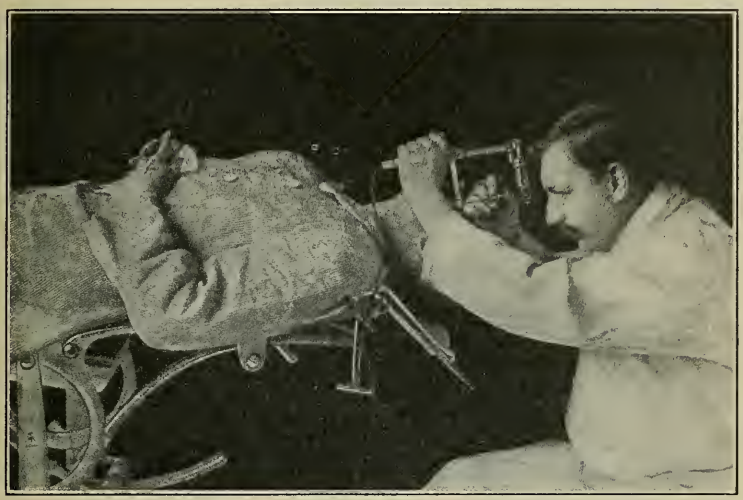
Treatment.—In acute cases the chances of spontaneous expulsion do not justify delay. Postponement may be followed by sudden death in the interval, as in Schlender's[4] patient, a boy, aged three years, who had aspirated a cartridge case, showed no alarming symptoms, and was to be operated the next day, but died in the night in an attack of suffocation. No time should be lost. Cough should not be excited, and such customary procedures as a blow on the back, shaking the patient and the use of emetics should be avoided lest the body become more firmly impacted or expelled from its original position and reaspirated into another bronchus. The effect of posture may be tried while making ready for the extraction, the patient lying with his face toward the floor and the body so inclined that the bronchi slope downward in the hope that gravity may assist in the expulsion. Examination for a foreign body in the pharynx and larynx should first be made and the body extracted with the finger or forceps, assisted, if necessary, by inspection with the laryngeal mirror.

In chronic cases an attempt should be made even though a long interval has elapsed since the aspiration of the foreign body. In one of Jackson's[5] two remarkable cases the removal by bronchoscopy, of a collar-button, lodged for ten years in the right bronchus was followed by complete recovery and freedom from any pulmonary symptoms whatever. In his second case the removal from the right bronchus of a price-tag fastener, aspirated seven years previously, was likewise followed by complete relief.

[1] Loc. cit.
[2] Bronchial cases have been abstracted from his table.
[3] Deut. Klinik, Band xii and Int. Zentbl. f. Laryngol., 1909, Jahrg., xxv, p. 554.
[4] Deut. Zeit. f. Chir., Band lxiv, p. 411.
[5] Jour. Amer. Med. Assoc., September 21, 1912.

Bronchoscopy.[1]—Although Voltolini,[2] Pieniàžek,[3] and others used this method, to Killian[4] belongs the credit of developing and making it practical. Coolidge[5] was the first to report the use of the bronchoscope in America. Gottstein[6] and Eicken[7] have recently reviewed the literature.

Fig. 3



Bronchoscopy. (Brünings.)

The bronchoscope[8] consists of a long, stiff, metal tube mounted on a handle, an illumination apparatus, and extracting forceps of various types. The instrument is introduced through the mouth and larynx (upper tracheobronchoscopy) or through a tracheotomy wound (lower tracheobronchoscopy). The former method presents many technical difficulties and requires skill and practice. General or local anesthesia is used. Tracheotomy is recommended when there is severe dyspnea or with a body so large as to be extracted through the glottis only with difficulty. The upper route (upper tracheotomy) is to be preferred over the lower. Aortic aneurysm and severe cardiac decompensation are contra-indications. Slight bleeding, edema of the larynx, and aphonia may follow upper tracheobronchoscopy. Emphysema may develop after lower tracheobronchoscopy.

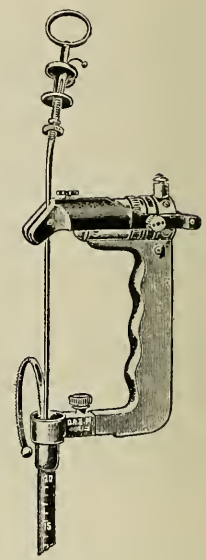
[1] For technical details, special works must be consulted.
[2] Berl. klin. Woch., 1875, p. 71.
[3] Arch. f. Laryngol., 1896, Band v, p. 210.
[4] Kallofrath, Münch. med. Woch., 1897, p. 1038; Killian, Münch. med. Woch., 1899; Deut. med. Woch., August 31, 1911.
[5] New York Med. Jour., September 30, 1899.
[6] Mitt. a. d. Grenzg. d. Med. u. Chir., 1907, 3 Suppl.
[7] Deut. Klinik, xii, and Int. Zentbl. f. Laryngol., 1909, xxv, 554.
[8] See Gottstein, loc. cit., Jackson, Laryngoscope, St. Louis, 1908, xviii, 214; and Brünings, Deut. med. Woch., 16 Mai, 1912.

Other Methods.—In case bronchoscopy fails, such other procedures as intrathoracic tracheotomy, bronchotomy by way of the posterior

Fig. 4

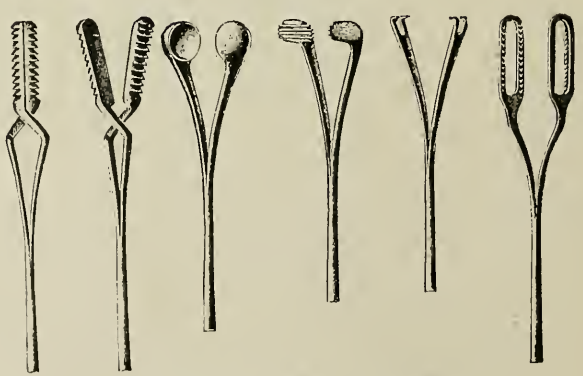
Bronchoscopy. (Brünings.)

Fig. 5



Universal electroscope for lower tracheobronchoscopy. (Brünings.)

Fig. 6



Extracting forceps. (Brünings.)

mediastinum, or pneumobronchotomy, under positive (Brauer's method[1]) or negative pressure (Sauerbruch's method[2]) may be considered, but as yet have only rarely proved successful.

6. FOREIGN BODIES ARISING FROM WITHIN.

Under this heading may be described foreign bodies in the air passages and the lung, for the most part the result of pathologic changes and capable, when dislodged from their site of formation, of giving rise to such manifestations as have been considered in the preceding section. Poulalion[3] collected and reviewed the literature at length.

Etiology and Pathology.—In a large proportion of the cases these bodies consist of *caseous* or *calcified masses*, developing in the course of chronic tuberculosis of the lung or bronchial lymph glands, and gaining entrance to the air passages by inflammatory softening and ulceration of the surrounding and supporting tissue. The inspissated contents of pulmonary cavities or bronchiectases, the pus of an old empyema, retained blood-clot, fragments of bronchial, pulmonary or pleural tissue, bits of tumor or hydatids may also become infiltrated with lime salts and expelled into the bronchi. In rare instances an aspirated foreign body is incrusted with lime salts and extruded.

In some instances the deposition of lime salts takes place over a wider extent of tissue and in connection with less obvious inflammatory changes. In old persons *petrifaction of the bronchi* with the formation of coral-like and branching structures occurs as in the case described by Andral.[4] A *diffuse incrustation* of the pulmonary tissue may also be observed. Local circulatory disturbances and diminished vitality of the tissue in consequence of venous stasis from cardiac failure, embolism, or thrombosis, as suggested by Kockel,[5] may be responsible for the deposition in the affected region. A constitutional anomaly has also been assumed, but seems a less likely explanation.

The cartilages of the trachea or bronchi or small masses of bone arising by metaplasia of cartilage or connective tissue in any part of the respiratory tract[6] may be freed by ulceration and expelled. In the course of destructive pulmonary processes, such as ulcerative tuberculosis, abscess or gangrene, fragments of lung tissue, and in pneumonoconiosis fragments of lung impregnated with inhaled dust may be expectorated.

Adhesion of caseous, calcified or anthracotic bronchial glands to the

[1] Mitt. a. d. Grenzg. d. Med. u. Chir., 1904, Band xiii, p. 482.

[2] Ibid., p. 399.

[3] Les pierres du poumon, de la plèvre et des bronches et la pseudophthisie pulmonaire d'origine calculeuse, Thèse de Paris, 1891.

[4] Clin. méd., 1837, T. ii, p. 109.

[5] Deut. Arch. f. klin. Med., Band lxiv, p. 332.

[6] See Pollak, Virchow's Arch., Band clxv, p. 168; Sippel, Ueber Knochenbildung in Bronchiektasen, Frankfurter Zeit. f. Path., 1910–11, 6.

bronchi may be followed by ulceration and perforation of the intervening wall. Among 6132 autopsies, Sternberg[1] noted the perforation of softened bronchial glands in 19 cases into the bronchus (14 into the right and 5 into the left bronchus) and esophagus, in 1 into the left bronchus and the aorta, in 3 into the bronchi (in one with coincident perforation of a second gland into the esophagus), in 1 into the trachea and esophagus, and in 3 into the trachea alone.

In 1902 Schaldemose[2] collected 19 cases and added 1 of his own in which caseous glands had perforated into the air passages. A number of cases have since been reported. Children are principally concerned. Various consequences may follow. The gland may be spontaneously expelled, with complete recovery, as in Jundell's[3] unusual case, partially extruded with incomplete or total occlusion of the bronchus or impacted in the trachea or glottis, causing sudden death by suffocation. The inhalation of infected material may lead to local or widespread pulmonary tuberculosis or putrid bronchitis, bronchopneumonia, and pulmonary gangrene.

Expectorated calcareous masses are more common in adults than in children, and may vary from a single one to several hundred. Boerhaave[4] states that Sebastianus Vaillantius, a famous botanist, expectorated 400 stones before his death. In Stern's[5] case twenty were expectorated at one time. They vary in size usually from that of a pin's head to a pea, are grayish or yellowish white in color, soft and friable or of stony hardness, and of an irregular shape, with a rough, uneven, or coral-like surface. At times they are of very foul odor. On section they present a lamellated or homogeneous structure. After decalcification in nitric acid, hardening in alcohol, and imbedding in paraffin, stained sections usually show only a structureless, homogeneous mass of detritus. In cases reported by Stern[6] and Bürgi,[7] tubercle bacilli were demonstrated in the masses. Chemical analysis usually shows calcium phosphate and carbonate as principal constituents, with also at times traces of magnesia. In Gerhartz and Strigel's[8] case the composition was calculated to be 61.29 per cent. $Ca(PO_4)_2$, 23.42 per cent. $CaCO_3$, and 5.96 per cent. $MgCO_3$, with 9.33 per cent. nitrogen containing organic substance.

Symptoms and Signs.—The symptoms are usually those of chronic pulmonary tuberculosis or suppuration, in the course of which a small caseous or calcified mass or a fragment of pulmonary tissue is expelled without significant manifestations, and first discovered by chance

[1] Ueber die Erwiechung bronchialer Lymphdrüsen und ihre Folgen., Verhandl. d. deutschen path. Gesellsch., 1904–05, 7–9.

[2] Hospitalstidende, 4 Räkke, Band x, p. 562.

[3] Spontane Perforation einer tuberkülosen Bronchialdrüse in die Luftwege, spontane Expektoration derselben, Genesung, Jahrbuch f. Kinderheilk., 1904, lx, 76.

[4] Praelectiones Academicæ, Editit A. Haller, T. vi, Gottingæ, mdccxliv, p. 121.

[5] Deut. med. Woch., 1904, No. 39, p. 1414.

[6] Loc. cit., first case.

[7] Ibid., 1906, i, 32, second case.

[8] Beiträge z. Klinik d. Tub., 1908, 10.

during an examination of the sputum. Larger masses may be felt to pass through the glottis. In rare instances the presence in or

FIG. 7

Specimens of calcareous concretions expectorated by Poulalion's patient No. 32. × 4.

passage through the air passages of a calcified mass causes striking and characteristic symptoms, to which the term "bronchial colic" or "stone asthma" has been applied.

During the attack the patient may complain of a feeling of weight, pressure, burning or cutting pain referred to the lower sternal region or other part of the chest, with spasmodic and severe cough and dyspnea. Fever may accompany and follow the attack. One or more stones may be expelled during the paroxysm, which may last for a variable period, in one of Poulalion's[1] cases for nearly forty-eight hours. Small amounts of blood may appear in the sputum, and the stone when expectorated may be blood-stained. In Cazeau's[2] case an accompanying hemoptysis was fatal. Ordinarily the expectoration of the stone exerts no important influence on the course of the underlying disease. At times, however, more abundant sputum may follow, or attacks of cough and expectoration cease, the patient remaining thereafter well, or an interval of comparative health is followed by recurrence of symptoms and more stones.

The perforation of bronchial glands into the bronchi is accompanied by paroxysmal cough, dyspnea, sense of suffocation, and cyanosis and such other symptoms as occur with aspirated foreign bodies. Actual pain is infrequent. Impaction in the glottis or trachea is followed by death from suffocation, as in the cases described by Löhler,[3] who found twenty similar instances in the literature.

The physical signs are those of the underlying condition, to which, if a bronchus is partially or completely occluded, such features as have been described for aspirated foreign bodies may be added.

Diagnosis.—The clinical features may be sufficient to determine the presence of a foreign body in the air passages, but it is seldom possible to establish its nature and origin unless there is a history of previous and similar disturbance. Calcified lung and bronchial stones may appear as shadows on the *x*-ray plate, but it is difficult to identify them by this means as a cause of existing symptoms. The expectoration of calcareous masses from in or about the teeth, the crypts of the tonsil, the ventricles of the larynx or the nose must be excluded. A bronchial gland may be suspected in children if an aspirated foreign body can be ruled out. The diagnosis of a bronchial gland as the cause of the symptoms has usually been first made at autopsy, but in the cases described by Peterson,[4] Fronz,[5] Nachod[6] and Schaldemose[7] it was established during life by removal of portions of the gland by tracheotomy, and in Jundell's[8] case by spontaneous expulsion of the mass. A sudden suffocative attack from partial occlusion of the trachea by a gland is not unlike an attack of thymic asthma, and the mode of death from this cause may resemble thymus death.

[1] Loc. cit., p. 185.
[2] Hémoptysie foudroyante d'origine calculeuse, Bull. de la Soc. anat. de Paris, 1837, T. ix, p. 100.
[3] Münch. med. Woch., 1904, li, 1205.
[4] Deut. med. Woch., 1885, p. 145.
[5] Two cases, Jahrb. f. Kinderh., 1897, N. F., Bd. xliv, p. 1.
[6] Prag. med. Woch., 1897, p. 393.
[7] Hospitalstidende, 4 Räkke, Band x, p. 562.
[8] Loc. cit.

Prognosis.—For lung and bronchial stones which are expelled the prognosis is that of the underlying disease, which is tuberculous in a majority of the cases, and of which the foreign body may be regarded as a symptom. Inasmuch as disintegration of tissue is ordinarily a necessary forerunner of dislodgement of the stone, its appearance in the air passages may be regarded as an indication of an active disease. Traumatic and inflammatory lesions may follow the expulsion, thus adding to the unfavorable aspect of the situation. In some cases, however, all symptoms subside after expectoration of a stone The outlook is not favorable with perforation of bronchial glands into the air passages. Much depends on successful treatment. Fronz's 2 cases died in spite of tracheotomy, but successful removal by this means in Peterson's, Nachod's, and Schaldemose's cases and spontaneous expulsion in Jundell's were followed by recovery in spite of the presence of tubercle bacilli in the masses in two of the four.

Treatment.—In most cases this must be limited to measures against the underlying disease. The encapsulation of and deposition of lime salts in tuberculous tissue is favorable in so far as it makes the local infection obsolete and innocuous. In many cases mild tuberculous invasion is cured in this way, and it has even been suggested that an attempt should be made to hasten the calcification by the administration of calcium salts. The dislodgement and expulsion of calcified areas are so infrequent as to make the dangers incident thereto a minor consideration against such a course if it could be successfully carried out. Thus far greater reliance seems justly placed on hygienic-dietetic measures. Active treatment against foreign bodies arising from within the individual is required only in cases in which they give rise to troublesome symptoms, and is most urgent when the air passages are obstructed. Under these circumstances, bronchoscopy with or without tracheotomy is most likely to prove successful, following the indications already mentioned in the preceding section.

CHAPTER II.

BRONCHIAL ASTHMA.

Among the older writers, many affections with paroxysmal dyspnea were classed as asthma. The existence of asthma as an independent disease was denied by some and upheld by others. Thus Rostan, Beau, Louis, and others looked upon asthma as dependent on bronchial catarrh or emphysema. Willis suggested a connection with spasmodic constriction of the bronchi, but did not differentiate bronchial and cardiac asthma. Laënnec connected asthma with "catarrhe sec" and other forms of bronchitis. He acknowledged the possibility of a tonic spasm of the bronchial muscles, and believed that the majority of asthmatic attacks were principally due to an alteration of nervous influence. His belief would thus accord well with the present view of asthma. Romberg and Bergson especially emphasized the idiopathic nature of the disease. The existence of an independent affection, unconnected with obvious disease of the heart, the lungs, or other organs is now generally accepted, and principal interest centres in the explanation of the paroxysms.

The disease is characterized clinically by paroxysmal attacks of dyspnea affecting both phases of respiration, but especially expiration. The attack is followed by cough and the expulsion of a tenacious, viscid sputum. During the attack the lungs are distended and the diaphragm is low. Repeated attacks are likely to lead to chronic bronchitis and emphysema.

Theories of Asthma.—As yet the cause of the disease is unknown. The various theories may be grouped under (1) spasm of the bronchial muscles, (2) swelling of the bronchial mucous membrane, (3) spasm of the diaphragm, (4) the nervous system as a factor, and (5) bronchial asthma as a phenomenon of anaphylaxis.

1. **Spasm of the Bronchial Muscles.**—The character of asthmatic dyspnea suggests an obstruction to respiration. The apparent freedom of the upper respiratory tract and the lungs, the character of the rales, and the caliber of the Curschmann spirals suggest that this obstruction is in the finer divisions of the bronchi.[1] The general distribution of the rales throughout the lungs indicates a general rather than a local bronchial involvement. The suddenness of onset and cessation of asthmatic paroxysms may be regarded as an argument in favor of a

[1] Riehl's (Münch. med. Woch., 1906, p. 2240, Nos. 46 and 47, p. 2302) cases are exceptions. In the sputum of each of four patients were "giant" spirals from 6 to 24 cm. long and 3 to 3.5 cm. wide.

spasm of the bronchial muscles, which, on theoretical grounds, would explain the paroxysms.

This theory has been supported, among others, by Trousseau,[1] Romberg,[2] Bergson,[3] Salter,[4] and especially by Biermer,[5] who argued strongly in its favor and showed that it would account for the symptoms of the disease.

A spasm of the bronchial muscles would obstruct both inspiration and expiration. It would account for the greater hindrance to expiration and the overdistention of the lungs. Owing to the greater force of the inspiratory muscles, the resistance to inflation is more readily overcome than that offered to deflation. Expiration, moreover, is accomplished at a greater mechanical disadvantage, for in consequence of insufficient deflation the alveoli become overdistended and the already constricted bronchioles are still further compressed by an increased intrathoracic pressure. The sibilant and sonorous rales are then due to the obstruction offered to the entrance and exit of air.

The structure of the bronchial muscles is not at variance with such an hypothesis. Aufrecht[6] found that the unstriped musculature of the finer bronchi of man contains a thick, strong layer of circular muscle fibers and a much weaker layer of longitudinal muscle fibers. Both are intimately interwoven. The normal function of these muscles is unknown, but it was suggested by Biermer that they are antagonists of the inspiratory muscles. They may perform a protective function, preventing too forcible inspiratory inflation and the entrance of foreign bodies or irritating substances into the lungs. It is also possible that they play a part in forced expiration and expectoration.

Some confirmation of the bronchial spasm theory of asthma is found in the results of experimental work. Williams[7] first showed that the lungs could be made to contract by passing a current of electricity through them. Of the various experiments since performed to determine the innervation of the bronchial muscles, those of Einthoven[8] and Beer[9] are noteworthy. The researches of Dixon and Brodie[10] are of special interest. From their experiments it is shown that the bronchial muscles are innervated by the vagus nerve, which contains both bronchoconstrictor and bronchodilator fibers. The sympathetic nerve has no demonstrable effect on the bronchial muscles. By electrical stimulation of the vagus they were able to demonstrate a diminution in the amount of air entering and leaving a lobe of the lung.

The clinical observation of a relation between affections of the nose and bronchial asthma received support by their experiments, since

[1] Clinique médicale, 2 ed., ii, p. 460.
[2] Lehrb. d. Nervenkrankh., Berlin, 1855, 3 Aufl.
[3] Das krampfhafte Asthma der Erwachsenen, Nordhausen, 1850.
[4] On Asthma, London, 1850.
[5] Volkmann's Samml. klin. Vorträge, 1870, No. 3.
[6] Deut. Arch. f. klin. Med., 1900, lxvii, 586.
[7] British Assoc. Reports, 1840, p. 411.
[8] Pflüger's Archiv, 1892, li, 367.
[9] Arch. f. Anat. u. Physiologie, 1892, Suppl., p. 101.
[10] Trans. Path. Soc., London, 1903, vol. liv.

electrical, mechanical, or chemical stimulation of the nasal mucous membrane also diminished the amount of air entering the lung. Stimulation of the upper and posterior part of the nasal septum was most effective. Section of the vagus entirely abolished the result, and was followed by relaxation of the reflex constriction.

It cannot be said that the experimental data substantiate the muscle spasm theory of asthma. It does show, however, that spasm of the bronchial muscles, caused either by direct stimulation of the vagus or reflexly through the nasal mucous membrane, is capable of causing an obstruction to the inflation and deflation of the lung. If, as Strümpell[1] suggests, hypertrophy of these muscles could be shown at autopsy in cases with asthma, it would lend support to the view of their implication as a cause of the paroxysms. Thus far this has not been demonstrated.

Certain drugs influence the bronchial muscles. The bearing of such data on the muscle-spasm theory is not easy to interpret. Thus "muscarin, pilocarpin, physostigmin, and digitalin produce marked constriction by peripheral stimulation of the vagal endings. Gold salts, barium salts, and veratrin produce constriction by a direct action on the muscle fibers. Atropin, hyoscyamin, and hyoscin paralyze the vagal endings and thus lead to dilatation if constriction is present." A perfectly typical attack of asthma can be produced in an animal by giving it a small dose of muscarin. There is dyspnea, distention of the lungs, and with only small doses no excessive secretion in the bronchi and bronchioles. The attack thus produced can be instantly cut short by an injection of atropin. Lobelia produces a transitory relaxation in an animal in which bronchial constriction has been produced by pilocarpin. Morphin also tends to produce relaxation. Chloroform and ether paralyze the nerve endings and produce relaxation. (Brodie and Dixon.) Januschke and Pollak[2] observed a widening of the bronchial lumen under the influence of adrenalin. The favorable effects of atropin, adrenalin, lobelia, morphin, chloroform, and ether in releasing an artificially produced bronchial constriction and their favorable effect in asthma in man suggest a similarity between the two conditions.

While spasm of the bronchial muscles as a cause of asthma has much in its support, it does not alone satisfactorily explain the practically constant presence of bronchial secretion unless it be assumed that this also is due to the bronchial spasm. It is difficult to understand how this can be the case.

2. **Swelling of the Bronchial Mucous Membrane.**—The assumption that the bronchial obstruction is due to swelling of the mucous membrane rather than to spasm of the bronchial muscles would as satisfactorily account for the symptoms of asthma. It would cause dyspnea and, for reasons similar to those mentioned under Bronchial

[1] Med. Klinik, Berlin, 1908, iv, 6–10.
[2] Arch. f. exp. Path. u. Pharmakol., Band lxvi.

Spasm, would lead to distention of the lungs and low position of the diaphragm. An obstruction alone would account for the rales, but an affection of the mucous membrane more satisfactorily explains the presence of secretion. The nature of such a cause of asthma has been the subject of much speculation.

Traube[1] regarded a catarrhus acutissimus of the finer bronchi as the cause, supporting this belief by its frequent onset with coryza. Some clinical confirmation of this is offered by Störk's[2] observation of strong congestion of the larynx and the air passages even to the bronchi during an attack. In explanation of the swelling of the mucous membrane, Weber[3] suggested a nervous vasomotor widening of the bloodvessels in the lower air passages, similar to a sudden and transient swelling of the nasal mucous membrane, so frequently observed.

The peculiar character of the sputum in asthma was first recognized by v. Leyden,[4] who regarded the elongated, octohedral crystals, which he discovered, as a cause of reflex bronchial spasm, a view which Curschmann contested on the ground that asthmatic attacks occur without crystals, and in cases of asthma in which crystals are found their number and development are not always in relation to the intensity and duration of the attacks.

Bronchiolitis Exudativa.—Curschmann[5] describes an independent disease of the bronchioles, bronchiolitis exudativa, with a distinctive clinical picture, as a frequent cause of asthma. The disease is almost always chronic, seldom subacute. Intervals of freedom or periods of severe bronchitis alternate with isolated and transient or recurring and protracted attacks of asthma. Chronic catarrh and emphysema are frequent complications. The onset of the asthmatic attacks is less sudden than in essential asthma, but is preceded by a period of dyspnea lasting for a variable length of time. In the intervals of freedom there may be a slight cough, with scanty sputum, but such symptoms are usually due to complications. The sputum is diagnostic—whitish gray, transparent, very tough, and of the consistency of white of egg. The amount varies from a few teaspoonfuls to a half-liter in twenty-four hours. Among the small flakes or masses in suspension are the peculiar "spirals" within which Charcot-Leyden crystals are found. The spirals bear a direct relation in number to the frequency and intensity of the asthmatic attacks. They are expectorated in especially large numbers after the cessation of the attack. To them may be attributed the obstacle to the entrance into and exit of air from the lungs. But the sudden onset and cessation of asth-

[1] Ges. Beitr. z. Path. u. Physiol., ii, 981; iii, 360–617.

[2] Mittheilungen über Asthmabronchiale, etc., Stuttgart, 1875.

[3] Tagebl. d. 45 Natur-forsch. Versamml. zu Leipzig, 1872, p. 159.

[4] Zur Kenntniss des Asthmabronchiale, Vorträg auf d. Rostocker Naturforsch. Versamml., 1871, Tagebl., p. 24, u. Virchow's Arch., Band liv, u. Deut. militärärztl. Zeit., 1886, Heft 11.

[5] Ueber Bronchiolitis exudativa u. ihr. Verhältniss zum Asthma nervosum, Deut. Arch. f. klin. Med., Band xxxii, p. 1–34.

matic dyspnea can hardly be ascribed to the spirals, and in explanation of this a spasm of the bronchial muscles must be assumed, as an accessory factor, and probably in consequence of the respiratory efforts. The presence of spirals indicates bronchiolitis exudativa, and their presence is exceptional without asthmatic attacks. If the extent of the process is slight and the patient insensitive, asthmatic attacks may be absent. In susceptible individuals, with an extensive process, asthmatic paroxysms of the greatest severity are most certain to occur.

The observations of v. Leyden and Curschmann have served to emphasize an important feature of asthma, viz., the almost constant occurrence of a peculiar and almost distinctive expectoration. Though Curschmann's spirals may contribute to the dyspnea, from the mechanical obstruction which they offer to respiration, they cannot be regarded as bearing an etiologic relation with the disease. They are probably secondary, and arise from mechanical conditions in the bronchioles.

3. **Spasm of the Diaphragm.**—Wintrich[1] and Bamberger,[2] among others, regarded a tonic spasm of the diaphragm as the cause of asthma. This would explain the inflation of the lungs and the low position of the diaphragm, but it does not account for the prolonged expiration, the bronchial rales, and the presence of a peculiar sputum.

4. **The Nervous System as a Factor.**—The subjects of asthma often present what for want of a better term has been spoken of as a neuropathic constitution. In some instances a consideration of the family history and attendant manifestations has suggested a special predisposition to nervous instability, and it has been assumed that in such individuals causes so slight as to be otherwise ineffective are capable of giving rise to asthmatic attacks. Thus irritation of the nasal mucous membrane or such psychic factors as fright or emotion may start an attack. In estimating the importance of the nervous system it should be remembered that the so-called neuropathic constitution may as well be regarded a consequence as a cause of asthma.

5. **Bronchial Asthma as a Phenomenon of Anaphylaxis.**—The clinical features of bronchial asthma closely resemble hypersusceptibility or anaphylaxis experimentally produced in animals by the injection of small doses of alien proteid, as noted by Meltzer.[3] If, for example, a guinea-pig be injected subcutaneously or intraperitoneally with a small dose of horse serum, and again be given 1 c.c. of the same serum after an interval of at least twelve to fourteen days, the animal dies within a few minutes with symptoms of respiratory failure. The lungs become greatly distended and so remain even after removal from the body after death of the animal. This pulmonary inflation has been shown by Auer and Lewis to be due to bronchostenosis of peripheral

[1] Virchow's Pathologie, 1854, vol. v.
[2] Würzb. med. Zeitsch., 1865, Bd. vi.
[3] Trans. Assoc. Amer. Phys., 1910, xxv, 66.

origin, which probably arises in consequence of tonic contraction of the bronchial muscles, and can be prevented and the life of the animal saved by a previous injection of atropin. At present this seems the most likely explanation of bronchial asthma. Patients with this disease may have become sensitized to some form of protein by absorption from the alimentary canal into the circulation, and react with an attack of asthma as a manifestation of subsequent absorption of an intoxicating dose of the same substance. An individual sensitized in some way to pollen dust or the emanations from certain animals has an anaphylactic reaction when reëxposed to the specific substance to which he is sensitized. The fact that hypersusceptibility to foreign proteid may be transmitted from mother to offspring in animals is a further point of resemblance, as the disposition to asthma may be inherited or acquired. The influence of atropin in the prevention of the anaphylactic attack in animals and its effect in relieving bronchial asthma may also be mentioned.

Koessler[1] has reported 3 cases in which attacks of bronchial asthma could be traced to hen's eggs. Talbot[2] has reported six similar cases.

Conclusions.—Of the different theories, that which assumes a spasm of the diaphragm may be set aside as unlikely. A disturbance in the bronchial mucous membrane accompanied by swelling and hypersecretion would account for the symptoms of the disease. A coincident spasm of the bronchial muscles cannot be excluded. The intimate association of the mucous membrane and the bronchial muscles and their common nerve supply suggest that both may participate as the immediate cause of the paroxysm.

Granted, however, that the immediate cause lies in the bronchial mucous membrane or the bronchial muscles or both, some underlying and principal factor must still be assumed to exist in explanation of the disturbance. Whether this is in or outside the individual it is impossible to say, but it may be conjectured that both external and internal influences play a part in the disease. The external causes apparently capable of initiating a paroxysm in susceptible persons are so variable as naturally to suggest that an important determining factor lies within the individual himself. There is no evidence in favor of a "neurosis" as the cause. Meltzer's theory that asthma is an anaphylactic phenomenon, *i. e.*, that asthmatics are individuals who are "sensitized" to a specific substance and the attack sets in whenever they are "intoxicated" by that substance seems the most plausible explanation.

Etiology.—This is unknown. Many of the predisposing and exciting factors commonly enumerated can be established in so small a proportion of cases as to make their actual importance doubtful.

Predisposing Factors.—*Heredity.*—This appears to bear some relation to the disease. Thus Salter[3] observed an inherited disposition

[1] Illinois Med. Jour., January, 1913.
[2] Bost. Med. and Surg. Jour., November 5, 1914.
[3] On Asthma, London, 1850.

to the disease in 14 of 35 cases. Berkart[1] noted it in 16 per cent. Asthma may have existed in the parents or show itself in the patient's brothers or sisters. Migraine, neurasthenia, hysteria, epilepsy or gout may occur in the family history. *Age:* No age is exempt. It is not infrequent in young children and may be seen in infancy. Of Salter's 225 cases, in 31 per cent. the asthma began before the age of ten. More than a third of Berkart's cases were under ten years of age. Of 105 patients in Sokolowski's[2] series, 65 were forty or under. *Sex:* Males appear to be more frequently affected; 67 of Sokolowski's cases were males.

The Nose and Asthma.—Voltolini[3] was the first to call attention to the relation between diseases of the nose and asthma. He obtained relief of asthma by the removal of nasal polypi. Confirmatory observations have been made, among others by Hänisch,[4] Schäffer,[5] Porter,[6] Daly,[7] B. Fränkel,[8] Hach,[9] Schmiegelow,[10] and Heyman.[11] The proportion of cases of asthma with nasal disease may be gathered from the statistics of Francis,[12] who found mucous polypi in 36 marked obstructive lesions in 27, and the nasal passages apparently free in 379 of 442 cases of asthma. When the frequency of such nasal lesions in patients at large is considered this is not a very striking proportion. On the other hand, patients with nasal disease only occasionally have asthma. In Schmiegelow's[13] 139 cases with nasal polypi, 31 had asthma, and of 514 patients with chronic rhinitis, 40 had asthma. The proportion was even smaller in Böcker's[14] series. Of 310 cases of nasal polypi only 9 had asthma. It is sufficiently obvious, therefore, that asthma is not always due to nasal disease and that nasal disease is more often unaccompanied by asthma than the contrary. The relation of nasal disease to asthma, however, cannot be thus lightly dismissed. To be sure the results of treatment of the nose in asthmatics with nasal disease is often unsuccessful in relieving the asthma. Thus Sokolowski, after various operations in more than 20 patients, obtained a favorable and permanent result in only 1, an improvement for two months in a second, and negative results in the remaining cases. But even an occasional success justifies the belief in a possible relation between nasal disease and asthma, at least in certain individuals whose nasal mucous membrane may be especially sensitive, or in whom the nasal lesions are so situated as to implicate a particular region in the nose. Brodie and Dixon's finding that stimulation of the upper and posterior

[1] On Bronchial Asthma, its Pathology and Treatment, London, 1889, 2d ed., pp. 81 to 89.
[2] Klinik der Brustkrankheiten, 1906, 1.
[3] Anwendung der Galvanokaustik im Innern des Kehlkopfes, 1872, 2 Aufl.
[4] Berlin klin. Woch., 1874.
[5] Deut. med. Woch., 1879.
[6] New York Med. Record, 1879.
[7] Trans. Amer. Laryng. Assoc., 1881.
[8] Berlin klin. Woch., 1881.
[9] Wein. med. Woch., 1882–83.
[10] Stagerng's "Forlag," Copenhagen, 1889.
[11] Deut. med. Woch., 1886.
[12] Asthma in Relation to the Nose, London, 1903.
[13] Asthma Considered Specially in Relation to Nasal Disease, London.
[14] Deut. med. Woch., 1886, Nos. 26 and 27.

part of the nasal septum caused a reflex contraction of the bronchial muscles in animals should not be forgotten. Francis claims to have cured over 300 cases of asthma by cauterizing the nasal septum. He regards that part of the septum which lies opposite and immediately above the anterior third of the middle turbinate body as the most satisfactory spot to cauterize.

Some relation has been thought to exist between asthma and such diseases as rickets, scrofulosis, hysteria, neurasthenia, gout, urticaria, and psoriasis. It is believed to be more common among the well-to-do. No constant relation has been established between renal or pulmonary disease and asthma. It is said, however, that asthmatics rarely become tuberculous and that tuberculous patients seldom suffer from asthma. An explanation of the paroxysms has been sought in a reflex from such organs as the stomach, intestines, ear, teeth, skin and genitals, but without much justification.

Exciting Causes.—Much variation is noted in different patients in respect to the influence of the season, but in general the disease is more prevalent from spring to autumn. No definite and constant influence can be ascribed to geographic factors. In some patients, attacks may be induced or aggravated by residence in a dry climate. Others seem equally susceptible to moist regions. Some are subject to asthma in the city, other in the country, or in special localities only. Of the many and various exciting causes, among others may be mentioned such psychic influences as excitement, fright, anxiety, and even autosuggestion from "the fragrance of an artificial rose." An almost indefinite number of causes capable of exciting an attack in susceptible individuals might be mentioned. Exposure to pollen dust coal dust, or wood dust, to ipecacuanha, resin, coffee, or sulphur, the odor of freshly mowed fields, of violets or roses, even the emanations from animals (horse, dog, or cat) or from certain persons may be sufficient to induce a paroxysm. Attacks have been noted when the wind shifts to a certain quarter. They may occur only during pregnancy or at the menopause.

Pathology.—The opportunity to make postmortem examinations on patients who have died during an attack of asthma is seldom offered. Cases have been reported by von Leyden[1], Berkart,[2] Schmidt,[3] Fränkel,[4] Jezierski,[5] and by Ellis,[6] who has reviewed the literature. The pathologic picture is not uniform or characteristic of asthma. Redness of the bronchial mucosa, dilatation of the bronchi, and pulmonary emphysema are common. The medium and smaller bronchi are likely to be wholly or partially occluded by an exudate of mucus, which may contain a granular or apparently fibrinous material, and intact

[1] Deut. militärärztl. Zeit., 1886, Heft 2.
[2] On Bronchial Asthma, 1889, 2d ed.
[3] Zeit. f. klin. Med., 1892, Bd. xx, p. 476.
[4] Ibid., 1898, Bd. xxxv, p. 559, and Deut. med. Woch., 1900, No. 17, p. 269.
[5] Deut. Arch. f. klin. Med., 1905, Bd. lxxxv, p. 342.
[6] Amer. Jour. Med. Sci., September, 1908.

or degenerated epithelium. Partly wound threads or spirals may also be observed. Polynuclear leukocytes, round, oval, or spindle cells, with or without eosinophiles and Charcot-Leyden crystals, may also be present. The epithelium of the bronchial mucosa may be intact or desquamated. The bronchial wall itself may be unchanged. It may show hyperemia or even small hemorrhages, or thickening and infiltration with round cells. Eosinophiles may be present. Charcot-Leyden crystals have been found in the bronchial wall. The elastic tissue may be increased. The pulmonary alveoli may appear normal, dilated, or atelectatic. Eosinophile cells were noted in the alveoli of Ellis' case.

Symptoms.—The asthmatic attack may be preceded by very variable premonitory symptoms. These may be catarrhal and such as accompany a cold, chilliness, coryza, conjunctival injection, lacrimation, nasal occlusion, sneezing, and laryngeal irritation, which gives rise to cough. In other cases the patient is warned of an approaching paroxysm by substernal oppression or an indefinable general feeling of malaise. Some patients are depressed; others experience a feeling of special well-being just before the attack. There may be epigastric discomfort or flatus. The passage of a large amount of urine may usher in an attack. In children the attacks are specially likely to be preceded by bronchitis and initiated by catarrhal symptoms. In a considerable proportion of the cases the paroxysm occurs without previous warning.

The Attack.—The onset is almost always sudden. It may come on at any time, but is most likely to occur at night, after a few hours of sleep. The frequent nocturnal onset is difficult to explain. It may be due to the influence on a hypersensitive respiratory mucous membrane of secretion accumulated during sleep. The patient is aroused by a distressing sense of oppression and want of breath, which rapidly increases to extreme dyspnea. There is a short, dry cough, at first without expectoration. As the intensity of the paroxysm increases the patient may become greatly alarmed for fear of suffocation. He sits up or leaves the bed and seeks, very likely in vain, to assume a more favorable position, sitting, half supported by his arms, upright with his hands beside him, bent forward with his elbows on his knees or the arms of a chair or backward with arms outstretched. He may rush to the open window. The face may be pale, its expression anxious and speech difficult or impossible. In spite of the most strenuous inspiratory efforts, in which all the accessory respiratory muscles are brought into play, very little air enters or leaves the lungs. The expiration is prolonged. In severe attacks, both phases of respiration, especially expiration, may be accompanied by loud wheezing, audible even at a distance from the patient. With the continuance of the attack signs of defective aëration are manifest. The patient becomes cyanotic, a cold sweat breaks out, especially on the face, and the extremities are cold and clammy.

The paroxysm may last from a few minutes to several hours. Improvement is likely to be gradual. During the course of the attack the cough increases and the expectoration of tenacious mucus becomes easier and more abundant. The patient, exhausted by his efforts, may fall asleep, perhaps to be again interrupted on the same or another night.

Physical Signs.—During the attack, owing to the excessive respiratory efforts and deficient expiration, the amount of residual air in the thorax is increased and the lungs abnormally inflated. On *inspection* the distended thorax and the lack of thoracic motion, even with the most strenuous respiratory efforts, are striking features. The breathing is costal in type. The diaphragm is low and its excursion, as indicated by the diaphragm shadow, is diminished or absent. The abdominal muscles actively participate in the expiratory effort and are firmly contracted. Inspiration is quick and shallow. Expiration is much prolonged. The rate of respiration is unchanged or diminished from the prolongation of expiration.

On *percussion* no abnormality may be noted in the character of the sound. If the patient has long been the subject of asthma it is likely to be hyperresonant. It may have a tympanitic quality—Biermer's "box tone." On percussing the pulmonary boundaries their lower limits are usually found to be abnormally low and their downward excursion with inspiration limited in extent. The pulmonary distention may diminish or even obliterate the superficial cardiac dulness. The hepatic dulness may be greatly depressed.

On *auscultation* the inspiration is weak, the expiration abnormally loud and long. Both inspiration and expiration may be inaudible from the presence of numerous sibilant and sonorous rales which are very variable in their character, high or low pitched, loud or soft, and long or short. Toward the end of the attack there may be numerous moist rales. The pulse may be elevated during the attack. The temperature is normal in the absence of complications.

Sputum.—There is usually no expectoration until toward the end of the attack. In uncomplicated cases the sputum is distinctive of bronchial asthma. It is often raised only with great effort, and consists of small, rounded, sago-like balls, mixed with a small amount of thin mucus. These small masses are more or less translucent, grayish white to yellowish green in color, and very tenacious. They are the so-called "perles" of Laennec. The expectoration usually continues for several days after the cessation of the paroxysm.

Curschmann Spirals.—Examination of the finer structure of the specimens is best conducted on a black background. Some of these pellets can be unfolded into elongated masses in which with the naked eye a twisted, cork-screw-like character can be demonstrated. They are the so-called "spirals." It is indeed surprising that such peculiar structures should have been overlooked until Curschmann's description in 1883.[1] They vary greatly in size, but are approximately from

[1] Deut. Arch. f. klin. Med., 1883, vol. xxxii.

0.5 to 1 mm. in diameter and 2 or more cm. long. Under the low power of the microscope they are seen to be composed of a variable number of coarse or fine threads loosely or tightly twisted into cork-screw-shaped structures, in some of which an interruption of the circular winding may give place to a bundle of straight or curved, divergent or convergent fibers. Within the substance of the spirals, higher powers of the microscope usually disclose large numbers of round cells, the majority of which from their coarse granulations or after appropriate staining can be recognized as eosinophiles, with spindle-shaped cells in smaller proportion. Within some of the spirals only a granular detritus is found. Charcot-Leyden crystals are almost constant.

Fig. 8

Curschmann's spirals. (Curschmann.)

The spirals often present a still more interesting and peculiar structure. There may often be found, within the centre and axially placed, a delicate, sharply outlined, extraordinarily clear and translucent filament, the "central thread." Under the low power of the microscope it appears single and homogeneous. With higher magnification it is usually found to be made up of the most delicate, closely twisted, separate filaments, which may, however, in places be partly unwound. In rare instances the central thread is apparently actually single and cannot thus be resolved into associated, individual filaments.

Much variation in the structure of the spirals is common. As well as typical spirals, with and without central threads, there may be isolated single filaments or central threads, about which only one or more delicate threads are spirally twisted. In some instances the spirals may be hollow and air-holding, cylindrical, or even nearly spherical in shape. In cases complicated with bronchitis and an abundant excretion, they may be readily overlooked unless the specimens

of sputum are carefully examined. Riehl[1] has made the unusual observation in four patients of "giant" spirals, ranging from 6 to 24 cm. long, and at times reaching a diameter of 3 to 3.5 cm. and without spirals of the ordinary size.

Curschmann's spirals are found with greater frequency and in larger numbers in the sputum of bronchial asthma than in other conditions, but they are not peculiar to asthma.[2]

The exact nature of the spiral filaments is uncertain. Fränkel[3] believes them in part to be elongated ciliated epithelium. The denser central threads are probably of the same nature as the encircling filaments. Spirals with central threads may be artificially made by spirally twisting mucus from the sputum of various pulmonary conditions. In explanation of their formation, Osler offers the suggestion that the course of the currents produced by the ciliated epithelium may be rotatory, and that this, in combination with spasm of the bronchial muscles, may twist the mucus formed in the tube into a spiral form.

Charcot-Leyden Crystals.—These were first described by Charcot and Robin[4] at autopsy in the blood, spleen, and liver of patients with leukemia. Since Charcot and Vulpian's[5] description they have usually been regarded as elongated octohedra. Von Leyden[6] first noted their almost constant presence in asthmatic sputum and demonstrated them in six of seven cases. Curschmann[7] found them constantly absent in only 4 of 38 cases. It may be necessary to let the sputum stand for a time to demonstrate them. Their presence may be indicated by a gritty resistance between cover-glass and slide. The crystals are present during the paroxysms, absent in the remissions. They are most abundant in and about the spirals, throughout the length of which they may be equally or unequally distributed, but at times demonstrable in the more fluid parts of the specimens. A later and more careful study of their shape by Th. Cohn[8] indicates that they are hexagonal rather than octahedral crystals, appearing as very delicate, elongated and sharply pointed, double pyramids. They are colorless, of a dull luster, and vary in size from those visible only with the highest magnification up to 0.075 mm. long and 0.04 mm. wide, with an apical angle of from 17 to 20 degrees.

[1] Münch. med. Woch., 1906, No. 46, p. 2240, and No. 47, p. 2302.

[2] Curschmann spirals have also been found in pneumonia by Vierordt (Berl. klin. Woch., 1883, No. 29), v. Jaksch (Centralb. f. klin. Med., 1883, No. 31, p. 417), Pel (Zeit. f. klin. Med., Bd. ix, pp. 29 to 52), Patella (Annali universali di medicina, 1884, vol. cclxvii), Curschmann (Deut. Arch. f. klin. Med., Bd. xxxvi, pp. 578 to 585) and Predtetschensky (Zeit. f. klin. Med., 1906, lix, 29). Kaufmann (Lehrbuch der spez. Path. Anat., 1907, Auf. 4, p. 204) repeatedly found them in the tough mucus behind bronchial stenosis due to anthracotic bronchial lymph nodes or primary and secondary tumors of the bronchial wall.

[3] Spez. Path. u. Ther. d. Lungenkrankheiten, 1904, p. 90.

[4] Comp.-rend. de la Soc. de Biol., 1853, p. 47.

[5] Gaz. hebd., 1860, vii, 47.

[6] Virchow's Arch., 1872, vol. liv.

[7] Deut. Arch. f. klin. Med., 1883, vol. xxxii.

[8] Ibid., 1895, vol. liv.

Owing to the difficulty of isolating the crystals from the medium in which they are found, their chemical properties are uncertain, but tested microchemically, Th. Cohn found them insoluble in cold water, ether, alcohol, xylol, chloroform, creosote, and iodin solution; soluble

FIG. 9

Charcot-Leyden crystals. (v. Leyden.)

in warm water, hydrochloric acid, nitric acid, sulphuric acid, phosphoric acid, acetic acid, oxalic acid, picric acid, and carbolic acid, potassium and sodium hydrate, and ammonia.

The crystals are not peculiar to asthma, but are present in a great variety of other conditions.[1]

[1] The crystals have been demonstrated after death in the blood and tissues of leukemic patients by Charcot and Robin (loc. cit.), Charcot and Vulpian (loc. cit.), Neumann (Arch. f. mik. Anat., 1866, Band ii, p. 507), Eberth (Virchow's Arch., 1868), Lauenstein (Deut. Arch. f. klin. Med., 1876, Band xviii, p. 120), Zenker (ibid., p. 125), and others; in blood from living patients with leukemia by Prus (Warschauer med. Zeit., "Medecyna," 1886, Nos. 39 and 40); in material obtained by puncture of the leukemic spleen by Westphal (Deut. Arch. f. klin. Med., 1890–91, 47); in ordinary bronchitis by Bizzozero (Handbuch der klinischen Mikroscopie, 1863, p. 215); in tuberculous sputum by Meissen (Berl. klin. Woch., 1883, No. 22); in the feces of patients with helminthiasis by Bäumler (Correspondenzbl. f. Schweizer Aerzte, 1881, No. 19); Nothnagel (Zeit. f. klin. Med., Band iii, p. 352), and Leichtenstern (Deut. med. Woch., 1892, No. 25); in normal bone marrow after death by Neumann (loc. cit.); in nasal polypi and cancer of the cervix uteri by B. Lewy (Zeit. f. klin. Med., 1900, 40); and the pus from pleural empyema by Eichhorst (Handbuch der spec. Path. u. Ther., 4 Aufl., i, p. 550).

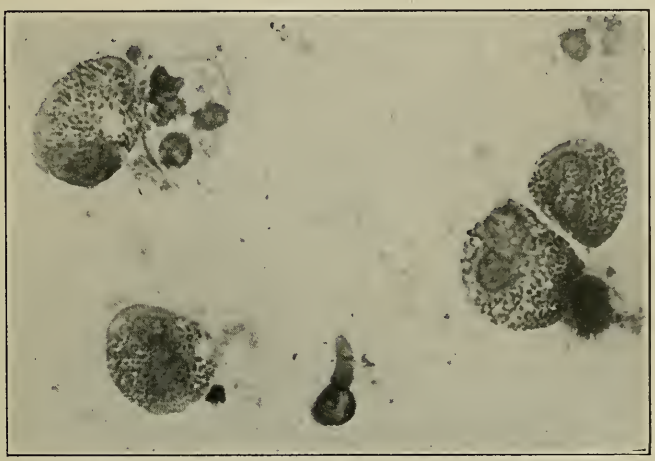
The identity of Böttcher's sperm-crystals and Lubarsch's testicular epithelium crystals with Charcot-Leyden crystals is doubted by Th. Cohn (loc. cit., and Centralb. f. allg. Path. u. path. Anat., 1899, Band x, p. 940).

Von Noorden (Zeit. f. klin. Med., 1892, Band xx, pp. 98–106) specially called attention to the presence within the leukocytes and alveolar epithelium of yellow and brown pigment, which he regarded from its microchemical reactions as hemosiderin and probably due to small hemorrhages.

The origin of the Charcot-Leyden crystals is unknown. The close association of eosinophiles and Charcot-Leyden crystals, in number and distribution, not only in the sputum of bronchial asthma but under other conditions, suggests a possible relation between them.

Von Leyden was disposed to regard the crystals as a cause of the asthmatic paroxysm, from irritation of the bronchial mucous membrane and the terminations of the vagus, with consequent reflex spasm of the bronchial muscles. It is more likely that they are secondary to degenerative processes in the sputum, a view which receives some confirmation from Ungar's[1] experimental formation of crystals in sputum preserved in a moist chamber.

FIG. 10



Asthma sputum. Four eosinophiles and one polynuclear leukocyte.

Eosinophiles.—The numerous large granular cells and intercellular granules noted by v. Leyden in the small masses of sputum from patients with asthma were probably eosinophiles and their fragments. The identity of such cells with the eosinophiles of the blood and their increase in asthmatic sputum were shown by Fr. Müller, Gollasch,[2] Fink,[3] and others. They may be found in small numbers in the sputum of patients with various pulmonary conditions. They are often very numerous in the sputum from cases of bronchial asthma, and may outnumber other cells in the specimens. In Fink's case they amounted to from 20 to 90 per cent. of the cells in the sputum; in Aronson and Philip's[4] case to nearly two-thirds. Both mononuclear and polynuclear types are found, but mononuclears are more common. They are most numerous in and about the spirals.

[1] Centralbl. f. klin. Med., 1880, No. 40.
[2] Fortschritte der Med., 1889, No. 7, p. 361.
[3] Beiträge z. Kenntniss des Eiters und des Sputums, Diss., Elberfeld, 1890.
[4] Deut. med. Woch., 1892, No. 3, p. 48.

An increase of eosinophiles in the bronchial secretion is usually associated with an eosinophilia also in the circulating blood. This is not constantly present, and when it occurs is usually confined to the period of the attack, as in the cases reported by Neusser,[1] Mandybur,[2] v. Noorden,[3] and Fink.[4] The differential counts often show from 10 to 20 per cent. eosinophiles. In Billing's case[5] they reached the unusual proportion of 53.6 per cent., in Herrick's[6] 72.5 per cent. Although the increase in eosinophiles is usually confined to the period of the attack and a short time after it, it may be persistent. In Zappert's case[7] there were 8.77 and 12.36 per cent. during intervals of freedom, and Wolff[8] observed a case for over a year, during six months of which the patient was free from asthmatic attacks, and yet the blood constantly showed about 10 per cent. of eosinophiles, without increase during the paroxysms.

It is uncertain whether the eosinophiles are formed locally in the bronchial tissue or in other organs and carried thence to the bronchi.

Course and Complications.—The severity of the attacks varies greatly. Their frequency likewise is subject to much variation in the same or in different patients. There may be a daily repetition of one or more attacks. Successive attacks over a period of days or weeks, in the intervals between which the patient coughs and is short of breath, are frequent. The paroxysms may occur singly, with long intervals of freedom. Recurrences may be limited to one season of the year or occur only after exposure to certain exciting causes already mentioned.

If the attacks are frequently repeated and severe, a cough and some shortness of breath is likely to persist between the paroxysms. The sputum, both during the attacks and in the intervals of freedom, gradually becomes more abundant, and changes from its more typical mucous character to mucopurulent and finally becomes purulent. The clinical features are now those of chronic bronchitis, to which bronchiectasis and emphysema may be added. As the pulmonary embarrassment increases, and usually after the disease has lasted for years, hypertrophy of the heart may be demonstrated. Signs of cardiac insufficiency finally ensue. Under the burden of such complications, the patient becomes more and more an invalid. Such severe cases are likely to be fatally interrupted by an acute bronchopneumonia or cardiac dilatation.

Diagnosis.—This is usually easily made. It may be sufficiently obvious from the history. The sudden onset of dyspnea affecting both phases of respiration, but especially expiration, the cough, the peculiar expectoration, the distended thorax, and the sibilant and sonorous

[1] Wiener klin. Woch., 1892, Nos. 3 and 4.
[2] Ibid., Nos. 7, 8, 9.
[3] Zeit. f. klin. Med., Bd. xx.
[4] Loc. cit.
[5] New York Med. Jour., May 22, 1897.
[6] Jour. Amer. Med. Assoc., December 2, 1911.
[7] Zeit. f. klin. Med., 1893, Bd. xxiii, p. 227.
[8] Beiträge z. path. Anat. u. allg. Path., 1900, vol. xxviii.

rales are typical features. An eosinophilia in the sputum and the systemic blood, if present, may confirm an otherwise doubtful diagnosis. Curschmann's spirals and Charcot-Leyden crystals are of less diagnostic value.

Attacks of paroxysmal dyspnea, like those in essential asthma, may develop in the course of chronic bronchitis and emphysema. They are not very uncommon in such cases, and are probably due to spasmodic contraction of the bronchial muscles from irritation of the bronchial mucosa.

Capillary bronchitis of sudden onset, with constant cough, extreme dyspnea, marked cyanosis, and sibilant and sonorous rales, may occur in infants and children and closely simulate asthma. An initial chill, if present, and fever may serve to differentiate this disease; but there are cases in which the diagnosis may remain in doubt, and asthma may be excluded only by the subsequent course and the absence of recurrent attacks.

First attacks of asthma must be differentiated also from paroxysms of dyspnea which arise in consequence of obstruction in the upper part of the respiratory tract. Such obstruction is most common in the larynx or trachea. It may be due to pressure from without, as by enlarged glands, mediastinal tumors, goitre, or aortic aneurysm; the lodgement of foreign bodies in the pharynx, larynx, or trachea; inflammatory swelling of the larynx, as in croupous or subglottic laryngitis; edematous laryngitis; spasmodic laryngitis (laryngitis stridulus, thymic asthma), and paralysis of the adductors. In all these conditions the dyspnea is predominantly inspiratory, while it is more markedly expiratory in bronchial asthma. Inspiration is also likely to be accompanied by stridor. Such an accentuation of the inspiratory phase is to be ascribed to the greater velocity with which the inspired air must pass through the obstruction. When the larynx is involved there is likely to be hoarseness or even aphonia. In consequence of the increased negative pressure within the thorax during the labored inspiration the epigastrium, the lower lateral thoracic regions, the intercostal spaces, the suprasternal notch, and the supraclavicular and infraclavicular fossæ are depressed; the trachea and with it the larynx are forced downward. The history, the attendant symptoms, the character of the breathing, the change in or loss of the voice, and the laryngoscopic picture will usually serve to differentiate these conditions from asthma. It may rarely happen that a subglottic polyp with a long pedicle or a piece of freely movable membrane may give rise to expiratory dyspnea, by partially occluding the glottis during expiration. Inspiration may then be relatively free, as the obstruction falls back against the tracheal wall during the inflow of air. The various types of dyspnea, arising as a consequence of hysteria or from disease of the medulla, are easily distinguished from asthma.

The sudden onset of dyspnea, embarrassing both phases of respiration, may occur as a symptom of cardiac disease and simulate true

asthma, the so-called *cardiac asthma*. Asthmatic paroxysms beginning in persons past middle life are more likely to be of cardiac origin than true bronchial asthma. Expiration is not likely to be predominantly involved, and other symptoms of cardiac insufficiency are usually present. Careful examination of the heart will usually determine the diagnosis. Renal insufficiency may give rise to a type of dyspnea known as *renal* or *uremic asthma*. Here too the respiratory disturbance may occur suddenly. Both inspiration and expiration are affected. Other symptoms are usually present, and examination of the heart, the urine, and the blood-pressure will establish the diagnosis.

Prognosis.—An asthmatic paroxysm of itself is practically never fatal. Predictions as to the outcome of the disease are very uncertain. In general those cases are most favorable in which a determining cause can be early detected and removed. The patient's willingness or ability to seek favorable conditions or places must also be considered. Youth is of favorable moment. A disease which begins in childhood may end in recovery at puberty. Long intervals of freedom between attacks of diminishing severity are hopeful. On the other hand the onset of the disease after forty or forty-five years is seldom followed by full recovery. A persistent bronchial catarrh between attacks is likewise unfavorable. With the advent of such complications as chronic bronchitis, bronchiectasis, emphysema, cardiac hypertrophy and dilatation the prognosis becomes more unfavorable.

Treatment.—There is no specific treatment. Further study of anaphylaxis in animals may lead to more successful therapy. In the majority of cases the disease appears to run its course, but little influenced by the numerous measures suggested for its relief. New methods apparently successful in isolated or small groups of cases have repeatedly found a place in the literature, only to be replaced by other and still newer measures. A drug which appears at one time to have afforded relief may utterly fail at the next trial in the same or another patient. The more distressing features of the paroxysms can often be alleviated. They may recur at longer intervals or even stop, but it is difficult to estimate the influence of treatment in so variable a disease. The treatment is most conveniently considered under the following headings:

1. **The Attack.**—An abundance of fresh air enables the patient to breathe more easily. An upright and sitting position, with the elbows supported on the arms of a chair, often assists him in his efforts to bring the accessory muscles of respiration into play.

Morphin is the most valuable remedy for an attack of asthma, but the possibility of inducing its habitual use must always be borne in mind. Isolated or successive attacks of great severity may justify its administration by the physician or the nurse under his direction, but it should never be left in the hands of the patient to prescribe for himself. The subcutaneous injection of morphin, gr. $\frac{1}{6}$ (0.010 gm.), gives the most immediate relief. It may, if necessary, be repeated in

two hours. Larger doses may be required. Atropin, gr. $\frac{1}{120}$ (0.00054 gm.), may well be combined with the morphin. Adrenalin chloride, 1 to 1000 solution, 0.5 to 1 c.c. given subcutaneously, acts well in some cases.

Heroin, gr. $\frac{1}{200}$ (0.00325 gm.), is sometimes an efficient substitute for morphin. Chloral hydrate, gr. 10 (0.650 gm.), repeated if necessary in an hour, may be successful, but should not be used in patients with weak heart because of its depressing effect on the circulation. Bromides may also be used. A spray of cocain hydrochlorate (5 per cent.) into the nasal passages and throat has been recommended. The cocain may also be applied by means of a cotton swab moistened in the solution, or a few drops allowed to fall into each nasal cavity from a medicine dropper. As with morphin, there is danger of inducing its habitual use, and its administration should only be considered in severe cases, and then only at infrequent intervals. Pilocarpin, gr. $\frac{1}{8}$ (0.008 gm.), has been found to be efficient at times.

In mild or recurring attacks, inhalations may be tried. Many asthma powders, cigarettes, and medicated papers are on the market. They usually contain the leaves of some plant belonging to the family Solanaceæ, to which potassium nitrate is added to increase their combustion. Stramonium and belladonna leaves are most commonly used. A small amount of powdered stramonium leaves and potassium nitrate, of each equal parts, may be placed on a metal plate, ignited, and the fumes inhaled. Graves' often quoted experience illustrates the varying susceptibility of patients. Of two asthmatics visited on one day the first ascribed his attack, the second his relief, to a smoking chimney. It is unwise to prescribe preparations the composition of which is unknown. Opium or Indian hemp enters into the composition of some of them. The composition of some of the more popular mixtures is said to be as follows:

"Poudre Cléry" contains powdered opium (3.0), powdered belladonna, and stramonium leaves (āā 45.0), saturated with a solution of potassium nitrate (7.0) and distilled water (20.0).

Fischer's Antiasthmatic Powder consists of stramonium leaves (250.0), sweet clover flowers (25.0), potassium nitrate (50.0), and distilled water (250.0).

Schiffmann's Asthma Powder is made up of potassium nitrate, stramonium leaves, and the root of skunk cabbage.

Reichenhaller Powder contains stramonium, potassium nitrate, benzoin, the leaves of Grindelia robusta, and eucalyptus.

Espic's Cigarettes contain belladonna leaves (60.0), hyoscyamus, and stramonium leaves (āā 30.0), phellandrium seeds (10.0), extract of opium (3.0), and cherry-laurel water a sufficient amount (about two volumes). The leaves and seeds are macerated for twelve hours and expressed, the extract of opium then dissolved, bibulous paper next moistened with the liquid and well dried, in order that cigarettes may be made. A small amount of nitre is added to the infusion to makes the cigarettes burn freely.

"Carton Fumigatoire," of the French Codex, contains nitre combined with powdered belladonna, stramonium, digitalis, and lobelia leaves with myrrh and oliban. Pieces of the paper are ignited in the room.

"Himrod's Cure for Asthma" is said to be well imitated as follows: Powdered lobelia, black tea, and stramonium leaves, of each one ounce, to which two ounces of a saturated solution of nitrate of potash is added, mixed, and dried.

Trousseau, himself an asthmatic, and unaccustomed to the use of tobacco, often found a few puffs of an ordinary cigar an efficient remedy. He gives the following prescription: Belladonna leaves (0.36), hyoscyamus (0.18), phellandrium aquaticum (0.06), and stramonium (0.18). The leaves are carefully stripped from the ribs, dried, and treated with a trace of extract of opium. The cigarette papers, prepared by washing in cherry-laurel water, are then filled with the mixture.

McPhedran[1] cites the following prescription: Stramonium leaves (8.0), anise (4.0), tobacco leaves (0.2), potassium nitrate (4.0), a teaspoonful of which is ignited in an open vessel and the fumes inhaled.

The smoke from "Saltpetre paper" may be used. This is prepared by moistening filter paper in a half-saturated solution of potassium nitrate. The paper is dried and the fumes inhaled after ignition. It may also be rolled into cigarettes.

Other inhalations are used as follows: The smoke from cigarettes of stramonium and camphor, inhalation of amyl nitrite (3 to 5 minims in capsules), or amyl valerianate, ether, chloroform, turpentine, the fumes of ammonia, the vapor of warm water, to which compound tincture of benzoin (1 dram to the pint) is added, oxygen, pyridin (1 dram) in a saucer in the room, or 5 to 10 drops on a handkerchief about the neck.

2. **Prevention of Recurrences.**—This is difficult and at times impossible The various measures may be considered under the following headings:

(*a*) *Removal of the Cause.*—The possibility of nasal disease as a cause of asthma must always be considered, and pathologic conditions here, as elsewhere, should receive appropriate treatment. The influence of reflex irritation from more remote parts of the body cannot be denied. A careful inquiry concerning possible exciting causes, mentioned under Etiology, may suggest certain precautions against recurrent attacks.

(*b*) *General Treatment.*—In poorly nourished and specially in neurasthenic patients an improvement of the general nutrition by means of abundant food and fresh air is most helpful. No special diet can be recommended. Experience teaches many patients that it is better to avoid a hearty evening meal and to wait until digestion is complete before retiring. In some patients there seems to be a relation between flatulency and the attacks, and those foods which are likely to lead

[1] Osler's Modern Medicine, vol. iii.

to this condition, such as the carbohydrates and fats, may well be limited. Autosuggestion is capable of aggravating and in some instances, even of inducing the attacks in susceptible individuals. In such cases the explanation of the influence of a fixed impression and the substitution of a hopeful attitude may be successful.

(*c*) *Drugs.*—The iodid of potash in doses of gr. 5 to 15 (0.325 to 0.975 gm.), two or three times a day, beginning at once after the cessation of the attack, may be successful in delaying, in diminishing the severity, or even in the prevention of recurrences. Arsenic in the form of Fowler's solution may also be used. A course of atropin may also be tried, beginning with gr. $\frac{1}{120}$ (0.00054 gm.) and doubling the dose every three to four days until gr. $\frac{1}{30}$ (0.00216 gm.) or more is reached or until a disturbance of accommodation or dryness of the throat follows. Strychnin may also be given alone or combined with the atropin.

(*d*) *Danger of Anaphylactic Shock following the Use of Diphtheria Antitoxin in Patients with Asthma.*—Partial or complete relief from asthma has been noted to follow the injection of diphtheria antitoxin in a considerable number of instances. Some of the patients thus relieved have been subject to asthmatic attacks in the presence of the emanation from horses. Many unfortunate experiences have shown, however, that the administration of diphtheria antitoxin in patients with asthma, and especially horse asthma, is dangerous. Gillette[1] collected 28 cases, of which 12 were followed by collapse and 15 by death after the administration of horse serum. Of the 28 cases, in 17 there was a history of asthma, and in one each a previous history of cardiac dyspnea, of sneezing and irritation of the eyes when about a horse, of hay fever, and of chronic bronchitis. Of these 21 cases, 10 were followed by collapse, 10 by death, and in 1 the result is not stated. Four instances of death and one of collapse following the injection of diphtheria antitoxin in patients with asthma have been brought to my attention. The symptoms closely resemble the anaphylactic shock produced in sensitized animals by a reinjection of the same foreign serum. Immediately following the injection there may be irritation of the skin and an urticarial rash, sudden and intense dyspnea, cyanosis, sense of suffocation, unconsciousness, and death within a period of less than ten minutes, Death is probably due to spasm of the bronchioles, as in anaphylaxis in animals. All patients for whom the use of diphtheria antitoxin is under consideration should be questioned regarding a previous history of asthma or susceptibility to the presence of horses. Prophylactic injection of serum should, if possible, be avoided when there is ground for suspecting anaphylaxis. In such cases, when it is deemed necessary to give antitoxin for prophylaxis or treatment against diphtheria, the patient's susceptibility may be tested by the application of diphtheria antitoxin to the skin, as in

[1] Therapeutic Gazette, 1909, S. 3, xxv, 159.

von Pirquet's cutaneous test with tuberculin or by the subcutaneous injection of a small dose (0.1 c.c.) of the serum. Hypersusceptibility may be demonstrated by the appearance of a reaction within a half-hour of the use of the serum. It may be that in sensitive individuals, anaphylaxis can be prevented by the injection of a small dose and the use of the serum for therapeutic purposes in the refractory stage which follows. Besredka and Lissofsky[1] found that guinea-pigs sensitized to serum could be rendered immune to an otherwise fatal dose by previous injection of a minute quantity. In their experiments, four hours were required to produce the refractory stage by subcutaneous injection. Atropin in full doses may be successful in preventing or relieving anaphylaxis.

(*e*) *Immunization of Patients Susceptible to Egg Albumen.*—Schloss[2] noted that the symptoms of egg poisoning in his patient were those of anaphylaxis. In a child who was poisoned whenever he ate eggs, oatmeal, or almonds an urticarial wheal could be produced by the application to the skin of the protein of any one of these substances. Immunization to egg white was secured by the administration by mouth of gradually increasing doses of ovomucoid in capsules. Immunization to oatmeal and diminished susceptibility to almonds were coincident. Talbot[3] detects hypersensitiveness to eggs in children by the appearance of an urticarial wheal after rubbing white of egg into the unbroken or scarified skin, previously cleaned with soap and water and with alcohol. Egg may be removed from the diet or insensitiveness secured by the administration of gradually increasing doses of egg albumen in capsules.

(*f*) *Climate.*—An assurance of relief cannot be promised in any climate, and yet a change of location is sometimes successful in preventing recurrences. City is often better than country life. A change from one place to another nearby may be as beneficial as to a resort far away. Patients whose financial condition will permit, may well try one location after another. In general a mild and equable climate is to be preferred, and thus Florida, Southern California, the Riviera, and Egypt may be favorable. Poorly nourished and neurasthenic patients may be benefited by a stay in a well-regulated sanitarium. In such institutions, psychotherapy, pneumotherapy, electrotherapy, and hydrotherapy may be added to the prescriptions.

[1] Ann. de l'Inst. Past., vol. xxiv, No. 12.
[2] Am. Jour. Dis. of Children, 1912, p. 341.
[3] Bost. Med. and Surg. Jour., November 5, 1914.

CHAPTER III.

BRONCHITIS FIBRINOSA.

This has also been termed plastic bronchitis, bronchitis pseudomembranosa, and bronchial croup. It is characterized by the formation of casts within the bronchi.

Occurrence.—The cases are rare. The literature was collected to 1869 by Lebert,[1] who found 44 cases. West[2] added 54 more to 1889, and in 1902 Bettmann[3] brought the number reported since Lebert's review to 145. Posselt[4] gives a summary of the literature and a short account of the reported cases since 1900.

Classification.—A division of the cases into two groups according to the predominance of fibrin or mucus in the casts has been made by Posselt,[5] and at times maintained in later descriptions. Fränkel[6] separates from the cases of essential fibrinous bronchitis those in which there is the formation of mucous casts, and suggests the term *bronchitis pseudomembranacea mucinosa* to indicate such cases. These he believes should be included among cases grouped as bronchial asthma. A sharp distinction between these two groups cannot be maintained on the basis of the composition of the casts, which probably always contain both fibrin and mucus in somewhat varying proportion. Moreover, the fibrinous form of bronchitis may develop in the course of bronchial asthma.

A grouping of the cases may also be made into those which are *secondary* to some recognizable disturbance of the lungs or other organs and those which are *primary* or without discoverable association with other conditions.

A distinction is often made between acute and chronic forms of the disease. In the former there is only one attack, while in the latter there are recurrences at longer or shorter intervals.

Etiology.—The condition may occur at any age, but appears to be less often observed in the old. Males are more frequently affected than females. Cases are more often observed in the colder months of the year.

Cases occurring in the course of acute or chronic bronchopulmonary infection form the largest single group. In a considerable number of the instances in this class the clinical manifestations are those of

[1] Ueber das Vorkommen fibrinöser Entzündungsproducte in den Bronchien und Lungenalveolen, Deut. Arch. f. klin. Med., Bd. vi, p. 74.
[2] Practitioner, 1889, xliii, 83.
[3] Amer. Jour. Med. Sci., 1902, cxxiii, 304.
[4] Med. Klinik, 1909, Nos. 33 and 34.
[5] Präger med. Woch., 1899.
[6] Spez. Path. u. Ther. d. Lungenkrankheiten, 1904.

simple chronic or acute bronchitis. Pulmonary tuberculosis occupies a prominent place among the infections. Lehmann-Model[1] found tuberculosis associated in 10 of 26 autopsies reported on cases with fibrinous bronchitis. Of his 6 cases, 3 showed tuberculosis at autopsy. Extension of the fibrinous exudate from the lung to the smaller and even the larger bronchi is occasionally observed in lobar pneumonia with the expectoration of delicate fibrinous casts of the bronchi. The condition is at times observed as a complication of typhoid fever, measles, and scarlet fever; in rare instances with erysipelas, variola, articular rheumatism, and influenza. Diphtheria is an important cause, the fibrinous bronchitis being most often part of a descending infection, the primary manifestations of which are in the pharynx and larynx. Primary involvement of the deeper parts of the tract are observed in rare instances. Of 220 autopsies on cases with diphtheria, Councilman, Mallory, and Pearce[2] found membranous deposits in the bronchi in 43. Rupture of caseous lymph glands into the bronchi was a cause in Weigert's[3] 2 cases. Actinomycosis of the lung complicated by fibrinous bronchitis is reported by Finckh.[4] In the case reported by Devillers and Renon,[5] greenish membranes composed of the mycelium of Aspergillus fumigatus were expectorated. The patient selected seeds for cultivation by testing them with her teeth.

Fibrinous bronchitis is reported in rare instances following the inhalation of steam, the fumes of ammonia, and smoke. Vintras[6] reported the occurrence of casts as a complication of an epithelioma of the esophagus with compression of the trachea in the region of the bifurcation. In Cesaris-Demel's[7] case there was an aneurysm of the aorta, with compression of the root of the lung. Fibrinous casts were found at autopsy in the atelectatic lung.

A relation between bronchitis fibrinosa and bronchial asthma has been noted. In a small proportion of the cases bronchitis fibrinosa develops in the course of bronchial asthma, and with Charcot-Leyden crystals, Curschmann's spirals, and eosinophiles in the sputum. Small fibrinous structures are not infrequently found in the sputum in asthma. In Liebermeister's[3] and in Bettmann's[9] cases the casts terminated in Curschmann spirals. In Vierordt's[10] case, Curschmann's spirals were demonstrated in the sputum after the casts had disappeared.

Organic disease of the heart with failure of compensation is complicated by fibrinous bronchitis in a small number of cases. Passive congestion of the bronchi and lung may be regarded as a predisposing

[1] Ueber Bronchitis fibrinosa, Inaug. Diss., Freiburg, 1890.
[2] A Study of the Bacteriology and Pathology of Two Hundred and Twenty Fatal Cases of Diphtheria, Boston, 1901, p. 93.
[3] Virchow's Arch., Bd. lxxvii, p. 294.
[4] Beitr. z. Chir., 1904, Bd. xli, Heft 3, p. 676.
[5] La presse méd., 1899.
[6] Lancet, September 15, 1900, p. 809.
[7] Giorn. della R. Accad. di med. di Torino, 1900, p. 577.
[8] Münch. med. Woch., 1904, xvii, 781.
[9] Loc. cit., p. 324.
[10] Berl. klin. Woch., 1883, No. 29.

factor in this group. The evacuation of a large pleural exudate may be followed by pulmonary edema and the expectoration of casts. In rare instances the condition has been observed in association with diseases of the skin, such as impetigo capitis, herpes zoster, herpes of the lips, throat and pharynx and pemphigus. In Mader's[1] case there was pemphigus of the mucous membrane of the mouth, throat, and conjunctiva. Extension to the larynx was accompanied by dyspnea and the expectoration of bronchial casts. Death followed two years after the onset of the respiratory disturbances. An apparent relation with menstruation has been noted in rare instances.

FIG. 11

Expectorated cast from a case of fibrinous bronchitis. Three-fourths natural size. Drawn from fresh specimen. (After Bettmann.)

Cases unassociated with any apparent disturbance of the bronchi, lungs, or other organs, to which the fibrinous bronchitis can be regarded as secondary, form a small group. Such cases are classed as primary or idiopathic fibrinous bronchitis.

[1] Wiener med. Woch., 1882, Nos. 11 to 14.

The conditions with which bronchitis fibrinosa are associated are variable and in many instances can be regarded as little more than a coincidence. In the majority of the cases, however, the bronchial casts develop in the course of diseases in which the bronchial mucosa may be assumed already to have suffered some injury of an inflammatory, mechanical, or toxic character, and it is natural to suspect that herein may lie the predisposing cause of the disease. Basing his contention on Weigert's[1] observation that destruction of the protective epithelium is a fundamental condition for the development of a fibrinous pseudomembrane on the surface of mucous membranes, Fränkel[2] asserts that fibrinous exudation into the bronchial lumen can occur only when the epithelium is destroyed or sufficiently altered to allow the passage of fibrin-forming material. Small defects may permit the outflow of coagulable material and its diffusion over still intact parts of the tract. To this Müller[3] raises the objection that evidence of loss of bronchial epithelium is lacking. The fact that the disease may last for years without any substantial injury does not suggest a deep alteration of the bronchial surface, and severe bronchitis and bronchopneumonia with destruction of the bronchial epithelium often occur without the formation of fibrin. Josué and Paillard[4] obtained coagulation in a solution of mucin by the addition of a glycerin extract of the patient's expectoration and the casts. Glycerin extracts of the expectoration of other subjects proved relatively less active. Observations on the phenomena of coagulation by Bordet and Delange[5] may throw light on the formation of bronchial casts.

Evidence in favor of any constant or necessary bacterial infection is lacking. Attempts to produce the disease experimentally in animals by the introduction of bacteria into the trachea have proved negative.

Pathology.—A considerable number of autopsies have been performed on patients with fibrinous bronchitis, but few investigators have interested themselves in other than the gross changes. More complete studies are desirable and an investigation of the condition of the mucous membrane of the tract. If casts have been expectorated, none may be found at autopsy. Intact casts or their fragments may be found, lying free in the bronchial lumen or in places adherent to the wall. The bronchial involvement may be diffuse and include all branches even to their finest ramifications or involve only a circumscribed region. Diffuse involvement and failure to expectorate the casts with fatal asphyxia as a result is more common in the acute cases.

Changes in the bronchial wall may apparently be limited to swelling and redness of the mucosa. Rollet[6] found tubercles in the wall of the

[1] Ueber Krupp und Diphtheritis, Virchow's Arch., Bd. lxxii, p. 253.
[2] Loc. cit., p. 117.
[3] Deut. Klinik, 1903–07, p. 261.
[4] Bull. et mém. Soc. Méd. d. Hôp. de Paris, 1909, 3 s., xxviii, 97.
[5] Ann. d. l'Inst. Pasteur, 1912, Nos. 9 and 10.
[6] Wien. med. Woch., 1866, Nos. 20 and 21.

bronchus. Lehmann-Model[1] found caseous infiltration of the wall of the bronchus containing a cast. Kretschy[2] found loss of epithelium and infiltration with white cells in the region of a cast *in situ*. Hochhaus[3] demonstrated small defects in the mucous membrane of the larger bronchioles and infiltration of the wall with leukocytes. Grandy's[4] observations are of special interest. The cast was found *in situ*. The mucous glands were dilated with mucus which could be seen to extend from the excretory ducts and merge with the bronchial casts. Leukocytic infiltration was noted about the bases of the mucous glands and in the peribronchial tissue. Goblet cells were present in large numbers. Schlittenheim[5] made a careful study of a case with pulmonary tuberculosis. Fibrin and desquamated epithelial cells were found in the alveoli and the bronchi of the right lower lobe. The mucous glands were dilated and contained desquamated cells and mucus, and the peribronchial tissue was infiltrated with leukocytes.

Symptoms.—Dyspnea, cough, and the expectoration of casts are the principal symptoms. Symptoms of bronchial catarrh usually precede and follow the attack. One or more chills may initiate the paroxysm. In a small proportion of the cases there are no preliminary symptoms. The dyspnea and cough are commonly paroxysmal and last for from twenty-four to forty-eight hours before the casts are expectorated. The cough is severe and dry unless the condition complicates bronchopulmonary disease associated with expectoration. Hoarseness is absent unless the larynx is involved. The dyspnea is due to the accompanying catarrh, passive hyperemia of the lung, or bronchial obstruction. Suffocation rarely occurs owing to the limitation of the process to certain bronchi only, but in Fagge's[6] case death occurred from occlusion of the bronchi at the bifurcation of the trachea. In some instances cough and dyspnea are absent. Expulsion may be affected by hawking. A feeling of tightness or oppression is often experienced. Pain is usually absent. When present it may be due to the violence of the cough, and in rare instances is referred to the apparent seat of formation of the casts. The expectoration of casts usually lasts for several days, after which there is relief of the symptoms. Moderate elevation of temperature is often observed, and may be seen not only in the secondary, but also in the primary cases.

Certain differences between the acute and chronic cases may be noted. The acute cases are less frequent and usually more severe with fever, paroxysmal cough, marked dyspnea, oppression and feeling of suffocation. Cyanosis may be intense. The severity of the symptoms in this form is due to the formation of casts over a wider extent of bronchial territory. In severe cases with widespread involvement,

[1] Loc. cit.
[2] Wien. med. Woch., 1873, Nos. 14, 15, and 16.
[3] Deut. Arch. f. klin. Med., Bd. lxxiv, p. 11.
[4] Centralbl. f. allg. Path. u. path. Anat., vol. viii, p. 513.
[5] Deut. Arch. f. klin. Med., 1900, Bd. lxvii.
[6] Trans. Path. Soc. London, vol. xvi, p. 48.

efforts to expel the casts may be ineffectual. Increasing dyspnea, cyanosis, and somnolence may then terminate in death from asphyxia. The duration of the primary acute cases is usually from one to three weeks.

The chronic cases are more frequent and less severe. The onset is more gradual and may be long preceded by symptoms of chronic bronchitis interrupted at varying intervals by attacks of paroxysmal cough, dyspnea, and oppression, followed by the expectoration of casts and relief. Fever is usually absent. In this form the process is more often circumscribed, and the casts may be so small and easily detached as to give rise to no dyspnea. The number and duration of the attacks is very variable. They may recur daily or at intervals of days, weeks, months or years.

On physical examination there may be no other signs than those of bronchial catarrh which may be diffuse or limited to the involved region. In outspoken and typical cases, the signs are those of bronchostenosis. On inspection there may then be diminished excursion of the affected side. Percussion is usually negative, but dulness may be present from atelectasis or pulmonary infiltration. On auscultation, diminished or absent respiratory murmur may be noted over the region supplied by the occluded bronchus with return of the breath sounds after expulsion of the casts. Sonorous or sibilant rales may be limited to the affected region. In rare instances peculiar flapping sounds due to the partial detachment of the casts may be heard. The lower lobes are most often affected. The signs of emphysema may be present in uninvolved parts of the lung. In Mader's[1] case laryngoscopic examination disclosed the presence of a membrane in the pharynx and on the epiglottis. In West's[2] case the percussion note was greatly impaired over the whole left side; the voice and respiration were everywhere absent with the exception of the left interscapular region, where they were somewhat exaggerated. The heart was displaced toward the affected side. After the expulsion of the cast the upper part of the left lung became resonant, and the breath sounds distinct, while the base remained dull. The apex of the heart returned to the nipple line.

The sputum is variable in amount and character, but is usually scanty and mucopurulent, at times blood-streaked or frankly hemorrhagic. Hemoptysis may precede or accompany the expectoration of casts. Small amounts of blood may come from the rupture of the attachments of the cast to the bronchial wall. Large amounts probably come from the lung.

The casts are usually found as nondescript masses which, if small, may be readily overlooked, and must first be carefully unrolled in water before their identity can be established. They vary in thickness from a few millimeters to a centimeter and a half and in length up to six or seven inches. From one to a dozen or more may be expectorated

[1] Wiener med. Woch., 1882, Nos. 11 to 14.

[2] Lancet, 1908, i, 489.

daily. They are usually pearl gray or white, at times of a reddish color. The larger casts are firm, the smaller soft in consistency. They are for the most part of cylindrial form, at times flattened, and are branched in accordance with the divisions of the bronchi in which they arise. A rapid division into short branches suggests an origin from the upper parts of the bronchial tree, while a more gradual division and longer branches suggests an origin from the lower parts of the lung, as noted by Biermer.[1] The finest divisions may be pointed, cork-screw-like, and resembling Curschmann's spirals, or show small clubbed terminations representing molds of the infundibula. Their surface is usually smooth, but the inclusion of air-bubbles may lead to the production of nodular swellings and a beaded appearance. The thicker branches and the smallest ramifications are usually solid, while those of intermediate size are not infrequently hollow and filled with air and mucus. On section of the larger branches of the casts, a concentric and folded lamination may be observed, and represents the deposition of the material of which it is composed in layers, the innermost ring being the oldest.

Microscopic examination of casts shows a varying number of fine fibrillæ and an interlacing network of fibers in a ground substance composed of a structureless, hyaline material containing mononuclear and polynuclear leukocytes, fat droplets, occasional eosinophiles, and alveolar epithelium and isolated ciliated cylinder cells. Red-blood cells are rarely found within the substance of the cast, but are not infrequent on its surface. Mast cells are found in rare instances. Charcot-Leyden crystals and Curschmann spirals are occasionally found in the casts. Bacteria may or may not be demonstrable. The pneumococcus, Friedländer's bacillus, streptococcus, and staphylococcus pyogenes albus and aureus have been found in primary cases, and the pneumococcus, diphtheria bacillus, tubercle bacillus, and influenza bacillus in secondary cases. The bacteriologic findings are so inconstant as to indicate that the formation of the casts cannot be ascribed to the influence of any one organism.

Various chemical tests have been used for the determination of the fibrinous or mucous character of the casts, but their interpretation is difficult. Fibrin swells in dilute acetic acid, in potassium hydrate and in hydrochloric acid, and is digested at body temperature by artificial gastric juice (pepsin-hydrochloric acid), while mucus is resistant against these reagents. Fibrin may be stained by Weigert's method, but mucus does not stain. Thionin is used as a stain for mucus by Hoyer[2] and Hari.[3] Brilliant green and neutral red are used by Hecht.[4] Müller[5] finds that the pure mucus of the respiratory tract

[1] Virchow's Handb. d. spec. Path. u. Ther., Bd. v.
[2] Arch. f. mikr. Anat., 1890, Bd. xxxvi.
[3] Ibid., 1901, Bd. lviii.
[4] Wiener klin. Woch., 1908, No. 45.
[5] Deut. Klinik., 1904, p. 261.

splits into 36 per cent. glucosamin while bronchial casts contain 66 per cent. mucin.

Diagnosis.—This can be made with certainty only by the expectoration of branching casts of the character already described. Small casts may be readily overlooked unless the sputum is carefully inspected and the attempt is made to unroll any solid particles or masses after suspension in water. Confusion with blood-clot is possible unless this is done. Microscopic examination will assist in the identification of small particles without branching. In the absence of branching, small laminated particles of casts may be mistaken for fragments of echinococcus cyst membrane.

When casts are absent from the sputum, the diagnosis may be suspected in patients with a previous history of fibrinous bronchitis and symptoms of bronchostenosis. Without a history of previous attacks, the distinction from other and more common causes of bronchostenosis is difficult or impossible. Bronchial occlusion by tenacious secretion in children with capillary bronchitis and bronchopneumonia is more transient and oftentimes relieved by vigorous cough. A careful history and physical examination, *x*-ray examination and the Wassermann test will assist in the exclusion of foreign body, syphilis, and aneurysm. The sputum should be carefully examined for tubercle bacilli, actinomyces, and diphtheria bacilli. Laryngoscopic and bronchoscopic examination may make the diagnosis possible.

Prognosis.—The immediate outlook is less favorable in the acute than in chronic cases, and worse in children than in adults. Death occurs in about half of the acute cases. The extent of the bronchial involvement, the strength of the patient and the character of the underlying disease in secondary cases must be considered in estimating the prognosis of individual patients. In chronic cases the prognosis for life is relatively favorable, death occurring in only four of 36 cases collected by Championnière.[1] Recurrences are frequent in this form. Even long intervals of freedom cannot be regarded as an assurance against a return of the disease. In Brik's[2] case following the first attack at thirty-six, the disease recurred at forty-one, forty-two, and sixty. In Kisch's[3] remarkable case, attacks recurred at intervals for twenty-five years.

Treatment.—There is no specific treatment. The indications are to remove or assist in the removal of the casts and prevent their subsequent formation. Neither indication can be satisfactorily met. Provided the strength of the patient permits, the subcutaneous injection of apomorphin hydrochlorate may be used. Iodid of potash internally has seemed to be effective in some cases. Inhalations of warm steam or a spray of lime water may be tried. The lime water (25) may be combined with solution of sodium hydrate (2) and water

[1] De la bronchite pseudomembraneuse chronique, Thèse de Paris, 1876.
[2] Wiener med. Presse, 1882, p. 828.
[3] Prager med. Woch., 1888, xiii, 69.

(200). Whether a dissolving action on the cast *in situ* can be effected by such means is doubtful. Compression of the chest by the hand during expiration has also been recommended. While the bronchial cast is still unexpelled, the patient is in danger of suffocation from occlusion of the bronchi at the tracheal bifurcation or impaction of a detached cast in the glottis. The possibility of removal of a cast by bronchoscopy should be entertained and may be life saving in these cases. To prevent recurrence attention must be paid to the removal of the cause if this can be discovered. The prevention and treatment of bronchial catarrh must be considered in this connection.

CHAPTER IV.

BRONCHITIS OBLITERANS.

In 1901, Lange[1] first recognized the existence anatomically of connective-tissue occlusion of the finer bronchi, bronchitis and bronchiolitis obliterans, as a relatively independent affection and unassociated with extensive involvement of the lung. Soon after his publications, Fränkel[2] made the diagnosis of the condition during life in a patient suffering from severe dyspnea following the inhalation of the fumes of nitrous acid.

Etiology.—In addition to Fränkel's first case, similar changes have been observed following the inhalation of the fumes of nitrous acid with chlorine by Edens,[3] plaster of Paris by Fränkel,[4] and after phosphorus poisoning by Schmorl.[5] Similar pathologic changes were observed by Hart[6] following measles and whooping cough in children. In Schmorl's[7] case with tertiary syphilis, isolated organisms morphologically like the spirochæta of syphilis were found in the peribronchial granulation tissue. Colombino[8] has reported the condition after diphtheria. Pernice[9] at times found obliteration of the bronchioles after apparently uncomplicated catarrhal bronchitis. Müller[10] regards the condition as a development in the course of especially severe forms of acute or subacute bronchiolitis, and refers to two cases. Circumscribed obliterative bronchiolitis may follow lobar pneumonia. In Wegelin's[11] case of a boy who died eight weeks after the aspiration of a plum-stone, obliterating bronchitis and bronchiolitis were found in many of the smallest bronchi and bronchioli of the right lung.

Pathology.—Of special importance in the production of characteristic symptoms is the diffusion of the process over the greater part of the bronchioli of both lungs, in contrast to the more circumscribed but otherwise apparently similar changes which at times follow pneumonia. The disturbance is predominantly an involvement of the

[1] Ueber eine eigenthümliche Erkrankung der kleinen Bronchien und Bronchiolen (Bronchitis et Bronchiolitis obliterans), Deut. Arch. f. klin. Med., Bd. lxx, p. 342.

[2] Ueber Bronchiolitis fibrosa obliterans nebst Bemerkungen über Lungenhyperämie und indurierende Penumonie, ibid., Bd. lxxiii, p. 484.

[3] Deut. Arch. f. klin. Med., 1905–06, lxxxv, 598.

[4] Verhandl. d. Berl. med. Gesellsch., 1908, xxxix, 460.

[5] Quoted from Colombino, Deut. med. Woch., 1910.

[6] Deut. Arch. f. klin. Med., 1903–04, lxxix, 108.

[7] Verhandl. d. deut. path. Gesellschaft, 1907, xi, 281.

[8] Loc. cit.

[9] Arch. del anat. path. et sc. affini, 1906.

[10] Deut. Klinik, 1903–07, iv, 250.

[11] Beitr. z. path. Anat. u. z. allg. Path., 1908, xliii, 438.

terminations of the bronchi with relatively little change other than emphysema in the lung tissue itself. On section the lung presents an appearance very similar to that with miliary tuberculosis from the presence of numerous, grayish-white, hard, slightly projecting nodules about the size of miliary tubercles, from which they differ, however, in their angular or stellate form as seen with the hand lens, and their connection with the small bronchi of which they may be found on dissection to form the termination. On microscopic examination the bronchial lumen in the affected regions is partly or wholly occluded by an ingrowth of connective tissue, which apparently takes its origin from the bronchial wall. Partial destruction of the epithelium probably precedes the new formation of tissue and proliferation of the membrana propria and peribronchial tissue with rupture of the elastic coat accounts for the invasion of the bronchial lumen. Connective-tissue invasion is also observed in the neighboring alveoli, with the formation of Lange's "miliary indurative pneumonia." Galdi[1] has described the case of an engraver of music with nodular induration of isolated groups of alveoli, loss of epithelium and inflammatory thickening of the terminal bronchioli, but without invasion of the lumen by connective tissue. This case does not belong in this group, but may indicate the varying results of injury of the tissue by different agents.

Symptoms.—In Fränkel's first case in which the condition followed the inhalation of the fumes of nitrous acid, there was an initial irritative stage with severe dyspnea, acute emphysema, and widespread crepitant rales, but no outspoken dulness. The first stage was the result of the corrosive action on the bronchial wall with resulting hyperemia, loss of the protecting epithelium, and serous exudation into the lumen. This was followed by a period of complete relief of symptoms and a condition of well-being coincident with the subsidence of the inflammatory exudation. With the development of connective tissue and obliteration of the bronchioles there was a return of the earlier symptoms on the fourteenth day, and death occurred six days later. A similar clinical course was observed in Edens' first case following the inhalation of the fumes of nitrous acid with chlorin and with death on the twenty-sixth day. In his second case, in which the condition likewise followed the inhalation of nitrous acid with chlorin and in his third case after inhalation of ammonia gas the initial acute symptoms subsided and the patients recovered. Clinical data are lacking or not characteristic in other reported cases.

Diagnosis.—This was made during life and later established at postmortem examination in two of Fränkel's four cases and in Edens' first case. The disease resembles acute miliary tuberculosis from the presence of cyanosis, dyspnea, emphysema, and crepitant rales over both lungs, and the absence of dulness, but may be differentiated by the history, evidences on examination of tuberculosis in the lung or

[1] Deut. Arch. f. klin. Med., Bd. lxxv, p. 239.

other parts of the body, including a search for choroidal tubercles and the finding of tubercle bacilli in the sputum. Widespread capillary bronchitis with bronchopneumonia as a result of bronchopulmonary infection may present closely similar clinical features. An unusual degree of pulmonary inflation may suggest the possibility of an obliterative bronchiolitis developing in the course of such a condition. In the circumscribed forms of the disease the clinical diagnosis can hardly be made.

Prognosis.—This is grave as might be expected from the clinical and anatomic features. The condition even when widespread is not necessarily fatal, as is indicated by the recovery of Edens' second and third cases. The cases thus far reported are too few to admit of safe prediction concerning the outlook in individual cases. In Edens' first case the initial symptoms were mild, and the patient was able to continue at his work for three weeks after the inhalation of the acid fumes. The symptoms then became more intense, and he died five days later.

Prophylaxis.—Sufficient ventilation should be secured in rooms where corrosive fumes are generated. Workers in danger of the inhalation of acid or alkaline fumes should wear suitable masks containing a piece of gauze or a sponge moistened in mild alkaline or acid solution.

Treatment.—Fränkel recommends the inhalation of oxygen when there is danger of suffocation. At present there are no means of checking the formation of connective tissue, and the treatment must otherwise be that of severe bronchitis and bronchopneumonia.

CHAPTER V.

BRONCHITIS.

1. ACUTE TRACHEOBRONCHITIS.

This is the most frequent disturbance of the air passages, and in its milder forms a matter of every-day observation.

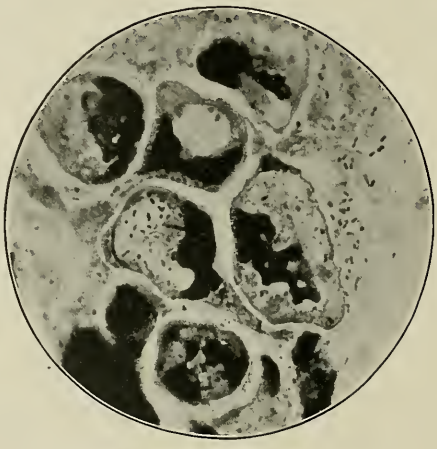
Classification.—The clinical features of tracheobronchitis justify its inclusion among the *infections*. Its relation to influenza cannot be regarded as settled, but certain etiologic features to be mentioned later make it probable that many if not most of the cases of tracheobronchitis occurring in the intervals between the outbreaks of pandemic and endemic-epidemic influenza are to be regarded as examples of sporadic influenza. If the influenza bacillus be regarded as the cause of true influenza, cases of tracheobronchitis should be classed as a manifestation of this disease when, as occurs in a certain number of the cases, this organism is present, while those cases with a similar clinical picture, but in which the influenza bacillus cannot be found, should be classed as influenza nostras or "la grippe."

Etiology.—It is difficult to present a satisfactory grouping of the cases according to their etiology. A division into cases due to (1) infection and (2) mechanical and toxic causes seems least open to objections.

1. **Infections.**—Acute tracheobronchitis is an infection of the respiratory tract usually beginning in the nose as a "cold" and proceeding downward with or without involvement of the nasopharynx, the tonsils, or larynx to the deeper parts of the air passages. In some cases the process starts as a disturbance low down in the tract and extends upward, but this is less common. Cases are most numerous in the colder months of the year, and children are much more frequently affected. Some persons seem specially disposed and suffer a succession of attacks at frequent intervals during the winter. Group infections are common in the family and among persons closely associated, but the type of the disturbance is likely to differ, appearing as a simple rhinitis in one, tonsillitis in another, and tracheobronchitis with or without manifestations referred to the upper parts of the tract in a third. The contagiousness of such infections is a matter of every-day observation, and the disease develops following an interval of only a few days after exposure. Transmission from person to person seems more common early in the disturbance and in the presence of the acute symptoms.

The use of the term "*cold*" and its German equivalent "*Erkältung*" indicates a prevalent belief that chilling of the body is an important factor. It is a common observation that exposure in wet weather, sitting in wet clothes or in a draught, and rapid cooling of the body after perspiring from overexertion precipitate an attack, and there is some experimental evidence to show that such indiscretions may produce abnormal bronchial conditions. Rossbach,[1] Müller[2] and others have shown that in animals, chilling of the body is followed by a transitory increase of bronchial secretion. In Müller's experiments, atelectasis in the territory supplied by occluded bronchi, desquamation of alveolar epithelium, and an exudate of albuminous fluid containing

Fig. 12



Influenza bacilli in sputum. × 1000.

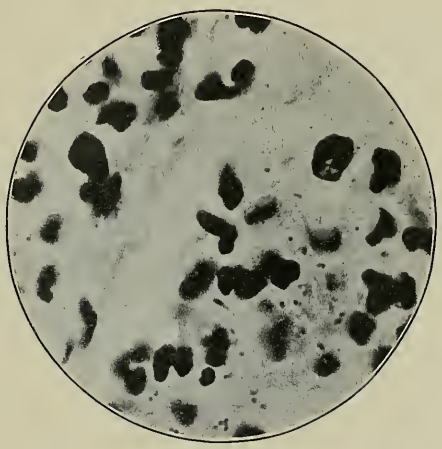
some fibrin and blood were also noted; and it may be that after exposure to cold, conditions become more favorable for the development of organisms in the bronchial tract of an already infected individual. While it cannot be denied that exposure to cold and wet may bear more than a chance relation, yet it is probable that its influence is overestimated. Many such exposures are experienced without ill effects, and then to the indiscretion immediately preceding an infection an unwarranted importance is accorded. Nansen's often quoted experience of freedom from colds among the members of his expedition while exposed to the extremely low temperature of the far North and the development of colds and cough among many of the party when on their return they landed at a thickly inhabited port, suggest that exposure to cold alone is not a sufficient cause.

An important cause in this group is *influenza*, the prevailing picture of which in all epidemics has been that of a respiratory infection,

[1] Berl. klin. Woch., 1882. [2] Deut. Klinik, 1903–04.

affecting for the most part the upper parts of the tract as a rhinitis, but in the more severe cases extending to the deeper parts and even into the smallest branches of the bronchi. Not a year has elapsed

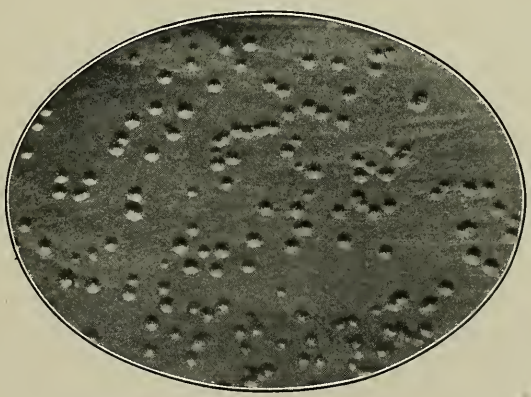
FIG. 13



Influenza bacilli in alveolar exudate. × 1000.

since the great pandemic of 1889–90 without local outbreaks in some part of the world. The relation which isolated and small groups of infection with acute respiratory symptoms occurring in interepidemic periods bear to epidemic and pandemic influenza is an interesting

FIG. 14



Culture of influenza bacilli on blood-agar (low magnification).

question which cannot yet be regarded as settled. It is certainly reasonable to assume that in some form the infecting organism in epidemic and pandemic influenza must be kept alive during the inter-

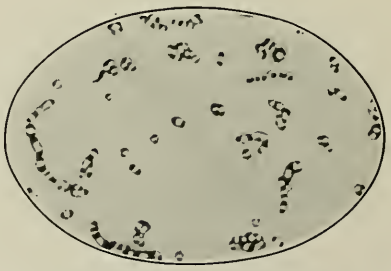
epidemic period, and the contagious character of and the similarity of the symptoms in the severer types of the primary acute respiratory infections suggest that these and the influenza cases may be due to a common cause. So far as the influenza bacillus is concerned, it must be regarded as an important infecting agent in a large number of acute

Fig. 15

Smear preparation of influenza bacilli from culture. × 1000.

and chronic disturbances during the interepidemic period and as a contributing factor in many other cases when mixed with the pneumococcus, pyogenic cocci, Micrococcus catarrhalis, and other organisms. The cases in which it exists as a practically pure infection present no striking or constant difference from the respiratory infection with

Fig. 16

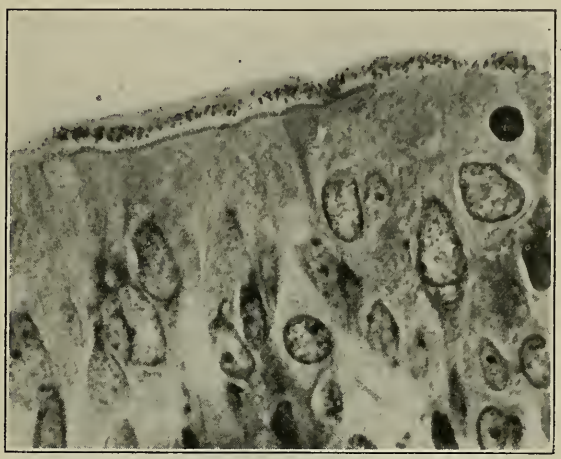


Smear preparation of influenza bacilli from culture, showing the occasional larger size of the organisms and their safety-pin appearance. × 1000.

other organisms and without association with influenza bacilli. The organism behaves in this respect like any other of the common respiratory parasites. In the interepidemic period the clinical diagnosis of "influenza" often fails of confirmation by the finding of influenza bacilli in the sputum.

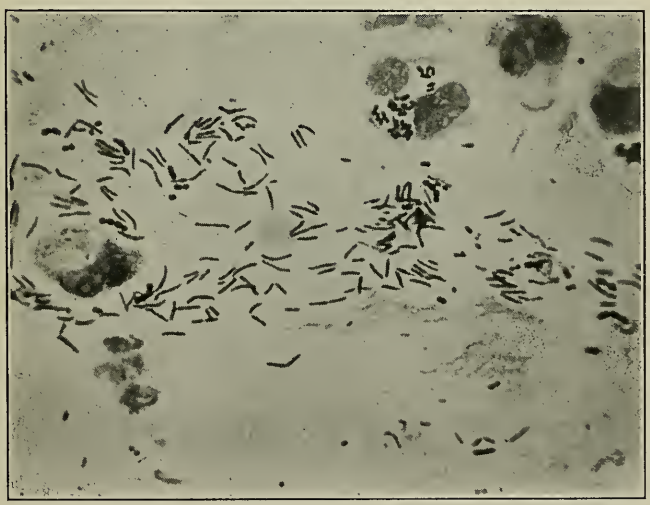
In *whooping cough,* invasion of the trachea and bronchi by the Bordet-Gengou bacillus is directly responsible for the symptoms. The researches of Mallory and Horner[1] indicate that a location of the

FIG. 17



Bacillus of pertussis. Masses of the bacilli intimately associated with the cilia of the epithelium of the trachea in a case of Pertussis. (Dr. J. H. Wright.)

FIG. 18



Diphtheroid bacilli with pneumococci and influenza bacilli in sputum.

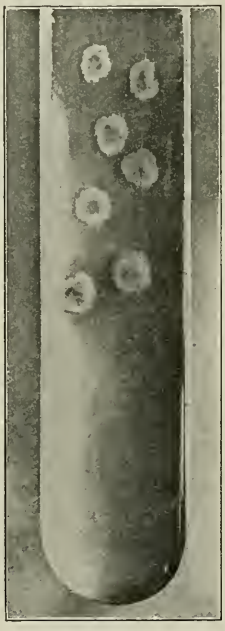
organisms between the cilia of the epithelial cells lining the trachea and bronchi is apparently characteristic of this disease and probably

[1] Jour. Med. Research, November, 1912.

responsible for the continuous irritation which results in coughing and whooping.

As an example of this group *measles* may also be mentioned during the prodromal stage of which coryza, redness of the eyes and the lids, hyperemia of the mouth and throat, and catarrh of the trachea and bronchi are observed. Similar but less intense respiratory symptoms may be seen in *German measles*. Manifestations of secondary and tertiary *syphilis* are occasionally noted in the trachea and bronchi and are more fully considered in another section. Tracheobronchial catarrh is common in *typhus fever* and may complicate the lesions in the mouth, pharynx, and larynx of *smallpox*. In *typhoid fever*, bronchitis

Fig. 19



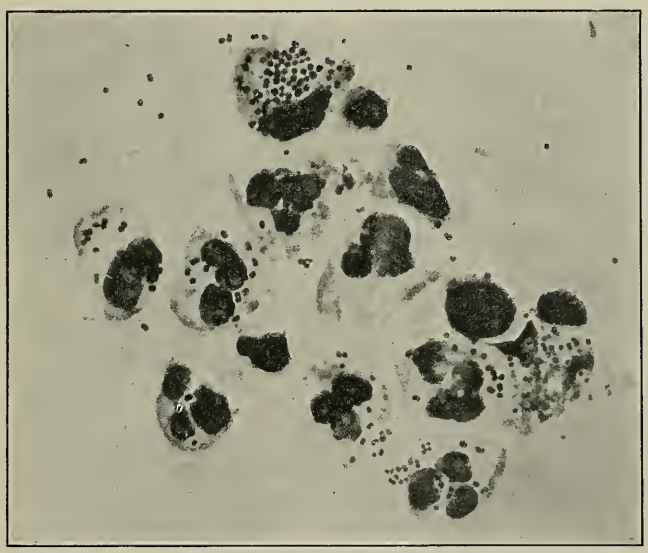
Micrococcus catarrhalis colonies on agar.

is an early and important symptom, and may so predominate in the clinical picture as to lead to an error in diagnosis. Typhoid bacilli were cultivated from mucopurulent sputum without blood in uncomplicated bronchitis in typhoid fever by Jehle.[1] The organisms were in pure culture in one, mixed with diplococci and streptococci in another and with influenza bacilli in 2 cases. The bronchitis may be due to the typhoid bacilli or other organisms. The development of the latter may be favored by congestion of the mucous membrane from toxemia or hypostasis.

[1] Wien. klin. Woch., February 27, 1902.

In *diphtheria,* extension of the infection from above may take place into the deeper parts of the tract. This occurs more often when the process starts in the pharynx or larynx and from the latter the lower parts of the trachea, the larger and even the finer bronchi may be invaded with the formation of a membrane in the affected regions. McPhedran[1] refers to two fatal cases seen by Goldie without exudate in the fauces and general bronchitis without membrane formation. Pure cultures of the diphtheria bacillus were obtained from the secretion. The extension of facial *erysipelas* to the mucous membrane of the mouth and pharynx may be followed by edema of the glottis, laryngitis, tracheitis, and bronchitis. Primary erysipelas of the larynx has been described. Bronchitis may also be observed in connection with *variola, anthrax,* and *glanders.* An intermittent bronchitis has been ascribed to *malaria,* but is not well established. Bronchitis may accompany *plague pneumonia.*

FIG. 20



Micrococcus catarrhalis in smear from sputum.

One of the most common and important causes is pulmonary *tuberculosis* which is accompanied by acute catarrhal inflammation of the bronchi leading to the affected region in the initial stages or during an exacerbation of the localized forms of the disease and a diffuse bronchitis in the pulmonary form of miliary tuberculosis. Involvement of the finer bronchi leading to the involved territory

[1] Osler's Mod. Med., vol. iii, p. 639.

is also a constant accompaniment of *croupous pneumonia* and *bronchopneumonia*, the invasion in the former taking place from below, and in the latter most often from above.

2. **Mechanical and Toxic Causes.**—The inhalation of *dust* as a carrier of contagious material may be regarded as a contributing factor in many of the acute infections of the bronchi. In *bronchostenosis* from whatever cause the multiplication of bacteria already present in the bronchi or brought in with an aspirated foreign body leads to inflammation of the bronchi and to the serious consequences referred to in the section under this heading. Following narcosis from *ether* inhalation, acute bronchitis with or without pneumonia may be observed, and is more especially to be feared in persons already subject to an infection of the respiratory tract, the existing organisms probably finding conditions more favorable for development in the increased bronchial secretion. Of other gases, the inhalation of the fumes of *nitrous, nitric, sulphurous* and *hydrochloric acid, ammonia* and *chlorin* may be mentioned as occasional causes. The internal administration of the *iodids* may cause toxic symptoms spoken of as iodism and most often manifested as a catarrh of the upper parts of the tract, but at times with involvement of the lower passages and the bronchi. Similar though less severe disturbances may follow the use of the *bromids*. Passive congestion of the bronchi is a frequent predisposing cause of a type of bronchitis which may be spoken of as a "*stasis catarrh.*" It is commonly seen in the later stages of broken cardiac compensation from whatever cause, and is doubtless due to the growth of organisms always present and ready to multiply under conditions favorable for their development. Bronchitis observed in the course of chronic nephritis and obesity is probably also to be ascribed to this cause.

Bacteriology of the Normal Respiratory Tract.—The presence of pathogenic organisms of varying degrees of virulence in the mouth in health is well established. Numerous observations on the deeper parts of the tract have been made. Jundell[1] examined mucus obtained from the trachea after cocainization of the larynx and found streptococci and a gonococcus-like diplococcus (Micrococcus catarrhalis ?) in 20 of 42 cases. In the remaining cases inoculated culture media remained sterile. Positive findings in the normal human lung are recorded by Dürck,[2] Beco,[3] Kerschensteiner,[4] and Norris and Pappenheimer;[5] and in the normal lung of animals by Boni[6] and Barthel.[7] The attempt to demonstrate organisms was negative or showed only a few bacteria in the examinations of normal human lungs by Klipstein,[8] Polguère[9] and

[1] Baumgarten's Jahresbericht, 1898, p. 857.
[2] Deut. Arch. f. klin. Med., vol. lviii, p. 368.
[3] Centralbl. f. innere Med., 1900, p. 846.
[4] Quoted from Müller, Deut. Klinik, 1903–04, p. 229.
[5] Jour. Exp. Med., 1905, vol. vii, No. 5.
[6] Deut. Arch. f. klin. Med., vol. lxix.
[7] Centralbl. f. Bakt., 1898, vol. xxvi, No. 11.
[8] Zeit. f. klin. Med., vol. xxxiv.
[9] Des infections secondaire, Thèse de Paris, 1888.

Barthel;[1] and in the examination of the lungs of animals by Hildebrand,[2] Beco,[3] and Müller.[4] Kerschensteiner[5] had the opportunity to examine the normal lungs of an individual immediately after execution by decapitation, and found among other organisms staphylococcus albus and pseudodiphtheria bacillus, but inoculation of mice with material from the lung failed to produce an infection. Norris and Pappenheimer call attention to the readiness with which after death bacteria can find ingress into the deeper parts of the respiratory tract from the mouth and throat.

In spite of the somewhat conflicting results by different observers the lower parts of the air passages and even the lungs can by no means be regarded as free from bacteria even in health, and their presence may in large measure be ascribed to the inhalation of infected dust. The infrequency with which infection occurs in spite of the prevalence of bacteria is due to the passage of air through a sinuous channel on its way to the deeper parts of the tract, the protective action of ciliary motion constantly tending to drive small particles outward, the barrier offered by a surface layer of mucus and epithelium against penetration into the tissue, the defensive action of phagocytes, and expulsion by cough of larger particles of foreign material.

Bacteriology of the Sputum with Bronchitis.—Numerous observations have shown that in the majority of cases the influenza bacillus, the pneumococcus, the pyogenic cocci, the staphylococcus, the Micrococcus catarrhalis, and less commonly other pathogenic organisms may be found in the sputum singly or combined in the specimens. It is the general experience that material from the upper parts of the tract contains a great variety of organisms, and the examination of carefully selected and washed purulent particles from below more often discloses only one or possibly two organisms as the apparent cause of the process. Workers at different times and in different places have found now one and then another organism predominating in the specimens.

In 1892 Pfeiffer[6] published his discovery of the influenza bacillus, and this was followed in 1893[7] by his more elaborate report. This organism was found in all the uncomplicated cases of influenza in pure culture in the sputum and regarded as the cause of the disease. Contrary to Pfeiffer's observations it has since been found in interepidemic periods, with or without influenza, by a great many investigators. Between August, 1902, and January, 1904, I[8] examined 186 sputa from patients suffering from acute or chronic disease of the respiratory tract, for the most part bronchitis. In 110 (59 per cent.) organisms having the morphology and staining reaction of influenza bacilli were found in

[1] Loc. cit.
[2] Ziegler's Beiträge, vol. ii, p. 143.
[3] Loc. cit.
[4] Deut. Arch. f. klin. Med., vol. lxxi, p. 513.
[5] Loc. cit.
[6] Deut. med. Woch., 1892, ii, 28.
[7] Zeit. f. Hyg., 1893, vol. xiii.
[8] Infections of the Respiratory Tract with Influenza Bacilli and Other Organisms, their Clinical and Pathological Similarity and Confusion with Tuberculosis, Boston Med. and Surg. Jour., May 11 and 18, 1905.

varying numbers. In 56 (30 per cent.) the organisms were shown by culture to conform in all respects to Pfeiffer's influenza bacillus, and in 47 (25 per cent.) they were in overwhelming numbers. Organisms resembling pneumococci were found in 70 per cent. of the cases, but were represented as a pure infection in only eight. The Micrococcus catarrhalis was found as a practically pure infection in 5 cases. Ghon, Pfeiffer, and Sederl[1] found the Micrococcus catarrhalis alone or mixed with pneumococci, influenza bacilli, staphylococci and streptococci in many cases of acute or subacute bronchitis and bronchopneumonia. Fränkel[2] found pneumococci and streptococci most often in acute bronchitis. Marfan,[3] Duflocq and Ménétrier,[4] Bartel,[5] and Jundell[6] found the pneumococcus in acute bronchitis. In children, Holt[7] found Staphylococcus aureus, pneumococcus, the influenza bacillus, and the streptococcus in the bronchial secretion of children with bronchitis. The occasional presence of Friedländer's bacillus, Micrococcus tetragenus, and the colon bacillus is noted by various observers.

These and numerous other investigations have shown that there is little uniformity in the bacteriologic findings. Mixed infections are the rule, and one organism as a practically pure and persistent infection the exception. One group may be found to predominate in the first examination, but subsequent investigation of the sputum from the same case frequently shows that contaminations have taken place, and since no sharp distinction can be drawn between the pathogenic power of different organisms found in the sputum the observer must remain in doubt as to the relative importance of any one infecting group.

It should be noted that these common respiratory organisms occur in all forms of bronchitis. They may be found in the sputum in the bronchitis following a "cold," influenza, whooping cough, measles, typhoid fever, diphtheria, tuberculosis and pneumonia. They occur as the apparent sole cause in the bronchitis of "cold" and influenza, but are now recognized as secondary invaders in the more specific infections. They uniformly appear also in the bronchitis due to mechanical and toxic causes. The suggestion is obvious that they cannot fairly be regarded as an adequate cause of either the bronchitis of "cold" or influenza, but that in these as well in all other forms of bronchitis they are rather to be regarded as secondary invaders. The independent position so long occupied by the influenza bacillus is largely discredited by its constant appearance in company with other common parasites, and it is no longer to be regarded as in good standing as a cause of

[1] Zeit. f. klin. Med., 1902, vol. xliv.
[2] Spec. Path. u. Ther. d. Lungenkrankheiten, 1904, p. 141.
[3] Traité de méd. Charcot, Bouchard, Brissaud, T. iv, p. 296.
[4] Arch. gén. de méd., 1890, 1894, and 1895.
[5] Centralbl. f. Bakt., Abth. i, Bd. xxiv, p. 401.
[6] Baumgarten's Jahresber., 1898, p. 857.
[7] Jour. Amer. Med. Assoc., October 8, 1910.

influenza, which is probably due to another and as yet undiscovered cause.

Correlation of the Bacteriologic Findings with the Clinical Picture.—An attempt has often been made to separate the cases into clinical groups according to the type of the bacterial infection. After the exclusion of cases showing mixed cultures, examples of single infections are so uncommon, even in large series, that only a small group is left for comparison, and in these the symptoms of onset, the course and duration do not seem to be distinctive. The amount of prostration may be as great in one as in the other, and all tend to set up diffuse or local bronchitis and a varying degree of bronchopneumonia.

Pathology.—Opportunities for postmortem examination of simple and uncomplicated bronchitis are exceptional owing to the infrequency of a fatal termination, and our knowledge of the changes is for the most part the result of autopsies made on patients dying with bronchopneumonia. In a few instances the gross appearance has been studied during life with the bronchoscope.

The mucous membrane is reddened, injected and swollen, and its surface is the site of a mucoid, mucopurulent or purulent exudation. Inflammatory swelling of the smaller bronchi may lead to closure of the lumen and to atelectasis of the corresponding pulmonary region. This is much more common in children owing to the narrowness of the passages. Enphysema of parts of the lung not involved with bronchopneumonia may also be observed.

Bronchoscopic inspection of the changes in the smaller bronchi during life have been made, among others by Schrötter,[1] and offers an explanation of the mechanical relations during inspiration and expiration. If the mucous membrane is only moderately swollen and the lumen still patent, inspiratory enlargement and expiratory narrowing of the passages can usually be observed. Even with apparent total occlusion of the bronchus, a quick forcible inspiration may open the lumen. Involvement of a large number of bronchi may considerably obstruct the inspiratory current of air, and the greater narrowing of an already contracted lumen during expiration will still further impede and delay the outgoing current. During forcible expiration with cough, the bronchial walls are everywhere pressed together. The bronchial secretion is momentarily held back and then moves upward with the sudden relief of the obstruction.

On microscopic examination of the acutely inflamed larger bronchi, swelling and degenerative changes may be observed in the ciliated epithelial cells. The epithelial layer and the tunica propria, and in severe grades of inflammation, even the muscular fibers, the mucous glands, the neighborhood of the cartilages and the fibro-elastic tunic are infiltrated with polymorphonuclear leukocytes. Desquamation of the epithelium takes place. The capillaries of the tunica propria

[1] Klinik der Bronchoskopie, 1906, p. 184.

are swollen and engorged with blood. The mucous glands of the bronchial wall are in a condition of active secretion and drops of mucus or mucopus may be found protruding from the orifices of their excretory ducts. Müller[1] found the goblet cells not only of the larger, but also of the medium and finer bronchi, increased in number on comparison with preparations from normal bronchi. The abundance of mucus is to be ascribed to increased activity of the mucous glands and proliferation of the goblet cells.

Symptoms.—Prodromata are usually lacking. The attack commonly begins as a "cold" in the nose or as a sore throat. In children the adenoid tissue in the nasopharynx is frequently the starting-point of the infection. At the onset there is chill or chilliness, headache, malaise, general pains, loss of appetite, and slight elevation of temperature. The fever seldom rises above 101° to 102° in adults, but may be higher in children. All parts of the tract may be involved in the course of a day or two by extension downward, or the tracheobronchial region may be primarily invaded. Attacks vary in the intensity and extent of the tracheobronchial manifestations. The disturbance may be limited to the trachea and larger bronchi, involve as well the medium and smaller passages or extend to the bronchioles and the lung.

The first intimation of the tracheobronchial involvement is usually a sensation of persistent tickling or irritation in the cervical and substernal course of the trachea, and this may be increased by tracheal pressure or extension of the head, putting the trachea on the stretch. Implication of the larynx may be indicated by hoarseness or aphonia.

Cough begins at once, and is usually constant, harassing, and without expectoration. At this stage it is largely reflex and due to the irritation of the trachea and bronchi, the most sensitive parts of which are the posterior walls and the regions just below the glottis and the tracheal bifurcation. It may be paroxysmal, and in children, spasmodic partial closure of the glottis may give rise to a stridulous inspiratory sound resembling the whoop in whooping cough. The cough is aggravated by talking, crying, excitement or change of temperature, and is likely to be worse at night, perhaps because of restricted expansion of parts of the lung and a tendency of accumulated secretion to irritate the more sensitive posterior regions in the prone position. The lung itself is insensitive and lesions here do not excite cough. In conditions of extreme weakness or somnolence cough may be absent. In children a severe attack of cough is frequently followed by vomiting, which is seldom observed in other than highly sensitive adults.

The rate of respiration is usually unaltered in uncomplicated cases beyond such acceleration as can be ascribed to the fever. A more rapid rate suggests a pulmonary complication. Dyspnea is not ordinarily a feature of uncomplicated bronchitis of the larger passages, but is one of the most important symptoms of involvement of the

[1] Deut. Klinik, 1903–04, p. 245.

smaller tubes, and its degree may well be taken to indicate the severity and extent of the disturbance. The dyspnea is both inspiratory and expiratory, never exclusively inspiratory as in laryngeal stenosis.

Moderate elevation of temperature is common during the first twenty-four to forty-eight hours of the attack, after which it usually falls to normal even though the cough and expectoration continue. Persistence of fever without abatement for longer than two to three days, or an elevation following a previous decline, suggests a complication with the chances in favor of bronchopneumonia. The fall in the temperature is usually by lysis. The pulse is elevated in proportion to the fever.

Pain is not ordinarily a feature, but for some days after an attack during which there has been much irritative cough, the lower parts of the chest and the epigastrium may be painful, with deep inspiration and cough, and tender on pressure in consequence of muscular strain.

Digestive disturbances are usually limited to anorexia in adults and vomiting in children. During the attack the tongue may be coated. Some loss of weight and strength are common. Sputum may be obtained with difficulty or not at all in children, the aged, and in extreme adynamia from any cause. It is usually then swallowed and not expectorated. It is at first mucoid (sputum crudum) and scanty, but soon becomes mixed with small white or yellowish streaks and masses of purulent material, and is then spoken of as mucopurulent (sputum coctum). As the disturbance progresses, and frequently after the subsidence of the acute symptoms, it becomes more and more purulent and yellowish or yellowish green in color. It is seldom abundant in uncomplicated cases unless the bronchial involvement has been severe and extensive. Gradually diminishing cough and expectoration may outlast the acute symptoms for several weeks. The sputum may be blood-streaked or faintly blood-tinged, but frank admixture with blood is uncommon with simple bronchitis and bronchopneumonia, and the rusty tenacious sputum of croupous pneumonia is almost never seen. Microscopic examination of the mucoid sputum of the early period shows oftentimes an abundance of ciliated epithelial cells, occasional red-blood corpuscles, and a few large epithelial cells with vacuolated single nucleus and pigment-containing protoplasm. As the sputum becomes more purulent, the number of pus cells increase and the ciliated epithelial cells diminish or disappear. The bacteriologic findings have already been described.

Signs.—There are no physical signs in the milder cases with involvement alone of the trachea and primary bronchi.

Inspection is usually negative, but diminished inspiratory expansion of the affected side may be observed with unilateral bronchitis and cyanosis, rapid and superficial breathing and dyspnea with extensive bilateral involvement of the finer passages. Inspiratory depression of the lower sternal and lateral aspects of the chest may also be noted. On *percussion* there are no changes with the exception of circumscribed

dulness with atelectasis or hyperresonance with emphysema. On *palpation* delayed inspiratory motion of an affected region and coarse rales may be felt.

The most important and often the only evidence of bronchitis is obtained on *auscultation*, by means of which the distribution in respect to the various parts or the whole of both lungs and the size of the affected tubes may be determined. Auscultation is usually negative when the disturbance is limited to the trachea and primary bronchi, but coarse, sonorous sounds over both lungs may be due to secretion in the trachea or at the tracheal bifurcation.

Inflammation of the medium and smaller bronchi may be indicated at first, while there is swelling of the mucous membrane without any considerable amount of fluid by dry rales of a sonorous or sibilant quality. The rales are due to the vibration of viscid secretion lining the wall or traversing the lumen of the passage or to the motion of air through the narrowed channels. The sonorous rales usually arise in the larger and the sibilant rales in the smaller bronchi. They are commonly of about equal intensity over both lungs, and may be audible to the patient as well as the examiner or even at a distance.

Later in the course of the disease, moist non-consonating rales appear during both inspiration and expiration. They are due to the bubbling of air through fluid in the bronchi and are coarse, medium or fine, according to the size of the affected passage. They are to be distinguished by their less clear-cut, sharp and distinct quality from the moist consonating or resonant rales which arise in bronchi surrounded by consolidated pulmonary tissue, a distinction which is important but not always easily made. Fine non-consonating moist rales may be distinguished from fine crepitation heard at times during deep inspiration at the pulmonary margin of persons in health, and over atelectatic areas by the smaller size of the latter and their disappearance after repeated deep breathing or cough. Moist non-consonating rales may be evenly distributed over all parts of the chest, but are usually more numerous at the bases in uncomplicated bronchitis. It is important to determine and record their distribution, which is often variable in successive examinations. The posterior and lower parts of the chest are most often affected. It may be stated as a general rule that whether non-consonating or consonating, the persistence of rales over any one place in the lung is evidence not of bronchitis alone, but of invasion of the pulmonary tissue in the region in question, even without other evidence of involvement of the lung. Persistence of rales at the apices almost invariably indicates pulmonary tuberculosis, but may be due to other causes.

Changes in the character of the breathing may be noted. A diminished respiratory murmur over regions supplied by the involved bronchi is common and due to diminished ingress and egress of air through the narrowed channels. At times, especially in infants and young children, the breath sounds may be absent in consequence of complete occlusion

of the tubes and atelectasis of the corresponding territory. If the patient is asked to breathe deeply or cough, the dislodgement or removal of secretion may be followed by normal breathing. Another change of frequent occurrence is a prolongation of expiration which arises in consequence of the greater narrowing of an already contracted lumen and delay of the outgoing current of air during this phase of respiration. Rough or uneven inspiration is occasionally heard and may be ascribed to variation in the caliber of the bronchi from adherent secretion. Cog-wheel breathing may also be heard. In some cases the rales are so loud or abundant as to make the respiratory murmur inaudible.

Complications.—The acute infections of the respiratory tract are not infrequently complicated by otitis media and at times by involvement of the accessory nasal sinuses. But the most common complication is bronchopneumonia which invariably accompanies capillary bronchitis and is frequent in the more severe types of infection involving the medium and smaller bronchi. Acute bronchiectasis may develop in consequence of the bronchopulmonary infection. When pleuritis is observed in the course of bronchitis, a complicating bronchopneumonia is also likely to be present.

Diagnosis.—The onset with catarrhal symptoms in the nose and throat followed by a sense of irritation along the course of the trachea and cough and expectoration running a mild and short course are the chief clinical features. The absence of physical signs on examination of the chest is to be expected when only the trachea and primary bronchi are involved. The secretion from nasopharyngeal catarrh may be expectorated by cough, and in doubtful cases an inspection of these regions and the trachea will be helpful. Laryngoscopic examination and the finding of redness and secretion in the trachea may be needed to establish the deeper parts of the tract as the source of the expectorated material. The presence of rales is confirmatory, and from their character and distribution certain deductions, already discussed, may be drawn concerning the parts of the bronchial tree affected.

For the present there are no means of differentiating the simple infections which start as a "cold" from cases of sporadic influenza, and no clinical distinction can be made between infection with the pneumococcus, the pyogenic cocci, the influenza bacillus and the Micrococcus catarrhalis, singly or combined. Measles should be considered in the presence of an acute infection of the upper respiratory tract, and may be suggested by a history of exposure, the presence of oculonasal catarrh, and the discovery of Koplik's spots before the rash appears. Whooping cough may be simulated in children with paroxysmal cough, accompanied by cyanosis and dyspnea and terminating in an attack of vomiting, but the characteristic inspiratory whoop is lacking in the simpler infections. Tracheobronchitis occurring in the course of typhoid, should be suspected when the fever

persists longer than a few days and may be established early by blood-cultures, investigation of the urine and stool for typhoid bacilli, and later by rose spots, enlargement of the spleen and positive Widal test. There are cases of syphilis in which tracheobronchial catarrh is a prominent symptom during the secondary and tertiary period, and if this disease cannot be otherwise excluded a Wassermann test should be made. Bronchostenosis should be considered in cases without preceding catarrhal symptoms in the nose or throat and with paroxysmal cough and dyspnea.

An acute bronchitis may precede or accompany croupous pneumonia, and twenty-four to forty-eight hours may elapse from the beginning of the latter without evidence of pulmonary consolidation on physical examination. If the initial chill and pain in the side are absent, the pneumonia may not be suspected. High and persistent fever, marked toxic symptoms and rusty sputum occurring in what seems a simple bronchitis should suggest croupous pneumonia even in the absence of other signs which are likely to appear later.

Infection of the deeper parts of the bronchial tract is likely to be followed by bronchopneumonia of which there may be little or no evidence on physical examination. The differentiation between early pulmonary invasion with the tubercle bacillus and the more persistent types of infection with other organisms considered in this section, is an ever-present difficulty which cannot be resolved by the absence of tubercle bacilli and the finding of other organisms in the expectoration. The distinguishing features of bronchitis, simple bronchopneumonia, and pulmonary tuberculosis are contrasted in the section on Bronchopneumonia.

Examination of the sputum is important, and material may be obtained in children by exciting a cough by irritation of the pharynx and catching the resulting expectoration on a swab. Bacteriologic examination so far as the common organisms is concerned, is rather of academic than of practical interest, but should be made for the purpose of finding tubercle bacilli, the diphtheria bacillus or other specific organisms.

Course and Prognosis.—In primary tracheobronchitis the prognosis is good, and the acute symptoms are commonly over in the course of a few days, but the cough and expectoration usually continue with diminishing severity for a period of from ten days to two weeks or longer. In infants and young children and in the aged, or in those already gravely ill from another cause, the outlook is less hopeful, largely owing to the frequency with which bronchopneumonia arises as a complication. Even in healthy adults there is a tendency of the severe infections to end in permanent damage to the pulmonary substance, but such a termination is also to be ascribed to bronchopneumonia. In patients already subject to infection with the tubercle bacillus, a previously inactive or slowly advancing tuberculous lesion may be excited to more rapid progress.

Prophylaxis.—In view of the contagiousness of the acute respiratory infections, isolation should be practised when possible, and the patient and family instructed concerning measures of protection. The sputum should not be allowed to dry, but should be expectorated carefully into a special receptacle without soiling the beard or moustache. If the patient coughs or sneezes, expelled particles of sputum should be caught in a piece of cloth placed in front of the mouth. Soiled cloths may be placed in a paper bag pinned to the bed and later burned or washed after boiling. The fingers should not be moistened in the mouth in turning the leaves of books, public documents, etc. Soiled bed and body linen should be boiled before being sent to the laundry. Thermometers and table utensils should be kept separate. Dusting should be done with a damp cloth and sweeping with a damp broom. An infected individual should sleep alone. An abundance of sunlight and fresh air limit the danger of contagion. Expectorated material should be burned. These and other recommendations similar to those applicable to the prevention of pulmonary tuberculosis may be made for the simpler respiratory infections.

Persons subject to repeated attacks of acute respiratory infection should be especially careful to avoid exposure to wet and cold. Some protection may be afforded by thin woolen underwear and such efforts at increasing resistance as sleeping with the window open, spending much time in the open air, and cool morning baths followed by friction. A good reaction should follow the bath. It is well to begin the hardening process in warm weather. Enlarged tonsils and adenoids may be the starting point of the infection, and if so, their removal should be considered.

Treatment.—There is no specific treatment. In the majority of cases the disease runs its course quite independent of attempted relief. The most important measures are those undertaken to spare the strength of the patient and alleviate symptoms.

Even the mild cases should be regarded as serious because of the proximity of the infection to the lung, and the patient should be confined to the house and the bed and remain there until the acute symptoms and fever have subsided. A milder and shorter course with less danger of complications may be expected when this is done. Smoking should not be allowed and conversation should be reduced to a minimum. At the onset the patient may take a hot bath and then get to bed between warmed blankets with hot-water bottles at the feet. A drink of hot lemonade may start perspiration which often seems to relieve the headache and general pains. Chilling of the body may be followed by an aggravation of symptoms, and cold should be limited to cold applications for the relief of pain.

There are no special restrictions concerning diet, and the patient may take as much of light and easily digestible food as he likes.

Medicines are often unnecessary, but if the headache and general pains are distressing, an ice-cap and Dover's powder gr. 10 (0.650

gm.) may be ordered. If the bowels have not moved, a mild saline, as sodium phosphate gr. 30 (1.950 gms.), in a half-tumbler of lukewarm water, may be given. The coal-tar products should be used with caution, but if the headache or general pains are distressing, antipyrin or phenacetin gr. 10 (0.650 gm.), combined with caffein gr. 3 (0.195 gm.), may give relief, but their use should not be long continued. Aspirin gr. 10 (0.650 gm.) may also be tried.

If the patient is harassed by irritative and unproductive cough which disturbs his sleep and unnecessarily taxes his strength, heroin gr. $\frac{1}{12}$ (0.0054 gm.) or morphin may be used. Cough is necessary for the expulsion of secretion which, if it remains, may increase the danger of atelectasis or aspiration pneumonia, and narcotics should not be used without such a special indication and only as a temporary expedient.

When a scanty and tenacious sputum is raised with difficulty, a stimulating expectorant such as ammonium chloride gr. 10 (0.650 gm.) often seems to be of great assistance. Senega and squill are at times used, but are less desirable. Nauseating expectorants such as tartar emetic, ipecac, apomorphine, etc., are unnecessary in simple bronchitis.

2. CAPILLARY BRONCHITIS.

Infection of the finer ramifications of the bronchial tree is always accompanied by invasion of the adjacent parts of the lung, and it therefore seems best to consider capillary bronchitis in connection with bronchopneumonia.

3. CHRONIC BRONCHITIS.

This is usually to be regarded as a symptom of some more important and more serious underlying disease rather than as an independent condition. It is difficult to distinguish between catarrh and inflammation of the bronchi. In passive congestion of the lungs and bronchi, and in bronchial asthma, the bronchial disturbance is usually at first catarrhal, and becomes inflammatory only after an infection complicates the process, but it is difficult to judge when the one ends and the other begins, and it therefore seems best to describe the two conditions under a common heading.

Etiology.—There are three groups of cases depending on the seat of the underlying disease in the circulatory system, the lungs or the bronchi.

Circulatory System.—Passive congestion of the pulmonary circuit in consequence of cardiac insufficiency is the most common cause, and the resulting bronchial disturbance is often spoken of as a "stasis catarrh." This occurs in a small proportion of patients in the later stages of broken

compensation from valvular disease, or chronic adhesive pericarditis and myocardial weakness from disease of the coronary arteries, arteriosclerosis of the aorta or chronic nephritis. Syphilitic aortitis is not uncommon as a cause of the cardiac failure. Aortic aneurysm may be a cause as the result of congestion of the pulmonary circuit from cardiac insufficiency or give rise to localized forms of chronic bronchitis in connection with bronchostenosis from compression of the bronchi. Of 161 cases with symptoms of chronic bronchitis coming to autopsy at the Massachusetts General Hospital, the condition was apparently due to circulatory disturbance in consequence of such causes as those just mentioned singly or combined in 103 (63 per cent.). In seven of nine patients who gave a history of regularly recurring winter cough, cardiac insufficiency in consequence of arteriosclerosis of the aorta, valvular disease or chronic nephritis was found at autopsy as a probable underlying cause. An aggravation of the cardiac failure during the stress of winter weather is probably responsible for the majority of such cases. In others, the winter cough may be ascribed to a mild and persistent infection with organisms always present and ready to multiply under the conditions of lowered resistance.

Pulmonary Disease.—Of diseases of the lung, infection with the tubercle bacillus occupies first place, and is represented in this series by 31 cases (19 per cent.), of which 22 were chronic ulcerative tuberculosis, and the remaining nine the miliary form of the disease. Concerning miliary tuberculosis, it should be noted, however, that bronchitis is an unusual feature, and that a large majority of such cases run their course without bronchial manifestations. As in the bronchitis of stasis, so here also the growth of organisms commonly present in the respiratory tract is probably favored by the abnormal local conditions, and the bronchitis is due not to the tubercle bacillus but to secondary invaders. The most striking example of such secondary invasion occurred in a patient with an intense and persistent general bronchitis and the constant presence of pneumococci in the sputum. Postmortem examination after an illness of eleven weeks showed disseminated miliary tubercles in the lungs and other organs. Recurring winter cough may be observed in chronic pulmonary tuberculosis, as in one of this series.

Non-tuberculous pulmonary infection is responsible for a large proportion of the remaining cases. Measles, whooping cough, and "grippe" may initiate the disturbance. Chronic infection in the upper parts of the tract such as rhinitis, pharyngitis or tonsillitis may be the starting point of the disease. The inhalation of dust as a carrier of infectious material is a predisposing cause. Non-tuberculous pulmonary infection in the form of subacute or chronic bronchopneumonia, lobar pneumonia with abscess formation and abscess and gangrene was found at autopsy in 15 (9 per cent.) of the cases in this series. Bronchiectasis was associated in 4 cases. Abscesses too small to give rise to physical signs may be demonstrated at autopsy in a

small proportion of the bronchopneumonias, and such defects may remain in those who survive as permanent pockets for the development of bacteria. Elastic tissue with an alveolar arrangement may occasionally be found in the sputum without evidence of losses of pulmonary substance on physical examination and in the absence of tubercle bacilli, and it is probable that persistance of cough and signs of localized or diffuse bronchitis are usually due to chronic pulmonary infection. Chronic bronchitis develops in the tubes leading to the infected territory, and this is in turn followed by bronchiectasis.

Malignant disease of the lung or mediastinal glands may be complicated by chronic bronchitis. There were 5 such cases in the present series. Echinococcus disease, distomatosis, pulmonary embolism and thrombosis, syphilis, actinomycosis and pneumonoconiosis may be similarly complicated.

Bronchial Disease.—There are cases in which attacks of bronchitis recur during a period of many years, finally terminate in more or less persistent cough and expectoration, and at autopsy the bronchi are diffusely involved with or without bronchiectasis. Emphysema is usually present, and the patients die from intercurrent pulmonary infection, progressive hypertrophy and dilatation of the heart, with increasing passive congestion, or pulmonary embolism and thrombosis. The absence of independent circulatory or renal disease suggests the dependence of the cardiac insufficiency on chronic bronchitis and emphysema. The clinical records of such cases usually indicate that they have suffered from bronchial asthma, as in six cases (3.7 per cent.) in the present series.

It is possible that a chronic diffuse catarrh may remain limited to the bronchi and exist as an independent condition apart from passive congestion, pulmonary disease or bronchial asthma, but it is difficult to understand how an infection can remain strictly limited to the bronchi for long periods without extension of the inflammation to the peribronchial and pulmonary tissue. Diffuse purulent bronchitis and bronchiectasis may be seen in connection with chronic interstitial pneumonia and multiple pulmonary cavities without a history of asthma, and the bronchial manifestations may predominate in the clinical picture, but it is difficult to differentiate the site of the primary disturbance in such cases in the lung or the bronchi.

Many cases of asthma are sooner or later complicated by bacterial infection, and their classification in this or the preceding group may then be difficult of determination. It is to be remembered also that bronchial asthma is relatively uncommon in comparison with other causes of chronic bronchitis, and that asthmatic symptoms are frequent in patients with passive pulmonary congestion from cardiac insufficiency.

Chronic bronchitis is observed in connection with bronchostenosis from any of the causes mentioned in the preceding sections. Syphilis of the trachea and bronchi was found at autopsy in one patient who

had complained of recurring winter cough and died of hemorrhage from rupture of a syphilitic cicatrix of one of the primary bronchi into the left pulmonary artery. The pressure on the trachea or bronchi of enlarged tuberculous mediastinal and bronchial glands may give rise to irritative cough and is more especially a cause in children.

Disease of the Nasopharynx and Tonsils.—In children, and at times in adults, enlargement of the tonsils, the adenoids and other lymphoid tissue of the nasopharynx is associated with chronic nasopharyngeal catarrh and mouth breathing. Secretion which accumulates on the posterior pharyngeal wall is hawked up or expelled by cough. Some irritation of the larynx and hoarseness may also be present. Infection in the tonsils or adenoids may be the starting point of infections of the deeper parts of the tract.

Other Causes.—There has been a disposition to regard many cases of chronic bronchitis as due to a constitutional anomaly and to include under this heading those examples of the condition in which the cause is vague or intangible. The study of the 161 cases in this series, however, seems to indicate that while for long periods the cause may be obscure and perhaps undiscoverable clinically, yet the cases can be grouped almost without exception under the three classes already given when postmortem examinations are made, and many cases ascribed to indefinite causes probably belong in one of the groups cited above. Cases due to cardiac decompensation have probably most often given rise to confusion owing to the difficulty of deciding clinically whether the circulatory disturbances are primary or secondary.

An inherited disposition to chronic bronchitis has been noted by various writers, but is probably of little moment except in so far as a tendency to the development of arteriosclerosis or bronchial asthma can be regarded as a family disease. Gout and obesity are of importance as factors in leading to disturbances in the circulation and cardiac weakness. Alcohol has been regarded as a cause and its excretion by the bronchi suggested in explanation. Among the Germans, "schnapps-catarrh" is a recognized form, but stasis in the pulmonary circuit is a more probable cause. Contagion is of importance in those forms in which an infection can be transmitted from person to person. There is no evidence that the use of tobacco is capable of causing bronchitis. The alternation of attacks of eczema and bronchitis has been thought to indicate a relation between the two, but is so uncommon as to suggest nothing more than coincidence. The supposition that bronchitis can be referred to disturbances in the gastro-intestinal tract has no foundation in fact. Such terms as dentition-, stomach-, liver-, intestine-, spleen-, and uterine-cough and arthritic- and albuminuric-bronchitis are far from describing any actual condition.

Age and Sex.—Age is of some importance in the etiology, but very variable in the individuals making up the different groups. Patients

with arteriosclerosis as a cause are usually past middle life and often over sixty, while those with valvular disease and pulmonary infection average between thirty and forty when they first come under observation. Of the 6 cases with bronchial asthma, two were forty, two between thirty-five and forty, and one twenty-five at the onset of symptoms. The last patient, a woman of sixty-five, stated that she had had asthma "all her life." Males in general far exceed females, the proportion being 3 : 1 in this series.

Pathology.—The changes are variable. Swelling and redness may be seen in the chronic as in the acute form. This represents what may be spoken of as the hypertrophic variety, in which the mucous membrane is thickened and indurated and presents a villous, shaggy, or velvety appearance in consequence of the abundant new formation of bloodvessels. Proliferation of the glands may also take place. Microscopic examination may show cellular infiltration of all parts of the bronchial wall. The thickening and induration may extend to the peribronchial and neighboring pulmonary tissue. In the atrophic form, following the round-celled infiltration and transformation into connective tissue, the glands, muscle fibers and even the cartilages atrophy and the mucous membrane is desquamated. Ulceration of the mucous follicles may be observed. The bronchi are converted into inelastic tubes and are often dilated in consequence of the stasis of secretion and the pressure to which they are subjected by cough with the glottis closed. Emphysema may occur, and is most common when asthma is the underlying cause of the bronchial changes. Hypertrophy and dilatation of the heart may be a consequence of the increase of pressure in the pulmonary circuit.

Symptoms.—Cough, expectoration and varying degrees of dyspnea are common to all cases, but the order of their appearance, their intensity and character differ in the different groups.

With passive congestion as a cause, dyspnea is usually the first symptom and cough is added after a longer or shorter interval. In other cases cough and dyspnea occur together at the onset. In rare instances, cough is the first symptom and after a time is followed by dyspnea. This unusual sequence is illustrated in the case of a man aged sixty-six years (Autopsy 462) who complained of cough, scanty expectoration and wheezing, more especially at night, for two to three winters, but without dyspnea until about nine months before his death. The dyspnea was then only slight and did not prevent continuance at his work of lifting in a lumber yard. Edema appeared two or three weeks before his death, and at postmortem examination the aorta and great branches were dilated, tortuous, and markedly sclerotic. The heart was hypertrophied and dilated, but there were no other significant changes than a marked degree of chronic passive congestion in the lungs, liver, spleen and kidneys, and hydrothorax and anasarca. In this group, the cough is usually little troublesome at first, may be started by some unusual exertion and persist for a time thereafter, or

occur on lying down or in the morning on rising. It may be accompanied or replaced by wheezing. Once started, cough is usually persistent throughout the course of the disease, but may consist of a succession of attacks, each tending to last longer than those which have preceded. Such attacks are more likely to occur in the winter months, with partial or complete freedom during the summer. They usually differ from ordinary attacks of bronchitis in the absence of initial symptoms referred to the upper parts of the tract, the scanty expectoration and afebrile course. The cough may long precede death. Among 106 cases in this series, 32 had lasted one year or longer, and of these, 14, five years or more, and 2, twenty to thirty years. Expectoration is at first absent, or scanty, and usually consists of only small amounts of frothy, white, thin, watery or mucoid material, with or without blood in streaks, masses or homogeneous admixture. Copious amounts of sputum may be seen with acute pulmonary edema. If an infection is present, the sputum is mucopurulent or purulent.

The dyspnea is at first chiefly noted on exertion, finally becomes persistent, and is likely to be worse at night. Attacks resembling bronchial asthma may be observed. Orthopnea and edema occur late in the course of the disease. On examination the lungs may be negative, or non-consonating fine, medium or coarse rales may be heard. They may be confined to the bases behind or at times are more widely distributed over the chest, but most numerous at the dependent parts. In some cases sibilant and sonorous rales are heard throughout both lungs. Emphysema is a complication in rare instances. The pulmonary symptoms and signs do not differ in any essential particular according to the cause of the cardiac failure, but a clinical distinction can usually be made between the different causes from other features of the case. A further discussion of passive congestion will be found in the section on that subject.

When bronchitis occurs as a complication of tuberculous or non-tuberculous pulmonary infection, it is usually characterized by cough as an early symptom and the expectoration of mucopurulent or purulent sputum. In both groups the chronic cough may be initiated by some well-defined acute infection, but in many instances the onset is insidious. Cough and expectoration are the most prominent features of the illness. Dyspnea becomes manifest after some time has elapsed and in consequence of the extension of the lesions or the development of emphysema. Climate and season influence such cases, an improvement being almost constantly observed in a warm equable temperature with freedom from dust, and during the summer months. These causes are for the most part concerned in the production at first of localized forms of bronchitis, but as the disease progresses, bronchopulmonary infection may spread from the original site of infection to the greater part or the whole of one or both lungs. General emphysema and symptoms of cardiac weakness are uncommon unless the pulmonary infection is a complication of asthma. In non-tuberculous

cases the course is afebrile unless complicated by intercurrent bronchopneumonia or other septic infection.

The chronic bronchitis of asthma is characterized by the occurrence of sudden attacks of dyspnea, affecting both phases of respiration, but especially expiration. Emphysema is almost constantly observed. Sibilant and sonorous rales throughout both lungs are usually present. An eosinophilia in the sputum and the circulating blood may be determined. Curschmann spirals and Charcot-Leyden crystals may also be found. The disease usually begins under forty and may last for many years. By the time persistent cough and expectoration have developed, the sputum is likely to have changed from its tenacious mucoid character to mucopurulent or purulent. The condition is further discussed in the section on Asthma.

Clinical Varieties.—If cases are grouped according to the character of the expectoration, the following classes may be observed.

1. **Dry Catarrh.**—*Catarrhe sec* is a term applied by Laënnec[1] to an inflammation of the bronchi with little or no expectoration. The expectoration when present consists of small, tenacious, grayish, semitransparent masses not unlike boiled sago, and was termed *crachats perlés* by Laënnec. Microscopic examination shows numerous large round, mononuclear cells resembling alveolar epithelium and often containing pigment granules. Ciliated epithelium, polymorphonuclear leukocytes, eosinophiles and bacteria are usually present only in small numbers. Dyspnea is a prominent symptom, at first only on exertion, later while at rest, and at times to such a degree as to resemble that in asthma. Cough and expectoration begin toward the termination of the attack, and with their appearance the dyspnea diminishes. The cough may be dry, or for the most part without expectoration and recurs only once in the twenty-four hours or only every two or three days. It may cease during the summer. On examination an occasional sibilant or non-consonating moist rale may be heard. In places the respiratory murmur may be diminished or absent for a time, and then again become normal, probably in consequence of varying degrees of engorgement of the bronchial mucous membrane over the affected regions and the occlusion of the passages by tenacious secretion or its expulsion by cough.

Pathologically, according to Laënnec, the mucous membrane of the bronchi is swollen and of a red or violet color. The swelling is most marked in the small branches which may at times be entirely obstructed. The obstruction may be due to swelling of the mucous membrane or to the accumulation of viscid secretion such as that found in the sputum. Extensive or universal involvement of the bronchi is followed by the development of emphysema.

The cause of the *catarrhe sec* of Laënnec is not clear. The cases conform in their clinical aspect to those in which passive congestion

[1] Traité de l'auscultation méd., T. i, p. 203.

is responsible for the symptoms. Slight degrees of congestion in the pulmonary circuit may predispose to catarrhal inflammation and an increased secretion from the bronchial mucosa. The cardiac weakness is insufficient in degree to give rise to outspoken pulmonary edema or the expectoration of serous fluid. Bronchial asthma may be concerned in some cases and is more likely to be a cause in those with emphysema.

2. **Eosinophile Bronchitis.**—Under this title, Teichmüller[1] has described a form of chronic bronchitis in which there is a greater number of eosinophiles than in ordinary bronchitis. There is moderate dyspnea and in the less favorable, relapsing cases emphysema of the pulmonary margins. Dry sonorous and sibilant rales and prolonged expiration are heard on auscultation. The sputum is transparent and mucoid. Eosinophiles are present in abundance in the mucus, and here and there may be the only cells in the cellular parts of the sputum. Desquamated bronchial epithelium and red-blood cells are uncommon. Charcot-Leyden crystals may be present and imperfectly developed forms of Curschmann's spirals with central threads are at times found. Müller[2] found an eosinophilia of 10 to 13 per cent. in the blood of one case.

The disturbance is probably a rudimentary form of bronchial asthma. Varying and usually only small numbers of eosinophiles are found in the sputum in acute bronchitis and in chronic bronchitis secondary to passive congestion and tuberculous and non-tuberculous pulmonary infections. For the demonstration of eosinophiles in sputum, Teichmüller spreads the sputum on a glass slide, allows it to dry in the air and fixes it over the flame. While still warm the slide is immersed in 0.5 per cent. alcoholic eosin solution for five minutes or longer. The preparation is then washed in water and counterstained by the application for two minutes of a concentrated aqueous solution of methylene blue. Only the eosinophiles retain the eosin and may be readily recognized even under the low power of the microscope.

3. **Mucopurulent and Purulent Bronchitis.**—The sputum may be largely mucoid with admixture of pus in small streaks or points, or consist of larger purulent balls, each surrounded and prevented from confluence by a layer of mucus. The amount is variable. In long-standing cases in which the bronchitis is diffuse and associated with bronchiectasis, the daily amount of purulent sputum may reach a pint or more. In cases in which the bronchial mucous glands are atrophied the sputum may consist of homogeneous pus with little mucus. Discrete purulent masses surrounded by mucus are also seen with ulcerative tuberculosis, pulmonary abscess and empyema or subdiaphragmatic abscess perforating the lung when the purulent material is slowly expectorated. If large quantities are rapidly evacuated from a cavity the pus is homogeneous and little mixed with mucus.

[1] Deut. Arch. f. klin. Med., 1898, vol. lx, and ibid., 1899, lxiii, 444.
[2] Deut. Klinik, 1903-07, p. 278.

Bacteriologic examination usually shows a mixed infection with two or more organisms, among them the influenza bacillus, Micrococcus catarrhalis, the pyogenic cocci, pneumococci, Bacillus mucosus capsulatus, and the Streptococcus capsulatus. Comparatively pure infections with one organism may be demonstrated and the influenza bacillus is apparently concerned in the largest number, with other organisms in a smaller proportion of the chronic cases. Repeated examination over long periods usually shows that one group of organisms does not long remain unmixed in the sputum.

The purulent forms of bronchitis are not independent affections. In many cases the clinical picture may be predominantly bronchial and there may be no evidence of pulmonary involvement on examination. Invasion of the pulmonary tissue may safely be assumed in chronic cases, however, from the experience at the autopsy table. With the chronic bronchitis, bronchiectasis, peribronchitis, pulmonary abscesses, and chronic interstitial pneumonia are to be expected.

4. **Putrid Bronchitis.**—Fetid expectoration is occasionally observed in bronchitis in connection with bronchiectasis, abscess, gangrene, ulcerative tuberculosis, chronic indurative pneumonia, and empyema or subphrenic abscess perforating the lung. It is doubtful if it exists as a chronic condition other than in connection with changes in the lung. The cause of the putrefaction is not clear. The sputum is abundant and foul, of a dirty green or yellowish color, and on standing tends to separate into an upper greenish yellow, opaque fluid capped with frothy mucus, a middle zone of more transparent serous fluid and at the bottom a sediment of thick pus in which at times may be found dirty yellow or white mushy, soft, foul-smelling masses varying in size from that of a millet seed to a bean, the so-called Dittrich's plugs. Microscopic examination of these masses shows numerous bacteria, leptothrix threads, fatty acid crystals, occasional pus cells, and detritus. Symptoms of sepsis are usually present and extension of existing bronchopulmonary suppuration is likely to take place into previously uninvolved regions. Acute cases may recover, but in the chronic cases the outlook is grave.

5. **The Serous Form of Catarrh.**—(*Bronchorrhea serosa.—Catarrhe pituiteux of Laënnec.*)—In this uncommon form a profuse liquid, watery, clear or cloudy fluid, with a variable amount of mucus is expectorated. Müller[1] finds the specific gravity low (1004), albumin present only in traces, and on microscopic examination only few cells, among which eosinophiles predominate. Isolated Curschmann spirals and Charcot-Leyden crystals may also be found. Fluids of this character are consistent with increased bronchial secretion and may be found with asthma (asthma humidum). Müller observed the expectoration of as much as a liter a day of thin, frothy sputum, with a specific gravity of 1003 and almost free from albumin in a

[1] Deut. Klinik, 1903–07, iv, 279.

patient with myasthenia gravis pseudoparalytica. Isolated Curschmann spirals, but no increase in eosinophiles and no crystals were found. Large amounts of thin, foamy sputum were also expectorated by a patient with severe acute polyneuritis of unknown origin. In this case a rapid pulse suggested involvement of the vagus in the neuritic process. The patient recovered and with the fall in the pulse rate the abundant sputum stopped. Thin, fluid expectoration may also be seen as a result of pulmonary edema from passive congestion or following thoracentesis (albuminous expectoration). A larger percentage of albumin and higher specific gravity will serve to differentiate such forms from the preceding. Wanner[1] estimates the amount of albumin after removal of mucin by the addition of acetic acid. To a measured quantity of sputum 3 per cent. acetic acid is added. The mixture is energetically shaken, and the precipitated mucus filtered out. The albumin is estimated directly in the acid filtrate by means of potassium ferrocyanide solution or coagulated by heat after neutralization with sodium carbonate or sodium hydrate.

Complications.—Emphysema is one of the most frequent complications. It may be seen in all forms of chronic bronchitis, but is most frequently observed with asthma. Peribronchitis, bronchiectasis, and acute and chronic pulmonary infection are common. Increased resistance in the pulmonary circuit in consequence of emphysema may induce cardiac hypertrophy and dilatation. Clubbing of the fingers and toes may be noted. It is more common in connection with bronchiectasis than with other forms of bronchitis and is more fully considered in that section. Metastatic cerebral abscess may complicate purulent bronchitis. Amyloid degeneration may be a consequence of long-continued bronchopulmonary suppuration.

Diagnosis.—Persistent cough, expectoration and rales establish the diagnosis of chronic bronchitis, but the diagnosis should never be allowed to rest here. Chronic bronchitis is almost invariably only a symptom, the cause of which must be determined before the problem can be regarded as solved.

Evidence of bilateral or diffuse chronic bronchitis occurring in a person past middle life and with winter or persistent cough and scanty expectoration should be suspected of cardiac origin. A history of dyspnea preceding the onset of cough, the signs of cardiac involvement from valvular, myocardial or pericardial disease, or the establishment of arteriosclerosis of the aorta, aneurysm or chronic nephritis are of importance in fixing the blame on the circulatory system. Attacks of dyspnea, cyanosis and cough with scanty sputum or wheezing beginning in persons past middle life are more often due to cardiac than to bronchial asthma.

Bronchitis due to tuberculous or non-tuberculous pulmonary infection may be distinguished by the occurrence of cough and mucopuru-

[1] Beiträge z. Chemie d. Sputums, Deut. Arch. f. klin. Med., 1902–03, lxxv, 347.

lent or purulent expectoration as an early and prominent symptom, with dyspnea as a later manifestation, other features of the history, and the signs of pulmonary involvement. Even without other evidence on physical examination of invasion of the lung, the persistence of rales at one place may be taken as an indication of involvement of the lung tissue rather than of the bronchi alone. Moist rales of a consonating character are also suggestive. The signs of cavity may be present. Examination of the sputum may show tubercle bacilli, actinomyces or elastic tissue with an alveolar arrangement. Radioscopic examination will assist in the interpretation. Tuberculosis should be rigidly excluded before a diagnosis of a simpler infection is made. In doubtful cases, tuberculin may be given after other means of investigation have been exhausted.

Bronchial asthma may be distinguished by a history of typical attacks beginning in youth or early life with intervals of comparative freedom or complete absence of pulmonary symptoms between the paroxysms. Examination of the sputum and the blood may assist in the diagnosis. Persistent cough, mucopurulent or purulent sputum, emphysema and dyspnea with signs of failing cardiac compensation may develop after a time, and it may then be difficult to differentiate between passive congestion with cardiac asthma and bronchial asthma with secondary cardiac insufficiency.

Diffuse rales with a sibilant and sonorous quality are common to both conditions, but more frequent with bronchial asthma. Emphysema of an extreme grade is seldon observed in passive congestion. It is common in bronchial asthma. Hypertrophy and dilatation of the heart from increased resistance in the pulmonary circuit is frequently associated with blowing systolic murmurs at the apex from relative mitral insufficiency, but hypertrophy and dilatation from other causes may be indicated by the presence of other valvular lesions. Primary myocardial disease may be suggested by a history of angina. Chronic adhesive pericarditis should be excluded. A rough systolic murmur of maximum intensity in the second right interspace and transmitted to the neck may indicate arteriosclerosis of the aorta. A positive Wassermann test may confirm the suspicion of syphilitic aortitis. Radioscopic examination will assist in the diagnosis of aneurysm. A blood-pressure of 200 mm. Hg. or over should suggest chronic nephritis.

Foreign bodies are to be considered in the localized forms of apparent simple chronic bronchitis, more especially in children. *X*-ray examination will be of assistance in their exclusion. Syphilis of the trachea and bronchi may be suggested by a history of the disease, late syphilitic lesions elsewhere, and a positive Wassermann test. Bronchoscopic examination may be of assistance in these as well as in other conditions.

Prognosis.—This is that of the underlying condition and is always serious. In the cases due to passive congestion, the outlook depends on the cause of the cardiac weakness and the possibility of adequate

measures for its relief. It can be estimated only after thorough consideration of the individual case, and even then only in general terms. In rare instances the bronchitis is one of the earliest manifestations and may precede death, as in one of the hospital series, for as long as thirty years. Much may depend on the period at which the diagnosis is made. The prognosis of the cases due to pulmonary infection and bronchial disease will be found in the separate sections dealing with the conditions to which the bronchitis is secondary. In some instances the bronchopulmonary infection may last for years and tens of years with little apparent disturbance of the general health. In one of the present series (Autopsy 1037) there was a history of cough and purulent expectoration for forty-four years.

Treatment.—As chronic bronchitis is usually a symptom and not an independent disorder, the treatment should be directed against the cause. It is important to remember that a cough which is due to excessive secretion is necessary for the expectoration of accumulated material, and that measures directed toward the suppression of the cough without removing its cause do not strike at the root of the trouble, and if successful, would be likely to aggravate the underlying disturbance. With the exception of syphilis, none of the conditions causing chronic bronchitis are susceptible of specific medication and cure. When an arrest of the process is secured, it is usually due to the recuperative powers of the patient, assisted, it may be, by helpful suggestions as to a more healthy mode of life. Reliance should be placed chiefly on the avoidance of deleterious influences and efforts to increase individual resistance. Vaccines, sera and drugs have thus far proved valueless as curative measures. Some alleviation of symptoms occasionally follows the use of certain drugs.

In cases in which the chronic bronchitis is dependent on failure of the circulation, the largest single group, treatment should be directed against the cause of the cardiac failure and the compensation restored and maintained. Although already existing lesions may be irremediable, yet an effort should be made to stop their further progress by appropriate means. Treatment against syphilis should be instituted in patients with this disease. Etiologic factors for other forms of arteriosclerosis should be sought and removed. Further infection of a chronic valvular endocarditis should, if possible, be prevented by removal of a primary focus of infection in any part of the body. The tonsils should be especially considered in this connection. Chronic nephritis, if present, should be treated. For the restoration and maintenance of cardiac compensation much may be done, and chief reliance may well be placed on measures which spare the already overtaxed heart. Rest is of prime importance, the amount recommended being dependent on the degree of decompensation. Directions as to the diet, the amount of liquid intake, the quantity of salt ingested, and the regulation of the bowels should be given. In the more severe types of cardiac failure digitalis should be used. If acute cardiac failure with overfilling of

the right side of the heart supervenes, venesection may be of great benefit.

The recurring winter cough of elderly persons is usually a symptom of cardiac strain during the stress of winter weather. An increased liability to bronchial infection obtains in some patients with mild degrees of broken compensation. For such patients, in addition to the means already indicated, such preventive measures as are mentioned under Prophylaxis in the chapter on Acute Bronchitis are applicable. If the financial status permits, the winter may well be passed in a southern latitude. An alleviation of or freedom from symptoms may be found in southern California, Florida, Cuba, Jamaica or Bermuda, in the United States, and the Mediterranean coast, Egypt, Sicily, Madeira, or the Canary Islands, in Europe.

The bronchitis secondary to pulmonary infection with the tubercle bacillus, or other organisms, should be treated as indicated in other sections. Rest in bed while there is fever, improvement of the nutrition by abundant food, and fresh air by night as well as by day are important in the non-tuberculous as in the tuberculous cases. The treatment of bronchial asthma, syphilis of the bronchi, foreign bodies, and other forms of bronchitis is considered elsewhere.

Measures applicable to all forms of bronchitis may be considered under the following headings:

Hygienic Treatment.—During exacerbations of the chronic form, as well as during acute attacks of bronchitis, it is well for the patient to remain at home, or if greater freedom is permitted, to allow him out in the open only when the air is still and free from dust. Mouth breathing should be avoided, and the clothing should be sufficiently warm to prevent chilling of the body. Woolen undergarments are to be preferred both for summer and winter. Hot, dusty or smoky rooms are to be avoided.

Hydrotherapy may increase the patient's resistance and prevent exacerbations or reinfections. In patients unaccustomed to cool baths, water at a temperature of 75 to 80 degrees may first be used, and the body bathed in sections, beginning with the arms, then the chest, back, and finally the legs, each part being moistened with a large sponge, then dried and rubbed with a harsh bath towel before proceeding to the next. The temperature of the water may be gradually lowered, and the amount of surface bathed at one time increased, until finally the patient takes a full bath at the temperature of the tap water each morning. A good reaction should be secured after the bath.

Posture.—Elevation of the foot of the bed and the assumption of an inclined position of the body several times during the day, as described under the treatment of bronchiectasis, may assist in more thoroughly evacuating the bronci of accumulated secretion.

Local Treatment.—The injection of medicated fluids into the trachea and bronchi is now seldom used. A solution of 5 to 10 per cent.

menthol in olive oil is sometimes injected by means of a suitable syringe. The larynx is anesthetized with 4 per cent. cocain and the end of the cannula passed through the glottis under the direction of the laryngoscope. Iodoform gr. $\frac{1}{2}$ (0.032 gm.) or morphia gr. $\frac{1}{8}$ (0.008 gm.) to drams 2 (8 c.c.) of olive oil may be substituted. A 1 to 2 per cent. solution of tannic acid is occasionally used. Inhalation of the vapor of hot water or hot physiologic salt solution may be helpful. Creosote minims 5 to 20 (0.3 to 1.25 c.c.), eucalyptol minims 5 to 20 (0.3 to 1.25 c.c.), menthol gr. 2 to 5 (0.130 to 0.325 gm.), or compound tincture of benzoin dram 1 (4 c.c.) may be added to a pint of boiling water and the vapor inhaled. A solution of 2 to 3 per cent. sodium carbonate may be substituted. A spray of ipecacuanha wine is sometimes useful.

Internal Medication.—This is unsatisfactory, but a host of drugs are proposed. Among them, iodid of potash, in small doses of gr. 2 to 3 (0.130 to 0.195 gm.), gradually increasing to gr. 10 to 15 (0.650 to 0.975 gm.) three times a day is most commonly used. Ammonium chloride gr. 10 (0.650 gm.) three times a day is frequently employed. Bicarbonate of sodium gr. 15 (0.975 gm.), chloride of sodium gr. 5 (0.325 gm.) and spirits of chloroform minim 5 (0.3 c.c.) in anise water and added to an equal quantity of warm water is a common prescription. Terebene minim 10 (0.6 c.c.) and terpene hydrate gr. 2 to 5 (0.130 to 0.325 gm.) may be tried. When cough is due to irritability of the mucous membranes and is unaccompanied by expectoration, heroin gr. $\frac{1}{12}$ (0.005 gm.) or morphin may be used. Fetor, if present, may be lessened by the administration of myrtol gr. 2 to 5 (0.130 to 0.325 gm.) in gelatin capsules three or four times a day.

CHAPTER VI.

BRONCHIECTASIS.

Dilatation of the bronchi is only in rare instances an independent affection, but usually arises as a complication of different diseases of the bronchi, lungs and pleura, singly or combined. At times, the features of bronchiectasis predominate in the clinical picture, thus justifying its separate consideration. The condition is often masked by the diseases to which it is secondary, and it is thus more often first discovered at autopsy than during life. We owe the first description of bronchiectasis to Laënnec,[1] whose attention was called to the disease by Cayol.

Incidence.—Bronchiectasis is uncommon. Laënnec saw only 4 cases, 2 of which were Cayol's. Its incidence among clinical cases varies somewhat with the character of the material, and is doubtless underestimated from the difficulty of its recognition. Andral described only 5 cases. Barth[2] collected only 18 cases during fourteen years in the general hospitals for adults in Paris; 25 cases in six years from the hospital for old women in the Salpêtrière. Lebert[3] observed 36 cases (20 men, 16 women.) between 1860 and 1868 inclusive, among 22,427 patients in the clinic and polyclinic at Breslau, an incidence of 0.16 per cent. Among 48,659 clinical cases at the Massachusetts General Hospital, the disease was noted in only 38 (0.078 per cent.). Autopsy statistics show a considerably higher proportion. Willigk[4] found 201 cases (4.4 per cent.) among 4546 autopsies in Prague during five years. Biermer[5] had 8 cases (2 per cent.) of essential bronchiectasis in about 400 postmortems in four years at Berne. King[6] found 72 cases (2.2 per cent.) among 3227 postmortems on patients with thoracic disease. (Brompton Hospital for Diseases of the Chest.) At the Massachusetts General Hospital, to which patients with chronic disease are very rarely admitted, only 7 cases (0.3 per cent.) are recorded among 2200 autopsies. The figures are somewhat higher, but still below the foreign statistics, at the Boston City Hospital,[7] where 38 cases (1.19 per cent.) were found among 3183 autopsies.

Etiology.—No age is exempt. There is no striking predominance at any age. The disease may be congenital. It is relatively uncommon

[1] Traité de l'auscultation médiate, 1819, T. i.
[2] Mém. de la Soc. Méd. d'Obser., T. iii, p. 520.
[3] Klinik der Brustkrankheiten, 1874, p. 254.
[4] Prager Viertcljahrschrift, 10 Jahrg., Bd. ii; 11 Jahrg., Bd. ii.
[5] Handb. d. Path. u. Ther. v. Virchow, 1867, v, Bd. i, Abth., 746.
[6] Scottish Med. and Surg. Jour., June, 1904.
[7] I am indebted to Dr. F. B. Mallory for the privilege of using these records.

in early childhood. Among Lebert's 83 cases, 15.6 per cent. occurred in the first twenty years of life, 32.4 per cent. from twenty-one to forty, 31.2 per cent. from forty-one to sixty, 18 per cent. from sixty-one to eighty, and 2.4 per cent. from eighty-one to eighty-five. The cases are quite evenly divided before and after forty, with 48 per cent. for the former and 52 per cent. for the latter period. In King's series of 64 cases, 53.1 per cent. occurred between twenty and forty years.[1] As might be expected, the age at death is lower in the tuberculous cases, being ten to thirty years in 54.6 per cent. of his series.

Males are more frequently affected, comprising 55 per cent. of Lebert's 36, and 77 per cent. of King's 70 cases. The influence of the season on the onset is difficult to determine in such a chronic disease. Exacerbations and complications are more frequent in the colder months of the year. Thus of Lebert's cases, 73 per cent. sought the hospital clinic during November to March, only 27 per cent. from April to October.

Clinical Antecedents.—It is difficult to obtain exact data on the clinical character of the pulmonary disease from which bronchiectasis originates. In perhaps a majority of the cases, the patients are unable to recollect any striking features of onset, which seems to have been insidious. In a second group, the features of onset are those of an acute and apparently mild or moderately severe respiratory infection, which may start in any part of the tract from the nose to the bronchi, ultimately invading the latter, however, and, unlike other apparently similar infections, fails to resolve after the customary interval of a few weeks. In such cases the cough and purulent sputum persist. Some of these patients are undoubtedly already the subject of chronic respiratory infection of the nasopharyngeal, the bronchial or pulmonary tissue, dating from a previous attack which has not wholly subsided. In them, autoreinfections are superimposed one upon another, with successive involvement of larger and larger areas and increasing severity of symptoms. In their clinical aspect alone, such cases thus appear to take their origin from bronchitis. It is improbable that simple bronchial catarrh is a sufficient cause for bronchiectasis. Bronchial catarrh alone is much too common to explain so infrequent a disease, and a special type of bronchial inflammation present in only a small proportion of such cases must be assumed to exist. Impaired resistance of the bronchial wall itself, in consequence of the infection, is a probable explanation, and will be considered more fully later.

In a third group, pulmonary disease may apparently initiate the condition. In this class, tuberculosis appears to be the most frequent cause. It was present in 21 (30.8 per cent.) of Trojanowski's[2] 68 cases, in 22 (31.0 per cent.) of King's 70 cases, and in 17 (37 per cent.) of my 45 cases. The tuberculosis is of the chronic ulcerative and fibroid form almost without exception. In rare instances, a tuberculous

[1] Age at death. [2] Klin. Beiträge zur Lehre der Bronchiectasie, Dorpat, 1864.

bronchitis may coexist. Bronchiectasis may take its origin from unresolved lobar or latent or obvious bronchopneumonia.

Bronchiectasis may follow stenosis of the bronchi from syphilitic or tuberculous ulceration, new growths of the bronchial wall, pressure from without as from aneurysm or mediastinal or bronchial tumor, and the inhalation of foreign bodies.

In a small proportion of cases, the disease follows a persistent and usually purulent pleural effusion, which has perforated the lung and thus given rise to pulmonary and bronchial inflammation.

Bacteriology.—Bacterial infection of the bronchial wall must be regarded as the underlying cause of all bronchial dilatations. The infection may be primary in the bronchi, secondary to other parts of the respiratory tract or a sequence of stenosis. It is improbable that the disease can be especially ascribed to any one organism. The influenza bacillus, Micrococcus catarrhalis, the pneumococcus, streptococcus, staphylococcus and the tubercle bacillus, singly or combined, are the most frequent varieties of pathogenic bacteria found in the sputum during life, or in the lungs after death in these cases. Among 18 cases of chronic pulmonary infection with influenza bacilli which I studied from 1902 to 1905,[1] there were 7 with certain or probable bronchiectasis. In these cases, influenza bacilli were in practically pure culture in the sputum over a long period of observation and could fairly be regarded as the cause of the process. Boggs[2] in 1905, reported 6 cases of bronchiectasis with influenza bacilli in practically pure culture in the sputum. He obtained pure cultures of influenza bacilli at autopsy from the washed and teased bronchial wall in one, and found great numbers of small organisms resembling influenza bacilli and a few pneumococci in stained sections from the bronchial wall in another.

Pathology.—The bronchial dilatation may assume various shapes in the same or in different cases. Among these the cylindric, fusiform, and saccular are the most common. Bead-like or moniliform dilatation is less common. Obliteration of afferent and efferent bronchi may convert the dilatation into a cyst. Club- or cone-shaped dilatations may also be seen. The size of the dilatation is variable. Ectasis of the smaller tubes may give rise to cavities from microscopic dimension to that of a pea or an almond, and more often peripherally placed, while involvement of the larger bronchi leads to cylindric and central dilatations as large as the finger or thumb, and saccular cavities the size of a walnut, an apple, or even larger. The dilatation of communicating bronchi of different size may lead to tortuous canalization of the lungs. Dilatation of numerous small bronchi may convert the lung into an appearance not unlike that of honeycomb. The bronchi

[1] F. T. Lord, Eleven Acute and Eighteen Chronic Cases of Influenza, etc., Boston Med. and Surg. Jour., December 18, 1902, and Infections of the Respiratory Tract with Influenza Bacilli and other Organisms, etc., ibid., May 11 and 18, 1905.

[2] The Influenza Bacillus in Bronchiectasis, Amer. Jour. Med. Sci., November, 1905.

emptying into bronchial dilatations are often obliterated. In rare instances they are of normal size.

Bronchiectasis affects one bronchus only in rare instances. Thus of 45 cases (Massachusetts General Hospital and Boston City Hospital series), a single bronchiectatic cavity was found in only 3, all of which were apical and tuberculous in origin. Multiple dilatations may be circumscribed and confined to one lobe as in 5 of this series. Multiple and diffuse lesions are far more common. They may be confined to one lobe, as in 10 cases (22 per cent.). Among Lebert's 54 cases, 15 (27 per cent.) were unilobar. Unilateral disease is recorded in 52 per cent. of Lebert's 54, and 37.7 per cent. of King's 69 cases. In the presence of extensive, multiple lesions, one part of the lung is likely to be more extensively involved. In general, the multiplicity of lesions is one of the most striking and important features of bronchiectasis. If no distinction be made between the different types of ectasis, no striking predilection is shown for any particular pulmonary region. If the different types be considered separately, certain generalizations concerning the location can be made. Thus tuberculous bronchiectasis is especially likely to affect one or both apices alone or predominantly. In 17 tuberculous cases in my series, the bronchiectasis affected one or both apices with or without similar lesions elsewhere in 11. In these cases, the most pronounced dilatation is usually at the apices. In non-tuberculous bronchiectasis, the lower lobes are affected in a somewhat larger proportion than in the tuberculous cases. Bronchiectasis due to stenosis from syphilitic ulceration, pressure from without or the inhalation of foreign bodies is more likely to be unilateral for a time at least.

The wall of the dilated bronchus almost constantly shows a catarrh which exists also in undilated bronchi, with an increase of bronchial secretion. The mucous membrane is usually reddened. In exceptional instances it is pale, or slate colored. The bronchial wall may be thin, but is commonly thickened, firm and inelastic. Its surface is often uneven, and may present a shaggy, villous appearance not unlike that of the intestinal villi. In advanced cases, intersecting transverse and longitudinal ridges of elevated tissue may convert the surface into an irregular network of trabeculæ. Thin, smooth-walled dilatations are sometimes seen, and more often in the smaller terminal portions of the bronchi unsupported by cartilage. Erosion, ulceration, and perforation of the bronchial wall may occur. In one of Lebert's cases, a perforation involved a branch of the pulmonary artery with fatal hemorrhage. Suppurative and gangrenous pulmonary processes may arise in consequence of perforation. Calcareous plates may be found in the dilated bronchi.

On microscopic examination, the appearance varies with the stage of the disease. In early processes, the mucous membrane is uneven. The bronchial wall, throughout, is rich in bloodvessels and shows a striking increase in small round cells. Dilated and anastomosing

vessels are especially numerous in the papillary outgrowths. Cellular infiltration is seen in the mucous membrane, about and between the cartilages and glands, about and within the muscular and elastic layers. The epithelium may be maintained, or partially or wholly detached. In later stages, proliferated connective tissue may partially or wholly replace and efface the characteristic bronchial structures. Invasion and compression of the glandular, muscular, and elastic elements may end in their atrophy and ultimate disappearance. Even the cartilages are gradually diminished in size, distorted, and may finally disappear. The peribronchial tissue usually participates in the indurative process. The bronchial wall is finally converted into a thickened, dense, scar tissue, with or without the remnants of glandular, muscular, elastic, and cartilaginous elements. Invasion of the neighboring alveolar tissue may occur to a variable extent. The superficial layers of the mucous membrane are usually spared. A thin layer of ciliated epithelium commonly persists.

The differentiation of bronchiectasis from pulmonary losses of substance may at times be difficult or impossible. The following features, however, may serve to distinguish them. Dilated bronchi are likely to present a smooth and shiny surface, in unbroken continuity with the mucous membrane of undilated portions of the tube. Microscopic examination is likely to show ciliated epithelium, with or without glandular, muscular, elastic and cartilaginous elements or their remnants, in more or less typical arrangement. The walls of pulmonary excavations, on the other hand, are usually more uneven, shaggy and distorted from unequal losses of pulmonary substance, or the contraction of a more abundant connective tissue. The transition from normal bronchus to the cavity is likely to be more abrupt. As pointed out by Virchow,[1] the relation of the bloodvessels to the cavity is an important guide. Careful search of pulmonary excavations is likely to disclose the ends of eroded vessels. Beside the communicating bronchus, a place may usually be found where several stumps, easily recognizable by their white ends, project together from the surface. At times one can plainly distinguish the obliterating thrombus and the neighboring wall of the vessel. Partial ulceration of the wall of an ectatic bronchus may be a cause of confusion.

The condition of the pulmonary tissue is very variable. It is practically always the site of changes, the primary or secondary relation of which to the bronchiectasis is often difficult to determine. In one ('98–250 B.C.H.) among 45 cases, the bronchiectasis was apparently independent of any pulmonary affection. The bronchi and bronchioles were dilated, the latter reaching as much as 1 cm. in diameter. The lungs showed vesicular emphysema and edema. They were firmly bound down to the posterior thoracic wall and the diaphragm by fibrous pleural adhesions. Death was due to chronic endocarditis, myocarditis,

[1] Verhandl. der Physikalisch-Medicinischen Gesellschaft in Würzburg, Erlangen, 1852, Bd. ii, p. 24.

and multiple cerebral hemorrhages. It is not uncommon to find dilated bronchi terminating in normal, in emphysematous and in diseased pulmonary tissue in the same lung. Emphysema is often observed and may be local or diffuse. It was present in 11 of Barth's 40 cases and in one quarter each of Biermer's[1] and Lebert's series.

Chronic interstitial pneumonia is common. It may be local and limited to the region of the dilated bronchi, involving principally the peribronchial, interlobular, and subpleural connective tissue. More extensive induration may convert the pulmonary tissue of a part or the whole of one or more lobes into a dense, dry, gray, slate-colored or even black, airless mass contracted to a third, one-half or even more of its normal volume, and in which the dilated bronchi terminate blindly. Acute pneumonia is not infrequent. It was present, as a cause of death, in 21 (!) of Rapp's[2] 24 cases. Pneumonia was found in 12 of Barth's 40 and Biermer's 54 cases. Lobar pneumonia was present in 9, and bronchopneumonia in 10 of the 45 cases in my series. Both lobar and bronchopneumonia may initiate or complicate bronchiectasis. Pulmonary abscesses may exist independently or in association with the bronchial dilatations. Pulmonary gangrene was a cause of death in 5 of Lebert's cases.

Pleuritis is almost a constant finding. It is rather a complication of the pulmonary disease with which the bronchiectasis is associated than of the bronchiectasis itself. Its frequency and character are of interest in connection with the question of surgical interference. In 42 cases in my series, in which the condition of the pleura was noted, an obliterating pleurisy was found over both lungs in 8, over the involved lung in 9, and over the whole of that part of the lung containing dilated bronchi in 5. The pleural sac was in part obliterated over the involved region in 5. An acute fibrinous, serofibrinous or purulent pleurisy over the whole or a part of the affected lung was found in 5. Weak bands of fibrous adhesions were present in 6 and the lungs were free in 4 cases. Thus in 32 cases (76 per cent.), a more or less extensive pleurisy coexisted with the bronchiectasis. The pleurisy often forms the outer boundary of indurated and contracted lung; at times bands of fibrous tissue of variable extent connect the pleura with deep or superficial foci of pulmonary induration, or, in rare instances, the pleurisy and bronchiectasis are unassociated with changes in the intervening pulmonary substance. Pleural effusion, when it occurs, is likely to be small in amount and limited by pleural adhesions. An abundant, free pleural effusion is likely to occur early, if at all, in the course of bronchiectasis.

Extrapulmonary lesions, secondary to the bronchiectasis, are hard to differentiate from those which develop independently. Hyperplasia

[1] Zur Theorie u. Anat. der Bronchienerweiterung, Virchow's Arch., 1860, Bd. xix, p. 160.

[2] Verhandl. d. Physik-med. Gesellsch. zu Würzburg, Sitzung vom 25 Mai, 1850, Bd. i, S. 145, Erlangen 1850; quoted from Biermer.

of the bronchial lymph glands of a tuberculous or simple character is probably the most common extrapulmonary complication. Hyperplasia of the spleen is not infrequent as a manifestation of toxemia or terminal septicemia. Cerebral abscesses were present in 3 of 45 cases. Meningitis occurred in 7 instances. It was tuberculous in 1. Pericarditis was present in 5 cases.

Acute or chronic endocarditis is not infrequently observed, and was noted in 7 of the present series. It may take its origin from the chronic bronchial or pulmonary infection. Cardiac hypertrophy and dilatation, with consecutive chronic passive congestion of the lungs, the liver, kidneys, and other organs may be ascribed to increased pulmonary resistance, in the absence of other etiologic factors. Venous thrombosis occasionally complicates bronchiectasis as it does pulmonary abscess.

Theories of Bronchiectasis.—Much difference of opinion has prevailed concerning the explanation of bronchiectasis. Biermer[1] has reviewed the earlier opinions. The different theories may be grouped under three principal headings. The disease has thus been thought to be of (1) bronchial, (2) pulmonary, or (3) bronchopulmonary origin.

1. **Bronchial Theory.**—Laënnec ascribed the dilatation to bronchial catarrh and stagnation of bronchial secretion. To this simple explanation the mechanical effect of cough and a disturbance in the nutrition of the bronchial wall with loss of elasticity, contractility and ciliary motion was added by such later writers as Andral,[2] Stokes,[3] and Williams.[4] Mendelsohn[5] especially emphasized the mechanical effect of forced expiration, with the glottis closed during cough, on the bronchial wall, weakened by disease.

2. **Pulmonary Theory.**—Corrigan[6] believed the bronchial dilatation to be due solely to the shrinkage of fibrotic pulmonary tissue between the bronchi, the diminished pulmonary volume being compensated either by thoracic retraction or dilatation of unobliterated bronchi.

3. **Bronchopulmonary Theory.**—Hasse,[7] Rokitansky,[8] Engel,[9] Rühle,[10] Biermer[11] and Lebert[12] accepted both the bronchial and pulmonary theories in whole or in part, with varying emphasis on one or the other as a principal factor.

[1] Zur Theorie u. Anat. d. Bronchielerweiterung, Virchow's Archiv, 1860, Bd. xix.
[2] Clinique méd., etc., 1824-27, T. iv, 1st ed., Paris; 2d ed., 1829.
[3] Diseases of the Lungs and Windpipe, Dublin, 1837.
[4] Lectures on the Physiology and Diseases of the Chest, London, 1840, 4th ed.
[5] Der Mechanismus der Respiration und Circulation, etc., Berlin, 1845, p. 255 u. ff.
[6] Dublin Jour., May, 1838, vol. xiii, No. 38.
[7] Anat. Beschreibung der Krankheiten der Circulations- und Respirations-organe, Leipzig, 1841.
[8] Handbuch der path. Anat., Wien, 1842, Bd. iii.
[9] Anleitung z. Beurtheilung des Leichenbefundes, Wien, 1846.
[10] Untersuchungen über die Höhlenbildungen in tuberculosen Lungen, Habilitationsschrift, Breslau, 1853.
[11] Zur Theorie und Anatomie der Bronchielerweiterung, Virchow's Archiv, 1860, vol. xix.
[12] Klinik der Brustkrankheiten, 1874, vol. i.

It must be assumed necessarily, I believe, that an affection of the bronchial wall is a principal factor and capable alone of giving rise to dilatation. Degenerative changes in the wall, already described under Pathology, are constant, and may be unassociated with pulmonary disease, thus excluding this as a necessary condition. Simple bronchial catarrh is much too common to explain so infrequent a disease as bronchiectasis. It is probable that in a certain and small proportion of cases of bronchial infection, the infecting agent more deeply invades and weakens the bronchial wall. The stagnation of bronchial secretion and the chronic cough with increase of expiratory pressure within the weakened bronchi may then easily cause dilatation. Increase of intrathoracic pressure under muscular strain may also be important. It is conceivable that unequal distribution of negative inspiratory pressure may unduly inflate certain parts of a lung in consequence of focal pulmonary or pleural disease, but such a cause, if it exists, must play but a minor rôle, and would affect the bronchi in normal rather than in diseased and relatively immobile tissue. The extrabronchial traction of fibrotic pulmonary tissue, as an accessory factor, cannot be wholly ignored. Its influence is probably accidental, at times serving to enlarge or distort, at other times to diminish the size of ectatic cavities.

Symptoms.—Cough and expectoration are the principal and often the only symptoms. The cough is constant, but usually much aggravated in the winter months. In the early period of the disease it may almost entirely subside during the summer, to reappear with the onset of cold weather. Acute exacerbations or a succession of "colds" are likely to leave the patient with a more severe cough. In some cases, the cough lacks distinctive features, but in the majority of patients with well-developed bronchiectasis, it occurs in attacks, with relative or complete freedom during the intervals. The number of attacks varies from one to several or more in the twenty-four hours. The intermittent character of the cough is doubtless due to insensitiveness of the diseased and dilated bronchi. The incentive to cough comes only after a certain degree of dilatation is reached or the level of the accumulated secretion rises to a more healthy bronchial region. A paroxysm on rising in the morning is quite constant, and is due to secretion accumulated during the night. Recurrences occur during the day with longer or shorter periods of freedom. The attack may last from a few minutes to a half-hour or longer. In some patients the inclination to cough comes without warning, and is sudden and irresistible. In one of my series, an unexpected, sudden and irresistible impulse constantly initiated a paroxysm, in which several ounces of pus were forcibly expelled from the mouth and nose. In this patient, partial inversion greatly aided the evacuation of the cavities. The assumption of certain positions may bring on a paroxysm of cough. When the disease is unilateral, longer freedom from attacks may at times be secured by lying on the affected side, thus preventing an overflow of secretion into healthy bronchi.

The sputum is very variable in amount. From 100 to 200 c.c. is not uncommon in twenty-four hours. As much as 500 c.c. or more may be expectorated. The elimination of considerable quantities ("maulvolle" expectoration of Wintrich) with each cough during a paroxysm may be a striking feature. The sputum is usually mucopurulent or purulent, a varying shade of green, and slightly tenacious from the presence of mucus which is likely to adhere to separate masses, thus preventing their coalescence. Even in severe and long-standing cases, with an abundant sputum, the expectorated masses usually remain discrete in the twenty-four-hour specimen. In rare instances, however, an almost pure, purulent sputum with little admixture of mucus may be observed even in multiple bronchiectasis. Such homogeneously purulent specimens are seen when extensive degenerative changes have occurred in the bronchial wall, with partial or total disappearance of the mucous glands. The expectoration may be odorless, stale, musty or foul. In rare instances, putrefaction of the secretion within the bronchi may give a putrid odor to the breath and the sputum in the absence of pulmonary gangrene. On standing, the sputum usually separates into three layers such as are described under Pulmonary Abscess and Gangrene. Dittrich's plugs (see Abscess and Gangrene) may be found.

Hemoptysis occurs in about equal frequency in tuberculous and in non-tuberculous bronchiectasis. It was present in 45.1 per cent. of King's 62 cases. A distinction of some clinical value may be made between those hemorrhages which come early and those which occur late in the course of the disease. As an initial symptom, or early in the course of an apparently mild pulmonary disturbance, the hemoptysis is likely to be tuberculous in origin. When it occurs in association with other symptoms, among which an abundant purulent sputum is a prominent feature, tuberculosis, although frequent, is less often a cause. The blood occurs in streaks or as moderate, profuse or fatal hemorrhage, as in 3 (4.8 per cent.) of King's cases. Small amounts of blood come from the vascular, papillary outgrowths in the walls of the bronchi, denuded of epithelium. More abundant hemorrhages may come from rupture of branches of the pulmonary artery by erosion of the bronchial wall. In some instances, bloodvessels lining the wall or traversing the lumen of pulmonary cavities are the source. It is at times impossible to determine the origin of the bleeding.

Pain, when it occurs, is usually due to complicating pleurisy. Dyspnea is not a prominent symptom, in most cases. It may occur in attacks, and the clinical picture may be that of bronchial asthma complicating bronchiectasis.

Physical Signs.—The general nutrition is usually little disturbed. Slight cyanosis of the lips, the hands and feet is common. It is likely to be marked after a paroxysm of cough. Dilatation of the jugular veins is also at times observed. The skin may be dry. Chills may occur if there is retention of secretion. The temperature is usually

unelevated, when the discharge of pus is unobstructed and in the absence of complications. Transient, irregular, intermittent or remittent fever, however, may be due to stagnant secretion, an acute exacerbation of the chronic infection, or extension of the disease to previously uninvolved parts of the bronchi or lung, giving rise to acute bronchitis, broncho- or lobar pneumonia, abscess, gangrene or pleurisy. The pulmonary signs present important differences in the purely bronchial and the bronchopulmonary form.

Pure Bronchiectasis.—This comprises only a very small proportion of the cases. As has been noted under Pathology, bronchial dilatation is only very rarely unassociated with pulmonary or pleural disease. The pulmonary process, however, is not infrequently focal or deep seated, and may thus readily escape detection. It happens, therefore, that pure bronchiectasis appears to be less frequent clinically than is actually the case. In this form, there are often no pulmonary signs whatever, even when there is a large amount of sputum. Coarse, medium or fine, non-consonating rales may at times be heard. They are likely to be variable in character and occurrence, present at one, absent at another examination. They may disappear after evacuation of the cavities in a paroxysm of cough. Persistent localization at one or several places in one or both lungs may suggest the site of the disease.

Bronchopulmonary Form.—This comprises a large proportion of the cases. The physical signs are very variable. If the pulmonary disease is of slight extent, the signs may be limited to rales, which are almost constantly present. They may be fine, medium, or coarse and consonanting or non-consonating. In the presence of extensive or superficial pulmonary induration or bronchopneumonia, there may in addition be dulness, bronchial breathing, increase of voice, whisper, and tactile fremitus. The bronchial cavities may be indicated by a dull tympanitic note on percussion, changes in the quality of the note when the patient's mouth is open and closed, and on shifting the patient's position, cracked-pot percussion note, bronchial and amphoric breathing and marked increase in the voice, whisper, and tactile fremitus. A difference in the signs before and after evacuation of the cavities is also suggestive. Distinctive physical signs of bronchial dilatation, however, are often absent and the location of the process may depend upon the site of the associated pulmonary disease. Extensive unilateral or predominantly unilateral pulmonary or pleuropulmonary fibrosis may cause restricted respiratory motion, thoracic retraction and narrowing of the intercostal spaces over the affected region. There may also be lateral deviation of the spine and dislocation of the heart toward the involved area. If pleural thickening is marked, it may mask the signs of the underlying pulmonary and bronchial disease.

Varying degrees of emphysema are likely to complicate both forms of bronchiectasis. If it is marked, it may introduce striking features into the physical examination. There may be round shoulders, barrel

chest, prominent clavicles, sternum and costal cartilages, diminished inspiratory excursion, invisible and impalpable apex beat, hyperresonance on percussion, partial or complete obliteration of the superficial cardiac dulness, displacement downward of the upper level of the hepatic and splenic dulness, and on auscultation, feeble breathing and prolonged expiration.

Complications.—These have already been considered under Pathology. In their clinical aspects, certain complications deserve further mention. Acute bronchopneumonia arising by extension or aspiration is common. It may be indicated clinically merely by an increase of the cough and expectoration, the appearance of rales in a region previously uninvolved, or evidence of a more severe or extensive local lesion. Varying degrees of general disturbance and fever are likely to accompany the attacks. The neighborhood of the already existing bronchial or bronchopulmonary lesions is most likely to be affected, but infection of more remote areas also occurs. It is usually found that the extent of the bronchopulmonary disease is increased after the attack. Lobar or bronchopneumonia may be a terminal event or end in partial or complete resolution. Pulmonary abscess is a frequent complication. Gangrene also occurs. Intercurrent attacks of pleurisy are common. They are usually unaccompanied by effusion. In some cases the symptoms of pleurisy dominate the clinical picture. An effusion may be putrid, as in 3 of 7 cases of empyema complicating bronchiectasis in Fränkel's series. Cerebral abscess and meningitis, probably arising by metastasis, are not infrequent. Hypertrophic osteo-arthropathy is more frequently associated with bronchiectasis than with other pulmonary conditions.

Hypertrophic "Pulmonary" Osteo-arthropathy.—This interesting condition was first described by Bamberger[1] and Marie.[2] Simple clubbing of the fingers and toes, frequently noted in patients with chronic pulmonary and cardiac disease (especially congenital cases), may for the present be regarded as an early or mild form of Marie's disease. Only those cases in which the clubbing is associated with bony changes should be classed in this group.

Hypertrophic osteo-arthropathy is commonly associated with chronic pulmonary or pleural disease, as in 65 (69 per cent.) of Janeway's[3] 93 cases. Bronchiectasis[4] is the most common pleuropulmonary condition, and was present in 20. Pulmonary tuberculosis with cavity formation was recorded in 14 cases. Chronic bronchitis, abscess, pulmonary tuberculosis without cavities, chronic pleurisy or pneumonia and malignant disease of the pleura have also been reported. The disease may be coincident with such other conditions as hypertrophic

[1] Wiener klin. Woch., 1889, p. 225, and Zeit. f. klin. Med., 1891, Bd. xviii, p. 193.
[2] De l'ostéoarthropathie hypertrophiante pneumique, Rev. de méd., 1890, x, 1.
[3] Amer. Jour. Med. Sci., 1903, cxxvi, 574.
[4] v. Criegern (Ueber akute Bronchiektasie, etc., Leipzig, 1903) noted swelling of the terminal phalanges in 18 of 35 cases of bronchiectasis.

cirrhosis (with jaundice), syphilis, valvular cardiac lesions, cancer of the esophagus, sarcoma of the parotid, chronic dysentery, chronic alcoholism, acute pneumonia and influenza, thus indicating that pulmonary lesions are not a necessary association and that the term "*pulmonary*" hypertrophic osteoarthropathy of Marie is inapplicable to all cases. In a small proportion of cases, the disease is apparently an independent affection, the patients being otherwise healthy or developing other lesions in the course of the process. The use of the term "secondary," as in Arnold's[1] secondary hyperplastic ostitis, is therefore also inappropriate. It occurs in both sexes, but much more commonly in the male, the relation of male to female in Wynn's[2] series being 83 to 11. No age is exempt. Most cases occur between the ages of twenty and sixty. The cause of the disease is unknown. The absorption of toxic substances, of an uncertain character, and venous stasis, singly or combined, are possible explanations.

The disease is characterized by symmetrical enlargement of the hands and feet. Clubbing of the fingers and toes is a striking feature. All the digits are affected. The thumb, index, and middle fingers are likely to be most markedly involved. The enlargement is both anteroposterior and lateral, and gives to the finger a drum-stick appearance. Swelling of the interphalangeal joints may give a spindle shape as well to the fingers. The nails are wider and longer than normal, curved like a parrot's beak, show longitudinal striation, and may be brittle and cyanotic. Pressure on the distal extremity of the nail tilts the proximal part with the formation of a ridge on the dorsal surface. Similar but less striking changes are seen in the toes. The hands may be widened from thickening of the metacarpal bones. In addition, there may be thickening of the distal ends of the bones of the forearm and leg. Enlargement of the lower end of the humerus and femur is at times also observed. In extreme cases, the outer third of the clavicle, the acromium process and spine of the scapula, the ribs, iliac crests and patella may also be affected. Posterior and lateral curvature of the spine and enlargement of the spinous processes have been observed. The wrists, ankles and knees may be stiff and swollen. The shoulders, elbows, and small joints of the hands and feet are at times similarly affected. The ankles may pit on pressure. The tip of the nose may be globular and the malar prominences abnormally developed.

The skin over the affected regions may be stretched and shiny from obliteration of the normal furrows and depressions. Some muscular atrophy, especially of the arms, is occasionally observed. Pain is usually absent, but discomfort or pain and tenderness may occur when the disease is rapidly progressing or during an exacerbation. The blood shows nothing characteristic.

[1] Ziegler's Beiträge z. Path. Anat. u. z. allg. Path., 1891, x, 1.
[2] Birmingham Med. Rev., 1904, vol. lv.

Postmortem examination of the affected regions has been made by Bamberger,[1] Lefevre,[2] Thérèse,[3] Rauzier,[4] and Thorburn.[5] The affected bones show periosteal thickening with the formation of new bone in the deeper layers. Irregular bony deposits may give the bone an irregular outline or form definite osteophytes. These are most abundant in the region of the epiphysis. The cortical bone is thickened and the process may thus be termed an osteoperiostitis ossificans. The medulla is diminished in size, rarefied and more fatty than normal. The joints may show both thickening of the synovial membranes and erosion of the articular cartilages, with an excess of fluid. The clubbing of the fingers is due to swelling of the soft parts and not bony enlargement, both in simple clubbing and that associated with Marie's disease.

The onset is usually slow and insidious, but may be rapid. West[6] reports the development of clubbing of the fingers within a fortnight and four weeks respectively. As a complication of pulmonary or other lesions, the disease usually develops within six months to a year of the onset of the associated condition. Its appearance may be delayed for from four to ten years. In rare instances, its onset coincides with or even precedes the manifestations of the other lesions. The course is usually slowly progressive. Acute exacerbations are occasionally observed. In rare instances, improvement has been noted. Moderate diminution in the size of the soft tissue was observed in osteo-arthropathy within two months by Schittenhelm.[7] Improvement has been noted after cure of the primary disease by Godlee[8] and by Mettenheimer.[9] Marked improvement of simple clubbing of the fingers secondary to empyema has been noted by Moussons,[10] complete disappearance by Gillet[11] and Moizard.[12]

Diagnosis.—This is difficult. Bronchiectasis should be suspected in the presence of long-continued cough with abundant, mucopurulent or purulent sputum, expectorated in attacks, with relative or complete freedom during the intervals. Similar symptoms occur also in chronic pulmonary abscess and gangrene, occasionally also in interlobar, diaphragmatic or ordinary pleural empyema, breaking through the lung into the bronchi. Inasmuch as dilatation of the bronchi may occur in the course of any long-continued pulmonary suppuration and be present without characteristic symptoms, it should be kept in mind as a possibility in any chronic cough with purulent expectoration.

[1] Loc. cit.

[2] Des déformations ostéoarticulaire consecutives à des maladies de l'appareil pleuro-pulmonaire (ostéoarthropathie hypertrophiante de Marie), Thèse, Paris, 1891.

[3] Bull. de la Soc. anat. de Paris, 1891, p. 143.

[4] Rev. de méd., 1891.

[5] Thorburn and Westmacott, Path. Trans., vol. xlvii, p. 177.

[6] Two Cases of Clubbing of the Fingers Developing within a Fortnight and Four Weeks Respectively, Clin. Soc. Trans., 1897, vol. xxx.

[7] Berl. klin. Woch., 1902, xxxix, 254.

[8] British Med. Jour., 1896, ii, 57.

[9] Zeit. f. rationelle prak. Aerzte, 1885, p. 449.

[10] Jour. de méd. de Bordeaux, 1890.

[11] Annales de la policlinique de Paris, 1892, ii, 93.

[12] Bull. et mém. Soc. Méd. des Hôp. de Paris, 1893, ser. 3, x, 359.

Acute losses of pulmonary substance (abscess and gangrene) are usually readily excluded by the short period which elapses between the onset of symptoms and the appearance of purulent sputum, the intensity of the general disturbance and fever, the signs of cavity, if present, and the presence of elastic tissue and shreds of pulmonary tissue in the expectoration. Chronic pulmonary excavations cannot be differentiated with certainty. The absence of signs of pulmonary disease may suggest bronchiectasis. Such positive features as the finding of tubercle bacilli, actinomyces, or elastic tissue with an alveolar arrangement, are certain evidence of pulmonary destruction, but do not exclude a complicating bronchiectasis. The absence of tubercle bacilli or elastic tissue is of little moment in the differential diagnosis between chronic abscess and bronchiectasis. Inactivity of the pulmonary process may account for their absence in abscess. The signs of cavity are more likely to indicate losses of pulmonary substance than dilated bronchi.

A long-neglected empyema perforating the lung may be a cause of confusion. Uncertainty between empyema and bronchiectasis is not likely to exist when the rupture into the lung is sudden and followed by the expectoration of a large amount of clear pus, but in the more latent cases, in which pus slowly finds its way through single or multiple channels from the pleura to the bronchi. If the patient comes under observation only after considerable pulmonary damage has occurred, the case may appear to be one of bronchiectasis of the broncho-pulmonary form with a complicating pleurisy. In such instances the history may be suggestive. Cough and abundant sputum are likely to antedate the onset of pleurisy secondary to bronchiectasis. In empyema perforating the lung, the pleural precede the pulmonary symptoms. Ordinary empyema is usually readily detected on physical examination. Ruptured interlobar empyema which fails to reach the chest wall may be suggested by dislocation of the heart, physical signs in the region of the interlobar septa and *x*-ray examination. Evacuation into the lung of an abscess between lung and diaphragm may be preceded by symptoms of diaphragmatic pleurisy, dislocation of the heart, the diaphragm, and with it the liver or spleen downward and *x*-ray examination.

The determination of the cause of the bronchiectasis may be difficult. Tuberculosis is the underlying cause in about one-third of the cases. A family history of the disease or known opportunity for contagion, loss of weight and strength, night-sweats, fever, hemoptysis or pleurisy as an initial symptom or early in the course of the disease, apical involvement, and a reaction to tuberculin suggest tuberculosis. Tubercle bacilli should be diligently and repeatedly sought. Their absence from an abundant purulent sputum is important, but not conclusive evidence against tuberculosis. Bronchiectasis and fibroid phthisis, with an abundant purulent sputum, may still exist without tubercle bacilli in the sputum. Such a process may be at the base of the

lung and due to tuberculosis, as shown by postmortem examination. In general, it may be said that the duration of life is shorter in the tuberculous than in the non-tuberculous cases, but this is of little moment in deciding the character of the individual infection.

Syphilitic stenosis as a cause may be suggested by the history, the finding of tracheal and bronchial ulcerations on bronchoscopic examination, the presence of syphilitic lesions elsewhere, or a positive Wassermann test. A foreign body should be considered. It may have been unconsciously inhaled and first disclosed by *x*-ray examination. The diagnosis of pressure from aneurysm or mediastinal growth is usually easily made from the history, the physical signs and *x*-ray examination.

X-ray Examination.—This is of less value than in pulmonary abscess and gangrene. It is of principal service in disclosing the presence of pulmonary changes. Little if any assistance can be expected from it in the cylindric form of the disease. In the saccular ectasies, a relatively less dense shadow may be observed in the midst of an involved region. Comparison of plates taken before and after evacuation of the bronchial dilatations may be very suggestive. A shadow on a plate taken before evacuation may disappear or show more translucent areas after evacuation. As in pulmonary abscess and gangrene, *x*-ray examination may be an important guide for surgical interference.

Exploratory Puncture.—This is inadvisable for the reasons given under Pulmonary Abscess and Gangrene.

Prognosis.—Restoration of the bronchi to normal cannot be expected. The disease runs a very chronic course, subject to exacerbations and remissions. The duration varies in different cases and according to the cause. Bronchiectasis, which complicates aneurysm or mediastinal new growth, may unfavorably influence the already grave outlook in these affections and shorten their course. The prognosis of tuberculous bronchiectasis is worse than in the non-tuberculous form, but is in general somewhat more favorable than in ordinary pulmonary tuberculosis, since the condition is more likely to be associated with the fibroid form than with other types of phthisis. The duration of 41 cases of non-tuberculous bronchiectasis (King) arising in consequence of bronchial, pulmonary or pleural disease was three to ten or more years in 46.2 per cent. In itself the disease is not incompatible with a long term of life, but is a constant menace to the individual as a source of infection of nearby or remote parts of the body. Bronchopneumonia, abscess, gangrene, empyema, pneumothorax, cerebral abscess and meningitis may be mentioned as among the most serious complications. Emphysema and interstitial pneumonia may be the cause of cardiac insufficiency. Amyloid may follow long-continued bronchial or bronchopulmonary suppuration. In rare instances, hemoptysis may be fatal.

Prophylaxis.—The constant presence in the abundant sputum of patients with bronchiectasis of such organisms as the influenza bacillus, the pneumococcus, the pyogenic cocci, Micrococcus catarrhalis, tubercle

bacilli and others, singly or combined, must be regarded as a menace, not only to the patient himself, but also to others in his neighborhood. These chronic carriers of infection may well serve as a source of contagion by their constant output of innumerable pathogenic bacteria. This applies to the non-tuberculous as well as to the tuberculous cases, and the same control should be exercised over both groups.

The patient should be made to understand that his sputum is a danger to others, and, if allowed to dry, may be capable of spreading disease. It should be carefully expectorated into a special receptacle to avoid soiling the beard or moustache. In coughing or sneezing, expelled particles should be caught in a piece of cloth placed in front of the mouth. These should be burned. The fingers should not be moistened in the mouth in turning the leaves of books, public documents, etc. The table utensils may well be kept separate from those of other members of the family. Soiled bed and body linen should be boiled. Dusting the patient's room should be done with a dampened cloth, sweeping with a dampened broom. The patient should sleep alone. An abundance of sunlight and fresh air limit the danger.

Instruction should be given in the best method of disposal of sputum. The safest is by cremation. Carbolic acid (5 per cent.) is the most efficient of the ordinary disinfectant solutions and should be left in contact with the sputum for twenty-four hours.

For the patient himself, certain measures may limit the danger of auto-infection or reinfection. The sputum should not be swallowed. The patient should be especially careful to avoid exposure to wet and cold, and rapid cooling of the body after exertion. Thin woolen underwear and an effort to increase individual resistance may afford some protection. Sleeping with the window open, spending much time in the open air and cool bathing followed by friction are helpful. A good reaction should be secured after the bath.

Treatment.—1. **General.**—Every effort should be made to improve the nutrition and maintain it at a high level. An abundance of food, extra feedings and fresh air by night as well as by day are of assistance. Patients with bronchiectasis are usually strikingly better during the warm months of the year. Their condition is improved by an outdoor life in a warm, equable climate and in an atmosphere free from dust.

2. **Special.**—An attempt is made by various means to disinfect and more completely evacuate the bronchi. It is unlikely that disinfection can be accomplished with safety by any means whatsoever. Any improvement which follows the attempt thus to control the disease must be ascribed to the more complete evacuation of the bronchial secretion by the more vigorous paroxysms of cough following irritation of the bronchial mucous membrane.

(*a*) *Inhalations.*—Owing to the increased respiratory excursion of sound parts of the lungs, a larger part of the inhaled substance may be expected to reach the normal than the diseased bronchi. The inhala-

tions are troublesome. An improvement in the cough and a diminution in the amount of expectoration is at times observed. The vapor of oil of turpentine (a teaspoonful to the pint of boiling water) may be used. The fumes of creosote may be inhaled.[1] A small air-tight room is used for the inhalation. The creosote is placed in a flat, open dish, heated by means of a spirit lamp. Gas should not be used, unless conducted to the burner by a metal tube. Rubber tubing may be ignited by burning creosote, which overflows the sides of the dish. The spirit lamp should be placed in a large flat, open metal vessel. The patient's eyes are protected from the irritating effect of the fumes by two watch glasses framed with adhesive plaster; the nose by plugs of absorbent cotton. Saturation of the hair and clothing may be prevented by a towel about the scalp and a dressing gown. Treatment is taken daily for twenty minutes to an hour or longer. Carbolic acid (2 to 4 per cent.) or thymol (2 to 4 per cent.) may also be inhaled. Vaporization may be accomplished by means of an inhalation apparatus, of which there are many models on the market. Simple normal salt solution may be similarly used. Ten drops or more of a solution of liquid carbolic acid or thymol, rectified spirit and glycerin, equal parts of each, may be dropped upon a face-mask and thus inhaled. They may disguise a foul odor of the breath.

(*b*) *Intratracheal Injections.*—Menthol, iodoform or eucalyptol (10 per cent.) in olive oil, a dram of which is injected once or twice a day through the glottis by means of a syringe with a curved nozzle, is sometimes used. Granger Stewart[2] recommends menthol 10 parts, guaiacol 2 parts, olive oil 88 parts.

(*c*) *Internal Medication.*—This is unsatisfactory. Ammonium chlorid gr. 10 (0.65 gm.) three times a day is sometimes used. Narcotics should be used with caution and only when specially indicated, as they may diminish the expectoration and favor stagnation.

(*d*) *Postural Treatment.*—This is more promising and should be tried in all cases. Quincke[3] recommended the inclined supine position. The patient lies flat in bed with the head turned to one side to favor expectoration. The foot of the bed is elevated 20 to 30 cm. This position is assumed for two to three hours in the early morning and again in the evening. It is well at first to have the bed horizontal in order that the patient may become accustomed to the supine position. The method is especially indicated in cases with cylindric and saccular ectasies, opening freely into the bronchi, situated in the lower lobes and without too tenacious or irritating a sputum. More rapid and complete evacuation of the secretion, the avoidance of stagnation, and a diminution in the size of the cavities are sought by the method. Among others, Jacobson[4] and Schäfer[5] have reported favorable results. The latter refers to an experience with 15 cases of bronchiectasis. Of

[1] Chaplin, British Med. Jour., 1895, p. 1371.
[2] British Med. Jour., 1893, vol. i.
[3] Berl. klin. Woch., 1898, p. 525.
[4] Ibid., 1900, No. 41.
[5] Deut. Arch. f. klin. Med., 1908–09, vol. xcv.

10 in whom the disease involved the lower lobes, improvement was observed in 6. Of this number, the sputum so far diminished in 2 that the patients would cough only a few times at the beginning of the treatment, and were free from cough the rest of the day. The result was uncertain in 4 of the 10 cases. In the remaining 5 cases, the disease involved the right upper lobe (2 cases), the middle and lower lobes (1 case), and the whole of both lungs (2 cases). No improvement was noted in this group. A temporary increase in the amount of sputum may be noted during the first week or two of treatment. In favorable cases, this is followed by a striking diminution.

Partial inversion, in which the patient favors the evacuation by leaning face downward over the side of the bed, his hands resting on the floor, may also be tried several times a day. Gerhardt's[1] prone position and manual compression of the thorax during expiration,[2] Rossbach's[3] chair, and Schreiber's[4] corset and thorax compressor may also be used. Ewart[5] has devised an apparatus for children by means of which exercising may be done in the prone position.

(*e*) *Surgery.*—This is unsatisfactory. Of 57 operations collected by Garré,[6] 21 patients died immediately or within the first few weeks thereafter. Forty-six patients (80 per cent.) were reported as cured, but among them unfortunately little more than a half could be regarded as actually cured. The remainder had fistulæ, chronic bronchitis or evidence of persistent bronchiectasis. The reports of individual operators of large experience are even less encouraging. Thus Körte[7] lost 11 (73 per cent.) of 15 patients operated for bronchiectasis. Three died immediately after operation. A fourth died seven hours after operation and the remaining 7 within three days to three months. Four patients (Numbers 10, 24, 36 and 30) only were cured, and of these a successful result was attained in 3 only after repeated operations. One of the 3 (No. 30) was subjected to extensive costatectomy, pneumotomy, and final resection of the right lower lobe.

In the consideration of surgery, it should be remembered that the diagnosis is difficult. The extent and number of the dilatations cannot be determined with certainty. The cavities are likely to be deep within the substance of the lung and surrounded by indurated tissue, thus increasing the danger of hemorrhage and preventing the collapse of the lung. Persistent pulmonary fistulæ not infrequently follow operation.

Disseminated bilateral bronchiectasis and tuberculous lesions are not as yet amenable to surgery. With circumscribed multiple or isolated saccular ectasies, a resort to surgical interference may be con-

[1] Zeit. f. Diät. u. physik. Ther., Bd. i, p. 11.
[2] Gerhardt, Berl. klin. Woch., 1873, No. 23, p. 25.
[3] Lehrbuch der physikal. Heilmethoden, 2 Aufl., S. 59.
[4] Zeit. f. klin. Med., Bd. xiii, p. 320.
[5] Reports of the Society for the Study of Disease in Children, 1908, vol. iii.
[6] Garré and Quincke, Grundriss der Lungenchirurgie, 1903.
[7] Arch. f. klin. Chir., 1908, vol. lxxxv.

sidered. The outlook is in general not sufficiently favorable to advise operation even in such cases, but it may be a justifiable procedure under certain circumstances. The disease may be intolerable. With persistent septic features, apparently due to insufficient drainage or complicating gangrene, operation may be undertaken as a life-saving measure. The operative technic is like that for abscess or gangrene. Of the various operative procedures, pneumectomy is a desperate measure. Extensive resection of the ribs overlying the pulmonary lesions may be followed by partial collapse of the involved lung and an amelioration of the symptoms. Incision and drainage of a large cavity may be successful. In rare instances, even when the site of the disease is not found, pus may later discharge into the canal. Several operations may be necessary to secure drainage of nearby cavities into the principal opening.

Artificial Pneumothorax.—This method has been used in the treatment of bronchiectasis in a number of instances, but without noteworthy success. The usual multiple character of the lesions and the frequency of extensive indurative changes in the lung diminish the chances of a favorable result. A complicating adhesive pleurisy is so common as to add greatly to the difficulty and danger of the operation. The procedure cannot be recommended.

CONGENITAL BRONCHIECTASIS.

In rare instances, bronchiectasis is found in the fetus, in dead-born children, or from its anatomic character appears to be due to persistence of a part of the lung in the fetal condition. It may exist throughout both lungs, or it may be unilateral or unilobar. Edens[1] has collected and classified the reported cases to 1904. Two principal groups are described.

Fetal Bronchiectasis.—(*Congenital cystic formation of the lungs; congenital cystic malformation of the lungs.*)—Grawitz[2] described as "universal bronchiectasis" cases in which the principal bronchus and its main branches to one lung or one lobe were dilated. There is a large central cyst. Secondary and tertiary cysts communicate with this and with each other. The inner surface of the cysts is lined with ciliated epithelium. In a second group, he termed the condition "telangiectatic bronchiectasis." Here there are numerous circumscribed ectasies, developed from the bronchi of the third and fourth order. They may be so placed that on one branch several are arranged one behind the other. Only a small opening may connect the bronchus and the cysts. In some instances, the bronchi end blindly and fail to communicate with the cyst. Changes in the pulmonary tissue itself are generally lacking. Cases of fetal bronchiectasis have also

[1] Ueber atelektatische Bronchiektasie, Deut. Arch. f. klin. Med., 1904, vol. lxxxi.
[2] Virchow's Arch., 1880, Bd. lxxxii.

been described by Meyer,[1] Virchow,[2] Biermer,[3] Barlow,[4] Frühwald,[5] Balzer and Grandhomme,[6] Kaufmann,[7] Störck,[8] Rokitansky,[9] Couvelaire,[10] Hondo,[11] and Sandoz.[12] The two cases reported by Sandoz were twin sisters, and he regarded the condition as probably due to congenital syphilis.

Atelectatic Bronchiectasis.—In this form, according to Heller,[13] there has been an arrest of development in certain parts of the pulmonary parenchyma (agenesis), or well-developed pulmonary alveoli remain airless or collapse soon after birth. Gradual widening of the bronchi occurs in the involved region. There are numerous multilocular cavities, which may or may not communicate with the bronchi, and are lined with a stratified pavement epithelium. Between the dilated bronchi are remnants of the atelectatic and non-pigmented fetal lung. Inflammatory changes are lacking. The bronchial walls may show an abnormal growth of cartilage. Cases of this type have also been reported by Gairdner.[14] Herxheimer,[15] Wollman,[16] Francke,[17] and Paul.[18]

[1] Virchow's Arch., Bd. xix.
[2] Zur Entwichelungsgeschichte des Kretinismus und der Schädeldifformität.
[3] Virchow's Arch., 1860, Bd. xix.
[4] British Med. Jour., January 3, 1880.
[5] Jahrb. f. Kinderh., 1885, Bd. xxiii.
[6] Rev. mens. des mal. de l'enfance, November, 1886.
[7] Untersuchungen über die sog. fötale Rhachitis, 1892.
[8] Wiener klin. Woch., 1897.
[9] Ibid.
[10] Ann. de gynéc. et d'obstét., 1903.
[11] Zentralb. f. allg. Path., February 29, 1904.
[12] Beitr. z. path. Anat. u. z. Allg. Path., 1907, vol. xli.
[13] Deut. Arch. f. klin. Med., 1885, Bd. xxxvi, S. 189.
[14] Glasgow Path. and Clin. Soc., 1885.
[15] Breslauer ärztl. Zeit., 1887, No. 3.
[16] Inaug. Diss., Freiburg, 1891.
[17] Deut. Arch. f. klin. Med., 1894, Bd. lii.
[18] Mitthl. aus. den Hamburgischen Staatskrankenanstalten, 1899.

CHAPTER VII.

BRONCHIAL BLASTOMYCOSIS.

Castellani[1] has described cases of bronchitis with large numbers of organisms resembling those described in the section on Pulmonary Blastomycosis in the Sputum. In mild cases there is mucopurulent sputum without blood, and examination shows a few coarse moist rales, or is negative. Recovery may take place in the course of several weeks or months. In severe cases there may be fever, emaciation, mucopurulent and bloody expectoration. Signs of pulmonary involvement may be present on examination. In this type the condition may closely resemble phthisis and the outlook is grave.

[1] Bronchooïdiosis, Jour. Trop. Med., April 1, 1913.

SECTION II.

DISEASES OF THE LUNGS.

CHAPTER VIII.

ATELECTASIS.

Atelectasis (from ἀτελής, incomplete, and ἔκτασις, dilatation) is a condition of the whole or a part of the lungs in which there is a persistence of or return to a fetal and airless state.

Historical Note.—Atelectasis in the newborn, previously regarded as pneumonia, was first described by Jörg[1] in 1832. It was more thoroughly studied and differentiated from pulmonary inflammation by Hasse[2] in 1841. Legendre and Bailly[3] first recognized an acquired form of the disease. Mendelsohn[4] showed experimentally that the introduction of foreign bodies (shot, paper-ball, thick watery solution of gum arabic) into the air passages, narrowing of the trachea by means of a ligature, opening the pleural cavity, or section of both recurrent laryngeal or both vagus nerves was followed by atelectasis. He suggested that persistence of an open foramen ovale, in connection with atelectasis, was due to deficient respiration, and called attention to the transition of atelectasis into pneumonia. Traube[5] showed that the atelectasis following section of the vagus or recurrent laryngeal nerves was due to the entrance of buccal secretion into the air passages.

Classification.—The term *congenital atelectasis* is applied to the condition when parts or the whole of one or both lungs persist in an uninflated, fetal state. The term *acquired atelectasis* or *pulmonary collapse* is used with reference to cases in which a previously air-holding lung returns to a fetal and airless state. The acquired form of the disease may be due to (1) obstruction of the air passages or to (2) retraction or compression of the lung.

[1] De morbo pulmonum organico ex respiratione neonatorum imperfecta orto, Diss. Lipsiæ, 1832; and Die Fötuslunge im geborenen Kinde für Pathologie, Therapie und gerichtl. Arznei-Wissenschaft, Grimma, 1835.

[2] Spec. path. Anat., Leipzig, 1841, p. 324.

[3] Arch. gén. de méd. jour. complémentaire des sc. méd., 1844, 4 sér., T. iv.

[4] Der Mechanismus der Respiration und Circulation, etc., Berlin, 1845.

[5] Beitr. z. exper. Path. u. Phys., 1846, Heft 1.

Etiology.—Atelectasis may occur at any age. It is most common in the newborn as a congenital manifestation. The disease is more frequent in infancy and early childhood than in later years, probably because of the relative weakness of the respiratory muscles at this age and the greater readiness with which small air passages become occluded.

Congenital Atelectasis.—This may be due to deficient strength of the respiratory muscles, as in premature or weakly infants or to diminished irritability of the respiratory centre in consequence of intracranial hemorrhage, compression of the skull or injury to the spinal cord during birth. Difficult or protracted labor favors its development.

Mechanical obstruction to the entrance of air into the lungs from the inhalation of amniotic fluid, meconium or mucus before, during or immediately after birth is a more important and more frequent cause.

Acquired Atelectasis.—In some instances, the lungs are found in a fetal and airless condition in infants who have come into the world alive, cried and lived several hours or even days.

Obstruction Atelectasis.—Atelectasis may be observed in the course of rickets, whooping cough, croup, capillary bronchitis, measles, scarlet fever, chronic diarrhea, typhoid fever, and acute rheumatism. Occlusion of the bronchi by tenacious secretion is probably the essential cause. Weakness of the respiratory muscles may be a predisposing factor. In typhoid fever, the development of atelectasis is favored by insensitiveness to ordinary stimuli, weakness of the respiratory muscles, ineffectual efforts to expel bronchial secretion, meteorism, and the maintenance for long periods of one position, as lying on the back.

Atelectasis may also follow bronchial obstruction by mucopurulent or fibrinous secretion, aspirated foreign bodies or tumors growing from the wall of the bronchus. Occlusion of the bronchi by compression from without, as from enlarged glands or new growths of the mediastinum, may also be a cause. Complete occlusion is essential to its production.

Retraction or Compression Atelectasis.—Atelectasis may be due to encroachment upon pulmonary space by the presence of tumors arising from the thoracic structures, the chest wall or by metastasis from without, the accumulation of fluid or gas in the pleural or pericardial sac, enlargement of the heart, deviation of the spine or elevation of the diaphragm (as from meteorism, ascites, etc.). The affected part of the lungs retracts until its elasticity is spent. Actual compression occurs only when a fully retracted lung is subjected to a force which still further diminishes its size.

Pathogenesis.—The origin of congenital atelectasis is easy to understand and need not be further considered. In those cases in which atelectasis is found in infants who have cried and died shortly after

birth, at least partial inflation of the lung may be assumed. In explanation of the airless condition of the lungs in such cases, Thomas[1] suggested that slightly less air is taken in during each gradually failing inspiration than is expelled during expiration. The disparity between intake and outgo ends in complete deflation and pulmonary collapse. Schröder[2] likewise supported this hypothesis. Disappearance of air from that part of the lung supplied by an obstructed bronchus, in Gairdner's[3] opinion, was due to the peculiar relation of the obstruction to the bronchial wall. He suggested that a mucus plug may act as a ball-valve in a bronchial tube of diminishing caliber, allowing the air to escape but preventing its entrance into the involved pulmonary region.

These hypotheses, however, do not serve to explain the disappearance of air from a part of the lung excluded from communication with the outside world by a foreign body firmly fixed in a bronchus. The persistence of air in an excised lung makes it unlikely that purely mechanical factors are a sufficient explanation. Virchow appears to have been the first to suggest that the air was absorbed by the circulating blood. This view, supported by Bartels,[4] and by others after him, was established as the correct explanation by Lichtheim,[5] who showed that the development of atelectasis in animals following artificial occlusion of the bronchus or opening the pleural cavity was delayed by interruption of the pulmonary circulation[6] at the hilus of the lung. When the lungs were inflated with oxygen, carbon dioxide or nitrogen gas, introduced through the trachea, and the left bronchus was tied, it was found that oxygen and carbon dioxide were absorbed more quickly, nitrogen less quickly, than atmospheric air. The deflation of a lung removed from the body takes place more slowly than from the lung in a living animal with an open pleural cavity. Air disappears more slowly from an inflated lung removed from the body and with the bronchus tied, than from an inflated lung in the living animal with the bronchus similarly tied. Atelectasis arising in consequence of bronchial occlusion or opening the pleural cavity may therefore be regarded as due to absorption of air by the circulating blood. Complete expulsion of air through the bronchi may be prevented even when the bronchi are patent by the approximation of the bronchial walls as the lung retracts. Atelectasis in connection with even inconsiderable encroachment upon pulmonary space is also to be regarded as due to absorption of air.

[1] Nederl. Tijdschr. vor Geneesk., June, 1864, viii, 337.
[2] Deut. Arch. f. klin. Med., 1869, Bd. vi, p. 398.
[3] Edinburgh Monthly Jour., 1850, vol. xii.
[4] Virchow's Arch., vol. xxi, S. 132 and 133.
[5] Versuche über Lungenatelektase, Arch. f. exp. Path., 1878–79, x, 54.
[6] Interruption of the circulation by ligating the hilus of the lung, including the bronchus, the pulmonary and bronchial arteries and the pulmonary veins, gave inconstant results owing to the production of hemorrhagic edema, but in isolated cases the lung was completely airless throughout.

Pathology.—The affected region in congenital atelectasis is uniformly dark brownish or grayish red, in sharp contrast with the pale red of the normal lung. It is compact, inelastic, firm and airless. Contraction is indicated by depression of the involved area below the level of the normal lung. The cut surface is smooth, homogeneous, nongranular and dry. Only a small amount of blood, unmixed with air, can be expressed. The extent of the process is variable and may embrace the whole of both lungs. Partial atelectasis, according to Peiser,[1] is more likely to be found in the central parts of the lung, in the paravertebral and suprathoracic portion. He states that the left lung is more often affected than the right. The pleura overlying atelectatic areas is at first smooth and shining, later slightly thickened and cloudy. When forcible respiratory efforts precede death, subpleural ecchymoses may be found. Retraction of the lung in consequence of atelectasis may uncover the heart to an abnormal degree. Uninvolved parts of the lung may be found in a condition of acute compensatory inflation.

Occlusion atelectasis is confined to the region supplied by the obstructed bronchus. The areas are here wedge shaped with the base toward the periphery of the lung. Retraction or compression atelectasis occurs at the site of the encroachment upon the pulmonary space. The involved regions differ little in their general characters from the congenital form of the disease. The color is, however, likely to be darker in consequence of circulatory disturbances, stasis and pigmentation of the tissue, and may then be steel blue. Stasis may also increase the amount of blood in the tissue and more or less dark-red fluid may be expressed from the cut surface. Such an appearance has been spoken of as splenization, and may readily be confused with hypostatic pneumonia. Retraction or compression atelectasis, in the absence of stasis, may have a gray or slaty color in consequence of a diminished blood-supply.

Microscopic examination of congenitally atelectatic areas, according to Peiser, shows an absence of alveolar structure, rendering the pulmonary tissue hardly recognizable as such, were it not for the presence of bronchi. Beside the bronchi are cubical epithelioid cells arranged in indistinct glandular structure and between them numerous blood-vessels and capillaries filled with blood. Incomplete atelectasis shows varying numbers of open alveolar spaces. Pulmonary hemorrhage and edema[2] were frequently found to complicate the process.

Congenitally atelectatic areas can usually be reinflated when the

[1] Jahrbüch f. Kinderheilk., 1908, N. F. 67, p. 589.

[2] Peiser's histological studies were made after fixation of the lungs *in situ* by means of Gregor's injection method: Before opening the thorax, the body was injected by way of the inferior vena cava with one-third formalin under low pressure and the injection continued as long as foamy fluid flowed from the nose and mouth. Ungar (Zur Lehre von der Lungenatelektase, Jahrbuch f. Kinderheilk., 1909, N. F. 69, p. 505) criticises his results and suggests that the histologic picture obtained was modified by the injection. For Peiser's reply see ibid., p. 673.

infant has died within a few days after birth. After a time, the length of which cannot be definitely stated, the affected regions in all forms of atelectasis become incapable of redistention. When we consider the unfolding at birth of the fetal lung, it seems improbable that atelectasis alone is responsible. Inability of the atelectatic lung to redistend may be due to persistence of the cause of the process or to invasion of the involved region with bacteria and consequent inflammatory changes. Dunin[1] in his experimental study of the pulmonary changes following the production of exudative pleurisy found that the affected lung at first showed degeneration and desquamation of the alveolar epithelium, partial collapse of the capillaries, and small-celled infiltration about the larger bloodvessels and the medium and larger bronchi, from which in the later stages fibrous connective tissue developed. The degenerative process leads to transformation of the parenchyma into connective tissue and obliteration of the bronchi. Such changes are doubtless in part responsible for the inability of the lung to re-expand after retraction or compression atelectasis. Inflammatory thickening of the pleura is also of importance in this form of the disease. Similar inflammatory pulmonary changes are likely to complicate persistent types of congenital and obstruction atelectasis and render the lung undistensible.

Early in the course of the atelectasis, invasion of the involved parts of the lung with bacteria which gain entrance through the bronchi may lead to outspoken bronchopneumonia. Hypostatic pneumonia may also complicate the condition.

The final outcome of persistent atelectasis was first described by Heller[2] who showed that, following the congenital form of the disease, there is in many of the cases an atrophy of the alveoli, hypertrophy of the bronchi, and the formation of so-called "atelectatic bronchiectasis" in the involved region. Absence of pigment was a striking feature in adults with deeply pigmented lungs. Heller's findings have in general been confirmed, among others by Recklinghausen,[3] Herxheimer[4] (3 cases), Berlin,[5] Francke,[6] Arnheim,[7] Paul,[8] and Lotmar[9] (2 cases). Certain minor differences in the pathologic picture may be noted. Thus, absence of hyperplasia of bronchial cartilage was noted by Herxheimer (Case 3), Recklinghausen, Paul, and Lotmar

[1] Anatomische Veränderungen in den Lungen bei deren Compression, Virchow's Arch., 1885, cii, 323.

[2] Die Schicksale atelektatischer Lungenabschnitte, Deut. Arch. f. klin. Med., 1885, xxxvi, 189.

[3] Schuchardt, Inveterierte Atelektase, Virchow's Arch., 1885, Bd. ci.

[4] Beiträge z. Kenntniss atelektatischer Bronchiektasien, Bresl. ärztl. Zeit., 1887.

[5] Uëber einen Fall von atelektatischer Bronchiektasie, Diss. Kiel, 1891.

[6] Lungenschrumpfung aus der ersten Lebenzeit, Deut. Arch. f. klin. Med., 1893, Bd. lii.

[7] Uëber einen Fall von kongenitaler halbseitiger Hypertrophie mit angeborenen Bronchiektasien, Virchow's Arch., 1898, Bd. cliv.

[8] Münch. med. Woch., 1899, S. 30.

[9] Ein Beitrag z. Kenntniss der Schicksale der fötalen Atelektase, Virchow's Arch., 1908, cxci, 28.

(2 cases.) Traces of pigment were found on microscopic examination by Herxheimer (Case 3), Francke, Arnheim, and Lotmar (2 cases). Bronchiectasis was absent in both of Lotmar's cases. In one of them in which the condition had lasted for fifty years, the alveolar structure of the subpleural parenchyma was retained without adhesion of the alveolar walls.

Medicolegal Aspect.—Principal interest centres in the importance which can be attached to air-holding lung as evidence of the birth of a living child, or to complete atelectasis of the newborn as evidence of a dead-born child.

The presence or absence of air is usually determined by testing the lungs in water. If the lung floats, or if on section air escapes, it suggests that the infant has lived and breathed after birth, but the evidence cannot be regarded as conclusive. Intra-uterine inflation of the lungs may follow the entrance of atmospheric air into the uterus through the vagina. Putrefaction by gas-forming bacteria may lead to the presence of gas in the lungs before or after birth. Artificial inflation of the lungs of a dead-born child may also be responsible for a positive test. Ahlfeld[1] reports the presence of aspirated vernix caseosa, giving an appearance of air-holding tissue to parts of the lung. In one of his cases, small pieces of the lung, although airless, floated in water.

On the other hand, complete atelectasis suggests a dead-born child, but, as already mentioned, may be found in infants who have come into the world alive, lived several hours or even days, and have cried. Lichtheim's experiments make it probable, as Ungar[2] holds, that the air may be absorbed from the lungs by the blood, provided the circulation outlasts the respiration.

Effect of Atelectasis on the Circulation.—The congenital form of the disease is most important owing to the extent of pulmonary involvement and the disturbance of the fetal circulation. Jörg constantly found the foramen ovale open in dead-born infants with atelectasis. Hasse confirmed this, but rightly suggests that a patent foramen ovale is not uncommon at this age. Weber[3] found the ductus arteriosus open in infants who had breathed imperfectly. Atelectasis excludes a part of the lung from the pulmonary circulation, maintains an abnormally high pressure in the pulmonary circuit, and thus tends to continue the passage of blood through these fetal channels, preventing their closure. In Francke's patient, a man aged fifty-eight years, with partial congenital atelectasis of both lower lobes, the foramen ovale was found at autopsy to be wide open and the ductus arteriosus was obliterated. Stasis in the pulmonary circuit leads also to dila-

[1] Schwimmende Lungen ohne Luftgehalt, Zeit. f. Geburtshülfe und Gynäkologie, 1907–08, lxi, 473.

[2] Können die Lungen Neugeborener, die geathmet haben, wieder luftleer werden? Vierteljahrschr. f. ge. Med., etc., N. F., Bd. xxxix, H. 1.

[3] Beiträge z. path. Anat. d. Neugeb., 2 Lief, quoted from Strassmann, Anatomische und physiologische Untersuchungen über den Blutkreislauf beim Neugebornen, Arch. f. Gynäk., 1894, vol. xlv.

tation of the right heart, and may favor the formation of thrombi in the right heart, the cerebral sinuses or elsewhere in the venous system.

Symptoms.—Congenital Atelectasis.—In extreme cases, the infant is asphyxiated at birth, and efforts at resuscitation fail or are only partially successful. In less severe cases, the infant may live for a few days or even weeks. It is usually feeble and poorly nourished, may refuse to nurse, cries feebly or not at all, and is dull and drowsy. The breathing is rapid and shallow. The cyanosis is marked and gradually increases. It is due to encroachment upon pulmonary space, resulting stasis in the venous system and admixture of venous and arterial blood through the persistent fetal channels. The pulse is feeble, the extremities relaxed and cold, and the superficial veins dilated. Cough and fever are absent unless the condition is complicated. Toward the end there may be muscular twitchings or convulsions. The child becomes unconscious and dies from asphyxia or exhaustion. If the pulmonary involvement is slight and the infant well nourished and strong, inflation of the unexpanded lung may gradually take place. In such cases complete recovery may follow. In rare instances, the infant survives and the atelectasis persists as a permanent defect in a part of the lung. Small areas of atelectasis probably occur without producing any symptoms.

As described by Gerhardt,[1] in cases in which the atelectasis is somewhat extensive, the breathing is of the stenotic type with inspiratory depression of the intercostal spaces, the clavicular fossæ and the neighborhood of the sixth and seventh chondral cartilage, where a transverse furrow, in part due to the tug of the diaphragm, may be seen.

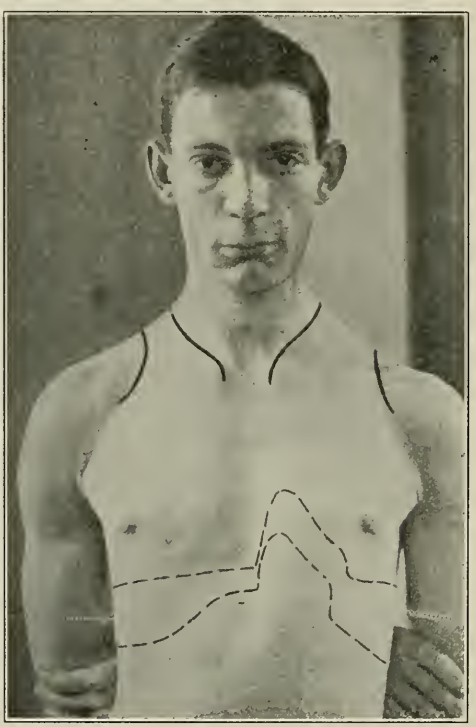
Physical signs, when present, are like those in pneumonia, with which the disease was formerly confused. The percussion note is dull or dull and tympanitic. The dulness is seldom marked and may be difficult of determination, when, as is commonly the case, the process is bilateral. Gerhardt states that at first the extent, intensity, and even the side affected may be varied by changing the position of the patient. The breathing over small areas is diminished and vesicular. When large areas are involved, it may be bronchial. Consonating rales may also be heard. An increase in vocal fremitus may be established over large areas. If the bronchi are plugged, the signs may be those of massive pneumonia, dulness, diminished or absent breathing and vocal fremitus. The area of cardiac dulness may be increased in consequence of retraction of neighboring parts of the lung or dilatation of the right side of the heart. If the stasis is extreme, the second pulmonic sound may be increased and edema may be present.

In Francke's case, a man aged fifty-eight years, in whom at autopsy partial congenital atelectasis of both lower lobes was found, there was a striking deformity of the chest. The thorax was lengthened. The

[1] Handbuch der Kinderkrankheiten, 1878, Bd. iii, Hälfte 3, p. 504.

anteroposterior diameter of its upper portion was increased. The upper part of the sternum and the first three ribs were bowed outward, the region below the sixth rib was constricted (wasp-waist), and still lower the thoracic margin was bent outward. In this case, as in others in which the remote consequences of congenital atelectasis have been described, there was chronic interstitial pneumonia, bronchiectasis and emphysema.

Fig. 21



"Collapse induration" of the right apex. (Krönig.)

Acquired Atelectasis.—In cases in which the condition complicates bronchial or pulmonary infection and is due to obstruction of the bronchi by tenacious secretion, there are usually no clinical features which can with certainty be ascribed to atelectasis. The symptoms and physical signs are then commonly masked by the underlying disease. The pulmonary collapse may contribute, however, to the respiratory disturbance. In some cases it may be demonstrated when over circumscribed areas, usually at the bases posteriorly, such signs as dulness, diminished or absent breathing, voice, whisper and tactile fremitus partially or wholly disappear after cough and the relief of the obstruction, on urging the patient to breathe deeply or on changing his position. Rales may be heard after the obstruction is relieved.

In mild cases, rales which disappear during the course of the examination may be the only manifestation.

When large portions of the lung are rendered atelectatic by the occlusion of one of the larger bronchi, as by an impacted foreign body, the symptoms and signs are marked. The dyspnea is likely to be intense. Respiratory motion and the breath sounds are diminished or abolished over the affected region, with dulness, diminished or absent voice, whisper and tactile fremitus. Inflammatory processes soon develop in the collapsed lung unless the obstruction is relieved.

Pulmonary collapse in consequence of encroachment upon pulmonary space, as from a pleural effusion, is in part responsible for the dyspnea which occurs. The physical signs vary with the extent of the pulmonary collapse. If this is slight, transient rales only may be heard. If the lung is considerably reduced in size, there is likely to be dulness or dull tympany, diminished and bronchial breathing at times of an amphoric quality, increased voice, whisper and tactile fremitus. Consonating rales may also be heard. The signs vary with the condition of the pleura. X-ray examination shows an increased density to the shadow over the atelectatic compared with the normal lung.

Abrams[1] has called attention to circumscribed areas of atelectasis in apparently normal individuals in certain parts of the chest as at the margin of the lungs near the inner and outer ends of the clavicles anteriorly and at the outer border of the lung in the supraspinous fossa and at the angle of the scapula posteriorly. These physiologic areas are dull on percussion. They disappear after repeated forced inspirations and reappear in a few moments when tranquil breathing is resumed.

Krönig[2] has noted the presence of non-tuberculous "collapse induration" of the right apex in patients with obstructed nasal breathing. The nasal obstruction is usually due to adenoids in the nasopharynx with which thickening of the posterior ends of the turbinates may be associated. There is retraction and diminished motion of the right apex, dulness of varying degree over the right supraclavicular or supraspinous fossæ, at times narrowing of the isthmus, and indeterminate or intense bronchovesicular breathing. In some cases, rales may also be heard. General signs of tuberculosis are lacking. Special stress in excluding it is laid on a normal respiratory excursion of the inferior pulmonary margin. The apical collapse is ascribed to relatively greater inspiratory expansion and diminished expiratory collapse of these compared with other parts of the lungs. Mouth breathing favors the inhalation of dust which is deposited in largest amount at the apices. Of the two, the right is principally affected because of the greater diameter of the right compared with the left primary bronchus and the proportionally greater bronchial and less pulmonary space at the right than at the left apex. Repeated catarrhal swelling of

[1] Medical Record, September 1, 1894.

[2] Ueber einfache, nichttuberkulöse Kollapsinduration der rechten Lungenspitze bei chronisch behinderter Nasenatmung, Medizinische Klinik, 6 Okt., 1907, No. 40.

the apical mucous membrane is followed by collapse of the involved alveolar region, with subsequent chronic inflammatory thickening, fibrous induration, and contraction.

Diagnosis.—This is not difficult in the congenital form of the disease. The occurrence of the pulmonary symptoms at or soon after birth, the cyanosis, absence of cough and fever, and the bilateral site of the process usually serve to exclude pneumonia. Congenital atelectasis as a cause of pulmonary changes in adult life can hardly be recognized before an autopsy is performed. In the acquired form secondary to bronchial occlusion, change in the signs on shifting the position of the patient or after cough and deep breathing is suggestive evidence against edema or pneumonia developing at the bases. Atelectasis is an adequate explanation for rales or signs of consolidation in the immediate neighborhood of an encroachment upon pulmonary space. Disappearance of the signs after removal of the cause may be necessary to exclude a complicating pulmonary process. Transient rales at the margin of the lungs, especially in the axillary region, in the absence of other symptoms or signs of pulmonary disturbance may be regarded as physiologic.

Prognosis.—The outlook in congenital atelectasis depends on the extent of the process, the nutrition and strength of the infant. The prognosis of the acquired form is that of the cause of the disease.

Treatment.—The treatment of congenital atelectasis is that of asphyxia. Aspirated fluids and mucus must be wiped from the nose and mouth, and, if necessary, aspirated from the trachea by means of a catheter. The respiration should be stimulated by slapping and rubbing the body, alternate immersion in hot and cold water, and, if need be, by artificial means. Sylvester's[1] method should be used, the infant meanwhile lying on its back, warmly covered, with the feet fixed and the tongue drawn forward to prevent obstruction of the air passages. The arms, grasped just above the elbows, are then alternately raised above the infant's head and lowered to the sides of the chest against which they are pressed. Schultze's swinging movements may also be used. If these measures fail, insufflation by means of a catheter introduced into the trachea may be tried, care being taken, however, to avoid forcible inflation for fear of producing vesicular and interstitial emphysema. After successful resuscitation, special attention should be paid to maintaining the body temperature. The child may be rolled in cotton and surrounded by hot-water bottles or placed in an incubator. Care should be taken not to constrict the chest by tight application of clothing. Persistence of partial atelectasis or recurrence should be treated by daily repetition of slapping, friction, and bathing, by inducing the infant to cry and by frequent changes of position. Careful attention should be paid to appropriate feeding.

[1] The True Physiological Method of Restoring Persons Apparently Drowned or Dead and of Resuscitating Stillborn Children, London, 1858.

The treatment of acquired atelectasis is that of the cause of the disease. In the obstructive form, due to retention of secretion, the general strength should be maintained by proper attention to food and fresh air, thus favoring the expulsion of bronchial secretion. An expectorant may also be of service. Frequent changes in position of a patient lying in bed favor the relief of the obstruction. In typhoid fever, cool baths, frequent changes of position, and the relief of meteorism are important measures. Aspirated foreign bodies should be removed. Secondary inflammatory changes are likely to permanently impair the collapsed lung if the obstruction is allowed to remain more than a few days. The early removal of pleural effusion may prevent the development in and about the collapsed lung of inflammatory changes which render it undistensible.

CHAPTER IX.

EMPHYSEMA.

Classification.—The term *Emphysema* (from Ἐμφύσημα an inflation) when used without qualification usually indicates what may more specifically be spoken of as *Diffuse Vesicular Emphysema.* It is to be distinguished from other forms which differ sufficiently to warrant their consideration under separate divisions, as *Acute Vesicular E., Compensatory E., Senile E.,* and *Interstitial E.*

1. DIFFUSE VESICULAR EMPHYSEMA.

Definition.—Diffuse vesicular emphysema, also known as Ordinary, Genuine or True E., Hypertrophic E., Large-lunged E., Substantive or Idiopathic E., is a chronic condition in which the infundibular passages and the alveoli are dilated and the alveolar walls atrophied more or less generally throughout the lungs. It is characterized clinically by varying degrees of dyspnea and cyanosis.

Etiology.—The condition is almost invariably associated with other pathologic bronchial or pulmonary changes accompanied by cough. It is a mistake to regard emphysema as idiopathic or essential. It is usually secondary to bronchial or bronchopulmonary disturbances. Chronic bronchitis in connection with bronchopulmonary infection or cardiac insufficiency, with a harassing dry cough and tenacious, mucoid secretion is the most frequent cause. Next in importance is bronchial asthma. Whooping cough is an occasional cause. In rare instances it is said that emphysema may follow partial obstruction of the larger air passages, as from nasal, pharyngeal, laryngeal or tracheal obstruction. Compression of the trachea from without, as by goitre or mediastinal new growths, is said to also be a cause.

Certain occupations have been said to predispose to the condition. Thus players on wind instruments, glass-blowers, singers, and laborers who lift heavy weights have been regarded as subject to the disease. Straining at stool is also mentioned as a possible cause. Forlanini[1] could determine no difference in the vital capacity, respiratory pressure, or amplitude of the pulmonary excursion among the trumpeters of the Italian mountain troops and musicians and other bodies of men among the troops stationed in the level country. Fischer[2] discovered

[1] Cent. f. klin. Med., 1891, No. 17, p. 310.
[2] Münch. med. Woch., 1902, No. 17.

no outspoken case of emphysema among about 500 military musicians. Prettin and Leibkind[1] investigated 230 glass-blowers. Among 164 occupied at the trade up to forty years, no cases of emphysema were found. Among 54 at work from forty to fifty years, 2 were found to have a slight degree of emphysema, while among 12 at work over fifty years, 3 showed the clinical picture of emphysema with much diminished thoracic excursion (2 to 4 cm.), very slight diaphragmatic motion, and diminished vital capacity (2500 to 2700). They conclude that glass-blowing is of no moment in the etiology of emphysema.

Among 196,549 out-patient cases at the Massachusetts General Hospital from 1905 to 1914 were 557 cases (0.28 per cent.) of emphysema. Of 528 adults, 347 were males, 181 females. This greater frequency among males is common to all statistics on the disease, and may be ascribed to the more frequent occurrence among men of those diseases most likely to lead to emphysema, especially bronchitis. The condition is not commonly found before the third decade and becomes more frequent as age advances. Cases observed in persons over sixty-five to seventy are perhaps to be classed as senile emphysema.

In autopsy material, Virchow[2] found emphysema at the Berlin Pathological Institute during an interval of nine years in only 0.6 to 0.7 per cent. of all cases. Fränkel's[3] pathologic studies have the merit of special attention to the presence of emphysema. Among 911 autopsies performed from April 1, 1896, to March 31, 1897, not less than 65 (or about 7 per cent.) showed extensive emphysematous changes as the essential condition of the lungs, associated only with diffuse chronic bronchitis with and without bronchiectasis. Of the 65 cases, 14 were from thirty-one to fifty, 34 from fifty-one to seventy. Of the remaining 17 cases, 15 were from seventy-one to ninety and the age of two was unknown. The disparity between the frequency of the condition among clinical and autopsy cases may be ascribed to the readiness with which the less marked degrees of emphysema may be overlooked in the former.

Inheritance.—Jackson[4] found that among 28 patients with emphysema, 18 were born of parents suffering from the same disease, and in some instances the brothers and sisters were likewise affected. On the contrary, of 50 non-emphysematous persons, only 3 had parents with emphysema. Lebert[5] could trace an inheritance to the disease in 13 of 108 cases. Hertz[6] refers to one family, all the members of which were affected with varying degrees of emphysema.

[1] Münch. med. Woch., February 5, 1904.
[2] Emphysema Pulmonum, Berl. klin. Woch., 1888, No. 1.
[3] Spez. Path. u. Ther. der Lungenkrankheiten, 1904, p. 219.
[4] Waters, British Med. Jour., 1860, p. 1012.
[5] Klinik der Brustkrankheiten, Tübingen, 1874, p. 394.
[6] Lungenemphysem, Ziemssen's Handbuch der spec. Path. u. Ther., 5, ii, p. 346.

Pathogenesis.—In explanation of the origin of emphysema, two principal theories are held, *i. e.*, the nutritive and the mechanical theory.

Nutritive disturbances, singly or in combination with mechanical factors, are regarded as an essential condition by various authors. Thus Villemin[1] referred emphysema to primary changes in the connective tissue. J. Lange[2] assumed a paralytic neurosis of the nerve branches supplying the finest bronchi and their muscle fibers. Bayer[3] regarded changes in the circulation and Isaaksohn[4] degeneration of the capillaries as the cause. Grawitz[5] implicates the circulation in the origin of emphysema and makes a division into hydropic, inflammatory, and atrophic emphysema. To Virchow[6] an onset in early youth was suggested by the deficient pigmentation of the emphysematous lung, and led him to assume that a primary disease, diminishing the pulmonary elasticity, was the predisposing cause, although mechanical factors may still be of moment in its further development. Eppinger[7] described a separation and reduction in size of the larger and disappearance of the smaller elastic fibers in the emphysematous lung. He also noted a laceration and splitting of the fibers with the formation of minute clefts in the alveolar walls. Hansemann's[8] discovery of the presence of normal pores between the alveoli may in part account for apparent dehiscence of the fibers. Artefarcts may be responsible for others. Sudzuki[9], Spalteholtz,[10] and Tendeloo[11] failed to find the elastic tissue altered to any considerable degree. Separation and reduction in size of the elastic fibers may be ascribed to distention of the alveoli in the emphysematous lung.

Freund[12] has long held the view (as his list of publications shows)

[1] Arch. gén. de méd., October and November, 1866.

[2] Ueber d. substant. Lungenemphysem. und dessen Behandlung mit comprimirten Luft, Dresden, 1870.

[3] Arch. der Heilkunde, 11 Jahrg., 1870.

[4] Virchow's Arch., vol. liii.

[5] Deut. med. Woch., 1892, No. 10.

[6] Verhandl. d. Berl. med. Gesellschaft., 1888, Bd. xviii.

[7] Prager Vierteljahrschr., 1876, vol. cxxxii.

[8] Ueber die Poren der normalen Lungenalveolen. Sitzungsbericht der Königl. Preuss. Akad. der Wissenschaften, 1896, vol. xliv.

[9] Virchow's Arch., clvii, 438.

[10] Quoted from Hoffman, Nothnagel, 1902, American edition.

[11] Studien über die Ursachen der Lungenkrankheiten, Wiesbaden, 1902.

[12] Beiträge z. Histologie d. Rippenknorpel im normalen und pathologischen Zustand., Breslau, 1858; Der Zusammenhang gewisser Lungenkrankheiten mit primären Rippenknorpelanomalien, Erlangen., 1859; Thorax-anomalien als Prädisposition zur Lungenphthise und Emphysem., Berl. klin. Woch., 1901; Die Beziehung der Heilungsvorgänge gewisser Formen der Lungenphthise zur Gelenkbildung am ersten Rippenringe, Therapeutische Monatshefte, Juni, 1902; Ueber primäre Thoraxanomalien speziell über die starre Dilatation des Thorax als Ursache eines Lungenemphysems, Berlin, 1906, S. Kaiser; Zur operativen Behandlung gewisser Lungenkrankheiten insbesondere auf starrer Thoraxdilatation beruhenden alveolären Emphysems (mit einem Operationsfalle), Zeit. f. exp. Path. u. Ther., 1906, Bd. iii, p. 479; Beiträge z. Behandlung des tuberkulösen Lungenspitzenphthise und des alveolären Emphysems durch operative Mobilisation und des starr dilatierten Thorax, Münch. med. Woch., 1907, No. 48; Freund and Mendelsohn, Der Zusammenhang des Infantilismus des Thorax und des Beckens, Stuttgart, Enke, 1908; Die chir. Behandlung d. Stenose u. d. starr. Dilat. d. Thorax., Deut. med. Woch., 1910, xxxvi, 730; Ueber Wechselbeziehungen zwischen Lunge u. Thorax beim Emphysem., ibid., 1911, xxxvii, 1254; Ueber das Emphysem. Kritik d. Arbeit von I. Plesch., ibid., 1913, xxxix, 19.

that nutritive changes in the costal cartilages followed by fibrous and fatty degeneration, cavity formation and calcification lead to loss of elasticity, thickening and enlargement, and give rise to rigid thoracic dilatation and the maintenance of a persistent inspiratory position. He regards emphysema as a consequence of this dilatation. In a considerable proportion of the cases of emphysema the costal cartilages are thus changed. Freund finds also that in ordinary substantive emphysema the lungs collapse on opening the thorax, thus suggesting that pulmonary is secondary to thoracic dilatation.

The objection may, however, be raised concerning these histologic and anatomic features that they may as reasonably be regarded as the result, as the cause of emphysema, and that their bearing on the etiology of the disease is thus questionable. A predisposition to the disease from congenital weakness of the pulmonary tissue can neither be denied nor affirmed. In spite of the difficulty of establishing evidence in support of nutritive factors as a cause of emphysema, such changes can by no means be wholly disregarded. Mechanical forces alone seem incapable in many cases of producing emphysema, as, for example, in those who play upon wind instruments or who make violent respiratory efforts in their occupation. If mechanical forces alone were a sufficient cause, emphysema would be far more common than is actually the case. It is therefore reasonable to assume that some nutritive disturbance, whether congenital or acquired, is a probable predisposing factor in the development of emphysema.

Mechanical factors are present in practically all cases. The relative importance of inspiration and expiration has been much discussed. Inspiratory overdistention of the lung may occur in consequence of exclusion of a part of the lung from participation in respiratory motion. Compensatory dilatation in alveoli adjacent to areas of atelectasis may possibly be explained in this way, but it is difficult to exclude the influence of nutritive disturbances and heightened expiratory pressure from cough as factors of equal or greater importance. According to Tendeloo, emphysema of a purely inspiratory type should manifest itself in the sternoparasternal and lateral caudal parts of the lung. It is possible that the pulmonary dilatation demonstrated by Hofbauer,[1] Seefeldt,[2] and Bruns[3] in normal individuals after deep breathing, in dyspnea, air-hunger, physical exertion and cardiac insufficiency may have a bearing on this question of the mechanical forces of respiration. In these conditions inspiration is more strongly increased than expiration, the disproportion being of such a degree that a part of the inhaled air remains in the lungs, causing overdistention. It is conceivable that the persistence of respiratory overexertion may induce emphysema.

[1] Zur Emphysemafrage, Berl. klin. Woch., 21 März, 1910, No. 12.

[2] Der Stand des Zwerchfelles bei Gesunden und Emphysematiker, Beitr. z. Klin. d. Tuberkul., 1910, xv, 457.

[3] Berl. klin. Woch., 7 Feb., 1910.

The expiratory theory is a more reasonable explanation. During forced expiration against the closed glottis, as in violent attacks of cough, the thoracic walls are firmly fixed and the abdominal contents forced upward by contraction of the abdominal muscles. The inferior portions of the lungs are compressed and the increased intrapulmonary pressure inflates the least protected and more yielding cranial suprathoracic and sternoparasternal regions. The emphysema is usually most advanced at the apices and the anterior pulmonary margins, thus emphasizing the importance of expiration in its production. Repeated overdistention may be assumed finally to lead to diminished elasticity and permanent distention.

Experiments on animals show that an acute pulmonary distention can be mechanically induced. In Lichtheim's[1] experiments, an acute pulmonary dilatation followed obstruction of a primary bronchus. Ligature of the trachea by Hirtz,[2] Köhler,[3] and Sudzuki[4] produced emphysema, but stasis of bronchial secretions may have influenced the result. Expiratory obstruction by means of inserted valves by Marey,[5] Cohnheim,[6] and Bert[7] led to an acute pulmonary distention. Schall[8] experimented on dogs with masks so constructed that inspiration or expiration or both could be obstructed at will. Inspiratory obstruction for nine months in one animal, expiratory obstruction for ten and one-half months in a second and both inspiratory and expiratory obstruction for eleven months in a third failed to produce emphysema or lead to atrophy of the pulmonary tissue. Schall concludes that one must be cautious in accepting the origin of chronic emphysema from acute inflation, and regards it as probable that bronchitis or pneumonia must first injure the tissue before changes in the respiratory mechanism can give rise to atrophy of the tissue.

In conclusion it may be stated as an hypothesis that emphysema arises when pulmonary tissue, the nutrition of which is impaired, is subjected to repeated or persistent distention, whether by inspiration or expiration or both.

Pathology.—The thorax is enlarged in all dimensions, especially in the anteroposterior diameter, and is of a barrel shape. In a considerable proportion of the cases the costal cartilages are enlarged, firm, inelastic, and calcified. According to V. Salis,[9] the costovertebral articulations show all grades of transition from mild fatty degeneration to complete ossifying arthritis. Such changes are present with and without emphysema, increase in frequency as age advances, and

[1] Versuche über Lungenatelektase, Arch. f. exp. Path., 1878–79, x, 54.
[2] Thèse de Paris, 1878.
[3] Arch. f. exp. Path. u. Pharmakologie, Bd. vii, p. 1.
[4] Virchow's Arch., 1900, Bd. xlvii.
[5] Journal de l'anatomie et de la physiologie, 1865, p. 425.
[6] Vorlesungen über allg. Path., Berlin, 1882, ii, 169.
[7] Leçons sur la physiol. comparée de la respiration, Paris, 1870.
[8] Beitr. z. Klinik der Tuberkulose, 1909, xiv, 407.
[9] Zur Bedeutung der Rippengelenke bei Lungenemphysem und Lungentuberkulose, Inaug. Diss., Wiesbaden, 1910.

appear to bear no direct relation with the disease. Schenker[1] finds atrophy of the intercostal muscles with and without degeneration constantly in the severe forms of emphysema, inconstantly in the less severe but still outspoken forms and absent in the mild cases.

On removing the sternum, the lungs do not collapse as usual, owing to diminished elasticity. The pleura is free or adherent if the condition is complicated. The pulmonary margins are rounded, cover the pericardium to an abnormal degree, and encroach upon the mediastinum over which they may meet or overlap in the middle line. The upper boundaries extend abnormally high above the clavicles and below, the lungs depress the diaphragm to a distance of one to two costal spaces beyond the usual limit. The lungs may show the impressions of the ribs and pit readily on pressure. On palpation, they present a peculiar soft, feathery feeling and crepitate but little on pinching. On section, the tissue is pale, grayish, deficient in but not free from pigment, and relatively dry and bloodless. Deficient pigmentation may be due to expectoration of inhaled particles of pigment caught in the bronchial excretion and its consequent failure to find lodgement in the lung. Dilatation of the alveoli and a wider separation of those particles deposited in the lungs may in part account for the appearance of deficient pigmentation.

In advanced cases, enlarged vesicles varying in size from that of a pin's head to a pea may be seen beneath the pleura or on section within the interior of the lung in the regions of most marked pulmonary involvement. Coalescence of several cavities may lead to losses of substance reaching the size of a pigeon's egg or larger. The bullæ are of an irregularly rounded or oval shape and transparent, and project (after the thorax is opened) above the surface of the partially retracted neighboring tissue. They usually collapse on section and present on their inner surface the remnants of dilated and atrophied pulmonary tissue. Beneke[2] analyzed the gas imprisoned in emphysematous bullæ in 2 cases, and found it almost exclusively nitrogen. Alveolar dilatation may be general throughout both lungs, but is more commonly partial and most marked at or confined to the suprathoracic or apical and the sternoparasternal or anterior marginal portions. The inferior lateral parts are less frequently involved. The central portions are seldom affected. Induration is absent unless the condition is complicated. The weight of the lungs is low compared with their increased volume. The changes are more obviously demonstrable after the lungs are distended and dried.

Microscopic examination shows the alveoli to be enlarged and the alveolar walls atrophied. In places, the atrophied septa about isolated infundibula have disappeared, forming smaller vesicles, while else-

[1] Beziehung zwischen starrer Thoraxdilatation und alveolärem Lungenemphysem. Inaug. Diss., Basel, 1910.

[2] Verhandl. d. deut. Path. Gesellsch., 1913, xvi, 448.

where rupture of interinfundibular partitions has given rise to larger cavities. The spaces thus formed may or may not communicate with normal or dilated bronchi. The pulmonary capillaries in the alveolar walls are elongated, straightened, and narrowed. Obliteration and division of constricted vessels takes place, leaving a blind stump at the point of separation. Consequent shrinkage in the pulmonary circulation diminishes the blood-supply and increases the work of the right ventricle to maintain the circulation. Compensatory dilatation of anastomotic channels between the pulmonary arteries and the pulmonary and bronchial veins occurs. Fatty degeneration is observed in the alveolar epithelium. No essential changes have been demonstrated in the elastic fibers, which may, however, appear reduced in size and number owing to the alveolar dilatation.

The bronchi almost invariably show the lesions of chronic bronchitis with reddening, roughening, and thickening of the mucous membrane. Atrophy, dilatation, and obliteration of the bronchial wall and peribronchial induration may also be found. Atelectasis, broncho-, lobar, and interstitial pneumonia, tuberculosis and adhesive pleurisy may be associated with the emphysema. Pneumothorax may occur from rupture of an emphysematous bleb.

As a result of the impeded pulmonary circulation, the pulmonary artery may become dilated and atheromatous. At first the right and later the left heart become hypertrophied and dilated. Changes secondary to the cardiac failure take place in other organs and the pathologic findings are those of chronic passive congestion.

Symptoms.—The intensity of the symptoms depends on the degree of emphysema, the condition of the heart, and the severity of the accompanying bronchitis. Dyspnea and cough are practically constant. In mild cases, the dyspnea is present only on exertion. In more severe cases, it is persistent and aggravated by physical effort, intercurrent attacks or exacerbations of bronchitis. In some instances the dyspnea is of a paroxysmal character and may be ascribed to bronchial or cardiac asthma. Cough is due to the accompanying bronchitis and is likely to be troublesome, especially in the early stages of the disease. At this period the sputum is often scanty, tough and mucoid, and is raised with some difficulty. Intervals of comparative freedom from cough frequently occur during the summer, to be followed by recurrent attacks of bronchitis during the winter, and finally by persistence of cough throughout the year. As the bronchial changes progress, the sputum becomes more abundant and less tenacious, and consists of yellowish purulent material, not infrequently streaked with blood, from the rupture of pulmonary capillaries or passive pulmonary congestion. Frank hemorrhages are uncommon, but may occur from dilated bronchial veins or branches of the pulmonary arteries. In rare instances pulmonary hemorrhages may be fatal. With the advent of cardiac insufficiency there are such symptoms referable to other systems as are common in cardiac cases.

Physical Signs.—The findings on examination vary with the degree of emphysema and the condition of the heart. On *inspection*, cyanosis is seldom absent, and as in congenital cardiac disease, may be strikingly out of proportion to the accompanying symptoms. In severe cases the extremities may be cold. The expression is likely to be anxious in consequence of the dyspnea.

Respiratory motion is diminished and labored and the accessory muscles may be brought into play. Inspiration is then accompanied by visible contraction of the cervical muscles and the sternocleidomastoids and the scaleni may be hypertrophied. The arms and the shoulders may be fixed, thus enabling the smaller pectorals to take part. Expiration is reinforced by contraction of the abdominal muscles which become tense, especially in the epigastric region, and form a transverse furrow above the navel as the patient expires. Contraction of the abdominal recti and the transversales narrows the lower thoracic aperture and displaces the abdominal viscera and the diaphragm upward. The patient may also resort, during expiration, to pressure of the hands against the sides of the chest. The thorax is enlarged in all dimensions as if in a position of permanent inspiration. The anteroposterior diameter is increased, giving the chest a barrel shape. Obliteration of the supraclavicular fossæ may occur from distention of the apical parts of the lungs. The neck looks short and thick, the shoulders are high, the sternal fossa deep, the sternum and costal cartilages prominent, the inferior intercostal spaces widened, and the lower thoracic zone large. The patient tends to bend forward, thus rounding the back.

The superficial veins may be swollen and prominent. The external jugulars, the jugular bulbs, and at times also the upper thoracic veins may be dilated during forced expiration or persistently prominent and further distended during expiration. In rare instances, a zone of distended venules may be seen on both sides of the chest along the diaphragmatic attachment.

In spite of the increased respiratory effort, thoracic expansion is less than normal. The inspiration is short and quick. Expiration is long and difficult owing to diminished pulmonary elasticity. On *palpation*, the tactile fremitus is found to be diminished. On *percussion*, the note is loud and low pitched, drum-like or hyperresonant. The inferior limit of pulmonary resonance may exceed by a distance of one to two or more ribs the normal lower boundary of the lungs. The amplitude of inspiratory excursion, determined by percussion, is much diminished or absent. The distended lungs lower the upper limit of hepatic and splenic dulness and encroach upon the cardiac area. Traube's semilunar space is diminished or obliterated. On *auscultation*, the breath sounds are feeble and often masked by rales of the sonorous and sibilant variety, with which fine, medium or coarse consonating and non-consonating rales may also be heard. Prolongation of expiration is usually a striking feature.

Special Methods of Examination.—The diaphragm shadow (Litten's phenomenon) may be absent. When present, it is of diminished amplitude. Examination by means of the *x*-rays show in addition that the diaphragm is less convex than normal. On inspection with the fluoroscope the inspiratory and expiratory changes in pulmonary density are less marked than in sound lungs. Measurement confirms the increase in thoracic circumference and may show a diminution in the amplitude of inspiratory excursion after forced expiration from a normal average of about 7 to 4, 2 or even 1 cm. Expiratory pressure measured with Waldenburg's pneumotometer[1] is diminished. The vital capacity, determined with the spirometer, may show a reduction of from 20 to 60 per cent. below the normal. Riegel's[2] pneumographic tracings show a diminished amplitude for respiratory excursion. The curves indicate a rapid rise of inspiration followed by a rapid initial fall and a slow, uneven termination of expiration.

Examination of the Heart.—Pulmonary distention makes the investigation difficult. The apex beat may not be seen, but marked pulsation may be present in the epigastrium from depression of the heart and enlargement of the right ventricle. The apex beat may be palpated with difficulty or not at all. On percussion the deep cardiac dulness may be found increased laterally in consequence of hypertrophy and dilatation, while the upper limit may be lower than normal. Determination of the deep cardiac dulness is often impossible, and the superficial dulness may be obliterated. The heart sounds, although usually of good quality, are likely to be faint because of the intervening lung. At times a systolic blowing murmur, due to dilatation of the mitral ring, may be heard. The second pulmonic sound may be accentuated. An abnormally low position and enlargement of the heart may be confirmed by *x*-ray examination. Cardiac insufficiency is likely to occur sooner or later in the course of the disease from increased resistance in the pulmonary circuit. Diminished pulmonary elasticity lessens the favorable action on the circulation of the rhythmic dilatation and retraction of the lung, and the resistance is increased by the heightened intra-alveolar pressure and atrophy of the capillaries. Compensation is at first affected by hypertrophy of the right side, which later becomes dilated and insufficient. As the cardiac nutrition suffers, the left side becomes involved, and the clinical aspect is then that of broken cardiac compensation, with weak and irregular heart sounds, pulmonary edema, hydrothorax, enlargement of the liver, ascites, edema of the feet, and passive congestion of the kidney.

The blood shows no distinctive features in emphysema. Such variations from the normal as occur may be ascribed to cardiac decompensation, in the first stages of which, as noted by Grawitz[3] the number

[1] Die pneumatische Behandlung der Respirations- und Zirkulations-krankheiten, Berlin, 1875.

[2] Deut. Arch. f. klin. Med., Bd. x, p. 124.

[3] Klin. Path. des Blutes, Leipzig, 1906.

of red-blood corpuscles and the amount of hemoglobin are diminished. As the cardiac failure becomes more chronic with dyspnea, cyanosis and edema, the blood becomes more concentrated with increase in the number of red-blood corpuscles.

Diagnosis.—When of slight degree, emphysema is likely to escape detection. Outspoken cases are easily recognized from the dyspnea and cyanosis, bronchial catarrh, enlargement and shape of the thorax, diminished and labored respiratory motion, hyperresonance, depression of the inferior pulmonary margins, diminished area of cardiac dulness, feeble breath sounds, prolonged expiration and diminished but not absent tactile fremitus. Acute pulmonary distention is to be distinguished from the chronic form by a history of recent onset, only moderate inflation seldom exceeding the limits of full inspiration and a tendency to subside within a limited period of a few hours or days. With pneumothorax there is hyperresonance, feeble breath sounds, and diminished or absent tactile fremitus, but the limitation of these signs to a circumscribed area, the presence of metallic tinkle, coin sound, succussion and dislocation of the heart will serve to distinguish it. If the patient is first seen in the later stages when the heart has failed, the cardiac features may dominate the clinical picture. In extreme cases, passive congestion of the lung, hydrothorax and hydropericardium may then mask the signs of emphysema. Unless a history of emphysema can be obtained and other cardiac or extracardiac causes of cardiac insufficiency be excluded, the diagnosis may be impossible.

Emphysema may in turn make the detection of an underlying pulmonary tuberculosis difficult or impossible, but the history may suggest tuberculosis and evidence of apical disease may still be demonstrable. Apical retraction may depress one or the other supraclavicular fossæ or restrict the degree to which this region is inflated when the patient coughs. Physical signs of apical disease may be accentuated by examination while the breath is held in full inspiration.

Prognosis.—Owing to the anatomic changes in chronic diffuse emphysema, return of the lung to normal cannot be expected. In rare instances the disease may become stationary. More commonly, however, it slowly and steadily progresses and lasts a long time, but shortens life by many years. In a majority of cases, the capacity for physical work is considerably diminished.

Owing to the usual presence of a chronic bronchial and bronchopulmonary infection, patients with the disease are in danger of acute exacerbations with extension of inflammation to previously uninvolved regions. An acute bronchopneumonia, pulmonary abscess or gangrene may thus arise. Invasion of the pleura may cause an acute or chronic pleurisy with or without exudation. In rare instances, rupture of an emphysematous bleb may cause pneumothorax. It is doubtful if emphysema exerts a restraining influence on pulmonary tuberculosis. It seems probable that the emphysema associated with long-standing

phthisis is rather the result of the accompanying nutritive and mechanical disturbance than a cause of the chronicity of the tuberculous process. The infrequency with which the two are associated may be due to the more frequent occurrence of tuberculosis in early and of emphysema in later life.

Aside from complications which may more or less suddenly terminate the slow progress of the disease, the outlook depends for the most part on the degree to which the circulatory system has suffered from the pulmonary disturbance. In estimating the probable expectation of life in any individual case, the duration of the disease, the degree of dyspnea and cyanosis, the amount of bronchitis, extent of the cardiac embarrassment, the age, strength, general nutrition and opportunity for limiting physical exertion must be taken into consideration. The condition is more likely to progress only slowly when the pulmonary features are mild, the bronchial catarrh stationary and uninterrupted by exacerbations, without cardiac weakness, with a strong constitution and under circumstances which admit of proper regulation of the daily life.

Functional tests of the pulmonary capacity may be of assistance in estimating the prognosis. The vital respiratory capacity for a man of average height may be estimated at somewhat more than 3000 c.c. Waldenburg regards a capacity under two liters as indicating a severe case. Considerable diminution of the average normal difference of 7 cm. between the thoracic circumference at the end of forced inspiration and at the end of forced expiration, the measurement being taken at the level of the nipple, may have a similar import.

Treatment.—This should be directed against the bronchitis, the cardiac weakness, when this is present, and the emphysema itself.

The treatment of the bronchitis need not be fully considered here. The patient may well be cautioned against exposure to cold or draught when overheated or insufficiently clad. Expectorants are at times of value, and sedatives may be used when sleep is disturbed by harassing and ineffectual cough. Partial inversion, as in the treatment of bronchiectasis, may be of service in clearing the bronchi of stagnating secretion. Measures which improve the general health are of importance. Cool morning baths followed by a rub with a harsh towel, an abundance of nourishing food and fresh air by night as well as by day may be recommended. An accompanying asthma should be appropriately treated and the nose examined for sources of reflex irritation. Gastrointestinal disturbances should be corrected. Flatus is to be avoided. A light evening meal may render the nights more comfortable. The bowels should be kept regular. When necessary, a change to an equable climate and an atmosphere free from dust are to be considered. Country is better than city life.

Cardiac weakness is to be combated by rest, limitation of food, liquids, and salt, the use of digitalis and other appropriate means. Venesection is justifiable when there is urgent dyspnea, intense cya-

nosis, venous engorgement, and overfilling of the right heart. It may then prove a life-saving measure. Inhalations of oxygen may be helpful. Camphor and caffein may also be used.

The treatment of the emphysema is unsatisfactory. The inelastic and atrophied pulmonary tissue cannot be returned to its normal condition. Such simple measures as rhythmic compression of the two sides of the thorax with the hands during expiration may be of service. Rossbach[1] recommended mechanical in place of manual compression. Hoffmann[2] recommends respiratory exercises. All tight clothing should be removed. The patient holds in each hand a light dumbbell (one pound) and raises the arms from the sides to a horizontal position. The hands are then brought into supination, with the palm upward, and at the same time an inspiration is taken. The movements are then reversed, the hands returned to the side of the body, and the knees bent until the dumbbells touch the floor. During this movement the patient expires. He regards six inspiratory movements of this sort as sufficient for most emphysematous patients. Treatment by means of the pneumatic cabinet is sometimes used. With the patient in the cabinet the air pressure is gradually raised, during a period of about a half-hour, to one and one-half to two atmospheres. The compressed air is breathed for one-half to one hour and the pressure then gradually lowered to normal, another half-hour being consumed in the process of reduction. Active pneumatic treatment can be carried out by means of portable apparatus, such as Waldenburg's or its modifications. The patient may inspire air under a positive pressure of one-sixtieth to one-fiftieth of an atmosphere or expire into air rarefied to a negative pressure of from one-sixtieth to one twenty-fifth of an atmosphere. Treatment by means of Zander apparatus, by simple or concussion massage, and by hydrotherapy has also been used. A cure cannot be expected, but some at least temporary alleviation of symptoms may be accomplished by these various means.

Hofbauer[3] instructs his patients to avoid any increase of inspiration and to prolong expiration, during which the accessory expiratory muscles of the abdomen are brought into play. During the first part of the treatment an apparatus is used which exerts automatic, rhythmic pressure on the abdomen during expiration. After some practice with the apparatus, the patient learns to use his abdominal muscles without such assistance during expiration.

Freund's theory of the origin of emphysema in degenerative changes, calcification and loss of elasticity in the costal cartilages has led to his recommendation of surgical measures for its relief. Unilateral or bilateral incision, combined usually with partial excision of the calci-

[1] Ueber einen Atmungsstuhl für Emphysematiker, Verhandl. d. VI Kongress. f. inn. Med., Wiesbaden, 1887, p. 217.

[2] Nothnagel's Encyclopedia of Practical Medic. Diseases of the Bronchi, Pleura, and Lungs, p. 353.

[3] Wiener med. Woch., 1908, No. 6, p. 289.

fied costal cartilages, has been performed in a considerable number of cases, and almost constantly with relief of the dyspnea and an increased capacity for physical exertion. The future of this procedure cannot yet be judged.

2. ACUTE VESICULAR EMPHYSEMA.

This is also known as acute pulmonary inflation. It is the volumen pulmonis auctum of Traube, and is most frequent in connection with asthmatic attacks, but may occur also in consequence of whooping cough, croup, capillary bronchitis, laryngeal diphtheria, the inhalation of irritating gases, suffocation by strangulation, pulmonary edema or foreign bodies in the air passages. In these conditions, strong inspiratory efforts are followed by forced expiration against the closed glottis when the patient coughs. The lungs are thus increased in size and the air vesicles become much distended. Acute pulmonary distention occurring in normal individuals after deep breathing or physical exertion, or in dyspnea, air-hunger, and cardiac insufficiency may be mentioned in this connection, and is probably due to inspiratory overdistention with persistence in the lungs of an abnormal amount of residual air. These forms of acute pulmonary distention, as well as those produced experimentally in animals, have already been discussed under Pathogenesis in the preceding section. In many instances, the condition is transient and subsides with the removal of the cause. Repeated or persistent overdistention, however, in association with impairment of pulmonary nutrition, may lead to chronic emphysema.

3. COMPENSATORY EMPHYSEMA.

This is also termed vicarious, collateral, complementary or partial emphysema. The condition is of pathologic rather than of clinical interest, as it is usually limited to the neighborhood of processes which occupy the foreground in the clinical picture, and so mask the situation as to make its detection during life difficult or impossible. It occurs in the neighborhood of atelectatic, inflamed or contracted parts of the lung, and may thus be associated with pleurisy with effusion or pneumothorax, simple or tuberculous bronchopneumonia, extensive pleural adhesions, pulmonary cicatrices or areas of interstitial pneumonia. Imperfect expansion of the airless, inflamed or contracted pulmonary tissue may be compensated either by depression of the chest wall or overinflation of the adjacent pulmonary tissue. If the area of diseased lung tissue excluded from participation in respiratory motion is of large extent, thoracic retraction and compensatory emphysema may both result. The larger the area of diseased lung, the greater the extent of the emphysema. Thus extensive contraction of one may cause emphysema of the other lung. The persistence of the process depends on the duration of the cause. If this is of short duration, an acute pulmonary

inflation only may result, and this may subside with the subsidence of the cause. In chronic cases, however, persistent overdistention is followed not only by enlargement and rarefaction of the air vesicles, but also by atrophy of the tissue. Aside from the limited extent of the process, the pathologic picture does not differ from that in the diffuse form of the disease. The dilatation and atrophy of the affected region impair its respiratory capacity and may thus aggravate symptoms due to the underlying cause. In cases in which the emphysema is demonstrable, the physical signs are those already described for the diffuse form.

4. SENILE EMPHYSEMA.

This form, also termed atrophic emphysema, is an involution process of advancing age in which the lung shares the wasting taking place in other parts of the body. Pulmonary elasticity is diminished and the lung in consequence more nearly assumes a permanent inspiratory position. The condition differs from the preceding forms in that the thorax and the lung are diminished rather than increased in size. There is likely to be kyphosis of the dorsal region of the spine, lateral narrowing of the thorax and a diminished width of the intercostal spaces. Respiratory motion is diminished, the inferior pulmonary margins are high rather than low, and the area of cardiac dulness is not decreased. According to Tendeloo the emphysema first makes its appearance and is most pronounced in the sternoparasternal and lateral caudal parts of the lungs, while the suprathoracic portions are more or less involved in consequence of chronic bronchitis so frequently present in the aged.

5. INTERSTITIAL EMPHYSEMA.

This is also known as interlobular emphysema and occurs when air enters the interstitial tissue of the lung following rupture of the bronchial mucous membrane or the alveolar septa. The condition was described by Laënnec,[1] and has been studied, principally in connection with mediastinal emphysema, among others by Roger,[2] Bartels,[3] Cruveilhier,[4] Fr. Müller,[5] and Fränkel.[6]

Interstitial emphysema is most common in children and youthful adults. It is usually due to greatly increased expiratory pressure during a severe paroxysm of cough, and may thus occur in whooping cough, laryngeal stenosis from diphtheria, in broncho- or lobar pneumonia, pulmonary abscess, gangrene or tuberculosis. Fraentzel[7] described 2 cases (one with autopsy) in which it occurred in the stage

[1] Traité de l'auscultation médiate, 1831, T. i, Troisième édition, p. 324.
[2] Arch. gén. de méd., 1862, T. ii, p. 129.
[3] Deut. Arch. f. klin. Med., vol. ii, p. 392.
[4] Gaz. hebd. de méd. et de chir., 1856, p. 179.
[5] Berl. klin. Woch., 12 März, 1888.
[6] Ibid., 24 Okt., 1910.
[7] Deut. med. Woch., 12 März, 1885, No. 11, p. 162.

of asphyxia in cholera, as he believed in consequence of the severe grade of dyspnea. It may also occur during parturition, from strangulation or result from too forcible insufflation or undue force in performing artificial respiration for the resuscitation of patients in a condition of asphyxia. A stab or bullet wound, a contusion or blow may be the cause. Laceration of the lung may take place without external evidence of the injury. It may follow severe or mild exertion, and in rare instances is apparently of spontaneous origin. In such cases, however, some pathologic condition may fairly be assumed. Latent pulmonary tuberculosis, the rupture of an emphysematous bleb or pleural adhesion are then possible causes.

On examination of a lung infiltrated with air, transparent, sharply circumscribed, parallel or intersecting lines or bands may be seen through the pleura in the interlobular tissue. They are likely to be most numerous toward the margins of the lung, and may coalesce to form bubbles of considerable size. The appearance may be not unlike that of a string of beads. The air spaces diminish in size toward the centre of the lung, and according to Laënnec, are wedge-shaped like the segments of an orange with the base of the wedge toward the pleura. The air may pass by way of the interlobular connective tissue along the bronchi, or bloodvessels, or by way of the subpleural connective tissue to the hilus of the lung, thence to the anterior or posterior mediastinum and the subcutaneous tissue of the neck. If an unadherent pleura is ruptured, a pneumothorax results. If adherent pleural layers are ruptured, the air may pass directly to the thoracic subcutaneous tissue. Mediastinal or subcutaneous emphysema of pulmonary origin is not necessarily associated with interstitial emphysema, since it may arise from laceration at the root or periphery of the lung directly into the mediastinal or subcutaneous tissue through an adherent pleura.

Distinctive clinical features are lacking with interstitial and subpleural emphysema. Dyspnea and cyanosis may result from the limitation of respiratory surface. Laënnec regarded a coarse, dry, crepitant rale (râle crépitant sec à grosses bulles) as pathognomonic of interlobular emphysema. He stated that an inspiratory and expiratory friction rub (frottement ascendant et descendant) was also usually present. His observations have not since been confirmed. Cruveilhier and Müller have noted the masking or modification by subpleural emphysema of auscultatory signs previously present. The diagnosis of interstitial or subpleural emphysema can usually be made, however, only by inference and the presence of a complicating mediastinal or subcutaneous emphysema or a pneumothorax. Because of its importance in this connection, mediastinal emphysema will be further considered.

Mediastinal Emphysema.—As already stated, this may be due to the passage of air from the interstitial or subpleural tissue to the root of the lung and thence to the mediastinum. It may also

arise from perforation of the root or peripheral parts of the lung adjacent to the mediastinum. Laceration of the trachea or the esophagus or extension downward of subcutaneous emphysema in the cervical regions are also causes. An origin from the lung is most common. The air infiltrates the loose mediastinal tissue. It may surround the pericardium and great vessels, the trachea and esophagus, separate the costal pleura from the ribs for a short distance laterally, extend downward as far as the insertion of the diaphragm, and upward along the trachea or the great vessels to the subcutaneous tissue of the neck. Here it may appear as a crepitating tumor in the supraclavicular region and more commonly on the left than on the right side. From this region it may spread to other parts of the body.

There may be pain or a sense of oppression referred to the precordial region, and increased by deep inspiration. Existing dyspnea may be aggravated. Dysphagia and changes in the voice have been described. On examination, the deep cardiac dulness may be absent, the superficial cardiac dulness very much reduced or entirely replaced by a resonant note with or without a tympanitic quality. Mediastinal resonance may extend to the right as far as the parasternal line, to the left to or beyond the nipple line, and downward to or beyond the costal margin in the sternal region, meeting here the liver dulness. The precordial resonance does not change on changing the position of the patient. The cardiac impulse is usually almost or quite invisible and impalpable. The most important sign is the presence of a fine crepitation over the cardiac region, heard during both systole and diastole, usually of maximum intensity during the former, at times increased during inspiration and present when the breath is held. The cardiac sounds may be normal, faint, masked by the crepitation or inaudible. Peterson[1] and Schotten[2] have each described as extrapericardial emphysema a case in which a splashing or whirring sound could be heard at a distance from the patient, but in these cases pneumopericardium could hardly be excluded. Mediastinal emphysema shares in common with pneumopericardium a resonant or tympanitic precordial percussion note, but with the latter precordial dulness may be elicited when the patient is bent forward so as to bring the heart against the chest wall, and owing to the usual presence of both fluid and air in the pericardial sac, there are likely to be loud, splashing, gurgling or churning sounds (bruit de moulin, or better, bruit de roue hydraulique, as suggested by Morel-Lavallée[3]) rather than a fine crepitation. Pneumothorax must be excluded. When pneumothorax is present, the precordia may be resonant or tympanitic, but physical examination assisted, if necessary, by the *x*-rays, will usually show the heart displaced toward the unaffected side, the absence of precordial crepitation in uncomplicated cases, and, in addition, unilateral limitation of respiratory motion, enlargement of

[1] Berl. klin. Woch., 1884, p. 699.
[2] Ibid., 1886, p. 882.
[3] Gaz. méd. de Paris, 12 Nov., 1864, No. 46.

the side, hyperresonance, diminished or absent fremitus and breathing, metallic phenomena, and succussion over the anterolateral or posterior parts of the chest.

The prognosis is in general that of the underlying disease, since interstitial, with or without mediastinal and subcutaneous emphysema, adds only little to the gravity of the situation, although this may be enough in already desperate cases to hasten a fatal termination from the added burden to the heart and the lung. In favorable cases, the air is usually absorbed in from one to three weeks. Treatment should be directed toward preventing an aggravation of the condition by an elevation of intrapulmonary tension. Rest in bed and suppression of cough, if necessary, by sedatives usually suffice.

CHAPTER X.

LOBAR PNEUMONIA.

Occurrence.—The frequency of pneumonia in comparison with all internal diseases is usually estimated at from about 3 to 6 per cent. Among 32,616 medical admissions at the Massachusetts General Hospital, from 1897 to 1913, were 2025 cases (6.2 per cent.) of lobar pneumonia.

In the United States, for the census year 1890, over 9 per cent. of all deaths were due to pneumonia, in 1900 over 10 per cent. and in 1909 9.5 per cent. The annual average death rate from lobar pneumonia per 100,000 population from 1900 to 1909 in the registration area was 117.6, but there has been a fairly steady decline from 158.6 in 1900 to 96.3 in 1909. In the registration cities, the annual average was 131.4, with a decline from 177.9 in 1900 to 107.7 in 1909. The death rate is lower in the rural districts of the registration area, amounting to an annual average of 90.4, with a similar diminution in the mortality from 113.9 in 1900 to 80.4 in 1909.

Predisposing Influences.—These may be divided into general and individual factors.

General Factors.—(*a*) *Geographic.*—Pneumonia occurs in all parts of the world, but appears to be more frequent in temperate regions. Altitude does not seem to be a factor of importance.

(*b*) *Racial.*—Pneumonia has not infrequently been noted to be more prevalent and more severe among negroes than among whites. Gorgas[1] states that in 1906, in an average force of 21,000 negroes employed in the construction of the Panama Canal, there were 396 deaths from pneumonia, giving a death rate of 18.74 per thousand. In 1907, in an average force of 28,600 negroes, there were 304 deaths from pneumonia, a death rate of 10.65. A high rate of mortality from pneumonia has similarly been observed among the negroes employed in the mines of the Rand. For the year 1912 among 21,000 tropical natives the death rate from pneumonia was 26.30, while among 199,000 non-tropicals the death rate was only 8. Both in Panama and in the Rand it has been noted that the highest mortality occurs among the recent arrivals and that the mortality rapidly diminishes after a short residence in the community. Thus it was found at Panama that pneumonia was four and one-half times as frequent among the men who had been on the Isthmus less than three months, as it was among

[1] Jour. Amer. Med. Assoc., 1914, lxii, p. 1855.

those in residence more than three months. A striking diminution in the mortality from pneumonia has been observed among the negroes employed on the Isthmian Canal in the years succeeding 1907, the death rate not exceeding 2.60 for any year up to and including 1912. The importance of race is difficult to estimate and it seems probable that apparent racial susceptibility is largely due to lack of acquired immunity. An initial susceptibility may be due to lack of exposure to virulent strains of the pneumococcus and the protective influence of minor pneumococcus infections of the upper parts of the respiratory tract.

(*c*) *Meteorological.*—Marked variation in temperature, small amount of rainfall, and high winds have been thought to increase the incidence of pneumonia, but no constant relation with these influences has been shown. A seasonal influence is the only factor which can be affirmed in this group. In practically all large series of cases it has been shown that the majority of cases occur in the months between November and June, but with some difference in the predominance of cases in different countries during the winter or spring months. An estimate of the importance of wind, weather and seasonal conditions is rendered difficult by the entrance into the problem of such other factors as the tendency of the people to live under less satisfactory hygienic conditions, in crowded and poorly ventilated rooms, during inclement weather.

(*d*) *Increased Virulence of the Organisms.*—Variation in virulence of the pneumococcus obtained from different sources can readily be established by animal experimentation in the laboratory. The virulence of an organism can be raised and maintained only by frequent transplantation on suitable media and the passage at proper intervals through susceptible animals. An increase in virulence probably occurs by passage through man as well as through animals, and the chances for infection of those exposed are greatly increased by the presence of a highly virulent strain. A relatively insusceptible person may act as a carrier without himself becoming infected.

(*e*) *Epidemics.*—Pneumonia is to be regarded rather as an endemic than as an epidemic disease, but numerous instances can be cited of more or less severe local outbreaks. Wells[1] presents a chronological table of epidemics from 1440 to 1888. They have occurred in all parts of the world, and most often during the winter and spring months. Certain outbreaks have presented special peculiarities. That at Ober Sichte in 1880 was confined to children under five, of whom 15 out of 50 were attacked. The epidemic in Alaska in 1881 affected the native population almost exclusively and was very fatal. In Rietnordhausen, in 1881, of 700 inhabitants, 42 were attacked with only two deaths, a strikingly low mortality. Numerous epidemics on board ships have been recorded. In 1863, the disease broke out on H. M. Ships St. Jean

[1] Jour. Amer. Med. Assoc., February 26, 1889.

d'Acre and Cressy, attacking 410 of 815 persons on the former and 298 of 720 on the latter. Of epidemics in jails, that at Moringen[1] in 1878 is most often noted. Of between 700 and 900 inmates, 58 were affected. Kerschensteiner[2] reported that of 1150 prisoners at Amberg, 161 had pneumonia, and 46 died during the first five months of the year 1880. Epidemics in barracks have been frequently reported. Of hospital outbreaks, that recorded by Edsall and Ghriskey[3] is most instructive. Within eleven days following the death of a patient in a certain bed in the Episcopal Hospital at Philadelphia, two patients temporarily placed in the same bed, developed pneumonia, and on the twelfth day pneumococci were found in the blood of a patient in a neighboring bed, but evidence of pneumonia failed to develop.

A succession of cases in the same house has occasionally been noted, and Jürgensen[4] offers, in support of his opinion that pneumonia is a house disease, the experience at Lustgau where in 223 dwellings, during an interval of eight years, the disease occurred once in 40, several times in 44, and not at all in 139. One of the most striking instances of house infection is reported by Schroeder,[5] who found that 34 cases had come to the local clinic at Kiel from one house during an interval of fourteen years. Kuhn[6] gives a striking example of apparent contagion from person to person. A man of seventy-six was attacked by pneumonia. On the third day of his illness his wife, who slept in the same bed, was taken with the disease and died on the second day, her husband dying a day later, *i. e.*, the sixth day of his illness. A daughter forty years of age, who lived at the other end of the village and came as often as possible to visit her parents and watch over them at night, was taken ill with pneumonia on the same day as her mother. She also died. On the day his parents were buried a son, aged thirty-two years, who lived with them, had a chill and elevation of temperature which subsided the next day without pulmonary manifestations. At almost the same time his half-year-old child had an eclamptic attack, with high fever, and developed a catarrhal pneumonia which ran a favorable course.

An increase in the opportunities for contagion among persons housed in overcrowded quarters is probably largely responsible for epidemic outbreaks of the disease. In 1907, the negroes employed on the Isthmian Canal and previously living in barracks were allowed to scatter out along the line of the canal, each man building his own hut and bringing in his family. To this change in the manner of

[1] See Kühn, Deut. Arch. f. klin. Med., Bd. xxi, p. 348, and Berl. klin. Woch., 1879, p. 552.

[2] Bayrisch. ärztl. Intelligenzbl., 1881, p. 424.

[3] Therapeutic Gazette, Detroit, 1904, xxvi, 6.

[4] Ziemssen's Handb. d. spec. Path. u. Ther., 5, iii Aufl., p. 21, quoted from Fränkel, Spec. Path. u. Ther. d. Lungenkrankheiten, 1904, p. 253.

[5] Quoted from Musser and Norris, Osler. Mod. Med., vol. ii, p. 544.

[6] Berl. klin. Woch., April 23, 1888, No. 17.

housing the laborers Gorgas[1] ascribes the striking coincident drop in the mortality from pneumonia noted above.

Individual Factors.—(*a*) *Age.*—Lobar pneumonia may rarely be congenital, as in the cases reported by Levy[2] and Netter.[3] In both instances the mothers had pneumonia. The mortality from pneumonia increases as age advances, as shown by the United States Census Report for 1900, the death-rate from fifteen to forty five years being 100, from forty-five to sixty-five years 263, and from sixty-five onward 733 per 100,000 of population. Musser and Norris[4] found the incidence greater by far in early adult life. Of 32,681 cases, 18,813 (57 per cent.) occurred between ten and forty years. Though the conclusion is probably not justified, these figures suggest that pneumonia is less frequent but more fatal as age advances. The frequency with which pneumonia occurs as a complication and terminal event in old age is a striking feature at postmortem examination, and such cases may be classified under other causes in death returns.

(*b*) *Sex.*—Men are found to be more frequently affected in all large series of cases. Of 12,098 cases collected by Musser and Norris, 73 per cent. were males and 26 per cent. females. According to their figures, the greater frequency among males does not seem to hold for early life, and it seems probable that the greater chances for exposure in occupations for males is responsible for the difference between the incidence of the disease in the two sexes.

(*c*) *Occupation.*—Army recruits appear to be more susceptible than hardened soldiers. Immigrants are more likely to take the disease than the native born. Those who work out-of-doors are more frequently affected than those in indoor vocations, probably because of the greater frequency of exposure. The incidence is greater among dwellers in the city, probably owing to overcrowding and poor ventilation.

(*d*) *Cold.*—There is a disposition to regard chilling of the body as an important cause. The greater frequency of the disease among recruits and immigrants may be due in part to greater susceptibility to changes of temperature. A greater incidence of the disease in those occupied out-of-doors and during the colder months of the year suggests that exposure to cold may be a factor. Lipari[5] obtained a greater degree of success in his attempts to produce pneumonia in animals by the intratracheal injection of pneumonic sputum when the animals were exposed to cold before or after the injection. The explanation is not clear, but in some way a lower resistance may be established by the exposure. This subject is also considered in the section on Bronchitis. A history of exposure to cold may be obtained in a considerable proportion of all large series of patients with pneumonia. Of 4244 cases

[1] Loc. cit. [2] Arch. f. exp. Path., Bd. xxvi, p. 155.
[3] Compt.-rend. d. la Soc. de Biol., Séance 9 mars, 1899.
[4] Osler. Mod. Med., vol. ii, p. 551.
[5] Lyon méd., October 19, 1890.

collected by Musser and Norris, 755 (17 per cent.) gave a history of exposure and "catching cold."

(*e*) *Trauma.*—Litten[1] divided the cases into "traumatic pneumonia," in which there was a direct injury to the lung, and "contusion pneumonia," in which the lung was injured in consequence of concussion. Actual injury to the pulmonary substance probably occurs in both forms, but in the latter may take place without obvious lesion of the chest wall. The site of the pneumonia does not always correspond with that of the injury, and in such cases contrecoup may be a factor. Pleural adhesions, pulmonary infiltration, emphysema or bronchiectasis, by limiting the elasticity of the lung, may be predisposing factors. It is probable that pneumococci or other organisms present in the respiratory tract find more favorable conditions for multiplication in the injured tissue. Not only croupous but also bronchopneumonia may thus arise. Litten observed 14 cases (4.4 per cent.) of contusion pneumonia among 320 cases of pneumonia, Jürgensen[2] one case among 768, and Fränkel[3] 7 out of about 830. Müller[4] has recently reviewed the literature.

The pneumonia usually begins within one to two days after the injury and differs from ordinary pneumonia principally in the hemorrhagic character of the sputum. The mortality has varied in small series of cases: 1 death (7 per cent.) in 14 cases observed by Litten; 4 (28 per cent.) out of 14 cases collected by Stern; and 3 (60 per cent.) of Paterson's 5 cases. Great variation in the character of the cases probably accounts for the difference in mortality. The combination of shock and pneumonia may be expected to make the prognosis more serious than with ordinary pneumonia.

(*f*) *Immersion in Water.*—Fränkel observed about a dozen cases the majority of which ran a favorable course. Bein[5] and Ravenstorf[6] have reported instances. The cases are not infrequent in hospital practice, and both croupous and bronchopneumonia may be observed. The condition is probably due to mechanical injury to the pulmonary tissue through the inhalation of water and auto-infection with organisms already present in the tract. Contusion and chilling of the body may also be factors.

(*g*) *Aspiration.*—This is more commonly a cause of bronchopneumonia and is considered in that section.

(*h*) *Inhalation.*—Occupations involving the inhalation of irritating gases, steam or dust may show a high incidence of pneumonia. Broncho- is more frequent than lobar pneumonia. Merkel[7] finds the incidence

[1] Zeit. f. klin. Med., 1882, Bd. i, pp. 26–28.
[2] Ziemmsen's Handb. d. spez. Path. u. Ther., iii Aufl., Bd. v, T. i, p. 21.
[3] Spez. Path. u. Ther. d. Lungenkrankheiten, p. 260.
[4] Centralb. f. d. Grenzgb. d. Med. u. Chir., 1910, xiii, 11, 56, 93, 137, and 187.
[5] Charité Ann., 1895, xx, 150.
[6] Aerztl. Sachverständigenzeit., 1906, No. 9.
[7] Pettenkofer's and v. Ziemmsen's Handb. d. Hyg. u. Gewerbekrank., Abt. 4, 1882, III Aufl., T. ii, p. 143.

of pneumonia among painters 7.5 per cent., room cleaners 6.9 per cent., porcelain makers 5 per cent., and cement workers 4 per cent.

(*i*) *Personal Condition.*—Debilitating influences of all kinds increase the susceptibility to pneumonia. In this group is to be classed alcoholism, with which oftentimes exposure is a contributing factor. Persons suffering from such chronic diseases as arteriosclerosis, valvular heart disease, nephritis and malignant disease are frequently carried off by an acute pneumonia. The pneumonia may be overlooked in the predominance of symptoms referable to other organs than the lungs.

(*j*) *Relation of Pneumonia to Other Acute Diseases.*—The relation which *influenza* bears to pneumonia is difficult to estimate. An increase in the mortality from pneumonia has been observed during practically all epidemics of influenza, but it is not certain from the reports that such cases are not due to influenza bacilli rather than to the pneumococcus. Bronchopneumonia is far more common than lobar pneumonia in influenza, but the two forms may coexist in the same case, as is shown by autopsy. The pneumococcus does not appear to bear any definite relation to influenza, as shown by sputum examination, and on the other hand influenza bacilli appear not to be concerned in typical cases of lobar pneumonia. I have never been able to demonstrate them in stained sections of material from the lung in such cases. In the cases of influenza in which lobar pneumonia occurs, it is probable that the respiratory disturbances accompanying influenza favor the multiplication of pneumococci and determine their invasion of the lung.

Typhoid fever and lobar pneumonia may coexist in rare instances. Hoffmann[1] found true lobar pneumonia in 18 of 250 autopsies on patients with typhoid. Fränkel observed only 6 certain or probable lobar pneumonias due to the pneumococcus among 500 cases of typhoid. Musser and Norris found the two diseases associated in 64 (1.4 per cent.) of 4459 cases of pneumonia. The term "typhoid pneumonia" is often used to indicate a severe type of pneumonia.

No definite relation appears to obtain between croupous pneumonia and *pulmonary tuberculosis*. A history of a typical attack of croupous pneumonia as a starting point for the disease is obtained only in rare instances in patients with pulmonary tuberculosis, and those already subject to pulmonary tuberculosis are not often attacked by croupous pneumonia. Flick[2] states that of 2999 cases of pulmonary tuberculosis at the Phipps Institute, 562 gave a history of pneumonia. This percentage of 18 per cent. would seem to contradict the usually accepted infrequency of pneumonia in the initiation of pulmonary tuberculosis, but the pneumonic process referred to in the histories may not have been of pneumococcal origin. In the great majority of cases of pul-

[1] Untersuch. über die path. anat. Veränderungen der Organe b. Abdominal typhus, Leipzig, 1869; quoted from Fränkel.

[2] Third Annual Report of Phipps Institute, 1907.

monary tuberculosis in which a history of pneumonia is obtained, it is probable that the pulmonary process was a subacute pulmonary tuberculosis such as is not infrequently observed, and may at first be indistinguishable from a non-tuberculous infection.

(*k*) *Previous Attacks.*—An arbitrary division of cases may be made into those in which the pneumonia is a "relapse" in the sense in which this term is used in typhoid fever, the pneumonia being observed within the period of convalescence, and those in which the disease is repeated after a longer interval of freedom. In the first instance, the return of the disease is probably due to infection from the persistence of virulent pneumococci. In the latter, the repetition may be due to persistence of the organisms or reinfection from without. *Relapsing pneumonia* is very uncommon. Wagner[1] saw only 2 instances (0.18 per cent.) of relapse among 1100 cases. The elaboration of protective substances under the influence of the infection is probably responsible, but the duration of the immunity is short, and may actually give place to a condition of increased susceptibility, as is suggested by the frequency with which later attacks occur. Stortz[2] found 26.4 per cent. of 280 cases, Schapira[3] 31.3 per cent. of 166 cases, and Morhart[4] 41.3 per cent. of 133 cases with a history of previous attacks of pneumonia. Several attacks are not uncommon. Chomel[5] observed as many as ten in the same patient, Peter Frank[6] eleven, and Rush[7] twenty-eight.

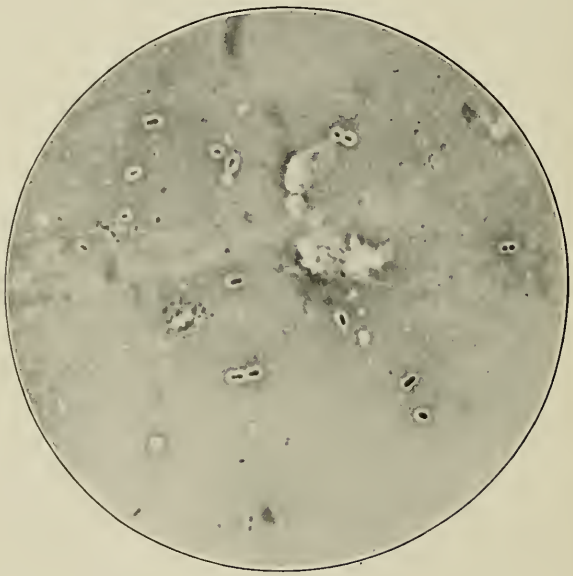
Bacteriology.—In September, 1880, Sternberg[8] found encapsulated diplococci in the blood of rabbits after inoculation with his own saliva. In December of the same year, Pasteur[9] found the same organism in the saliva of a child who had died of hydrophobia. As Pasteur's publication is dated January 18, 1881, while Sternberg's article did not appear until April, the priority of the discovery belongs to Pasteur.

The relation between the pneumococcus and pneumonia was first noted by Eberth,[10] who found ellipsoid cocci in the pleural, pulmonary, and pial exudate from a case of pneumonia with meningitis. The importance of this relation with pneumonia was not appreciated until April, 1884, when A. Fränkel[11] found that it was the most frequent organism occurring in acute pneumonia, and more carefully described its biologic and pathologic character. Weichselbaum[12] later confirmed Fränkel's observations and found the pneumococcus 94 times

[1] Die recidivirende Pneumonie, Deut. Arch. f. klin. Med., Bd. xlii, p. 405.
[2] Mitt. a. d. med. klinik z. Würzburg, 1885.
[3] Diss. Würzburg, 1887.
[4] Diss., Erlangen, 1892.
[5] Dictionnaire de médecine, vol. xvii, p. 214.
[6] Interpretationes clinicæ obs. selec. Tübingue, 1812, p. 86.
[7] Cyclop. of pract. med., vol. iii, p. 406.
[8] National Board of Health Report, Washington, April, 1881, pp. 74–75.
[9] Bull. Acad. de Méd., Paris, 1881, 2me sér., x, 379.
[10] Deut. Arch. f. klin. Med., Bd. xxviii, p. 1.
[11] Ueber die genuine Pneumonie, Kofferat, gehalten auf den III Kongress f. inn. Med., Wiesbaden, 1884, p. 17; Zeit. f. klin. Med., Bd. x, p. 401; ibid., Bd. xi, p. 437; Deut. med. Woch., 1886, No. 13.
[12] Wiener med. Jahrbücher, neue Folge Jahrg., 1886, p. 483.

in 129 cases of lobar pneumonia, 54 times in pure culture. As he found still other organisms such as the Streptococcus pyogenes, Friedländer's pneumobacillus and staphylococci, he concluded that genuine lobar pneumonia could be due to several kinds of bacteria. Later observations indicate that this organism is to be regarded as almost constantly present. Wolff[1] found it in 66 of 70 cases. G. and F. Klemperer[2] found pneumococci in the material aspirated from the upper borders of the infiltration in all of 15 cases of pneumonia. Their constant presence was similarly established by Gamaleia.[3] Weismayr[4] showed that pneumococci were the only organisms present in the carefully selected and washed sputum in 34 of 39 cases.

Fig. 22



Pneumococci in fresh sputum.

It is not very uncommon to fail to find pneumococci in the lungs of patients who have died of pneumonia even though the organisms were abundantly present in the sputum during life. In such cases it is probable that the pneumococci have died out or been overgrown under the influence of secondary invaders. Secondary invasion by the Streptococcus pyogenes, the pyogenic staphylococci, diphtheria bacillus, and influenza bacillus is not very uncommon. The typhoid bacillus and Friedländer's pneumobacillus are occasionally found.

[1] Wiener med. Blätter, 1887, x, 10–14.
[2] Berl. klin. Woch., 1891, No. 35, p. 873.
[3] Annal. d. l'Inst. Past., T. ii, p. 440.
[4] Zeit. f. klin. Med., Bd. xxxii, Suppl., p. 291.

The pneumococcus was the apparent cause in a large proportion of the cases coming to autopsy at the Massachusetts General Hospital, but among 192 cases, in 23 the infection was due to organisms of the type of streptococcus mucosus capsulatus and 6 to Friedländer's pneumobacillus.

The Pneumococcus (Fränkel).—*Synonyms.*—The organism is also termed the "microbe de la salive" (Pasteur), micrococcus Pasteuri (Sternberg), diplococcus pneumoniæ (Weichselbaum), and micrococcus lanceolatus.

Morphology and Cultural Peculiarities.—The pneumococcus is usually seen as a diplococcus, the segments of the pair being lancet-shaped with the broad bases apposed. It is occasionally found as single cocci or as short or even quite long chains. Staining is easily accomplished by the usual anilin dyes and by Gram's method. The organism is non-motile and forms no spores. A capsule can usually be demonstrated in preparations made from the sputum or fresh exudates and is apparently continuous throughout the length of the chain, with slight indentation at the point of division of the segments. Capsules are usually absent in cultures on ordinary media, but may occasionally be found in the first generation. To be certain of the identity of the organisms their cultural peculiarities must be noted. Growth occurs on all ordinary culture media, but is not luxuriant. The reaction should be neutral or slightly alkaline. Development of colonies is most abundant at 37°, but growth occurs at a temperature as low as 24° and as high as 42° C. Atypical varieties are occasionally observed and difficulty is experienced in differentiating the organism from the streptococcus pyogenes and the streptococcus mucosus. On Löffler's blood-serum, pneumococci develop into small, discrete, colorless, transparent colonies. On agar the colonies are small and transparent and hardly visible to the naked eye. On gelatin after twenty-four hours the colonies are small, round, sharply limited, white or grayish points with a finely granular centre and more transparent periphery. The gelatin is not liquefied.

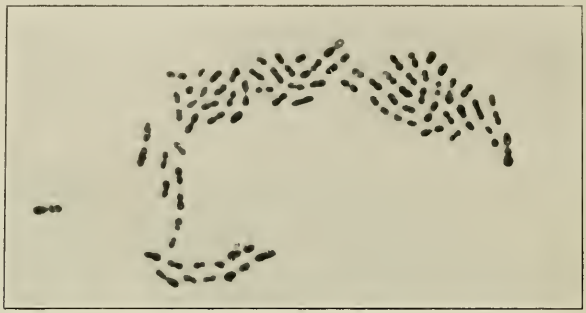
FIG. 23

Pneumococcus. Twenty-four-hour aërobic culture on blood-serum. (Dr. Oscar Richardson.)

Bouillon is only slightly clouded and a fine, white, amorphous sediment is formed. A colorless and almost invisible growth develops on the surface of potato. In milk, there is acid production and coagulation of casein.

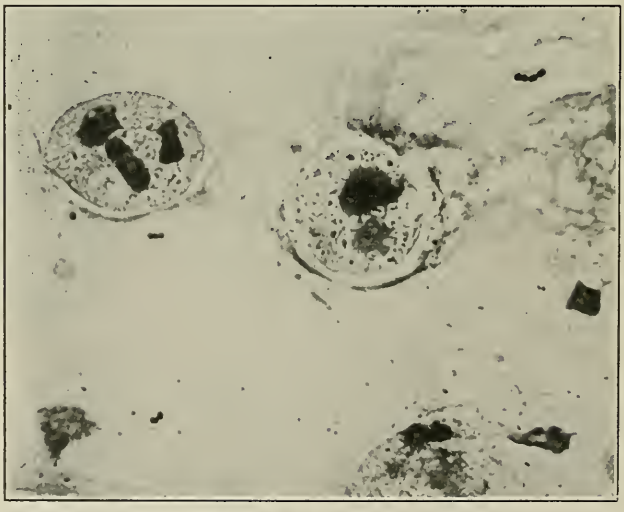
The work of Neufeld,[1] Dochez and Gillespie[2] indicates that among the pneumococci are certain varieties which are fundamentally different, as indicated by their immunologic reactions. Dochez and Gillespie, using two types of immune serum, obtained by inoculation of horses with two different strains of pneumococci, found that white mice

FIG. 24



Pneumococcus. Cover-glass preparation from culture on blood-serum. × 2000. (Dr. Oscar Richardson.)

FIG. 25



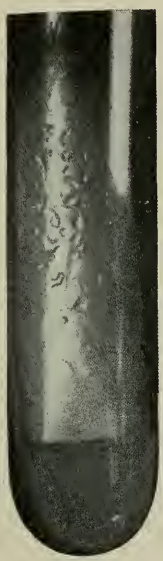
Streptococcus mucosus capsulatus in sputum.

could be protected against an otherwise fatal dose of virulent pneumococci only when the homologous serum was used, and that of 62 strains of pneumococci, 40 (64.5 per cent.) were susceptible to the

[1] Arb. a. d. Kais. Gesund., 1910, xxiv, 293.
[2] Jour. Amer. Med. Assoc., September 6, 1913.

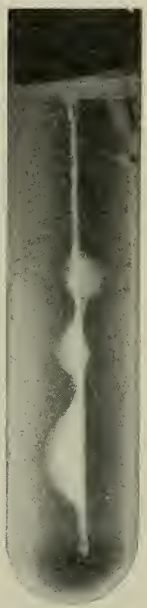
action of one or the other type of serum (Type I and II), while the remaining 22 strains were little or not at all affected. Of the 22 strains, nine could be differentiated by cultural and pathogenic properties into organisms with the characters of the streptococcus or pneumococcus mucosus (Type III), and the remaining 13 formed a heterogeneous group (Type IV), otherwise indistinguishable from typical pneumococci. Agglutinative reactions performed by mixing equal quantities of immune serum and twenty-four-hour broth cultures of the organisms showed that the pneumococci could be identified as belonging to one or the other of the two groups susceptible to the action of immune serum or as falling outside of these two groups.

FIG. 26



Streptococcus mucosus capsulatus. Twenty-four-hour aërobic culture on blood-serum. (Dr. Oscar Richardson.)

FIG. 27



Streptococcus mucosus capsulatus. Twenty-four-hour glucose agar stab culture. (Dr. Oscar Richardson.)

Certain differential features between the pneumococcus and other organisms with which it is likely to be confused may be noted. The streptococcus pyogenes grows on Löffler's blood-serum in smaller, drier, and somewhat whiter colonies. On agar its colonies are less transparent. The streptococcus does not produce acid in the inulin medium[1] of Hiss,[2] while the pneumococcus does. Streptococcus pro-

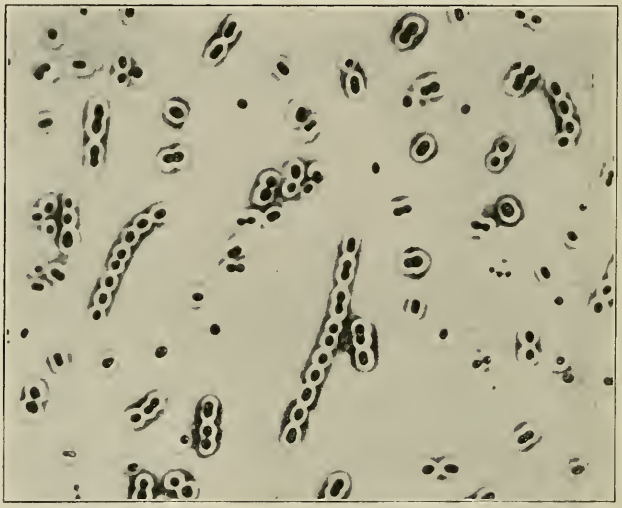
[1] Beef-serum, one part; distilled water, two or three parts, to which 1 per cent. of a 5 per cent. solution of a highly purified litmus was added. The medium is heated to 100° C. for a few moments, and inulin is added in the proportion of 1 per cent., after which it is sterilized in the regular manner on three successive days.

[2] Jour. Exp. Med., 1905, vol. vii, No. 5.

duces a precipitate in glucose-serum-agar[1] while the pneumococcus only rarely does so. The streptococcus is resistant against bile,[2] and the pneumococcus is dissolved as noted by Neufeld.[3]

The streptococcus mucosus capsulatus has distinctive growth characteristics and usually presents a more abundant, usually confluent, smooth, watery layer on the surface of blood-serum. Stab cultures in glucose-agar-agar of a reaction of plus 0.5 to plus 1.0 after twenty-four hours in the incubator present a grayish, translucent band of growth along the needle track as pointed out by Richardson.[4] Toward the middle and deeper parts of the tube this band widens out into oval form in one plane to three to four times the width of the intervening

Fig. 28



Streptococcus mucosus capsulatus. Cover-glass preparation from culture on blood-serum. × 2000. (Dr. Oscar Richardson.)

growth. The streptococcus mucosus ferments inulin, throws out a precipitate in glucose-serum-agar, and is dissolved by bile. According to Libman, the streptococcus grows on blood-plates (made from human or ox blood) in colonies which show a definite large (2 to 3 mm.) perfectly clear zone about them which should persist in several generations. Pneumococci produce a green color.

[1] 0.5 per cent. glucose is used and an ascitic serum having a specific gravity of 1015 or more. Libman, Jour. Med. Research, 1901, i, 89, also Trans. Assoc. Amer. Phys., 1910, vol. xxv.

[2] This test may be performed by mixing 1 c.c. of a twenty-four-hour culture of pneumococci with 1 c.c. of a freshly prepared solution of Merck's taurocholate of soda and shaking well.

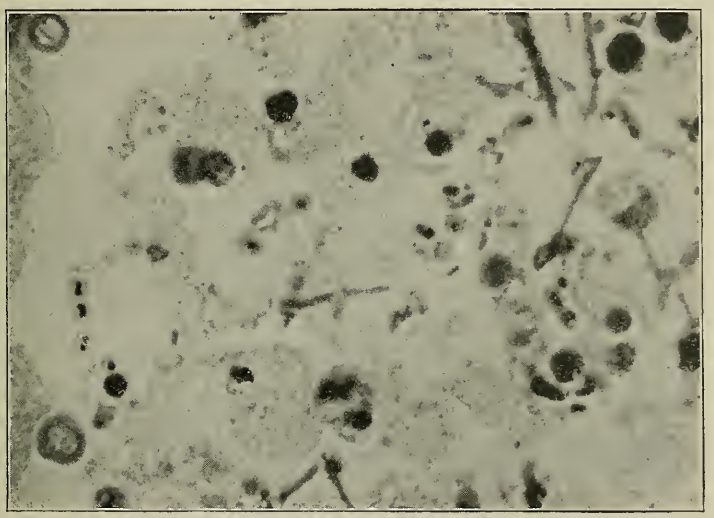
[3] Zeit. f. Hyg. u. Infektionskr., 1900, xxxiv, 454.

[4] Jour. Med. Research, May 23 and June 4, 1901, vol. v, No. 11.

The relation which the streptococcus and the streptococcus mucosus capsulatus bear to the pneumococcus cannot yet be regarded as settled, and it may be that closely related organisms of the streptococcus-pneumococcus group are modified pneumococci.

Rosenow[1] has succeeded in changing different strains of the streptococcus group (hemolytic streptococcus, streptococcus viridans, streptococcus mucosus) each one into the others and into pneumococci, and pneumococci into streptococci, and back again into pneumococci. Transformation of some of the strains was complete, as indicated by a study of morphology, capsule formation, fermentative powers, solubility or insolubility in bile and NaCl solution, behavior toward the respective broth-culture filtrates (Marmorek's test), production of opsonin, agglutination by antipneumococcus and antistreptococcus serum and the more or less specific pathogenic powers.

FIG. 29



Streptococcus mucosus capsulatus in pneumonic exudate. × 1500.
(Dr. Oscar Richardson.)

Pneumococci in Apparently Healthy Individuals.—The results of various observers working under the Medical Commission for the Investigation of Acute Respiratory Diseases, of the Department of Health of the City of New York,[2] show that pneumococci can be recovered from about one-half the number of cases in which the saliva of apparently healthy persons is examined. The experience of Hiss[3] is even more striking. Of 15 persons from each of whom one specimen

[1] Jour. Infect. Dis., January, 1914.
[2] Jour. Exp. Med., 1905, vol. vii, No. 5.
[3] Ibid.

of sputum was examined, typical pneumococci were found in 7 (46 per cent.) by mouse inoculation. In the remaining 7 cases,[1] repeated tests of the saliva were made, and in these cases typical pneumococci were found in 6 (85 per cent.). Atypical and avirulent strains are more common in the healthy mouth than in the sputum of patients with or convalescent from pneumonia. Residence in the city or country and indoor or outdoor occupations apparently play little part in the frequency. Longcope and Fox[2] found the percentage of the true pneumococcus type not very high in November, an enormous increase in December and January, and a gradual fall to a low level in March and April. A larger proportion of persons who come in contact with patients with pneumonia harbor the pneumococcus than of persons not so exposed. Convalescents from pneumonia may carry virulent organisms in the respiratory passages for weeks or months.

Pneumococci Outside the Body.—The viability of the pneumococcus outside the body is short, and cultures die out rapidly unless carefully attended. Transplants must be made every two to three days. Occasional passage through animals may be necessary for the maintenance of the strain. It is resistant against cold, but killed in the moist state by exposure to a temperature of 52° for ten minutes. Ordinary disinfectants are quickly effective. In sputum, the organism is resistant to a considerable degree. Wood[3] found that in moist sputum preserved in the dark at room temperature, the average life of the pneumococcus was with considerable variation eleven days; at 0° C. thirty-five days; and at room temperature in a strong light less than five days. In dried sputum in the dark, the organism was found to live on an average for thirty-five days; in diffuse light thirty days; and in sunlight less than four hours. In powdered sputum, even in the dark, death occurred in from one to four hours; under exposure to sunlight within an hour. On cloth the life of the organism was somewhat longer than on a non-absorbing surface. Sprayed sputum particles remained in suspension twenty-four hours, but all masses of a size sufficient to contain bacteria, settled at the rate of about 40 cm. per hour. When sputum containing pneumococci is sprayed, the organisms rarely survived for more than an hour and often died in less time. Under exposure to sunlight while in suspension, pneumococci in spray are destroyed within a half-hour.

Toxin Production.—Attempts to demonstrate a soluble toxin in pneumococcus cultures have usually failed, and the organism does not apparently produce such a substance in fluid media. The toxin is probably intracellular and set free within the body in the course of infection by destruction of the organisms. In support of this, Rosenow[4] and Cole[5] have found that the peritoneal exudates obtained by infecting animals with pneumococci are toxic. Cole has also shown that

[1] So stated in text, ibid., p. 576.
[2] Ibid., p. 449.
[3] Ibid., p. 623.
[4] Jour. Infect. Dis., 1912, xi, 94.
[5] Jour. Exp. Med., 1912, xvi, 644.

when pneumococci are dissolved in dilute solution of bile salts and the resulting solution is injected intravenously into guinea-pigs and rabbits, these animals very constantly show the same symptoms seen in acute anaphylaxis. The toxin is hemolytic for red blood corpuscles.[1]

Immunity.—In comparison with ordinary laboratory animals used for experimentation, man appears to be relatively insusceptible to infection with the pneumococcus, as indicated by the less common occurrence of rapidly fatal septicemia without marked local reaction. The degree of natural immunity probably varies in different individuals, but its importance is difficult to estimate in the face of wide variations in virulence of the infecting organisms. Little or no evidence can be presented in favor of the acquisition of any considerable or lasting protection against subsequent infection by the recovery from an attack of pneumonia. In fact, the frequency of recurrence of pneumonia is one of its most striking features, and one attack seems rather to predispose than to protect against later infection. Recent researches on man and on animals are hopeful, however, in that they suggest that a limited and transient immunity may be acquired. Rabbits can be immunized against infection with pneumococci in various ways. Filtrates of cultures or dead, attenuated or small doses of virulent cultures have been successfully used. The process of immunization is probably best accomplished, however, by gradually increasing intravenous doses of virulent organisms as described by Neufeld.[2] Susceptible animals can thus be protected against many times the otherwise fatal dose of virulent pneumococci, and the serum of an animal so immunized is capable of preventive and limited curative action against pneumococcus infection. Neufeld and Haendel[3] have obtained serum from immunized horses and donkeys which will protect against the 100,000- to 1,000,000-fold fatal dose. Antipneumococcus serum appears to be potent against typical strains of pneumococci, but not for all. Against atypical strains, according to Neufeld and Haendel,[4] ordinary immune serum is ineffective, and inasmuch as such strains may be a cause of pneumonia, a determination of the type of organism is desirable in any given case.

Investigations have been made for the purpose of demonstrating protective substances in man, and more especially in connection with the crisis in pneumonia, the striking features of which would suggest that at this period in the course of the disease such substances might be demonstrable. The results are not wholly in accord, but in general indicate that protective substances of a bacteriotropic nature are present. In 1891, G. and F. Klemperer[5] found that the blood of patients who had recovered from an attack of pneumonia would protect rabbits

[1] Cole. Jour. Exp. Med., 1914, xx, 346.

[2] Zeit. f. Hyg., 1902, Bd. xl, p. 68; ibid., 1900, Bd. xxxiv, p. 457; also Zeit. f. Immunitätsforsch., 1903, I Th., 3, orig., p. 159.

[3] Zeit. f. Immunitätsforsch., 1909, I Th., 3, orig., p. 159.

[4] Arb. a. d. k. Gesundheitsamte, 1910, xxxiv, 293.

[5] Berl. klin. Woch., 1891, xxviii, 833, 869.

against infection with the pneumococcus. Neufeld and Haendel[1] also found that the serum of convalescents, as a rule but not constantly, contained protective substances in variable amount. Seligmann and Klopstock,[2] Boettcher,[3] and Strouse[4] failed to confirm these observations. Neufeld and Haendel[5] offer an explanation of the negative results obtained by Seligmann and Klopstock and Boettcher in the employment of a different technic, and in this article report the successful demonstration of protective substances in every case. Dochez[6] finds protective substances usually present in the blood of patients recovering from pneumonia. Their appearance as a rule coincides rather sharply with the period of critical fall of the temperature and the disappearance of symptoms. An important matter in their recognition appears to be the use both of pneumococci and serum from the same patient.

The character of the protective substance in antipneumococcus serum cannot yet be regarded as settled. Toxin is not found in fluid media in which pneumococci are grown, but the success of Rosenow and Cole in demonstrating toxin in peritoneal exudates suggests that an endotoxin may be responsible, against which it is unsafe to assume that the body fails to produce antitoxin. Lysis of pneumococci has been noted by Neufeld,[7] Wadsworth[8] and others in the hanging drop of serum from a highly immunized animal. It appears to be slight when tested in this way in comparison with that obtained in a similar manner with the organisms of cholera or typhoid fever. The protective substances in immune serum are more generally ascribed to their content of bacteriotropine or opsonin which is thought to act on the bacteria and favor their ingestion and destruction by phagocytes. Attempts to demonstrate these substances *in vitro* are subject to great technical difficulties, and some doubt must be entertained concerning conclusions drawn from such studies.

A consideration of the results thus far obtained in the study of immunity in its relation to pneumococcus infections, suggests that recovery from pneumonia cannot be wholly ascribed to the production of protective substances in the blood, however important they may be as a partial solution of the problem. Antipneumococcus serum is apparently capable of only limited curative action in experimental infections and has as yet not been shown to be strikingly effective in man; protective substances in the blood-serum of patients after recovery are neither constantly nor decisively demonstrable, and recovery from pneumonia fails to confer any considerable or lasting protection against subsequent attacks. On the other hand, in pneumonia as in no other disease, the fight between host and parasite is not only fierce,

[1] Zeit. f. Immunitätsforsch., 1909, I Th., 3, p. 168.
[2] Ibid., 1909–10, orig., iv, 103.
[3] Deut. Arch. f. klin. Med., 1909–10, xcviii, 93.
[4] Jour. Exp. Med., 1911, xiv, 109.
[5] Arb. a. d. k. Gesundheitsamte, 1910, xxxiv, 166.
[6] Jour. Exp. Med., 1912, xvi, 665.
[7] Zeit. f. Hyg., 1902, xl, 54.
[8] Jour. Exp. Med., 1912, p. 16.

but ends decisively in favor of one or the other combatants, and it seems fair to expect that the defensive mechanism will when discovered be more obviously apparent. The most striking features of pneumonia are the crisis and the rapid and complete resolution of the affected lung. The pulmonary tissue seems to be the chief seat of the struggle, and it is not unnatural to expect that study of the lung itself may lead to more definite results.

Welch[1] in 1890 observed that lysis of pneumococci within their capsules could be demonstrated under the microscope during resolution of the pneumonic exudate. The nature and the source of the substance leading to dissolution of the organisms is not known, but various experimenters have shown that leukocytes yield substances capable of destroying bacteria and splitting protein, and it may be that a substance derived from the leukocytes is responsible for the local changes observed in resolution in pneumonia. Flexner[2] calls attention to this aspect of the defenses against pneumonia, and Lamar[3] and Jobling and Strouse[4] report suggestive experiments, the exact bearing of which on this problem cannot yet be regarded as settled.

Pneumococci in Non-pulmonary Lesions. — Direct extension of the pneumococci is responsible for the practically constant occurrence of pleuritis as a complication of lobar pneumonia. Pericarditis may likewise arise. Secondary lesions elsewhere may be due to passage along the lymphatics or invasion of the blood-stream. In certain cases, the passage of pneumococci through the lymphatics may be successfully blocked by the lymph nodes. In others, the barrier offered by the glands may be passed and the organisms thus reach the blood-stream. Direct invasion of injured bloodvessels may be the method of entry to the blood-stream. Septicemia complicating lobar pneumonia is usually unassociated with localizing lesions in other parts of the body, but endocarditis, meningitis, peritonitis, otitis media, and other processes may be observed. Pneumococci alone or mixed with other organisms may be responsible for bronchitis, tonsillitis, rhinitis, etc. In some instances complicating lesions are due to other organisms than the pneumococcus. The pneumococcus is not infrequently a cause of infection in various parts of the body in the absence of a primary lesion in the lung. Mixed infections are not uncommon in such instances.

Pneumococcus Septicemia.—Investigations show that pneumococci can be demonstrated in the blood in a large proportion of the cases. Prochaska[5] obtained diplococci from the blood in all (100 per cent.) of 50 cases. Rosenow's[6] cultures were positive in 160 (91 per cent.) of

[1] Johns Hopkins Hosp. Bull., 1890, i, 73.
[2] Jour. Exp. Med., 1911, xiii, 1.
[3] Ibid., pp. 6 and 380.
[4] Ibid., 1912, xvi, 269.
[5] Bakteriologische Blutuntersuchungen bei Pneumonien, Cent. f. inn. Med., 1900, xxi, 1145, and Untersuchungen über die Anwesenheit von Microörganismen im Blute bei den Pneumoniekranken, Arch. f. klin. Med., 1901, lxx, 559.
[6] Studies in Pneumonia and Pneumococcus Infections, Jour. Infect. Dis., 1904, i, 280, and The Blood in Lobar Pneumonia, Jour. Amer. Med. Assoc., 1905, xliv, 871.

175 cases. Others have demonstrated the organism in a smaller proportion, Schottmüller[1] in 23 per cent. of 209 cases, Cole[2] in 30 per cent. of 30 cases, Wiens[3] in 79 per cent. of 33 cases, Strouse and Clough[4] in 56 per cent. of 25 cases, and Dochez[5] in 18 (50 per cent.) of 37 cases. The organisms may be obtained from the blood before the physical signs of pneumonia are present, and occasionally as long as two to three days after the temperature has fallen to normal, but positive cultures are less often obtained as the crisis is approached, from patients who recover, hence a persistent septicemia in general may be regarded as relatively unfavorable. Positive cultures are most constant when large amounts of blood (10 to 20 c.c.) are taken. The blood should be diluted at once with 50 to 75 parts of nutrient broth in flasks. As soon as growths appear in the flasks, transplants may be made to solid media. Pneumococci were demonstrated in the heart's blood in 42 of 152 cases at autopsy at the Massachusetts General Hospital. They are not infrequently found in the blood at autopsy in cases without distinct localization in the lung. In most cases death in pneumonia is probably due to septicemia. Fränkel[6] reports a case in which by blood-culture during life, 2700 colonies of pneumococci per cubic centimeter of blood were found. Dochez found 10,000 in one case on the fourth day, and 65,000 at the time of death in another.

Animal Experimentation.—The pneumococcus is pathogenic for various animals, but presents considerable variation in virulence. The rabbit and mouse are most susceptible, the guinea-pig, dog, sheep and rat less susceptible, and the pigeon is immune. The type of infection in animals, however, differs from that in man in the production of relatively slight local reaction and usually marked general septicemia. At the point of inoculation there is a slight fibrinous inflammation. The spleen is usually enlarged and soft and large numbers of pneumococci are found in the blood. If less virulent cultures are used or the injections are made into less susceptible animals, the local lesion becomes more and the general infection less marked.

Numerous attempts by different methods have been made to induce pneumonia in animals with varying but usually negative results. Systemic infection, either by subcutaneous or intravenous injection of cultures, has constantly failed. The exceptional success of Gamaleia[7] in the constant production of pneumonic lesions in dogs and sheep by intrathoracic injection of cultures, and of Tchistovitch[8] in 7 of 19 intratracheal injections in cats, failed of confirmation by later observers. Wadsworth[9] reviews the literature and records in his own

[1] Münch. med. Woch., 1905, lii, 1425.
[2] Johns Hopkins Hosp. Bull., 1902, xiii, 136.
[3] Zeit. f. klin. Med., 1908, lxv, 53.
[4] Johns Hopkins Hosp. Bull., August, 1910.
[5] Jour. Exp. Med., 1912, xvi, 680.
[6] Internal Beiträge z. inn. Med., 1902, ii, 103.
[7] Ann. de l'Inst. Past., 1888, ii, 440.
[8] Ibid., 1890, iii, 285.
[9] Amer. Jour. Med. Sci., 1904, cxxvii, 851.

work a greater measure of success than had previously been obtained by most investigators. A high degree of virulence in the organisms used for the experimentation in susceptible animals often leads to fatal septicemia without the production of local pulmonary lesions. In his experiments, 11 rabbits, rendered less susceptible by preliminary immunization, were tracheally injected with 1 c.c. of a highly virulent culture of pneumococci grown in normal rabbits' serum diluted with broth. All showed pneumonia at autopsy.

Lamar and Meltzer[1] have obtained the most striking success hitherto reported. Dogs were infected by the injection of pure cultures of the pneumococcus through a catheter or small stomach-tube introduced into a bronchus by the insufflation method of Meltzer and Auer.[2] Of 44 animals dying or killed within twelve days of inoculation, 42 were found to have pneumonia. In the remaining 2 the lung was normal. The failure in these two instances was ascribed to introduction of the tube into the esophagus rather than the larynx. The mortality was at least 16 per cent. The fatal cases closely resembled lobar pneumonia in man. The non-fatal cases ran a milder and shorter course. The amount of the culture injected seemed to influence the result, larger quantities having been injected in the fatal cases. Variation in resistance of the animals was not noted. Success seemed to be due to obliteration of a large number of bronchi by the culture, thus affording a favorable opportunity for the growth of the organisms and the production of the local lesion.

That pneumonia of a lobar type is a special feature of pulmonary infection with pneumococci is suggested by the experiments of Wollstein and Meltzer[3] who found that intrabronchial insufflation of pure cultures of the streptococcus or the influenza bacillus produced broncho- and not lobar pneumonia. The differences in the nature of the lesion seem to be due to differences in the species rather than to the degree of virulence of the infecting organisms, since non-virulent pneumococci cause the development of a lesion with the gross appearances of lobar pneumonia and an exudate in the lung which in general leaves the framework unaffected, as shown by Wollstein and Meltzer.[4] But the pneumonia produced by non-virulent pneumococci tends to undergo a more rapid resolution, the disease is non-fatal, the blood is not invaded by the organisms, and the exudate is strikingly poor in fibrin.

The influence of leukocytosis in increasing the resistance of animals to pneumococcus infection is suggested by the work of Winternitz and Hirschfelder[5] and Kline and Winternitz.[6] Pneumonia was produced by the insufflation method of Lamar and Meltzer in rabbits previously rendered aplastic by the injection of benzol. In eight animals thus treated, the resistance to pneumonia was markedly

[1] Proc. Soc. Exp. Biol. and Med., 1909–10, vii, 102; Jour. Exp. Med., 1912, xv, 133.
[2] Med. Rec., 1910, lxxvii, 477, and Jour. Amer. Med. Assoc., 1911, lvii, 521.
[3] Jour. Exp. Med., 1912, xvi, 126.
[4] Ibid., 1913, xvii, 353.
[5] Ibid., 1913, xvii, 657.
[6] Ibid., 1913, xviii, 50.

reduced and there seemed to be a striking overgrowth of pneumococci in the lungs. On the other hand, animals treated with toluol, a similar chemical compound causing no leukopenia, showed no diminished resistance. The production of leukocytosis by the repeated injection of toluene or protein substances appeared to increase the resistance of the infected animals.

Pathogenesis.—It has been established that a large proportion of apparently healthy individuals act as host for virulent pneumococci, but it is not as yet clear how the pulmonary infection occurs. Primary invasion of the blood or the bronchial glands and secondary localization in the lung have been suggested in explanation. The constant failure to produce pneumonia in animals by intravenous injection is against the hematogenous theory. Aspiration of infected material from the mouth seems the most likely explanation. A very considerable proportion of patients with pneumonia give the history of a preceding acute respiratory infection. Such predisposing factors as a chill or trauma, increased virulence of the organisms or lowered resistance of the patient may be of importance. The inhalation theory is materially supported by the finding at autopsy of the disease in its more advanced stages in the central parts of the lung and the successful insufflation experiments of Lamar and Meltzer. Obliteration of the lumen of the bronchi by a fibrinous exudate caused by the pneumococcus may be an important determining factor in the lobar character of the pneumococcus infection. The varying response of animals to infection with the pneumococcus suggests that the relative insusceptibility of man and infection with organisms of high virulence also play a part in the localization of the infection in the lung.

Metabolism.—Atwater and Langworthy,[1] in a summary of 27 cases, found that the assimilation of the nitrogenous constituent of the food was poorer during the febrile period than in convalescence, and that a greater destruction of tissue protein took place during the febrile period and in two or more days of convalescence. A portion of the nitrogen of the food was retained during a part of convalescence when the patient began to take sufficient food. The increased output of nitrogen in the urine in the period immediately after the crisis may be chiefly accounted for by the intensified destruction of proteid tissue. The ratio of the extractives to uric acid and urea was higher than normal in all cases in the fever period and in the majority of cases during convalescence.

H. W. Cook[2] studied the nitrogen excretion in pneumonia and its relation to resolution. Determinations of the total nitrogen in the urine by the Kjeldahl method were made on 22 cases. He found that in most cases more nitrogen was excreted during the days of resolution than would correspond to the original quantity of exudate poured

[1] A Digest of Metabolism, Experiments, etc., Bulletin No. 45, Office of Experiment Stations, United States Department of Agriculture, 1898, p. 241.

[2] Johns Hopkins Hosp. Bull., December, 1902.

out into the involved lung. He regards the excess of nitrogen excreted as representing in great part a continuation of the formation and an absorption of inflammatory exudation plus other tissue destruction. In cases in which there is a marked delay in resolution, he believes that the continued high output of nitrogen indicates a continuation of the local inflammatory process. In rapid resolution the leukocytosis curve follows the nitrogen curve with a very striking parallelism and seems to point to a causal relation between leukocytes and resolution.

Wolf and Lambert[1] studied the nitrogen and sulphur metabolism in 19 cases of pneumonia of varying degrees of severity. They found that the cases of milder type show a smaller loss in nitrogen and sulphur than those of a more severe grade. The daily loss in nitrogen on a diet adequate to protect a resting individual from nitrogen loss may be from 20 to 25 grams. The relative desamidating capacity, as shown by the ratio of urea to total nitrogen, is comparable to that of a normal subject. The capacity for the oxidation of the cystin group, as exhibited by the ratio of total sulphate sulphur to total sulphur, is quite as high, if not higher than normal. During the period of hyperpyrexia, excessive amounts of creatinin are eliminated, and this is followed during convalescence by a subnormal excretion of creatinin. This is taken to indicate the endeavor on the part of the organism to repair the losses sustained during the height of the toxemia. In the severe cases of pneumonia, large amounts of creatin are also excreted. This is seen particularly during the time of greatest nitrogen loss. During convalescence the creatin disappears from the urine. In some of the lethal cases the amount of creatin excreted on the day terminating the illness is as high as the amount of creatinin excreted. During hyperpyrexia, especially in cases severely toxic in type, unusually high amounts of undetermined nitrogen are excreted. The sulphur excretion runs more or less parallel with that of the nitrogen, but it appears that in some of the cases the catabolism of proteins rich in sulphur is not so marked as those in which the content of sulphur is small.

Oxygen Content of Blood.—Butterfield and Peabody[2] found a reduction of oxygen capacity below the normal level without a corresponding diminution of hemoglobin in some cases of pneumonia (Peabody), and in guinea-pigs and rabbits with pneumococcus infection. It was also found that a definite drop in the oxygen capacity was constantly produced by the action of pneumococcus cultures on washed rabbit red-blood corpuscles *in vitro*, and that this was due to the formation of methemoglobin (or some derivative of hemoglobin with identical optical constants for three regions in the spectrum). In rabbits injected intravenously with sufficiently large doses of pneumococci to produce a severe bacteriemia, Peabody[3] noted polypnea, cyanosis of the mucous membranes and conjunctivæ, and a darker color of the blood in the ear veins. Death occurred in from four to six hours. He found that

[1] Arch. Int. Med., 1910, v, 406.
[2] Jour. Exp. Med., 1913, vol. xvii, No. 5.
[3] Ibid., 1913, vol. xviii, No. 1.

the oxygen combining power of the blood fell progressively up to the time of death, due to the conversion of hemoglobin into methemoglobin. In patients with lobar pneumonia, Peabody[1] found that in most cases the oxygen content of the blood was within normal limits, the decrease in respiratory surface being completely compensated. But in the terminal stage of the fatal cases in which death did not occur with great suddenness, there was often a progressive diminution in the oxygen content, and at the same time a progressive decrease in the oxygen combining capacity of the blood. These changes, usually seen in patients in whom an intense bacteriemia developed, were probably due to a change of oxyhemoglobin to methemoglobin, and may be regarded as a probable factor in the immediate cause of death in many cases of pneumonia. Cole[2] finds that the transformation into methemoglobin takes place only when the pneumococci are living.

Carbon-dioxide Content of the Blood.—A diminution in the carbon dioxide content of the blood in fever has been established by various observers, and is generally ascribed to a lowered alkalinity of the blood. Loewy[3] states that the carbon-dioxide content of venous blood normally is from 43 to 50 per cent. at a tension of 40 to 50 mm. of mercury. Peabody[4] finds it to be between 54 and 58 per cent. Peabody made 91 analyses on 26 patients with pneumonia. With the exception of 2 cases, the carbon dioxide was found to be regularly diminished during the febrile period, and in most cases was from 40 to 50 per cent. in the acute stage of the disease, but not infrequently from 50 to 53 per cent. or only slightly below normal. The lowest observation was 29.01 per cent. The carbon-dioxide content bears little definite relation to the severity of the disease, except that it tends to be lowest in severe cases and in the terminal stages of the disease, with less deviation from the normal in short or mild cases. The diminution bears no immediate relation to the temperature, as it may persist for some days after defervescence. The diminution in carbon dioxide corresponds to the other evidences of metabolic changes in infection and, like them, may be even greater after than during the febrile period. The changes in the carbon-dioxide content of the blood run parallel to the output of ammonia in the urine, and appear to bear no relation to chlorine excretion. In two of Peabody's cases the carbon-dioxide content of the blood was normal or above normal, and this was associated with a very low oxygen content of the venous blood.

Inorganic Substances.—The chlorids of the urine are greatly diminished, and may be absent during the course of the disease to return to normal after the crisis. Analyses have shown that too little is stored in the consolidated lung to account for the suppression, and that retention elsewhere in the body must take place. It is generally

[1] Jour. Exp. Med., 1913, vol. xviii, No. 1.

[2] Jour. Exp. Med.. 1914, xx, 363.

[3] Loewy, A. in von Koranyi, A., and Richter, P. F., Physikalische Chemie und Medizin, Leipzig, 1907, i, 255.

[4] Jour. Exp. Med., 1912, vol. xvi, No. 5.

believed that retention occurs throughout the fixed tissues. Hutchinson[1] and Hösslin and Kashiwado[2] regarded the permeability of the kidney as an insignificant factor. Madigreceanu,[3] as a result of the study of chlorin metabolism in animals with experimental pneumonia, general pneumococcus septicemia and pleural exudates induced by means of turpentine, concluded that the formation of the exudate is only one factor and alone incapable of producing such a degree of retention as occurs in pneumonia.

The investigations of Salkowski[4] showed that sodium as well as chlorin was retained. Moraczewski[5] demonstrated a retention of calcium, but no evidence of retention of magnesium. Peabody[6] found that while chlorin, sodium and calcium are retained, potassium and magnesium are excreted normally or in excess. Two cases showed a definite loss to the body of magnesium during the febrile period. He also found that during the period of retention the chlorin content of the blood is distinctly lower than normally, the calcium content is apparently slightly lower, and the magnesium content tends also to be a little lower.

Pathology.—Since Laënnec's time pathologists have recognized three stages in croupous pneumonia, *i. e.*, engorgement, red and gray hepatization.

The stage of engorgement is rarely observed alone, but may be seen at the periphery of pulmonary tissue already the seat of a more advanced inflammation. The tissue is deep red in color, more voluminous than normal, and abnormally heavy. On section a serous, slightly bloody fluid exudes. It is doughy to feel, still crepitates, and excised portions float in water. On microscopic examination, the capillaries, smaller arteries and veins are found engorged with blood. The alveolar epithelium is swollen and the alveoli contain a variable and usually small amount of serous fluid, red-blood corpuscles, and desquamated epithelium. Small strands of fibrin may be seen. This stage probably lasts but a few hours as a rule.

In the stage of red hepatization, the lung tissue is solid, reddish brown in color, still more voluminous, and shows indentations from the ribs. It is friable, firm and airless, excised portions sinking in water. The cut surface is dry and granular. A small amount of reddish-brown, somewhat viscid fluid, containing small granular masses, may be scraped from the cut surface with the knife. The fluid is more viscid when the infection is due to streptococcus mucosus capsulatus. The granular appearance is due to the expression of fibrinous masses from the elastic alveoli. The distinctness with which they can be seen varies with the age of the patient and the consequent size of the alveoli. Damoschino[7] states that in children the granulations have

[1] Jour. Path. and Bact., 1898, v, 422. [2] Deut. Arch. f. klin. Med., 1911, cii, 520.
[3] The Mechanism of Chlorin Retention in Pneumonia, Jour. Exp. Med., 1911, xiv, 289.
[4] Virchow's Arch. f. path. Anat., 1871, liii, 209.
[5] Ibid., 1899, clv, 11, and Zeit. f. klin. Med., 1900, xxxix, 44.
[6] Jour. Exp. Med., 1913, vol. xvii, No. 1.
[7] Des different formes de la pneumonie aigué chez les enfants, Paris, 1867.

a diameter of 0.07 to 0.11 mm., in adults 0.13 to 0.17, and in the aged 0.21 to 0.27 mm. When the pneumonia affects a lung, the site of emphysema, the granules may attain an unusually large size. Fibrinous plugs may be found in the smaller bronchi. The pleura adjoining the inflamed lung is clouded and covered with a fibrinous layer. On microscopic examination the alveolar walls are found to be infiltrated and their lumen filled with serum, fibrin, polynuclear and mononuclear leukocytes, and desquamated epithelium. The terminal bronchi contain a similar exudate. The fibrin is in the form of a network, which is most dense in the neighborhood of the alveolar wall and forms a wider mesh in the central part of the alveolar space. Isolated fibers or bundles of fibers of fibrin may be seen to pass through the alveolar wall from one alveolus to another, normal openings through which such a communication can be established, having been demonstrated by Hansemann[1] in the lungs of animals. The reddish-brown color of the tissue is due to the presence of red-blood corpuscles and hemoglobin in the exudate and to the congestion of the bloodvessels. The lymph vessels are filled with serum, leukocytes and fibrin, which may be in such abundance as to outline their course in the interstitial tissue.

In the stage of gray hepatization, the reddish-brown color of the tissue has changed to grayish or grayish white. The change from red to gray hepatization is gradual and not everywhere with equal rapidity, so that oftentimes both may be seen together in the same lung, giving it a spotted, marble-like appearance. The cut surface is more moist, still granular and friable, and on scraping yields a more turbid fluid. The granular appearance, though still present, is less distinct. Examination with the microscope explains the changed appearance of the tissue. There is less blood and a larger number of white cells, while the fibrin is much diminished or has disappeared. The compression of the bloodvessels and partial obliteration of their lumen by fibrin or thrombi are in part responsible for the color of the tissue.

With the advancement of the process the more cellular becomes the exudate. In the stage of purulent softening or resolution the pulmonary tissue is soft, loses its granular character, and on pressure exudes an abundant yellowish, purulent fluid. The process differs from ordinary suppuration in the rapid disintegration of the fibrin and cellular elements and their disappearance. On microscopic examination the white cells show fatty degeneration and the fibrin granular degeneration. The final disappearance of the exudate cannot be ascribed entirely to expectoration, for in some cases both cough and expectoration are absent from beginning to end of the disease. In some cases resolution may proceed to completion within twelve to twenty-four hours, to judge from physical examination.

Autolysis.—The exudate must therefore disappear largely through absorption. According to the investigations of Fr. Müller[2] and O.

[1] Sitzungsber. d. Kgl. Preuss. Akad. d. Wissenschaften, 1895, xliv, 199.
[2] Verhandl. d. Naturforschergesellsch. in Basel, 1901, Bd. xiii.

Simon,[1] the exudate probably disappears as a result of autolysis. Simon observed autodigestion in gray hepatization to a greater degree than in red hepatization, and this was later confirmed by Silvestrius[2] and Flexner.[3] A ferment-like substance is probably set free by the leukocytes and liquefies the exudate. This autodigestion may be observed *in vitro* if pieces of pulmonary tissue in the stage of gray hepatization are preserved in the incubator. The action of bacteria is excluded by the addition of toluol. As a result of the splitting of the proteid, such products as leucsin, tyroin, lysin and probably histidin may be found. Mayeda,[4] after autodigestion of the lung in the stage of gray hepatization, found splitting of the nuclein substances with the formation of xanthin in considerable amount, but the other purin bases (guanin, adenin and hypoxanthin) could not be found. The presence of free uric acid in the autolyzed pneumonic lung was also established. Nukada[5] has since succeeded in isolating uric acid from the pneumonic lung.

Site of the Disease.—In practically all large series of cases, the most frequent site of the disease is in the lower lobes, of which the right is the more frequently affected. In Jürgensen's[6] 6666 cases the right lung was involved alone in more than one-half (53.7 per cent.), the left lung in a little more than one-third (38.23 per cent.), and in a much smaller number (8.07 per cent.) both lungs were invaded. Among Fränkel's[7] 830 cases, he noted an involvement of the upper lobes in 136 (16.4 per cent.) cases and central pneumonia in only 14 (1.7 per cent.). The predominance of the disease on the right side and in the right lower lobe has been ascribed to the larger size and straighter course of the right primary bronchus, from which the branch to the right lower lobe is a direct continuation.

The affected part of the lung may present different stages of the disease in different places or uniform involvement in one stage. According to Tendeloo,[8] when the former condition obtains, the central parts are in the most advanced stage, as, for example, in resolution or gray hepatization; and from the centre toward the periphery gray-red, red hepatization, inflammatory engorgement, and in the adjacent tissue often stasis or acute collateral edema.

Pneumococci can usually be demonstrated in cover-glass preparations from the exudate in early cases of pneumonia. Other organisms are frequently present also, both in fresh material and in cultures from the lung. Such organisms may be secondary invaders or indicate postmortem contamination of the tissue. In sections from croupous pneumonia, in the stage of red or gray hepatization, the

[1] Deut. Arch. f. klin. Med., 1901, Bd. lxx.
[2] Bioch. Zentralb., 1903, Bd. i.
[3] Trans. Assoc. Amer. Phys., 1903, vol. xviii.
[4] Deut. Arch. f. klin. Med., 1909–10, xcviii, 587.
[5] Deut. med. Woch., 1912, No. 23, p. 1090.
[6] Ziemssen's Handb. d. spec. Path. u. Ther., 1874, p. 51.
[7] Spec. Path. u. Ther. d. Lungenkrankheiten, 1904, p. 274.
[8] Studien über die Ursachen der Lungenkrankheiten, Wiesbaden, 1902, p. 225.

pneumococci may often be found in enormous numbers both within and without the cells. With the advancement of the process they are more difficult of demonstration.

The bronchi are usually injected and their finer ramifications may contain fibrinous casts. Both visceral and parietal pleuræ are almost without exception inflamed over the region of pulmonary involvement. At autopsy a small amount of cloudy fluid is usually present in the pleural sac. On microscopic examination this is found to contain a predominance of polynuclear leukocytes with a few endothelial and small mononuclear cells. The mediastinal lymph glands, especially those about the larger bronchi, are frequently enlarged. Of other organs the spleen is often large and soft. The heart is frequently dilated and may contain thrombi. Both dilatation and thrombus formation affect for the most part the right auricle and ventricle.

Accidents of Resolution.—*Organizing Pneumonia.*—A termination of the pneumonia in organization rather than resolution occurs in a small proportion of cases. Among 210 cases at the Massachusetts General Hospital with genuine croupous pneumonia at autopsy, or with a history which may be interpreted as lobar pneumonia, were 16 (7.6 per cent.) of organizing or indurative pneumonia. Replacement of the inflamed tissue by connective tissue finally transforms it into a dense, firm, airless, and contracted mass of scar tissue. A termination in organization and fibrosis is responsible for the condition spoken of clinically as delayed resolution. In its clinical aspects organizing pneumonia is more fully discussed under delayed resolution. The subject is also considered in the chapter on Subacute and Chronic Indurative Pneumonia, of which organizing croupous pneumonia is an important cause.

Abscess and Gangrene.—In 51 cases of croupous pneumonia coming to autopsy at the Massachusetts General Hospital, pulmonary losses of substance either micro- or macroscopically, were found in 14 (27 per cent.). Croupous pneumonia is one of the most important causes of abscess and gangrene for which the compression of the bloodvessels by the exudate and their partial or complete obliteration by thrombi may be responsible. For further discussion, the section on Abscess and Gangrene may be consulted.

Incubation Period.—This is probably short. To judge from traumatic cases it may be placed at from one to two days. Certain epidemic cases suggest that it may last as long as eight days.

Prodromata.—The most constant symptoms preceding the onset are those of a mild acute respiratory infection. A history of a "cold" from a few days to several weeks before the onset and usually accompanied or followed by cough was obtained in 31 of 200 cases of pneumonia. The respiratory infection does not appear to differ from an ordinary "cold" until the patient is suddenly stricken with pneumonia. In other and less common instances malaise, general pains, headache,

chilliness and fever may be present for a day or two before the more striking features of the onset develop.

Symptoms.—These are both local and general. The local features are referable to the changes in the lung and neighboring tissues in consequence of the infection with pneumococci. The general symptoms are such as are observed in other infections. In the case of the pneumococcus infections they are probably due to toxemia in consequence of destruction of the organisms and the setting free of intracellular poisons.

General Clinical Description.—The onset is usually abrupt and with pain in the side, cough and chill or chilliness in a very large proportion of the cases. The pain, cough, and chill are usually coincident. The pain is commonly a very distressing symptom and is aggravated by exertion, deep breath or cough, and increases the dyspnea by limiting respiratory motion. The cough is at first dry and painful. The sputum usually becomes rusty within twenty-four hours. The chill lasts from a half-hour to several hours, and is accompanied or followed by a rapid rise of temperature, which may reach 102° to 104° within a few hours. A rise in the frequency of the pulse and respiration accompanies the symptoms of invasion. The normal relation of respiration to pulse may be much disturbed, the former being increased out of proportion to the latter. The patient is frequently found lying on the affected side, the alæ nasi dilating with inspiration, an audible grunt with expiration. The face is likely to be flushed and the lips cyanotic. Herpetic lesions may be present, but are seldom observed before the second or third day. If the patient is seen within twenty-four hours of the onset, the physical signs are usually limited to slight dulness and fine consonating rales with long breath or cough. Harsh inspiration, bronchovesicular breathing and slight changes in the voice, whisper and tactile fremitus may be demonstrable, but are often lacking. Diminished breathing may be the only sign. In some cases at this early period the lungs are negative. Usually by the second or third day the pulmonary findings are outspoken. Inspection shows restricted motion of the affected side, over which there is dulness, bronchial breathing, increased voice, whisper and tactile fremitus. In the absence of diffuse bronchitis, fine consonating rales can usually be heard over the involved region during the early period of the disease, but may disappear while it is at its height. In typical cases the extent of the involvement gradually increases until involvement of the greater part or the whole of one lobe may be determined. In atypical cases the evidence on physical examination may be uncertain for a time or remain so throughout the disease. In from five to ten days the temperature usually falls by crisis or lysis, and with defervescence signs of resolution may be heard in the affected lung. The fine consonating rales, redux crepitus, of the period of invasion return and the percussion note becomes more resonant. The rusty color of the sputum gives place to a more purulent and less tenacious expectoration.

In any large series of cases the course of the disease is very variable. All grades of severity may be observed. In the mildest cases the patient may be quite comfortable throughout. The sputum may be scanty or absent and the cough not discomforting. There may be no pain, and the pulse and temperature little elevated. Hardy subjects may continue their occupation as in the case of a man of thirty-one with a history of pain, cough with blood-streaked sputum and chill six days before entrance, who worked as a cigar-maker until he fainted in the shop the day before admission. The temperature may begin to fall in rare instances by the third, but more often in mild cases by the fifth day. Even in mild cases predictions are unsafe and there may be a rapid transition from a condition of apparent safety to one of great gravity. Such changes are usually gradual, however, and indicated by greater cyanosis, more rapid pulse and respiration, extension of the pulmonary lesions, restlessness, insomnia, and delirium. The severity of the general symptoms is a better indication of progress than the extent of the pulmonary involvement. Bilateral or multiple lobar involvement is less favorable.

Special Symptoms.—A chill usually marks the onset and from it the duration of the disease is reckoned. It was present in only about a half of my series. Louis noted chills in 61 (77 per cent.) of 79 cases and Grisolle 145 times (79 per cent.) in 182 cases. Chilliness may replace the chill. Chill is likely to be absent at the extremes of age, in alcoholic subjects, and when pneumonia complicates acute or chronic disease.

Fever.—The fever usually begins to rise with the initial chill, and may reach its maximum within twelve to twenty-four hours. In rare instances, the fastigium is reached only after several days, during which the evening record is slightly higher than that of the previous day. Having reached its height, the temperature is commonly remittent with a morning remission of from one to two or more degrees. More constant fever with variations of only a degree or less between the morning and evening record is occasionally seen. On the other hand, well-marked daily remissions or even intermissions may be observed. In the aged, and in debilitated subjects, with chronic disease, an otherwise typical pneumonia may be afebrile. Immediately preceding the termination of the disease the temperature occasionally rises above its previous level. From 102° to 104° is an average pyrexia. Fever of 105° to 106° is uncommon and 107° was reached only once in my series. Of 1987 cases collected by Musser and Norris, the fever terminated in from five to ten days in 1405 (70 per cent.). A pneumonia of two and three days' duration is occasionally seen. On the other hand the disease may run a protracted course of two to three weeks or more.

Defervescence is more often by crisis in which the temperature returns to normal within twelve to twenty-four hours. If the fall is prolonged for twenty-four to thirty-six hours, it is spoken of as a protracted crisis. Toward the end of the disease there may be a rapid

fall of temperature followed by a rapid rise. This fall is spoken of as a pseudocrisis. Defervescence usually occurs in the late evening hours and the signs of beginning resolution commonly just precede, accompany or follow it. Crisis is more common in children, in vigorous adults and in cases running a brief course. Complications are less frequently observed in cases terminating by crisis. Defervescence which lasts longer than thirty-six hours is spoken of as lysis. It is more common in the aged, those subject to acute or chronic disease, debilitated patients and in the presence of complications. Complications are nearly four times more frequent in cases terminating by lysis than by crisis.

The fall of the temperature by crisis and less commonly by lysis may be followed by such symptoms of exhaustion as sweating and rapidity and weakness of the pulse. A subnormal temperature for several days after defervescence is common. In some cases there is a slight evening rise of temperature for several days.

Cyanosis.—This is almost invariably present and increases as the disease progresses. It is probably in part due to diminished respiratory area, restricted respiratory motion from pain and mechanical interference with the pulmonary circulation. The investigations of Peabody (quoted under Metabolism) suggest that a low oxygen capacity of the blood and the formation of methemoglobin as a result of the pneumococcus infection may also be in part responsible.

Respiratory Symptoms.—Pain is the most striking and constant of the triad of initial symptoms—pain, cough and chill, and is due to invasion of the pleura. It was present in 272 (88 per cent.) of Grisolle's 309 patients and in 89 out of 100 cases in the Massachusetts General Hospital series. The pain is often described as a "stitch in the side" and is usually coincident with the chill and cough. It is commonly severe enough to make the patient cry out, double him up and awake him from sleep. It is of abrupt onset, lancinating in character and usually felt in the lower lateral thoracic region on the affected side, but may be referred to the shoulder, abdomen or hip. In rare instances it is felt on the unaffected side. It is less intense and may be absent in children, in apical or central pneumonia and in delirious patients. When severe, it contributes to the dyspnea and is usually aggravated by long breath, cough, sneezing, and talking. Amelioration follows immobilizing the chest. Cutaneous hyperesthesia over the painful region may also be noted. With the progress of the disease the pain diminishes or disappears, and is not a prominent feature toward the latter part of the illness.

Abdominal pain as an initial symptom may lead to the confusion of pneumonia with an acute abdominal affection such as gall-stones or appendicitis. It was noted in 12 out of 200 cases in this series. It is usually referred to the upper, but may be felt in the lower quadrants of the abdomen. Spasm and tenderness may accompany the pain. It is probably due to irritation of the terminal branches of the lower six

intercostal nerves which supply the abdominal wall with sensation. The eleventh nerve supplies the abdominal wall over the appendix region.

Respiration.—The character of the respiration is one of the striking features of the disease. In typical cases the respiratory movements are restricted and short, with inspiratory dilatation of the alæ nasi and "expiratory grunt." An increase in the rate of respiration to 30 or more per minute was observed in all but 9 of 200 cases, from 30 to 40 in 78 (39 per cent.), from 40 to 50 in 60 (30 per cent.), and from 50 to 60 in 25 (12.5 per cent.). An elevation to 60 or more is occasionally observed in adults. In children, a rate of from 40 to 50 is common and may rise to 100 or more. Increased respiration in pneumonia is due to restriction of respiratory excursion from pain, to exclusion of the involved part of the lung from participation in respiration, to fever, toxemia, and cyanosis. The rate of respiration is of only limited value in prognosis, but the mortality in adults is above the average among those with a rate of 50 or over. Varying grades of dyspnea usually accompany the increase in the rate of respiration.

Cough is almost invariably present at some time during the course of the disease. It is usually an initial symptom occurring simultaneously with the chill and pain in the side. In some cases it is delayed for a few hours or a day or more. It is a less prominent feature and may be absent when the upper lobes are involved, in the aged, in delirious patients, and in those already subject to acute or chronic disease. Von Jürgensen justly remarks that "Cough is rarely of use, always troublesome and sometimes dangerous." It may exhaust the patient's strength, disturb his sleep aggravate the pleural pain, and overtax the right side of the heart by increasing intrapulmonary pressure. It is at first dry, but later productive, and then more often necessary for the elimination of secretion. Sudden cessation of cough may indicate approaching exhaustion, stupor or coma.

Sputum.—In about one-half to three-quarters of the cases of croupous pneumonia (in 62 per cent. of my series), the sputum is quite typical of the disease. It is rusty, tenacious, glairy, and transparent. The rusty sputum appears usually in the course of the first or second day, but may not appear until the latter days of the illness. The brick-dust appearance is due to admixture with the blood corpuscles and hemoglobin. In other cases, the sputum fails to show a rusty, tenacious character, and is white and mucoid, yellowish or greenish and mucopurulent. It may consist of almost pure pus. Sputum of this character is probably due to the accompanying bronchitis. During the stage of resolution the rusty color begins to disappear, and for a short period during convalescence the patient continues to expectorate diminishing amounts of mucopurulent or purulent sputum. The amount of sputum usually averages about one to two ounces in the twenty-four hours, the exudate being for the most part absorbed rather than expectorated. Expectoration may be

absent throughout the course of the disease. This is almost invariably the case in children who swallow the sputum, and is common in the aged, in much debilitated, stuporous or delirious patients.

Hemorrhagic sputum may be seen in pneumonia complicating cardiac disease with broken compensation, and in pneumonia following trauma. When it occurs in other cases, pulmonary tuberculosis should be suspected. Stricker[1] noted hemoptysis in only 7 among 16,711 cases of acute pneumonia. The bloody sputum of pulmonary infarction may closely resemble or be identical with that in lobar pneumonia, but is usually more hemorrhagic, darker red, and less transparent. The sputum from cases in which the pneumonia is due to infection with Friedländer's bacillus has a more mucoid and stringy appearance.

Biliary coloring matter appears to be a constant finding in pneumonic sputum, as has been shown by Obermayer and Popper[2] and Pollak[3]. Herxfeld and Steiger[4] found that the different tests for biliary coloring matter in the sputum during the febrile stage were positive even in cases in which no subicteric color was present in the skin and mucous membranes. They also found in typical pneumonic sputum in many cases a substance which gave the reactions of urobilin.

On careful inspection of the sputum delicately branched white to reddish fibrinous casts can at times be found. They are best demonstrated by teasing the specimen apart under water. Curschmann spirals are at times also seen.

Examination of the Sputum for Pneumococci.—Care should be used in the selection of masses for examination to take the more suspicious particles. A small mass of rusty, tenacious material may be picked up with the platinum loop or small forceps. The best results are obtained if the mass is washed of adherent mucus in sterile salt solution, water or bouillon before examination. Thin smears should be made on cover-glasses and the material fixed in the flame in the ordinary way. Löffler's alkaline methylene blue heated in the Bunsen flame for a few seconds stains the organisms satisfactorily, but fails to bring out the capsule. Carbol-fuchsin (5 to 10 per cent.) may be used and will at times demonstrate the capsule. By these methods the morphology of the organism can be recognized and the presence of capsules suspected by a wide unstained zone about it. The use of Gram's stain followed by a saturated aqueous solution of eosin, as in Smith's[5] method is most satisfactory. By this method capsules, if present, are usually demonstrated. All specimens should also be stained for the tubercle bacillus as part of the routine examination.

Cultivation of Pneumococci.—Pneumococci may be cultivated from the sputum by the following method: Careful washing of the suspected

[1] Quoted from Sticker. Nothnagel's Spec. Path. u. Ther., xiv, Bd. ii, 1 Abt.
[2] Wien. klin. Woch., 1908, No. 28. [3] Ibid., 1908, No. 27.
[4] Medizinische Klinik, 1910, No. 36, p. 1415.
[5] Boston Med. and Surg. Jour., December 18, 1902.

mass by passage through several tubes of sterile solution is most important in obtaining satisfactory results. The sputum mass thus freed of adherent mucus may then be smeared on the surface of Löffler's slanted blood-serum. From this tube at the time of inoculation, other tubes should be inoculated in sequence to secure complete isolation of colonies after incubation. It is seldom necessary to make more than three or four such dilutions. The rabbit and mouse are most susceptible and the latter most often used for testing the virulence of the organism. Considerable variation in infective power is noted. Inoculation with fresh sputum may be made subcutaneously or within the peritoneum. With virulent organisms and a susceptible animal, the pneumococcus can be recovered from the heart's blood and the spleen.

Pneumococci are usually present in large numbers in the sputum during the febrile period, but rapidly diminish after the crisis is passed. For the identification of the various types, a study of their morphology, cultural peculiarities, protection experiments in animals with immune serum and agglutinative reactions may be necessary. For rapid isolation of the organism from the sputum for agglutinative tests, Dochez's method[1] is as follows: A likely mass of sputum is washed several times in sterile salt solution, rubbed up in a mortar with one-half a cubic centimeter of bouillon and injected into the peritoneal cavity of a mouse. The animal is killed after about eight hours and the peritoneal exudate washed out with 5 to 6 c.c. of salt solution or bouillon. This suspension of bacteria and leukocytes is then centrifuged at a rate sufficient to throw down the leukocytes. The supernatant fluid is withdrawn and centrifuged rapidly to collect the bacteria. A dense emulsion of bacteria thus obtained may be used for the agglutinative tests.

The mere presence of pneumococci in the sputum is of little moment in the diagnosis of lobar pneumonia, since these organisms are not infrequently the cause of bronchitis without demonstrable pulmonary lesions. The demonstration of pneumococci in a rusty, tenacious sputum is of greater importance, but cannot be regarded as conclusive evidence in establishing the diagnosis. Secondary infection of an area of pulmonary infarction may result in rusty sputum containing pneumococci. No constant relation obtains between the number of pneumococci in the sputum and the severity of the attack.

Circulatory System.—The pulse is usually strong and full in the early stages of pneumonia and throughout the course in mild cases. In cases of moderate severity, the rate does not usually rise above 100 to 110. From a third to a half of adult patients with a rate of 120 or over succumb to the disease. About three-quarters of those with a rate of 140 or over terminate fatally. In one of my cases in which pneumonia complicated chronic mitral endocarditis and auricular

[1] Personal communication.

fibrillation, the cardiac rate was counted at 200 over the apex and yet recovery followed. The pulse is more rapid in women and in those of small stature. In children a rate of 120 to 150 or more is common. Of 17 patients with an irregular pulse 13 died. The normal relation of the respiration to the pulse of about 1 to 4 is usually disturbed in pneumonia and the ratio may be reduced to 1 to 3, 1 to 2 or even 1 to 1. Bradycardia may be observed in the first few days after the crisis. Sphygmographic tracings show that the dicrotic notch is more marked in pneumonia than during health, but it is unusual to be able to demonstrate this with the finger.

Blood-pressure.—Judging from 152 cases in which the pressure was measured at the Massachusetts General Hospital, there is no noteworthy deviation from the normal in pneumonia, the recorded pressures being what might be expected for persons in health and usually ranging from 110 to 130 mm. of mercury. Crisis appears to be unaccompanied by any constant change in the pressure.

The Heart.—A careful note of the condition of the heart should be made at the time of the first visit in patients with pneumonia. The percussion outline of the deep cardiac dulness and the point farthest down and out toward the left at which the cardiac impulse can be palpated should be noted for comparison with subsequent findings when the question of displacement from pleural effusion or variations in consequence of pericardial effusion may be of importance. Careful percussion usually fails to show any noteworthy change in the cardiac outline during the course, even of severe cases with cardiac insufficiency. In some instances, however, an increase of the cardiac dulness beyond the normal limits to the right may be demonstrated. This may be due to dilatation of the right side of the heart from obstruction of the pulmonary circulation. Consolidation of a considerable volume of the lung lying next the heart may displace it slightly away from the affected region. Solidification on one side in a region remote from the heart may lead to slight displacement toward the affected region in consequence of compensatory emphysema of the other and uninvolved lung. In one patient (No. 190591), in whom a pneumonia at the right base developed under observation in the hospital, the heart was dislocated 3 cm. to the right and returned to its previous normal position with the subsidence of the pneumonia. Pleural effusion displaces the heart away from the affected side. When the right middle lobe is consolidated, it may be difficult or impossible to outline the right border of the heart.

Systolic soft blowing murmurs over the precordia, of maximum intensity at the apex or in the left second interchondral space, not uncommonly appear during the course of pneumonia. An apical systolic murmur may also be heard in the axilla and even in the back. Such murmurs may be unaccompanied by symptoms or signs of cardiac weakness, disappear during convalescence, and are to be regarded as of functional origin. They are probably due to relaxation of the myo-

cardium. Organic murmurs may be due to a complicating acute or preëxistent chronic endocarditis.

The behavior of the heart may be of great importance in estimating the chances for recovery and the indications for treatment. The second pulmonic sound is usually accentuated in consequence of the increased resistance in the pulmonary circuit, and daily observation may show a lessening of its intensity in cases in which the heart is failing. Transmission of the second sound through neighboring and consolidated lung may intensify it and thus interfere with the interpretation. A shortening of the first cardiac sound and approach to the second in quality (embryocardia), increased rapidity and weakness of the pulse, cyanosis, aggravated dyspnea, with or without nervous symptoms may come on gradually or suddenly. Heart weakness is unusual before the third day. It is not uncommon at the time of the expected crisis, and in rare instances may occur after the crisis is successfully passed. Sudden death from pulmonary embolism may occur when the patient sits up for the first time.

Skin.—Labial herpes occurs more frequently in pneumonia than in any other disease and may thus be of considerable diagnostic value. One or many vesicles may be present. Herpes may also appear at the angles of the mouth, about or just within the nose, on the chin, genitals, about the anus and rarely in other parts of the body. Various observers have noted herpes in from 7 to 50 per cent. of the cases. Of 200 cases at the Massachusetts General Hospital, it was recorded in only 5 per cent. The eruption usually appears about the third day of the disease, but may be observed at any time. Howard[1] found congestion, hemorrhage, cellular infiltration and degeneration of the cells in the Gasserian ganglion in cases in which herpes was present in the distribution of the fifth nerve. Herpes has been regarded as a sign of favorable import in pneumonia. Of 395 cases with herpes collected by Musser and Norris,[2] 43 (10.8 per cent.) died, of 239 without herpes 70 (29.2 per cent.) died. Sweating may occur during the course of the disease, but is uncommon. It is more often seen at the time of the crisis. Sudamina are occasionally observed. Redness of one cheek, usually on the same side as the pneumonia, may occur. Diffuse erythema, a roseola-like eruption, purpura and furunculosis have been described.

Urine.—This usually presents the characters common to other acute infections with fever, and is diminished in quantity, of a high color, increased acidity and high specific gravity. The quantity is often diminished to less than one-half the normal during the disease and commonly arises to or above the normal during crisis or lysis. No constant relation appears to obtain between the amount of urine and the favorable or unfavorable outcome of the disease. The high color is due to greater concentration and increase of urobilin. The urea and uric acid are usually relatively and absolutely increased. Nitrogen

[1] Amer. Jour. Med. Sci., February, 1903.
[2] Osler. Mod. Med., vol. ii, p. 577.

is increased during resolution, as has been shown by Fr. Müller.[1] If resolution is delayed, an excess of nitrogen may be maintained in the urine according to H. W. Cook's[2] observations. Pick[3] observed that the acidity of the urine may be diminished to such a degree as to become strongly alkaline in the first few days after the crisis. This was the case in 31 of 38 cases and may be ascribed to increased absorption of fixed alkali from the resolving exudate.

The chlorids are greatly diminished and may be absent during the course of the disease to return to normal after the crisis, as mentioned under Metabolism in Pneumonia. Suppression of chlorids has no prognostic significance. It is more common in pneumonia than in other conditions and may thus have a limited diagnostic value.

Of abnormal substances in the urine, acetone may be found as in other febrile diseases. The diazo-reaction may be present, but is less common than in typhoid fever. Traces of albumin are common and were found in 71 of 100 cases at the Massachusetts General Hospital. Even a considerable quantity of albumin with tube casts and blood may be due merely to temporary renal irritation. Albumin and formed elements may persist for a time after the termination of the fever. Their occurrence is explained by the examination of renal tissue from cases dying from pneumonia, as in the observations on 45 autopsies by Fränkel and Reiche,[4] who found pathologic renal changes in all but one of the cases. These consisted of changes in the renal epithelium (coagulation necrosis and plasmolysis), usually without involvement of cell nuclei. In some cases there was an exudate in Bowman's capsule at times with the presence of red-blood corpuscles. Proliferation of the capsular epithelium, interstitial and vascular changes were not observed. In some of the cases no albumin had been found in the urine during life. Deutero-albumose was found in the urine by Krehl and Matthes.[5] True peptone was found by Ito.[6]

The Spleen and Lymph Glands.—Enlargement of the spleen occurs in pneumonia as in other acute infections. The weight exceeded 250 grams in 43 (34.6 per cent.) of 124 autopsies on patients dying with pneumonia. Eug. Fränkel and F. Reiche[7] found enlargement in about 40 per cent. of their fatal cases. Musser and Norris state that splenic enlargement occurred clinically in 791 (34.6 per cent.) of 1416 clinical cases, while Fränkel[8] was able to establish enlargement in only 15 per cent. of his cases. The spleen was felt in only 3 per cent. of our cases. Enlargement of the lymph glands has not been noted in our cases.

Nervous System.—Headache is a frequent symptom in the early stages of the disease. Severe nervous symptoms are more common

[1] Verhandl. d. Naturforschergesellsch. in Basel, Bd. xiii, p. 312, quoted from Fränkel.
[2] Johns Hopkins Hosp. Bull., 1902, p. 307.
[3] Verhandl. d. XVI Kongresses f. inn. Med., Wiesbaden, 1898, p. 507.
[4] Zeit. f. klin. Med., Bd. xxv, p. 230.
[5] Deut. Arch. f. klin. Med., Bd. liv, p. 501.
[6] Ibid., 1901, lxxi, 35.
[7] Zeit. f. klin. Med., Bd. xxv, p. 230.
[8] Loc. cit., p. 308.

in children than in adults, and the disease at times begins with convulsions in place of an initial chill. In rare instances, convulsions initiate the attack in adults, more often in alcoholics, epileptics, neurotic individuals and the insane. Insomnia may be a troublesome symptom. There is no well-marked difference between the effects on the nervous system in pneumonia and in other severe acute infections.

Meningismus.—The clinical features embraced under this term are also spoken of as "cerebral pneumonia." In children and at times in adults the pulmonary character of the infection may be masked by a predominance of cerebrospinal symptoms. There may be severe headache, vomiting, irritability, involuntary urine and feces, stiffness or retraction of the neck and spine, increased irritability of motor nerves (Trousseau's sign), inability to extend the leg normally with the thigh flexed (Kernig's sign) and delirium or coma, so that for a time the case may be regarded as one of meningitis. Meningismus was observed in 13 of 500 cases by Kirchheim,[1] and in 26 of 250 children by Otten.[2] The absence of evidence of organic disease is important in the differentiation of such cases from those with meningo-encephalitis, meningitis, nephritis and uremia and otitis media. Paralyses and localized convulsive movements are lacking. The pupils and eye-grounds are normal. Clear fluid, without albumin or excess of formed elements, is obtained by lumbar puncture. The spinal fluid was under increased tension in a few of Kirchheim's cases, and in all but 1 of 13 of Otten's cases. A careful daily examination of the lungs usually discloses the pulmonary character of the infection. The symptoms of meningeal irritation subside with or shortly after the crisis. The prognosis appears not to be unfavorably influenced. Meningo-encephalitis and meningitis are considered under Complications.

Delirium.—This is common and usually toxic in origin. Inanition, alcoholism, and meningitis may be responsible. Delirium was noted in 1343 (17 per cent.) of 7624 of Musser and Norris' collected cases. It is more frequent with extensive pulmonary involvement and is thought to be more common when the apex is involved. Heinze[3] observed severe nervous symptoms in 98 of 317 cases. In 40.17 per cent. the pneumonia was apical and in 25 per cent. basal. The height of the temperature is of moment and the delirium is more marked during the evening exacerbations of the fever. The mortality is higher in those with than in those without delirium. Delirium may be an initial symptom, but is more common and more marked at the height of the disease. There may be only a mild, dreamy incoherence, a low muttering confusion or a more excited state with hallucinations, delusions of various sorts, and in rare instances acute mania. Homicidal or suicidal tendency may be present. The onset may be sudden and unexpected, and nurses and attendants should be cautioned

[1] Med. Klinik, 1908, No. 38, p. 1461.
[2] Jahrb. f. Kinderh., 1909, N. F., 69, p. 568.
[3] Arch. d. Heilk., 1868, Bd. ix, p. 49.

against leaving patients with pneumonia alone, lest they injure themselves or others. *Postcritical delirium* is occasionally observed, and is usually but not always associated with manifestations of exhaustion. Pöhlmann[1] noted delirium with or after the crisis in 6 of 239 cases. Two of the six died. Elsner[2] reports 4 cases of postcritical delirium, occurring from three to ten days after defervescence. All recovered. Postpneumonic psychoses are usually of short duration, but may last for weeks or months. According to Krafft-Ebing,[3] recovery occurs in 84 per cent. of the cases. In some cases the condition passes into dementia. Pneumonia is likely to precipitate *delirium tremens* in alcoholics. The mortality is high. Of 357 cases of pneumonia with delirium tremens in Musser and Norris' series, 132 (36 per cent.) died.

Digestive System.—The tongue may be coated and the whole mouth and lips may be dry. The appetite may be lost. Vomiting is frequent, especially in children. Of 5047 cases collected by Musser and Norris vomiting occurred in 1356 (26.8 per cent.); nausea in 134 (13.5 per cent.) of 991 cases. Vomiting may be troublesome from irritation of the pharynx by the expectoration. Constipation is more common than diarrhea. Intestinal flatus may be present and aggravate the dyspnea. It may be due to restricted movement of the diaphragm or toxic paresis of the intestine. Jaundice is considered under Complications.

Delayed Resolution.—Fränkel[4] observed an absence of resolution in 63 (6.3 per cent.) among about 1000 cases of pneumonia. Musser and Norris found delayed resolution reported in 105 (4.1 per cent.) among 2548 cases. Flexner[5] and others (see Autolysis, p. 180) have found that in the stage of gray hepatization, autolysis takes place quickly and perfectly, while in the stage of red hepatization it is very imperfect, a fact which is attributed to the small number of pus cells present in the latter condition. It is also found that if the lung in unresolved pneumonia is exposed to conditions favoring autolysis, the process is slow and incomplete as compared with what takes place in gray hepatization. The failure to resolve is due to organization of the exudate and replacement by connective tissue, as is shown by postmortem examination, but the underlying factors are not yet clear, although Opie's[6] observations on enzymes and antienzymes of inflammatory exudates may have a bearing on this question. He noted that the serum of an inflammatory exudate has the power of inhibiting the action of proteolytic ferments contained in the leukocytes, this antienzymatic power being possessed by the blood-serum from which it doubtless passes into the exudate. Fränkel regards a delay of resolution beyond three weeks as evidence of developing

[1] Statistische und klin. Beobachtungen über die genuine kr. Pneum., 1888, 8°, Erlangen, p. 50.
[2] Med. News, New York, January 8, 1898, p. 33.
[3] Lehrb. d. Psychiatrie, 5 Aufl., Stuttgart, 1893, p. 191.
[4] Loc. cit., p. 337.
[5] Trans. Assoc. Amer. Phys., 1903, xviii, 359.
[6] Jour. Exp. Med., 1905, vii, 316.

pulmonary induration, provided such other complications as abscess, etc., can be excluded. That so long an interval is unnecessary in exceptional instances is shown by the finding of organizing pneumonia at autopsy in 6 cases at the Massachusetts General Hospital within from seven to seventeen days of the onset of acute pulmonary symptoms, as noted in the section on Subacute and Chronic Indurative Pneumonia. Pulmonary tuberculosis, empyema, abscess and gangrene must be excluded before the diagnosis of delayed resolution is made.

Clinical Varieties of Pneumonia.—Certain types of pneumonia differ sufficiently from the ordinary forms to deserve special mention.

Central Pneumonia.—The solidification may begin at any part of the lung. If it begins at the root and spreads slowly toward the periphery, physical signs may be lacking for several days. In some instances the lungs are negative throughout. Other features, however, usually permit of a diagnosis. The acute onset with chill, rusty sputum, increase in the rate of respiration and leukocytosis are important signs. In rare instances the diagnosis may be in doubt until crisis occurs.

Massive Pneumonia.—In rare instances the bronchi of the involved region may be filled with fibrinous exudate. There may then be flatness on percussion, diminished or absent respiratory murmur, voice sounds, whisper and tactile fremitus. If the lower part or the whole of one lung is involved, pleurisy with effusion may be simulated. If the patient is asked to cough, fibrinous plugs may be expelled from the bronchi and the signs of solidification appear. Absence of Grocco's paravertebral triangle and the maintenance of the heart in a normal position are against an effusion. A zone of relative resonance in the paravertebral region on the affected side is in favor of pneumonia. A resort to exploratory puncture may be necessary to settle the diagnosis.

Migratory Pneumonia.—In a small number of cases, the pneumonia may spread from one lobe to another, resolution going on in one place while the infiltration progresses in another. In this way all the lobes of one or both lungs may be successively involved. In some instances a lobe previously attacked may be reinfected. From its character, such a course has been termed erysipelatous. The cases are likely to be protracted and severe. The spread may take place by continuity and to such cases the term migratory pneumonia is more strictly applicable. In some degree many pneumonias belong to this group, as is shown by the frequency with which at autopsy an extension is observed from one to a neighboring or another lobe.

Asthenic or Senile Pneumonia.—This form has also been termed "typhoid pneumonia," adynamic, putrid or pythogenic pneumonia, and is characterized by an extreme degree of prostration. It is more common in the aged and in those enfeebled by chronic disease. The diagnosis may remain for some days in doubt. The term typhoid pneumonia is unfortunate, as it suggests a form of the disease due to the typhoid

bacillus, which rarely if ever occurs. When pneumonia complicates typhoid, it is usually due to other organisms than the typhoid bacillus. The onset of asthenic pneumonia is usually insidious and without an initial chill. There may be intense nervous symptoms such as stupor or delirium. Such gastro-intestinal symptoms as vomiting, diarrhea and meteorism may be prominent features and distract attention from the lung to the alimentary canal. Cough may be absent. Cardiac weakness may be a prominent feature. If pulmonary signs are doubtful or absent, typhoid may be closely simulated. The absence of rose spots and enlargement of the spleen, negative blood-cultures and agglutinative tests for typhoid and paratyphoid, positive blood-cultures for pneumococci and leukocytosis may permit of the diagnosis of a pneumococcus infection. The course of such cases is likely to be protracted. Varying grades of jaundice may be present. The temperature is usually not high and may be unelevated. Defervescence is more often by lysis than crisis. Leichtenstern[1] states that a termination in abscess and gangrene is not infrequent. Fränkel[2] believes that in spite of their atypical course, the majority of cases of asthenic pneumonia are due to infection with true pneumococci. Heightened virulence of the organism, diminished resistance of the host or both may be responsible.

Pneumonia in Children.—Croupous pneumonia is relatively infrequent before the second year. The disease in children is likely to differ from the type seen in adults. The initial chill is less common and is likely to be replaced by such nervous symptoms as convulsions, delirium or stupor. Gastro-intestinal disturbances, as nausea and vomiting, are likely to be more prominent features. Cough is usually present but is rarely distressing. Expectoration is not common under five years of age. The temperature is likely to be more elevated and the pulse proportionally higher than in adults. The physical signs may appear later in the course of the disease and the diagnosis may be in doubt for some days. An expiratory grunt, with fever of an acute onset, leukocytosis and rapid respiration out of proportion to the elevation of the pulse may be the only suggestive signs. The leukocytosis is more constant and in general higher than in adults. The knee-jerks may be diminished or absent. The course of the disease is more favorable. Among 1482 cases collected by Holt,[3] death occurred in only 60 (4 per cent.). A fatal result is usually due to extensive disease or to complications. Delayed resolution is less common, empyema and otitis media more common than in adults. According to Fränkel[4] transient irregular heart action is not uncommon after the fall of the fever.

Apical Pneumonia.—The right apex is much more frequently affected than the left. Stupor and delirium, hyperpyrexia and pericarditis

[1] Uëber asthenische Pneumonien, Volkmann's Samml. klin. Vorträge, 1874, No. 82.
[2] Loc. cit., p. 320.
[3] Diseases of Infancy and Childhood, 1903.
[4] Loc. cit., p. 323.

are said to be more common in pneumonia of the apex than at other parts of the lung, but this is not confirmed by my cases.

Terminal Pneumonia.—Pneumonia is a frequent termination of chronic diseases, such as arteriosclerosis, chronic heart lesions, kidney disease and diabetes, as is shown by autopsy records. The initial chill and pain in the side are often lacking. Sputum may be absent. Fever may be slight or absent. The disease may be unsuspected during life.

Pneumonia in Alcoholics.—As in the aged, croupous pneumonia in alcoholics is likely to be of the asthenic type and to run an atypical course. Marked nervous symptoms are usually present and of the type usually seen in delirium tremens. Unless the lungs are carefully examined, the pneumonia may readily be overlooked. The mortality is high.

Pneumonia in Pregnancy.—Pneumonia appears to be infrequent in pregnancy. Among 13,611 cases of pregnancy collected by Musser and Norris there were only 120 instances of pneumonia (0.8 per cent.). The disease is likely to run a severe course and often leads to abortion. The frequency of abortion and the maternal mortality increase with the advancement of pregnancy. Of the infants who have reached a viable age, a large proportion die. Aufrecht[1] believes that abortion is produced by infection of the placental site with pneumococci. Some caution must be observed in the diagnosis of pneumonia in cases of abortion. Pulmonary embolism and infarction are more common than pneumonia in lying-in women and the clinical features may closely simulate pneumonia.

Postoperative and Ether Pneumonia.—In a collected series of 139,101 cases of anesthesia, Musser and Norris found pneumonia in 499 (0.35 per cent.). Postoperative pneumonias are usually lobular in type and are considered more fully in the section on Bronchopneumonia.

Abortive Pneumonia.—In rare instances, the course of the disease may be very short. Leube,[2] Weil,[3] and Bernhardt[4] each report the unusual occurrence of a typical pneumonia of one day in duration. Bechtold[5] found 10 cases occurring close together in one ward at the Würtzburg clinic. Cases in which from one to three days elapse from the beginning of symptoms to the fall of the fever may also be classed in this group. Pneumonias of two days' to three days' duration, although unusual, are occasionally seen. One case of two days' and a second of three days' duration occurred among 200 cases at the Massachusetts General Hospital.

Pneumonia and Other Diseases.—Pulmonary Tuberculosis.—Croupous pneumonia as a complication of pulmonary tuberculosis is rare. The diagnosis in a tuberculous subject must be made with caution

[1] Nothnagel's Practice, Disease of the Bronchi, Pleura, and Lungs, American edition, p. 501.

[2] Thuringer ärztl. Korrespondenzbl., April, 1877.

[3] Berl. klin. Woch., 1879, No. 45, p. 665.

[4] Zeit. f. klin. Med., Bd. i, p. 630.

[5] Münch. med. Woch., 1905, No. 44, vol. lii.

lest the subacute forms of pulmonary tuberculosis or acute pneumonic phthisis be mistaken for croupous pneumonia. Of 750 cases of pneumonia observed by Fränkel,[1] only 15 (2 per cent.) showed coincident and clinically recognizable pulmonary tuberculosis. Sello[2] reports that of these 15 cases, 5 terminated by lysis and 3 by crisis, while 7 died. Huss[3] reported 36 cases of which one-third died. A family history of the disease or opportunity for contagion, previous history of phlyctenular conjunctivitis, fistula in ano, cervical adenitis, primary pleurisy, hemoptysis out of a clear sky, or cough and failing health may be suggestive features. Signs of apical disease may be obtained on physical examination or with the *x*-ray, and tubercle bacilli may be found in the expectoration. The ultimate effect on pulmonary tuberculosis of lobar pneumonia from which the patient recovers is little known. In some instances the pneumonia appears to have little influence on the tuberculous process, in others the tuberculosis progresses more rapidly or miliary tuberculosis follows.

Pneumonia Complicating Heart and Renal Disease.—The disease is likely to present atypical features in cases of cardiac disease with broken compensation and in advanced renal disease. An initial chill is often lacking and the temperature may be little or not at all elevated. A differentiation between pneumonia and pulmonary infarction may be impossible. In some cases the two conditions coexist. The sputum may be rusty or contain pure blood. It is usually abundant, frothy, and less tenacious than in pneumonia uncomplicated by passive congestion. The mortality is high and at autopsy the hemorrhagic character of the exudate may be a striking feature.

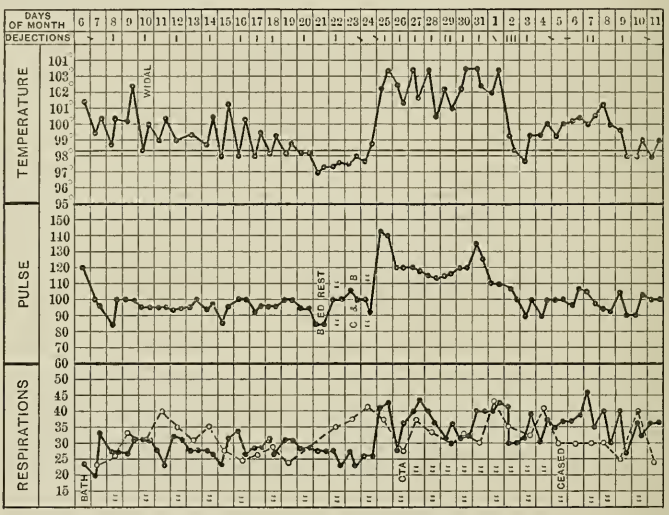
Pneumonia and Diabetes.—Pneumonia complicating diabetes usually runs an atypical and severe course. It may terminate in gangrene. Cases ending fatally commonly die in coma. As in other febrile complications of diabetes, the glycosuria is likely to diminish and may disappear. Pneumonia occurred as a complication in 6 (1 per cent.) among 530 cases of diabetes at the Massachusetts General Hospital. The onset was sudden with the usual, acute symptoms in four. In two the onset was insidious. The temperature was elevated in five, subnormal in the remaining case. Leukocytosis was present (between 14,000 and 21,000) in five. The white cells numbered only 8000 in one case. The pneumonia was fatal in all. Four of the six patients died in coma.

Pneumonia and Typhoid Fever.—Lobar is less common than bronchopneumonia in typhoid fever. Among 3514 cases of pneumonia collected by Musser and Norris, were 56 cases of typhoid fever with 26 deaths (42.8 per cent.). Among 2579 cases of typhoid fever at the Massachusetts General Hospital (1897 to 1913) were 13 cases of lobar pneumonia with 9 deaths (69 per cent.) There are three

[1] Loc. cit. [2] Zeit. f. klin. Med., Bd. xxxvi, p. 112.
[3] Quoted from Musser and Norris, Osler. Mod. Med., 1907, ii, 550.

groups of cases: (1) In the first group, the lobar pneumonia occurs early in the course of the typhoid and there may then be an initial chill, pain in the side, and cough with rusty sputum. Crisis may follow with subsequent elevation of temperature, but more commonly the fever persists beyond the period of its expected decline and the prolongation of the illness may be the first intimation of the presence of typhoid. Pneumonia occurring at the onset of typhoid fever was observed in 3 of 22 cases by McCrae,[1] but in none of this series. (2) In the second group, the pneumonia occurs while the typhoid fever is at its height after the second week of the illness, and its clinical features are then so masked as to make the diagnosis difficult. Chill,

FIG. 30



Typhoid fever followed by lobar pneumonia, beginning on the fifth day of convalescence. (567–200.)

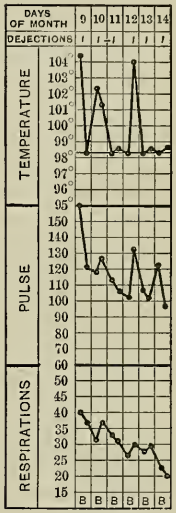
pain, cough and expectoration may be absent and the pneumonia may be suggested only by an elevation of the rate of respiration and pulse and cyanosis. If the patient is not severely toxic, one or more of these symptoms may be present. The temperature is usually little changed. An onset during the course of the disease occurred in 19 of McCrae's 22 cases and in 10 of 13 in this series. Of the 10 cases 8 died. A leukocyte count was done during the pneumonia in 5 of the 10 cases. In 3 cases there was no leukocytosis. In the two remaining cases the leukocytes rose from 3700 during the typhoid to 7400 during the pneumonia in one and from 4500 during the typhoid

[1] Osler. Mod. Med., vol. i, p. 122.

to 13,000 during the pneumonia in the second. (3) In a third group, the pneumonia occurs during convalescence and its recognition then presents no special difficulty. Three such cases were present in this series. In one (Fig. 30), the pneumonia began on the fifth day of convalescence and ran a typical course with crisis on the eighth day. The white count rose from 2000 during the typhoid to 10,000 during the pneumonia. In the second case, a typhoid of four weeks' duration was followed by a relapse of two to three weeks and pneumonia beginning on the tenth day of convalescence. The white count was 3800 during the typhoid and rose to 10,000 during the pneumonia, from which the patient recovered. In the third case, the pneumonia occurred after two days of normal temperature and proved fatal.

When pneumonia occurs at the height of the typhoid fever the diagnosis may be very puzzling. It is difficult to differentiate lobar pneumonia from bronchopneumonia, which is a more common complication. Pulmonary embolism and infarction may present practically identical clinical features, and if, as not infrequently happens, evidence of venous thrombosis in the peripheral veins is absent, the diagnosis may be impossible for a time. In one case of typhoid fever, pulmonary embolism was mistaken for pneumonia until four days later, when a phlebitis of the leg first became manifest. If the pain of pleural involvement in pneumonia complicating typhoid fever is referred to the abdomen, intestinal perforation may be simulated. In one case, a sudden drop in the temperature to normal, rapid elevation of the pulse and rigidity of the abdomen in the third week of typhoid suggested perforation which was not confirmed at operation. The signs of pneumonia developed the next day and the patient died.

FIG. 31



Pneumonia with intermittent fever simulating malaria. (703–55.)

Pneumonia and Malaria.—Lobar pneumonia may complicate any form of malaria. When it occurs in the course of the estivo-autumnal infection it is very fatal. There is no evidence that the malarial parasite can cause true pneumonia. The typical fever curve of malaria is usually masked by the elevation from the pneumonia. The fever curve of uncomplicated pneumonia may resemble that of intermittent fever (Fig. 31).

Pneumonia and Insanity.—According to Krafft-Ebing[1] pneumonia is the cause of death in a sixth of the cases. The pneumonia is likely

[1] Lehrbuch d. Psychiatrie, 5 Aufl., Stuttgart, 1893, p. 234.

to be latent without chill, cough or sputum and discovered only on physical examination.

Physical Signs.—*Inspection.*—Herpes and cyanosis of the lips, the inspiratory dilatation of the alæ nasi, the rapid respiration and the use of the accessory muscles in breathing give important indications of the presence of pneumonia. The patient usually lies on the back, at times more comfortably on the affected side, thus allowing the sound lung full play and diminishing the pain by limiting the motion of the inflamed pleuræ. Orthopnea is rare. Unequal expansion of the two sides of the chest may indicate the lung affected, a greater excursion being observed on the unaffected side. When the disease is in the lower lobe, the upper region of the chest on the same side may show increased inspiratory motion. Diminished amplitude of the diaphragm shadow may be noted on the affected side. But the diminished excursion of the affected lung is less marked with pneumonia than with pleural effusion. Pulsation of the involved part of the lung synchronous with cardiac systole may be seen in some cases.

Palpation.—Variation in the relative expansion of the two sides of the chest may be better felt than seen. Pleural friction and coarse rales may at times be palpated. The tactile fremitus is usually increased and becomes more marked with the progress of the infiltration. If the pleura is much thickened, however, it may be diminished. If the bronchi are filled with tenacious secretion or fibrinous exudate (massive pneumonia), the tactile fremitus may be diminished or absent. Removal of the bronchial obstruction by cough may be followed by reappearance of the fremitus. In women and children, owing to the high pitch of the voice, the tactile fremitus may be of little or no value. In central pneumonia the tactile fremitus may be unchanged. A perceptible increase in the temperature of the skin overlying the site of the pneumonia may be appreciated.

Percussion.—Both light and strong percussion should be used, the former at times making evident a dulness dependent on superficial and the latter that due to deep infiltration of the pulmonary tissue. During the stage of engorgement the percussion note is relatively dulled or dull; at times it has a tympanitic quality (Skoda's resonance). This tympanitic quality is more commonly observed when the aepx is involved. Its cause is not clear. It may be due to the relaxation of alveolar spaces which still contain air or, as seems more likely, to the transmission of the percussion impact through solid lung to the air contained in the bronchi and trachea. At times a change in the tympanitic quality is observed with the mouth open and closed (William's tracheal tone). In involvement of the lower lobes, tympany may be due to proximity of the stomach. A cracked-pot note may be present when pulmonary solidification surrounds a large bronchus.

In the stage of red hepatization the degree of dulness varies. The note may be flat, but there is not the total absence of resonance and the sense of resistance to the finger found in large effusions. The extent

of the dulness varies. It is often limited to a part of a lobe and all parts of the lung should be carefully investigated, not forgetting to percuss the upper parts of the axillary region. In other cases, one lung may be dull throughout, and the limits of the dulness may then exceed the normal boundaries from swelling of the pulmonary tissue. When the consolidation involves the inferior lobe and is of considerable extent, a zone of relative resonance may be determined in the paravertebral region on the affected side.[1] This is probably due to increased spinal resonance from compensatory emphysema of the unaffected lung.

In central pneumonia only slight impairment of the percussion note may be determined over the site of the involvement. In some cases there may be no change on percussion throughout the course of the disease. Compensatory emphysema over an involved region may so mask the dulness from underlying infiltration as to make it undetectable. Hyperresonance over neighboring parts of the same or the whole of the other lung can often be demonstrated.

Auscultation.—All parts of the lungs should be carefully covered with the stethoscope. The signs on auscultation are very variable in different cases. The finding of rales persistently present at one place in the lung during repeated examinations may in rare instances be the only auscultatory sign. In the early stages of the disease, fine, consonating, moist rales (crepitant rales) are commonly heard. They are usually heard toward the end of inspiration or forced inspiration as a succession of minute crackling sounds, and are probably due to a disturbance by the incoming air of the sticky exudate in the finest branches of the bronchi. They have also been thought to be pleural in origin. The crepitant rales in pneumonia are to be distinguished by their clear-cut, sharp and distinct or resonating (consonating) quality from non-consonating rales arising in bronchi in cases in which there is no consolidation of the surrounding pulmonary tissue. The distinction is not always easily made, but is of value in differentiating consolidation from simple bronchitis, hypostatic congestion and edema. Crepitant rales often disappear during the stage of red hepatization, to reappear during resolution—redux crepitus. If bronchitis of the larger tubes coexists, coarser rales may mask them.

Suppression of the breathing is usually one of the first signs of pneumonia. During the first twenty-four hours after the chill, slight dulness on percussion, diminished vesicular breathing and crepitant rales are often the only local manifestations. In some cases with the suppression of the breathing there is a change in its quality, the expiration being somewhat longer and of a higher pitch than over a corresponding place in the opposite lung. As the disease progresses, the breathing usually becomes more and more intense, with loud and high-

[1] F. T. Lord, Percussion of the Paravertebral Region on the Affected Side in the Differentiation of Pneumonia and Pleurisy with Effusion. Boston Med. and Surg. Jour., February 12, 1914.

pitched inspiration and markedly long, loud and high-pitched expiration. In no other disease does bronchial breathing reach such a degree of intensity as in croupous pneumonia, due to the propagation of laryngeal and tracheal sounds through the solid lung. If the pleura is much thickened or the bronchi are plugged (massive pneumonia), the breath sounds, as well as the tactile fremitus, may be much diminished or absent. If the bronchial obstruction can be relieved by cough, bronchial breathing may be made to appear. When the pneumonia involves the lung near the spine, the breathing may be bronchial over the neighboring part of the opposite lung.

The spoken voice is usually loud and high-pitched (bronchophony) over the consolidated region, and words may be more plainly distinguished than over unaffected parts of the lung. This is probably due to the more intense conduction through the solid tissue. A short interval of bronchial expiration usually follows the spoken voice. Bronchophony is more marked in men than in women or children owing to the deeper pitch of the voice in the former. It may be absent in massive pneumonia. At times the voice has a peculiar bleating or nasal quality and is then spoken of as ægophony. Increase in the intensity of the whisper is usually associated with bronchophony.

From Conner and Dodge's[1] study of 392 cases of pneumonia for the purpose of determining the relative value of various physical signs in the early stages of the disease, they tabulate the following findings in the order of their importance: (1) a circumscribed area of feeble and indistinct breathing; (2) circumscribed impairment without or with a tympanitic quality (sitting up); (3) crepitant rales; (4) slight increase in intensity and clearness of the vocal resonance. In doubtful cases it is necessary to test all the different signs. Considerable variation in the findings on physical examination is noted in different cases and in the examination of the same case from day to day.

Signs of solidification, dulness, bronchial breathing, increase of voice, whisper and tactile fremitus usually persist for a few days to a week after the crisis has occurred. In rare instances they may last for weeks or months. It is rarely possible, however, to demonstrate abnormal findings in uncomplicated cases which have fully recovered.

X-ray Examination.—Fluoroscopic or radioscopic examination is of value in indicating the site, extent and character of the pneumonic process. The radiograph is to be preferred from the permanence of the record and the opportunity for comparison of the findings at different periods of the illness. In most cases, *x*-ray examination merely serves to confirm the results of physical examination, but may demonstrate a central lesion or multiple areas not apparent on physical examination; or assist in the early detection of pleural effusion. The shadow caused by lobar pneumonia is uneven in density and mottled with ill-defined boundaries which fade out into the neighboring and

[1] Amer. Jour. Med. Sci., September, 1903.

uninvolved parts of the lung. An apical, central or marginal position and the presence of an uninvolved zone between the inferior limits of the shadow and the base of the lung may be of importance in suggesting the pneumonic character of the process. Absence of depression of the diaphragm and dislocation of the heart is also significant. The shadow caused by lobar pneumonia cannot usually be distinguished from that due to thick pleura, confluent bronchopneumonia or atelectasis. Pleural effusion presents a more dense, uniform and sharply outlined shadow with curved upper border. The shadow occupies the lower parts of the pleural space, and is often associated with depression of the diaphragm and dislocation of the heart. The shadow from tumor is more dense than that with lobar pneumonia and more sharply outlined. According to v. Jaksch and Rotsky[1] the shadow caused

Fig. 32

Lobar pneumonia of left lung. (v. Jaksch and Rotsky.)

by a developing infiltration may be seen to extend in the form of band- or strip-like shadows from an initial small area, but is more commonly more even and diffuse. Resolution may be observed to take place in the central parts and extend eccentrically toward the periphery or, as is more often the case, in several places at the same time and more diffusely. Signs of beginning resolution may be observed in the radiograph at a time when neither the physical findings nor the course of the fever indicate the proximity of the crisis. The picture may change in the course of twenty-four hours. Tuberculous pneumonia, on the contrary, may develop with equal rapidity, but usually remains stationary.

[1] Fortschr. a. d. Gebiete d. Röntgenstrahlen. Ergänzungsband, 1908, vol. xix.

Blood.—The presence of protective substances in the blood has been discussed under Immunity. Invasion of the blood by pneumococci is considered under Pneumococcus Septicemia. The oxygen and carbon-dioxide content of the blood is given in the section on Metabolism. Other features are considered under this heading.

During the course of pneumonia, the hemoglobin and red cells are practically normal. After defervescence the hemoglobin and red cells are usually below normal. The hemoglobin falls proportionally lower than the red cells and the blood picture is that of a mild secondary anemia. During convalescence the number of red cells may fall for a week to ten days and then gradually return to normal.

White Cells.—In Cabot's[1] series of 842 cases, the leukocyte count at the time of entrance to the Massachusetts General Hospital was as follows:

Under	10,000	=	90 (83 fatal)
Between	10,000	to 15,000—	125
"	15,000	to 20,000—	192
"	20,000	to 25,000—	186
"	25,000	to 30,000—	114
"	30,000	to 35,000—	47
"	35,000	to 40,000—	44
"	40,000	to 45,000—	20
"	45,000	to 50,000—	10
"	50,000	to 55,000—	7
"	55,000	to 60,000—	2
"	60,000	to 65,000—	3
"	65,000	to 70,000—	1
"	100,000	to 110,000—	1

Of 500 cases in the present series, also from the Massachusetts General Hospital, the following counts were obtained at the time of entering the hospital:

White cells.	No. of cases.
1 to 5,000	10
5 to 10,000	35
10 to 15,000	86
15 to 20,000	99
20 to 25,000	103
25 to 30,000	67
30 to 35,000	49
35 to 40,000	14
40 to 45,000	15
45 to 50,000	12
50 to 55,000	2
55 to 60,000	3
60 to 65,000	1
65 to 70,000	1
70 to 75,000	1
75 to 80,000	1
100,000	1

A leukocytosis (above 10,000) was observed in 455 (90 per cent.) of the 500 cases. In more than one-half, the count was from 15,000 to 30,000. The leukocytosis was somewhat more marked in children

[1] Clinical Examination of the Blood, 1904.

than in adults, and the only instance in the series in which the count reached 100,000 was in a child of two years and ten months. In this series, no constant relation appears to obtain between the degrees of leukocytosis and the severity of the infection, but it is to be noted that the mortality was relatively high among those without leukocytosis. Thus, of the 45 cases with counts below 10,000, 22 (48.8 per cent.) died. Of 90 cases in Cabot's series without leukocytosis, 83 (92.2 per cent.) died.

An increase in the leukocytes usually occurs as early as the time of the chill or a few hours after it, and continues throughout the disease. The counts, whether high or low, are likely to be maintained at a nearly constant level without relation to the temperature, throughout the height of the disease, but in exceptional instances a low or high count shows a tendency to rise or fall. The leukocytes do not fall with the drop in the temperature, but their number slowly diminishes and in favorable cases may reach normal within a week to ten days after defervescence. In delayed resolution and in the presence of complications due to suppuration, the leukocytosis usually persists until the lung clears or the complication is relieved.

Differential Counts.—During the febrile period the polynuclear neutrophiles usually comprise from 80 to 90 per cent. or more of the white cells and a relative increase in their number may be observed even in cases without leukocytosis. Their proportion diminishes with the crisis and during convalescence, and a relative lymphocytosis may be present after the white count has reached normal. Eosinophiles are diminished or absent during the febrile period. According to Cabot, the eosinophiles and blood plates are above normal after the crisis and the eosinophiles may run up to 5 or 6 per cent.

Iodophilia.—According to Cabot,[1] this is present and marked in practically all cases. Dunn (quoted from Cabot) has noted that while in cases ending in crisis and resolution the reaction disappears in a day or two, it persists in those with delayed resolution.

Coagulation Time.—An increase in the rapidity of coagulation has long been thought to occur during pneumonia. Cohen[2] found the average time for coagulation slightly shortened in 6 cases. Hayem[3] Pye-Smith,[4] Coleman,[5] and Dochez[6] found it prolonged.

Complications.—Bronchitis.—The history of an acute infection of the upper parts of the respiratory tract may be obtained in a considerable proportion of patients with pneumonia, and it is probable that a bronchitis due to the pneumococcus may be the starting point of the disease. Bronchitis involving the terminations of the bronchi in the affected region is constant during the course of the infection and diffuse bronchial involvement is often noted. Laryngitis is rare. Edema of the larynx and suppurative perichondritis have been reported.

[1] Loc. cit., p. 193.
[2] Arch. Int. Med., 1911, viii, 684, 820.
[3] Du Sang., etc., Paris, 1889, p. 323.
[4] Allbutt's System of Med., 1898, v, 91.
[5] Biochem. Jour., 1907, ii, 184.
[6] Jour. Exp. Med., 1912, vol. xvi.

Pleuritis, Serofibrinous and Purulent Effusions.—Fibrinous inflammation of the pleura over the involved part of the lung or a wider area is almost constant in lobar pneumonia. A varying but usually small amount of fluid was present in 57 (37 per cent.) of 154 autopsies at the Massachusetts General Hospital. Small effusions are usually serofibrinous. Of the 57 cases the fluid was clear or cloudy in 40, purulent in 9 and hemorrhagic in 6. Microscopic examination after sedimentation shows varying proportions of polynuclear leukocytes, lymphocytes, large mononuclear and endothelial cells. Even in clear fluids with low percentages of polynuclear cells, cultures may demonstrate pneumococci or other organisms. The pneumococci may be of diminished virulence. Empyema was present in 2.2 per cent. of 13,550 cases of pneumonia collected by Musser and Norris and in 19 (3.8 per cent.) of 500 cases at the Massachusetts General Hospital. A serofibrinous effusion complicated the pneumonia in 5 (1.0 per cent.) of the cases. The greater frequency of an effusion among autopsied cases must be ascribed to the readiness with which a small collection is overlooked during life. The subject is further considered in the section on Pleuritis.

Pneumothorax.—This may follow the perforation of empyema into the lung or the rupture of an area of pulmonary abscess or gangrene into the pleura. Lobar pneumonia is to be regarded as a cause only in so far as it leads to conditions to which the pneumothorax may be secondary.

Abscess and Gangrene.—So far as they relate to lobar pneumonia, abscess and gangrene are of rare occurrence, occurring in only 76 (0.63 per cent.) of 12,030 cases collected by Musser and Norris, in scarcely 2 per cent. of Fränkel's,[1] and in only 2 (0.4 per cent.) of 500 cases in this series. They are more common among autopsied cases, suggesting that they not infrequently escape detection clinically, and that small losses of pulmonary substance spontaneously heal. A more detailed discussion of this subject will be found in the chapter on Abscess and Gangrene.

Mediastinitis.—Weichselbaum[2] noted acute inflammatory edema of the areolar tissue in the mediastinum, the neck, clavicular fossæ and about the trachea, esophagus and cervical vertebræ, and his findings were confirmed by Foà and Bordoni-Uffreduzzi.[3] Thue[4] followed the pneumococcus infection through the lymph vessels of the pulmonary pleura to the mediastinum and the pericardium. Fränkel observed purulent mediastinitis as a complication of fibrinous pneumonia in 3 cases. An abscess may perforate the chest wall beside the sternum as in one of Fränkel's cases. In a second of his cases, dulness over an area 4 cm. wide was present near the right border of the

[1] Deut. med. Woch., Vereins Beilage, 1903, p. 204.
[2] Wiener med. Jahrbucher, 1886, N. F., p. 532.
[3] Zeit. f. Hyg., Bd. iv, p. 75.
[4] Zentralb. f. Bakteriol. u. Parasitenk, 1889, Bd. v, p. 38.

sternum between the clavicle and the fourth rib, with systolic pulsation in the second intercostal space. The diagnosis is difficult, and diffuse infiltration may give no indication of its presence, but abscess formation may be detected by the presence of dulness with diminished breathing in .the supracardiac region or over the spine between the third and the ninth dorsal vertebræ. X-ray examination may be of assistance in diagnosis. Complicating pericarditis, peritonitis, and empyema may also be present. An abscess may rupture into the bronchus with recovery.

Subphrenic Abscess.—Pneumonia is only rarely a cause. Cases have been reported by Lampe,[1] Claudius,[2] Winkelmann,[3] and others. The literature of subphrenic abscess is reviewed by Perutz.[4]

Cardiovascular System.—*Myocardial weakness* of varying degree is an important feature in pneumonia. It is due to obstruction of the pulmonary circuit and to toxemia, and is more marked in cases with preëxisting myocardial, endocardial or pericardial disease, or in those with arteriosclerosis or chronic renal changes. In most cases, however, recovery from pneumonia is not followed by lasting cardiovascular disturbance which can be ascribed to the infection.

Endocarditis.—Bouillard[5] first pointed out that pneumonia was one of the causes of endocarditis, and Herschl[6] reported 5 cases of ulcerative endocarditis following pneumonia and complicated by meningitis. In 1886, Netter[7] analyzed 73 cases from the literature and added nine personal observations, seven with bacteriologic examination of the lesions. Preble[8] found 50 cases added to the literature since that time and reviewed the entire 132 cases. The frequency with which pneumonia is a cause is shown by Wells'[9] analysis of 517 fatal cases of endocarditis, of which 115 (22.2 per cent.) were in connection with pneumonia.

Acute endocarditis is fortunately not a common complication of pneumonia, however, being noted in only 144 (0.44 per cent.) of Musser and Norris' 32,349 collected cases. Fränkel observed endocarditis in pneumonia clinically in only 0.8 per cent. of his cases; Aufrecht[10] only once among 1500 cases. It was detected during life in none of 500 cases at the Massachusetts General Hospital. but was found in 7 (4.5 per cent.) of 154 cases at autopsy. In autopsy cases collected by Preble, 86 (4.28 per cent.) instances of endocarditis were

[1] Münch. med. Woch., 14 Mai, 1895.
[2] Hospitalstidende, 1898, Bd. vi; see Jahrb. v. Virchow-Hirsch, Bd. ii, p. 381.
[3] Deut. med. Woch., 1899, No. 7.
[4] Centralb. f. d. Grenzgeb. d. Med. u. Chir., 1905, 8.
[5] Traité clinique des malad. du coeur., 1862.
[6] Osterr. Zeit. f. prakt. Heilk., 1862.
[7] De l'endocardite végétante ulcereuse d'origine pneumonique, Arch. de Physiol. norm. et path., 1886, p. 10.
[8] Amer. Jour. Med. Sci., 1904, N. S., cxxviii, 782.
[9] Jour. Amer. Med. Assoc., 1902, xxxix, 978.
[10] Nothnagel's Encyclopedia of Pract. Med., American edition,Diseases of the Bronchi, Pleura, and Lungs, p. 490.

present in 1775 cases. Preble places the average at about 1 per cent. of all cases and 5 per cent. of the fatal cases. The discrepancy between clinical and autopsy cases indicates that it must be frequently overlooked. Not all cases of acute endocarditis developing in the course of pneumonia are due to the pneumococcus. Preble estimates that something over 94 per cent. are due to this organism.

The endocarditis due to infection with pneumococci does not appear to differ from that caused by other organisms. In its early stages there are small, reddish, flesh-like vegetations, usually at the margins of the valves. These may later assume a polypous or ulcerative type, and Preble estimates that the chances are four to one that an endocarditis developing in the course of pneumonia will be of the so-called ulcerative or malignant type. The process may not be confined to the valves, but may involve the endocardium as well. In cases in which recovery from the acute infection follows, chronic fibrous endocarditis develops. Valves already the site of chronic inflammatory changes may become acutely inflamed during the course of pneumonia. Of 50 cases in Preble's series, 12 showed old endocarditis upon which fresh vegetations had developed. Among the 154 autopsied cases in the Massachusetts General Hospital series were 29 with chronic endocarditis, one of which was complicated by an acute endocarditis. The left side of the heart is affected in a large proportion of the cases, in 82 per cent. of Preble's series, while the right side was involved in 12 per cent. and both sides in 5.7 per cent. In his series the aortic valve was alone involved in 39.7 per cent. the mitral alone in 28.3 per cent., both aortic and mitral in 14.1 per cent., the tricuspid alone in 8.5 per cent., the pulmonary alone in 3.6 per cent., aortic, mitral, and tricuspid in 3.5 per cent., the mitral and tricuspid in 1.4 per cent., and the aortic and tricuspid in 0.7 per cent. Infarcts occurred in about one-half the cases. Meningitis complicated the pneumococcus endocarditis in about 60 per cent. of the cases. The complication is much more frequent after thirty years of age than before.

The clinical features are those with other forms of acute endocarditis. The initial symptoms are usually masked by those due to the pneumonia. Systolic murmurs are so frequently heard during pneumonia that they have little diagnostic value unless they vary from the functional type. Diastolic murmurs are of more importance and may be regarded as due to acute endocarditis when they develop under observation during an attack of pneumonia. A continuance of fever after the period of its expected decline or its reappearance after an afebrile period, recurring chills and sweats, persistent leukocytosis, ephemeral areas of nodular erythema or purpura, and the finding of pneumococci in blood-cultures are important signs. In the cases in which the endocarditis develops during the pneumonia and runs a rapidly fatal course, the diagnosis is usually impossible.

The prognosis is grave. Of 132 cases in Preble's series only 4 recovered, and in but one of these was the diagnosis complete. But

the frequency with which patients with chronic endocarditis give a history of acute pneumonia as the probable starting point of the endocardial infection makes the outlook somewhat more hopeful than these figures seem to indicate.

Pericarditis.—Acute pericarditis of the serous, plastic or purulent variety was found in 499 (1.2 per cent.) among 40,773 collected cases by Musser and Norris and in 268 (12.6 per cent.) of 2128 autopsied cases. The proximity of the pericardium to the pleura and the lung is responsible for the frequency with which pericarditis occurs in pneumonia. Infection by extension is probably the most common method of origin, but may also occur through the blood or lymph stream. A variable and usually small amount of serous fluid was found in the pericardial sac in 28 of 154 autopsied cases at the Massachusetts General Hospital. In many of these the fluid was doubtless due to cardiac insufficiency; in others the presence of a small amount of fibrin indicated an inflammatory origin. In 16 other cases there was a fibrinous or purulent exudate. These cases suggest that pericarditis is more frequent when the left lung is the site of the pneumonia. In the 16 cases the left lung was involved in 12, the left lung being involved alone in 6, both left and right lung in 6.

As pericarditis usually complicates the pneumonia at the height of the disease, pain referable to the pericardium may be lacking or masked by that due to pleurisy. The condition is frequently overlooked during life and first found at postmortem examination. Daily examination of the heart should be made in all cases of pneumonia. Pericardial friction may be heard or obscured by loud bronchial rales, pleural friction or stertorous breathing. If inaudible it may be palpated. A careful note concerning the upper and lateral percussion limits of the heart, the intensity and position of the cardiac impulse and the strength of the cardiac sounds should be made at the first visit in all cases of pneumonia, in order that any subsequent changes may be quickly noted and an effusion detected early. Pain on pressure over the lower sternal region may be present. Dyspnea out of proportion to that which can be accounted for by other features is suggestive. Dysphagia, paradoxical pulse, distention of the veins of the neck and aphonia may be present. Diminution or disappearance of the cardiac impulse; enlargement of the percussion limits, especially upward and to the left, downward and to the right, with the formation of an obtuse cardiohepatic angle, and downward and to the left so that the percussion limit in this region extends beyond the palpable impulse of the heart; disappearance or diminution of the pericardial friction, and weakening of the heart sound are of most significance. *X*-ray examination is of assistance in the diagnosis of doubtful cases.

Pericarditis adds to the gravity of the pneumonia by mechanically embarrassing the heart, weakening the heart muscle in consequence of the associated myocarditis and adding to the area of the infected

territory. Of 207 cases in Musser and Norris' series, 125 (60 per cent.) died.

Vascular Lesions.—Peripheral venous thrombosis is an uncommon complication. It was noted in 10 (1 per cent.) of 949 cases by Sears and Larrabee[1] and in 3 of 500 cases by Steiner,[2] who has reviewed 38 previously reported. In 27 of 32 cases the thrombosis occurred during convalescence, in one on the day of crisis and in 4 during the course of the disease. It is to be regarded in general rather as a sequel than a complication. The lower extremities were always involved, and the left extremity more often than the right. Of the 41 cases, 9 died, 25 recovered and no definite information was given in 7. Postmortem examination in 8 of the fatal cases showed that death was due to pulmonary embolism in 5.

Arterial embolism occurs, but is still less common. Embolism of the popliteal artery following pneumonia is reported by Irish.[3] Gibson[4] had 3 cases of gangrene of the leg developing suddenly in the course of pneumonia. In Aldrich's[5] case there was embolism of one of the lenticulo-optic arteries. The emboli may come from thrombi in the pulmonary veins of the pneumonic lung or cardiac thrombi.

Gastro-intestinal System.—Pneumococcus gastritis and membranous colitis have been observed. Acute dilatation of the stomach is a rare complication. Fussell[6] collected 6 cases from the literature and added 5 of his own. Of the 11 cases, 6 died and 5 recovered. Dilatation occurred before the crisis in 8, after the crisis in 3. Vomiting, abdominal pain, distention, constipation, collapse, splashing sounds and visible gastric peristalsis should suggest the diagnosis.

Peritonitis.—This is rare. It was found clinically in 28 (0.34 per cent.) of 8132 cases and at autopsy in 21 (2.16 per cent.) of 971 cases by Musser and Norris. Acute purulent peritonitis was found in 5 (3.2 per cent.) of 154 cases at autopsy in the Massachusetts General Hospital series. General pneumococcus peritonitis secondary to pneumonia is practically always fatal. Circumscribed peritonitis is occasionally observed and recovery may follow operation. It is to be remembered that abdominal pain, spasm and tenderness are not infrequent in pneumonia, in consequence of irritation of the terminal branches of the lower intercostal nerves. The possibility of pneumonia should be excluded in all acute abdominal conditions.

Jaundice.—Varying degrees of jaundice are present in a considerable proportion of cases of pneumonia. Owing to the readiness with which slight jaundice may be overlooked and the varying estimate of different observers as to what degree of discoloration is necessary to justify the use of this term, statistics as to its frequency are unreli-

[1] St. Paul Med. Jour., 1902, iv, 451.
[2] Johns Hopkins Hosp. Bull., June, 1902, 135.
[3] Albany Med. Annals, 1902, xxiii, 205.
[4] Annals of Surgery, 1903, xxxviii, 380.
[5] Med. News, July 27, 1901.
[6] Amer. Jour. Med. Sci., 1911, cxlii, 794.

able. Blumberg[1] found jaundice in 21 (7 per cent.) of 300 cases. The stools are completely acholic in only a part of the cases. The cause of jaundice in pneumonia is uncertain. Banti[2] holds the view that it is due to hemolytic action of the pneumococcus. Hemoglobinuria was produced in rabbits inoculated with pneumococci from cases with jaundice, but did not occur in animals infected with organisms obtained from patients with pneumonia without jaundice. McPhedran[3] estimated the fragility of the red cells in 14 cases with and without jaundice and found increased resistance in the jaundiced cases. The hemolytic theory needs further support before it can be accepted. Passive congestion of the liver from cardiac weakness is a possible explanation, but has little in its favor from analogy with other acute infectious diseases, and evidence of a sufficient degree of venous stasis to account for the symptom is usually lacking. An increased production of bile in consequence of the infection is purely hypothetical. An infective cholangitis is perhaps the most plausible explanation. Anders[4] reports 3 cases with cholecystitis as a complication of pneumonia. Jaundice was present in two and pyriform enlargement of the gall-bladder in the 3 cases. Clairmont[5] has reported cholangitis and abscess about the gall-bladder in a woman, aged seventy-nine years, with pneumonia due to Friedländer's pneumobacillus. Gilbert and Grenet[6] found the colon bacillus in the bile in 3 cases of pneumonia complicated by jaundice.

The mortality in some series of cases with jaundice is higher than in those not so complicated. In Mosler's[7] 15 cases it was 73 per cent., and in Norris'[8] 61 per cent. In other series there is little or no difference in the mortality among those with and those without jaundice. Whether the jaundice itself influences the mortality is uncertain.

Acute Parotitis.—This is a rare complication. Jürgensen[9] found six instances among 5738 cases of pneumonia. Norris[10] found one in 500 cases at the Pennsylvania Hospital and collected 17 from the literature. It may occur during the course of the disease, at the time of defervescence or in convalescence. In Fischel's[11] case it did not develop until twenty days after the crisis. One gland only is usually affected. In a small proportion both are involved. Infection may take place through the blood and give rise to the so-called metastatic parotitis, but direct extension from the mouth by way of Stenson's duct is probably more common, as is suggested by the more frequent presence of

[1] St. Petersburg med. Woch., 1907, No. 21, p. 203.
[2] Centralb. f. Bak., 1896, xx, 849.
[3] Johns Hopkins Hosp. Bull., 1911, xxii, 408.
[4] Amer. Med., March 18, 1905, p. 431.
[5] Wien. klin. Woch., October 26, 1899.
[6] Arch. gén. de méd., February, 1899.
[7] Deut. Arch. f. klin. Med., 1872, x, 266.
[8] Osler and McCrae's Mod. Med., vol. ii, p. 613.
[9] Handb. d. spec. Path. u. Ther., v. Ziemssen, 5, ii, 122.
[10] Philadelphia Med. Jour., April 27, 1901.
[11] Präg. med. Woch., 1893, xviii, 69.

other organisms than the pneumococcus in the pus from the gland in the few instances in which cultures have been made. The affected gland is painful, swollen and hard. The swelling may subside spontaneously or suppuration may follow. In Duplay's[1] case, pus could be expressed from Stenson's duct. Spontaneous evacuation of pus into the mouth through Stenson's duct and recovery after the discharge had lasted more than six weeks is reported by Pichler.[2]

Nephritis.—A mild degree of renal irritation is common in pneumonia, as indicated by the presence of varying amounts of albumin and tube casts, but the urine almost invariably returns to normal after the acute infection subsides. Outspoken nephritis occurs only in rare instances, and was noted by Fränkel[3] among 750 cases in only 6 (0.8 per cent.), with 4 deaths. In the 4 fatal cases, the unfavorable outcome was rather to be ascribed to the pneumonia than to the nephritis. In the 2 remaining cases the renal symptoms lasted for one and one-half and four months. Cardiac hypertrophy was not observed and the albumin and formed elements disappeared from the urine. Of 500 cases at the Massachusetts General Hospital, acute nephritis with edema developed in only one (761-229), and was followed by recovery. In fatal cases cloudy swelling and fatty degeneration of the renal epithelium is common. Pneumococci may be found in the kidney, as in 22 of 26 cases examined by Fränkel and Reiche,[4] but evidence of sufficiently intense renal changes to justify the term acute nephritis is found only in uncommon instances. In such cases the action of the toxin is for the most part upon the glomeruli. In 2 of 154 cases at autopsy, an acute intracapillary glomerulonephritis was found. Acute nephritis rarely terminates in the chronic form. The history of pneumonia as the starting point of chronic nephritis is seldom obtained. Eisenlohr[5] has reported the finding at autopsy of outspoken contracted kidney ten months after the onset of acute nephritis with pneumonia.

Nervous System.—Symptoms indistinguishable from those with meningitis and probably toxic in origin may be present, and meningitis may be absent at autopsy. These cases have been spoken of under Meningismus in a previous section. Otitis media should be suspected in children with marked cerebral symptoms.

Meningo-encephalitis. — Weichselbaum[6] described *acute meningo-encephalitis* due to the pneumococcus. Three cases, classed in this category, have been reported by Kirchheim,[7] who finds similar observations by Dörnberger,[8] Hensinger,[9] v. Lengerke,[10] Hereus,[11] and Schultze.[12]

[1] La Semaine méd., 1891, xi, 9.
[2] Wiener klin. Woch., 1903, No. 49, p. 1361.
[3] Loc. cit., p. 360.
[4] Zeit. f. klin. Med., Bd. xxv, p. 278.
[5] Deut. med. Woch., 1892, No. 32, p. 732.
[6] Wiener klin. Woch., 1888, No. 28.
[7] Med. Klinik, 1908, Nr. 38, p. 1461.
[8] Münch. med. Woch., 1904, Nr. 19.
[9] Deut. med. Woch., 1886, Nr. 12, p. 37.
[10] Mitt. a. d. Tübinger Poliklinik, Leipzig, 1882, H. 2.
[11] Ibid., 1892, H. 2.
[12] Nothnagel's Handb., Bd. ii, Verhandl. d. 6 Kong. f. inn. Med.

In the course of or after pneumonia, symptoms of localized cerebral involvement are observed, such as disturbances of the cranial nerves, monoplegia, convulsive movements of one or more of the extremities, ataxia, etc. The pathology is not clear, but meningo-encephalitis is suggested by Kirchheim. The outlook for complete recovery is uncertain.

Meningitis.—This occurred in 206 (0.42 per cent.) among 49,028 clinical cases collected by Musser and Norris and in 180 (3.5 per cent.) of 4833 autopsied cases. It was present in only 2 (0.4 per cent.) of 500 clinical cases and in 4 (2.5 per cent.) of 154 cases at autopsy in this series. Liebermeister[1] found meningitis on microscopic examination in 3 of 11 cases of pneumonia at autopsy. In these cases macroscopic examination showed no evidence of meningitis (!). The complication usually occurs while the disease is at its height. Infection may take place by extension from the ethmoid cells, the antrum of Highmore, the sphenoidal sinus, the middle ear or mastoid. It is possible that infection of the nasal sinuses may arise by extension through the areolar tissue of the neck from the mediastinum. In some cases no local source can be found, and in such instances the meninges may be invaded through the blood, but the almost constant presence of pneumococci in the blood and the rarity of meningitis suggests that something more than bacteriemia must be responsible. The pathologic picture in pneumococcus meningitis does not differ from that due to the meningococcus or the influenza bacillus. The exudate is purulent and of variable distribution, but usually involves the entire cerebrospinal system. The symptoms are often masked by stupor and delirium so common in severe forms of the disease. Headache, nausea and vomiting, delirium, stiffness of the neck and retraction of the head are suggestive, but may be present without meningitis. Opisthotonos and epileptiform convulsions may be observed. Paralysis of cranial nerves, monoplegia, hemiplegia, optic neuritis, Brudzinski's or Kernig's sign are more definite indications. The diagnosis may be established by lumbar puncture.

Meningitic symptoms may occasionally initiate the attack, and evidence of pneumonia appear later. In rare instances, meningitis may occur some time after the attack of pneumonia. In the case reported by de Chezelle and Prieur[2] a pneumococcus meningitis occurred three months after pneumonia. Cases in which purulent fluid containing pneumococci is obtained by lumbar puncture have apparently thus far always proved fatal. Holt[3] has reported the case of a child of two with pneumonia, twitching of the hands, fingers and face, rigidity of the neck, retraction of the head and definite convulsive movements of the extremities. Lumbar puncture showed *clear fluid* under high tension, *without cells,* but containing pneumococci. Recovery was complete.

[1] Münch. med. Woch., 1909, No. 15, p. 750.
[2] Arch. de méd. et de pharm. militaires, 1892, T. 20.
[3] Arch. of Pediatrics, New York, 1906, 23.

Inequality of the Pupils.—Inequality of the pupils with dilatation on the affected side is occasionally observed. Norris[1] examined 64 patients with special reference to the condition of the pupils, and found mydriasis in one and myosis in another on the affected side. The upper lobe was involved in 33. Dilatation of the pupil on the affected side may be ascribed to irritation of the cervical sympathetic.

Reflexes.—Schultze[2] observed absence of the pupillary light reflex in 4 cases during pneumonia and return of the reaction later to normal. Absence of the patellar reflex during pneumonia has been observed by Marinian,[3] Longard,[4] and Sternberg.[5]

Tetany in the course of pneumonia was observed by Siredey and Lemaire.[6]

Hemiplegia is rarely a complication. Cerebral hemorrhage, thrombosis or embolism from thrombi in the pulmonary veins or the heart may be the cause. In a case of bulbar and ascending paralysis, Seitz[7] found organisms resembling pneumococci in the central nervous system.

Neuritis.—Paralysis of the ocular muscles, the muscles of the larynx, palate, face and extremities has been noted to develop during or shortly after pneumonia, and is probably due to toxic neuritis. Multiple neuritis has also been described. The prognosis appears to be favorable.

Ocular Disturbances.—These are not common. *Conjunctivitis* was observed in 3 of 500 cases. In one case it was complicated by an ulcer of the cornea. *Ulcerative keratitis* occurred alone in one case. Mandl[8] has reported hypopyon-keratitis with sudden establishment of corneal abscess on the fourteenth day of canvalescence. The pneumococcus was found in the pus. Ulcus serpens probably arises as a result of inoculation of the pneumococcus through a slight injury of the cornea. *Metastatic panophthalmitis* has been described by Zobel,[9] Petit,[10] Brown,[11] and others. In Wopfner's[12] case, pneumonia and panophthalmia developed five days after a cataract operation. Death occurred five days later. The pneumobacillus of Friedländer was found in the involved parts of the lung and in the eye. Axenfeld and Goh[13] observed retinal hemorrhages and small areas of infiltration in a case in which pneumococci were demonstrated in the blood before and after death. Pneumococci were also found in the areas of retinal infiltration. In J. Fränkel's[14] case, round white areas were seen about

[1] Osler and McCrae's Mod. Med., vol. i, p. 262.
[2] Deut. Arch. f. klin. Med., 1902, lxxiii, 351.
[3] Rivista clinica, Bologna, 1884, p. 415.
[4] Deut. Zeit. f. Nervenheilk., Bd. i, p. 300.
[5] Die Sehnenreflexe, Wien and Leipzig, 1896.
[6] Soc. méd. d. Hôp. de Paris, 1904, T. 21, 3 S., p. 397.
[7] Deut. med. Woch., 1897, No. 19, p. 290.
[8] Wiener med. Woch., 1899, No. 41.
[9] Zeit. f. Augenh., vol. xi, p. 1.
[10] Soc. Française d'Ophtalmologie, 1901, xviii, 426.
[11] Glasgow Med. Jour., 1907, lxvii, 484.
[12] Klin. Monatsbl. f. Augenheilk, 1906, 44-1, N. F., 1.
[13] Von Graefe's Arch., vol. xliii, p. 1.
[14] Ibid., vol. xlviii, p. 456.

the macula in a patient with pneumonia. The lesions disappeared in six weeks. Such areas are probably of embolic origin.

Acute Otitis Media.—This occurred in 17 (3.4 per cent.) of 500 cases. In 9 of these the patients were under ten years of age. Among 42 cases in which at autopsy the ears were examined, otitis media was found in five. The infection of the ear may be the result of extension through the Eustachian tube of nasopharyngeal infection or may be hematogenous. One or both ears may be affected. The exudate is almost invariably purulent, and symptoms simulating meningitis may be present before the drum perforates. Paracentesis or spontaneous rupture is usually followed by subsidence of symptoms and recovery without loss of hearing. Mastoiditis is occasionally observed, and in rare instances extension to the cerebral sinuses and the meninges. The mastoid was involved in one of the 5 cases with otitis media at autopsy in this series. During the toxemia of pneumonia, the middle ears should be carefully examined as a routine, otherwise the complication may be overlooked and meningitis may arise by extension, as occurred in one of these cases.

Arthritis.—This is a rare complication. Among 28,040 cases collected by Musser and Norris, were 150 (0.5 per cent.) with acute arthritis. Of 500 cases in this series there were 2 with acute arthritis. Grisolle[1] was the first to note the resemblance between arthritis in pneumonia and abscess formation in pyemia, and to regard the arthritis complicating pneumonia as distinct from "rheumatism." Weichselbaum[2] was the first to demonstrate the pneumococcus as the cause of the arthritis. Brunner[3] in 1892 collected 22 cases; Leroux[4] in 1899 reported 28 cases. In 1901 Cave[5] brought the number to 31, in 1902 Herrick[6] made a total of 52, and in 1903 Howard[7] reported 3 cases and found the total number reported to be 72. The arthritis may occur at any period of the disease and attack any joint, but the larger joints, and especially the knees, seem to be more frequently affected. The infection may be mono- or polyarticular. Injury to the joint from a sprain, bruise or previous arthritis may be a predisposing factor by diminishing local resistance and increasing the danger of infection by organisms circulating in the blood. The process may occur as an arthritis, periarthritis, synovitis or bursitis, and in severe cases may destroy the cartilage and even invade the bone. In mild cases there is local pain, redness, and swelling, with an accumulation of serous fluid and little general disturbance. In more severe cases, in which the exudate becomes purulent, the local symptoms are aggravated and the general disturbance may be marked. Spontaneous recovery usually occurs in serous effusions, but a fatal termination is

[1] Traité de la pneumonie, Paris, II ed., 1864, p. 384.
[2] Wiener klin. Woch., 1888, Nos. 28–32.
[3] Corresp. f. Schw. Aerzte. Jahrg., 1892, vol. xxii, Nos. 11–12.
[4] Les Arthrites à Pneumocoques, Paris, 1899.
[5] Lancet, January 12, 1901.
[6] Amer. Jour. Med. Sci., July, 1902.
[7] Johns Hopkins Hosp. Bull., 1903, xiv, 303.

common in the general infections to which suppuration in the joints is usually due. An acute endocarditis may be present. Pneumococci alone or mixed with other organisms may be found in the joints. In some cases pneumococci cannot be demonstrated in the effusion. X-ray examination is of value in the determination of the character of the pathologic changes.

Diagnosis.—The history of an acute onset with chill, rapid rise of temperature, pain in the side, cough with rusty sputum and dyspnea, and on examination herpes, rapid and restricted respiration and dulness, crepitant rales, bronchial breathing, increase of voice, whisper and tactile fremitus over a circumscribed pulmonary area are characteristic features. Leukocytosis and the finding of pneumococci in the sputum and the circulating blood are confirmatory. In typical cases the diagnosis is readily made and the chief concern is the early detection of complications.

Differential Diagnosis.—Atypical cases may present a difficult problem, and may readily be confounded with acute tuberculous pneumonia, pulmonary infarction, bronchopneumonia, and pleural effusion. A variation from the characteristic picture is not uncommon in children and the aged and in those debilitated from any cause. Terminal lobar pneumonia is often overlooked, and central pneumonia may be in doubt for several days. Meningitis may be suspected when there are nervous symptoms with delirium and rigidity of the neck and typhoid fever in cases of gradual onset without definite pulmonary signs. Atelectasis in the course of bronchopneumonia may simulate croupous pneumonia complicated by an effusion. Passive pulmonary congestion with the expectoration of bloody sputum and elevation of temperature from a complicating bronchopneumonia may also simulate croupous pneumonia. Careful inquiry concerning the evolution of symptoms and repeated examination of the lungs of patients with fever of obscure origin will prevent some mistakes.

In the consideration of the various conditions with which lobar pneumonia may be confused, it is useful to bear in mind that consolidation of the lung from such other causes as bronchopneumonia, infarction or retraction and compression of the lung from accumulation of fluid in the serous sacs gives rise to similar physical signs, *i. e.*, dulness, bronchial breathing, increase of voice, whisper, and tactile fremitus, provided the bronchi communicate freely with the consolidated area. Pulmonary cysts, tumors, atelectatic areas from bronchostenosis and accumulations of fluid or solid material in the pleura give rise to dulness with diminished or absent breathing, voice, whisper, and tactile fremitus, owing to the lack of communication of the involved region with the bronchi. Plugging of the bronchi in massive pneumonia gives rise to signs similar to those in the latter group.

Acute Tuberculous Pneumonia.—This may present great difficulty and a differentiation in the first few days of the illness may be impossible. There may be an abrupt onset with chill, rapid rise of

temperature, pain in the side, cough and dyspnea, and, on examination, signs of consolidation as in croupous pneumonia. The sputum may even be rusty. A family history of tuberculosis or opportunity for contagion, hemoptysis out of a clear sky, a primary pleurisy, adenitis with resultant cervical scars, ischiorectal abscess or other features may suggest the possibility of tuberculosis. Cough and failing health, evening rise of temperature, night-sweats, and loss of weight may have preceded the acute onset of pulmonary symptoms by some weeks or months. Unusual irregularity in the temperature curve and especially a markedly remittent or intermittent fever, with failure of the temperature to fall to normal at the time of its expected decline, absence of leukocytosis during the febrile period, apical pneumonia, or signs of apical disease when the consolidation involves the base, are suggestive features. The sputum is likely to be purulent, and blood when present is more often in streaks or masses than in homogeneous admixture. The sputum is less tenacious and viscid than in croupous pneumonia. The finding of tubercle bacilli may be the only positive indication that the condition is not that of croupous pneumonia, but when in selected particles of sputum, well washed of adherent mucus by passage through several tubes of sterile bouillon or salt solution, examination by means of smears and cultures fails to show pneumococci, tuberculosis may be suspected. Careful and repeated examination for tubercle bacilli may, however, be necessary before the diagnosis can be established.

Pulmonary Infarction.—This may closely resemble lobar pneumonia, and the differentiation may be difficult in cases in which evidence of thrombosis of peripheral veins is lacking. There is likely to be pain in the side and cough with bloody sputum. Dyspnea and cyanosis may be a striking feature if a large branch of the pulmonary artery is plugged. When such symptoms occur in the course of cardiac decompensation, uterine sepsis, with or without relation to childbirth, following laparotomy for abdominal sepsis, otitis media or mastoid disease complicated by sinus thrombosis and after injuries to the extremities, pulmonary infarction should be suspected. Attention to the order in which the symptoms appear may make a probable diagnosis possible. Bloody sputum may appear within a few hours or be delayed for two to three days. The blood may be in the form of bloody streaks, but is more commonly intimately mixed and of a dark-red color. Particles of sputum washed in bouillon or sterile salt solution may show no bacteria in stained preparations or in culture. Chill at onset is at times observed, but less often than with pneumonia. Unlike pneumonia, the temperature does not rise at once with the onset of symptoms, but more gradually, and reaches its maximum, which seldom exceeds 103° only after a day or two. In some cases a musty odor may be detected in the breath. On examination the signs of consolidation and consonating rales may be found at one or both bases. Dry pleurisy or pleurisy with effusion

may be present. A moderate leukocytosis is often observed. In cases terminating favorably, the temperature falls by lysis and the physical signs slowly disappear. It is not uncommon for pulmonary infarction to occur from latent venous thrombosis of the lower extremity and the venous involvement become manifest some time after the infarction has taken place.

Bronchopneumonia.—This usually presents no special difficulty from its insidious onset during the course or at the conclusion of other conditions in which it occurs as a complication, patchy and limited involvement of one or both lungs and termination by lysis in favorable cases. Bronchopneumonia occurs chiefly in children under one year, while lobar pneumonia is more common after the third year. The differentiation of lobar from confluent bronchopneumonia in which the physical signs are the same may be impossible. Atelectasis is frequently observed in the course of bronchopneumonia in children and at times in adults, but the signs are more likely to suggest a pleural effusion or massive rather than ordinary lobar pneumonia. The dulness, diminished or absent breathing, voice, whisper and tactile fremitus over the atelectatic area are inconstant, and may be made to disappear with the expulsion by cough of the secretion occluding the bronchus supplying the affected territory.

Pleural Exudates.—In typical and uncomplicated cases there is no difficulty. In primary serofibrinous pleuritis, the onset is more often gradual than sudden, and an initial chill is rare, though chilliness is common. In the more exceptional cases the onset is abrupt, with chill, fever, and pain in the side, but usually no bloody sputum. Over the effusion there is dulness or flatness, diminished bronchial or absent breathing, and diminished or absent voice, whisper and tactile fremitus. When the exudate is of sufficient amount, the heart is displaced away from the effusion. Dulness in the paravertebral region on the affected side is greater in degree with an effusion than with pneumonia, and Grocco's paravertebral triangle of dulness may be demonstrable on the unaffected side. In the region posteriorly just above an effusion occupying the base of the pleural sac, there are the signs of consolidation, dulness, bronchial breathing and increase of voice, whisper and tactile fremitus. These signs are due to retraction or compression of the lung, and in some instances of uncomplicated effusion they extend over an unusually wide area and are a cause of confusion, but if the extreme base be investigated with care the presence of an effusion may then become clear.

On the other hand, atypical pneumonia may present features suggestive of pleural effusion. Cough and rusty sputum may be absent and the signs equivocal. The breathing may be suppressed and only faintly or not at all bronchial. Rales may be absent, and the voice, whisper and tactile fremitus diminished. In massive pneumonia the signs are those of effusion, and in the absence of bloody sputum an immediate decision may be impossible. The contour of the

affected region may be unlike that with effusion, and a zone of resonance may be detected between the lower limit of the affected region and the base of the lung. In pneumonia affecting the extreme base and of considerable extent, a paravertebral zone of relative resonance may be determined on the affected side, due to compensatory emphysema of the unaffected lung. Grocco's triangle of dulness is absent. If the bronchi can be freed of secretion by cough, the signs of consolidation may then appear. Dislocation of the heart is in favor of an effusion, but cardiac displacement may not be demonstrable with small effusions, and in doubtful cases exploratory puncture should not be delayed.

Persistence of Fever After the Time of its Expected Decline or Reëlevation of Temperature After Defervescence.—It is well to have in mind the causes of a protracted course or a febrile disturbance after defervescence. The explanation will usually be found in serofibrinous or purulent pleurisy, migratory pneumonia, organizing pneumonia, or otitis media. Less often pulmonary abscess or gangrene, pericarditis, endocarditis, phlebitis, meningitis or peritonitis may be responsible.

Prognosis.—Pneumonia is always to be regarded as serious, and even under the most favorable conditions threatens life in a considerable proportion of the cases. Of 465,400 cases collected from the literature by Wells, 94,826 died, a mortality of 20.4 per cent. In all large series, the mortality usually ranges from 20 to 26 per cent. Of 2025 cases at the Massachusetts General Hospital (1897 to 1913), 507[1] (25 per cent.) died. The lowest mortality in any one year was 20 (15.3 per cent.) among 130 cases in 1906 and the highest 38 (31.6 per cent.) among 120 cases in 1899. In a series of 500 cases, the largest number of consecutive recoveries was 16. The mortality is lower in private than in hospital practice.

The influence of sex is shown in practically all large series, the mortality being lower for men than for women. Of 46,278 cases collected by Musser and Norris with a mortality of 21.1 per cent., 33,351 were males with 6449 (19.3 per cent.) deaths and 12,927 were females with 3431 (26.9 per cent.) deaths.

Age.—Youth is a favorable factor. Jürgensen[2] had only 4 deaths among 110 cases during the first ten years of life. Barthez[3] had only 2 deaths in 212 children from two to fifteen years of age. In the collected statistics of Fränkel the mortality from the sixth to the twentieth year did not exceed 6.4 per cent.; from the twenty-first to the thirtieth year, 14.8 per cent.; from the thirty-first to the fortieth year, 26.4 per cent.; from the forty-first to the fiftieth year, 39.3 per cent., and from the fifty-first to the sixtieth, 43.1 per cent. Over sixty the mortality may rise as high as 65 per cent.

[1] Children comprise only a small proportion of the total admissions.
[2] Ziemssen's Handb. d. spec. Path. u. Ther., 1874, v, 137.
[3] Quoted from Jürgensen, loc. cit.

Personal Condition.—The condition of bodily health and the previous habits are of chief importance in determining the outlook. Debilitated individuals, those with chronic disease or obesity, and alcoholics are especially liable to succumb. Of 500 cases at the Massachusetts General Hospital, 122 died, a mortality of 24.4 per cent. If from among the fatal cases those who used alcohol to excess (28), those with chronic circulatory disease (14), with acute or chronic nephritis (5), diabetes (2), pernicious anemia (2), lymphatic leukemia (1), typhoid fever (1), cancer of the stomach (1), pulmonary tuberculosis (1), diphtheria (1), asthma and bronchitis (2), progressive muscular atrophy (1), pregnancy (1), inguinal hernia (1), and those remaining cases without obvious complication, but fifty years of age or over (15) be omitted, the number of deaths which can be ascribed to pneumonia or its complications is reduced to 46, a mortality of 9.2 per cent. In Osler's[1] series of 100 autopsy cases, 25 showed extensive interstitial changes in the kidneys. The mortality is low in vigorous, healthy adults. The statistics given by Fränkel[2] from the Imperial Prussian Army indicate how low the mortality may be in healthy, picked men. Among 85,000 cases occurring from 1878 to 1898, the mortality was only between 3.1 and 4.3 per cent.; in the Austrian Army from 1891 to 1896, 5.8 per cent., and in the French Army 8 per cent.

Character of the Organisms.—Concerning the influence of the type of organisms too little is yet known to permit of definite statements. Lobar pneumonia due to typical pneumococci is mild in comparison to that due to Friedländer's bacillus. The outlook in pneumonia due to the streptococcus mucosus capsulatus appears to be less favorable than that due to typical pneumococci, and this group thus appears to stand between pneumococcus and Friedländer's bacillus pneumonia in seriousness.

Complications.—Meningitis is the most serious and is always fatal. Acute endocarditis adds greatly to the gravity of the situation and acute pericarditis, though less serious than endocarditis, endangers the chances of recovery. Serofibrinous pleurisy does not appreciably increase the mortality. Empyema is more dangerous and fewer cases recover when thus complicated. Abscess and gangrene are grave complications.

Other Factors.—The presence of leukocytosis is of little value in estimating the prognosis, but its absence is an unfavorable sign. The mortality varies with the extent of pulmonary involvement, being higher in proportion to the number of lobes affected, and in the presence of a spreading infection. Extremes of temperature, such as hyperpyrexia or subnormal temperature, are of unfavorable import. As already noted, from a third to a half of adults with a pulse rate of 120 or over and about three-quarters of those with a rate of 140

[1] Practice of Medicine, 1905, p. 188. [2] Loc. cit.

or over succumb. Cardiac arhythmia is to be feared. Persistence of pneumococci in the blood in the latter part of the illness, subjective dyspnea, respiration rate above 50 in adults, extreme cyanosis or pallor and cyanosis, weakness, cold and clammy extremities, persistent insomnia, delirium, and coma are to be regarded as unfavorable. But estimation of the chances of recovery are at best uncertain in individual cases. Cases in which from the apparent mildness of the symptoms the outlook appears to be favorable may take a sudden turn for the worse, and, on the other hand, a condition of great gravity may terminate favorably. The mortality in those who have previously had pneumonia is somewhat lower than the average. The death rate in negroes is higher than in whites. High altitude has been thought to increase the death rate from pneumonia, but statistics do not show that it is a factor of importance. Brewer[1] concluded, from a study of the statistics for the United States Army from July 1, 1870, to June 30, 1874, that altitude has nothing to do with the mortality from lobar pneumonia.

Death.—This usually comes on gradually in pneumonia and with increasing symptoms of toxemia. In rare instances, the patient may be overwhelmed by the infection and die within two to three days of the onset, but the fatal termination is usually delayed until the fifth to the tenth or eleventh day and may not occur for several weeks. The temperature is usually elevated to the end, but at times falls to normal or subnormal as the end approaches. The degree of the toxemia is usually independent of the height of the temperature and the extent of the pulmonary involvement. Interference with respiration and cardiac failure are of less importance in the majority of cases than the results of the general infection, but nevertheless play a more important part than in other infections in which the pulmonary involvement is less extensive and more gradual in development. At times cardiac failure is a prominent feature as indicated by the degree of cyanosis, weakness and irregularity of the pulse, edema of the otherwise unaffected parts of the lungs and engorgement of the right side of the heart. Exhaustion of the vasomotor centre has long been thought to be an important factor in fatal cases. Porter and Newburgh[2] conclude from experiments in animals near death from pneumonia that the evidence for impairment of the vasomotor apparatus is inconclusive. Sudden death may occur during the course of the disease or after convalescence is established and recovery seems assured. In such cases the cause of death is usually cardiac or pulmonary thrombosis. In two cases in this series, sudden death occurred on the second and eighth day of convalescence respectively and at autopsy pulmonary embolism was found in one and pulmonary thrombosis in the other.

[1] Southern California Prac., 1906, xxi, 607.
[2] Boston Med. and Surg. Jour., January 22, 1914.

Prophylaxis.—The pneumococcus must be regarded as maintaining its existence by transfer from person to person and the respiratory tract is the usual channel of infection. Transfer of the virus by contact with moist sputum, droplet infection or the inhalation of material which through drying has contaminated the air is probably the common mode of transmission. Contact with utensils which have been used by persons who harbor the organism is another source of danger. Contamination of the air about an infected individual occurs when particles of sputum containing pneumococci are expelled by sneezing, coughing or talking. Indirect transfer through water, soil, food or intermediate host is unlikely. The problem of prevention is complicated by the fact that the pneumococcus is found in the saliva of a considerable proportion of healthy individuals, as well as in those suffering from acute respiratory infection.

General measures concerning which the public must be educated apply as well to ordinary "colds," influenza, tuberculosis, diphtheria, whooping cough, and many other diseases as to pneumonia. Cleanliness in its broadest sense and including freedom from pathogenic bacteria in places where they can gain entrance to the body must be secured with such discrimination as a knowledge of sources of infection and modes of communication will afford. The value of fresh air and sunshine as disinfectants should be understood by all. Regulations forbidding expectoration in public places should be enforced, as much for the purpose of creating public opinion against a dangerous and obnoxious practice as for diminishing the spread of disease from individual cases. The carriers of pneumococci are infinitely more numerous than patients with pneumonia. Every individual should know that his sputum may be a danger to others, and if allowed to dry may be capable of spreading disease. The sputum is more dangerous in the presence of acute or chronic respiratory infection, and should be expectorated carefully into a special receptacle to avoid soiling the beard or moustache. In coughing or sneezing, expelled particles of sputum, which may give rise to droplet infection, should be caught in a piece of cloth placed in front of the mouth. This cloth should be burned. The fingers should not be moistened in the mouth in turning the leaves of books, public documents, etc. The rooms of patients with acute respiratory infection should be dusted with a damp cloth and swept with a damp broom. An infected individual should sleep alone. All patients with cough and expectoration coming to polyclinics or seen in private practice should be warned against the danger of transferring infectious material from person to person with the same care that is recommended for tuberculosis. Such instructions will not only serve to limit the spread of disease by the patients themselves, but will have an educational value in the community.

Patients with pneumonia should be isolated, and those who care for them should see that proper precautions are taken against dis-

semination of pneumococci. The more immediate the contact with the patient the greater is the danger. If complete isolation is impossible, the patient's bed should be screened. Every effort should be made to prevent drying of the sputum and contamination of the air. Contamination of the clothing or bedding should as far as possible be avoided. Soiled bed or body linen should be immediately removed, shaken as little as possible in handling, and boiled for one-half hour before it is sent to the laundry. Care should be taken by those in attendance not to carry infectious material to the mouth. Patient's thermometers and utensils for food should be kept separate and the latter boiled after use. Persons debilitated by age, alcoholism, or chronic disease should avoid contact with or proximity to patients with pneumonia. Rooms which have been occupied by patients with pneumonia should be thoroughly cleaned and disinfected.

The safest method of disposal of the sputum is cremation. Carbolic acid (5 per cent.) is probably the most efficient of the ordinary disinfectants and should be left in contact with the expectoration for twenty-four hours.

The influence of exposure to cold and chilling of the body in precipitating an attack of pneumonia is uncertain, but worthy of attention. The danger seems to be greater in the presence of an acute respiratory infection. The subjects of such an infection should be warned against exposure to cold when insufficiently clad, overheated or physically tired. Some protection may be afforded those subject to "colds" by woolen underwear and an effort to increase individual resistance—sleeping with the window open, spending much time in the open air and cool morning baths followed by friction. A good reaction should be obtained after the bath. The hardening process had best not be begun in cold weather.

The greater incidence of pneumonia as well as other acute respiratory infections during the winter months is probably due to a number of causes, the relative importance of which is difficult to estimate. The tendency to live more within doors in crowded and poorly ventilated rooms is probably a factor. The greater amount of dust and less abundant sunshine may also be of importance. Infected dust is probably concerned in dissemination of the pneumococcus, and municipal authorities should take immediate steps to diminish the amount of dust and smoke in the cities.

Since overcrowding is an important factor in contagion in pneumonia, as in other infectious diseases, the proper regulation of housing conditions is a necessary measure for prevention.

Preventive Inoculation.—The protective value of inoculations with the pneumococcus has been demonstrated in animals, as already noted under Immunity. Whether man can be successfully immunized against pneumococcus pneumonia by this means cannot yet be regarded as settled. The method deserves an extended trial and may well be used as a preventive measure when in any community pneumonia

is unusually prevalent. It is desirable, however, that evidence for or against the value of the procedure be obtained as soon as possible, and with this end in view a portion of the group of persons living under precisely similar conditions as those subjected to inoculation should be reserved as controls. Preventive inoculations were recommended among the miners on the Rand by Wright. The experience at the Premier Mine in 1913 was promising. In 1912, among 17,000 inoculated, the death rate from pneumonia was 6.89 per thousand, while among 6700 controls the death rate was 17.72 per thousand.[1]

Treatment.—Specific Measures.—There is thus far no specific treatment for pneumonia. Drugs, immune sera, vaccines, and leukocytic extracts[2] have not yet been shown to be of definite value. Irritating drugs injected into the subcutaneous tissue to cause the so-called "abscess of fixation" and promote leukocytosis[3] have not proved effective.

Chemotherapy.—Experiments with derivatives of quinine offer some hope of successful medication in pneumonia. Since Morgenroth and Levy's[4] first publication on experimental chemotherapy in pneumococcus infections, further investigations have been made with ethylhydrocuprein, with which mice can be protected against subsequent infection with pneumococci,[5] and cured in 50 per cent. of the animals treated six hours after the onset of the infection (Morgenroth and Levy), and in some cases even as long as twenty hours after infection;[6] Wright[7] demonstrated bactericidal action of ethylhydrocuprein on the pneumococcus *in vitro*, in dilution of 1 to 400,000 in twelve hours, and Tugendreich and Rosso[8] in dilution of 1 to 64,000 in two hours at room temperature. A dilution of 1 to 256,000 at 37° did not prevent the growth of pneumococci but diminished the virulence. Pneumococci become resistant against the drug, both in the animal body and *in vitro*, when exposed to its action in insufficient amount to exert bactericidal effects. Fränkel[9] tested the effect of the drug in 21 cases of pneumonia. There were 4 deaths. Amblyopia occurred in 3, but disappeared after the drug was stopped. Wright[10] used it in 8 cases. Amblyopia was observed in 2. Vetlesen[11] used it in 9 cases, all of whom recovered, and Parkinson[12] in 8 cases with 2 deaths. Thus far no definitely favorable action has been shown in man.

[1] Gorgas, Jour. Amer. Med. Assoc., 1914, lxii, p. 1855.
[2] See His, Jour. Med. Research, 1908, xiv, 323; Floyd and Lucas, Jour. Med. Research, 1909–10, vol. xxi.
[3] Fochier, Dieulafoy's Text-book of Medicine, 1911, p. 139.
[4] Berl. klin. Woch., 1911, Nos. 34 and 44.
[5] Gutmann, Zeit. f. Immunitätsforsch., 1912, 1 Th., 15, orig., p. 625.
[6] Morgenroth and Kaufmann, ibid., June 7, 1913.
[7] Lancet, December 14 and 21, 1912.
[8] Zeit. f. Immunitätsforsch. und exp. Ther., August 30, 1913, 1 Th., orig.
[9] Berl. klin. Woch., 1912, p. 664.
[10] Loc. cit.
[11] Berl. klin. Woch., August 11, 1913.
[12] Zeit. f. Chemotherapie u. verwandte Gebiete, 1 Th., orig., Bd. ii, H. 1.

Immune Sera.—This offers the greatest promise, but as yet no convincing results have been published. Failure of previous attempts to cure by this means may have been due to the use of antipneumococcic serum without immune principles against the infection treated. Cole[1] finds that of 72 cases observed at the Rockefeller Institute, the mortality, according to the type of the infecting organism, was as follows: Of 34 cases in Group I, 8 (24 per cent.) died; of 13 cases in Group II, 8 (61 per cent.) died; of 10 cases in Group III, 6 (60 per cent.) died; of 15 cases in Group IV, 1 (6.6 per cent.) died. By the use of homologous antipneumococcic serum in a further series of cases in Groups I and II, the following results were obtained: Of 15 cases in Group I, 1 (6.6 per cent.) died, and of 8 cases in Group II, 2 (25 per cent.) died. The number of cases is too small for fair judgment concerning the efficiency of the treatment, but the method is more hopeful in other respects than in reduction of mortality. Of 10 cases with positive blood-cultures, the blood was found to be sterile after the first injection of serum, and protective substances could be demonstrated in the blood shortly after the administration of the serum even when it was given early in the disease.

Vaccines.—The prevention of infection by the use of dead or living organisms as vaccines is already established for certain diseases, but vaccines have never been shown to be definitely effective against an existing infection. Rosenow and Hektoen[2] treated 146 cases with partially autolyzed pneumococci, using 148 cases as controls. Of the injected group, 34 (23.3 per cent.) died, and of the uninjected group, 56 (37.8 per cent.).

General Considerations.—Statistical inquiries on pneumonia in various parts of the world have shown that the course and outcome of the disease are uninfluenced by venesection, epistaxis, wet cupping, such drugs as antimony, mercury, the iodids, veratrum viride, quinin, digitalis, salicylic acid, phenacetin, antipyrin, creosote, etc., or catharsis, diaphoresis, diuresis, inhalations, insufflations, hydrotherapy, and special diets. At present, the infection is beyond our control other than by such simple measures as tend to spare and support the strength of the patient by careful hygiene and nursing and the alleviation of symptoms. A recognition of the ineffectiveness of our efforts should not lead to the relaxation of vigilance, and lives may undoubtedly be saved by such simple means as are already in our possession, more particularly in those cases in which there is a balancing between life and death, and the utmost care may turn the scale in the right direction. Solicitous relatives and friends should be made to understand that careful hygiene and nursing are of first importance and that their coöperation will be of assistance in preventing physical and mental fatigue and in affording encouragement when needed. Useless medication is to be avoided. The toxemia

[1] The Harvey Lecture, New York, December 12, 1913.
[2] Jour. Amer. Med. Assoc., December 20, 1913, p. 2203.

may be favorably influenced by any increase in the resistance of the individual obtained by these measures and by efforts to favor elimination. It is therefore advisable to furnish an abundant supply of liquids and especially water. In severely toxic cases, enemata of water given by the drop method may be of service.

Examination of Patients.—A daily physical examination should ordinarily be made by the physician. The pulmonary lesion should be investigated and an estimate made of the degree of infection and toxemia. For the examination of the posterior thoracic regions the patient may be turned on his side, all exertion on his part being avoided during the procedure. Cough is less often excited if he is turned on the affected side. The windows should be closed before the patient is exposed, and, if necessary, perspiration should be wiped from the skin. In patients who are desperately ill the likelihood of obtaining valuable information by an examination of the back must be weighed against the exertion and discomfort to which the patient may be subjected by the change of position, but it is usually safer to investigate this region for a complicating pleural effusion than to waive this part of the examination. Throughout the course of the illness the physician should constantly be on the watch for complications. Pleural or pericardial effusion, phlebitis, acute dilatation of the stomach, abdominal distention, a full bladder, and otitis media are among the conditions against which prompt and appropriate treatment may be of great importance.

Hygienic Management.—The patient should of course be abed. The transfer of the patient to a hospital is to be judged after consideration of the facilities at home and the danger of moving the patient. A short journey by ambulance and with the patient in the reclining position may be permitted during the first part of the illness, but is inadvisable at the height of the disease and may diminish the chances of recovery.

The patient's room should be large and well ventilated. It should, if possible, be in a quiet part of the house. An open fireplace improves the ventilation. An abundance of sunshine and fresh air is desirable. The windows should be open, and if dust or snow is troublesome, cheese-cloth screens will afford protection. The temperature of the room should be kept at about 65° F., and the heating accomplished if possible by an open fire. If necessary, nurses or attendants should wear extra clothing. The patient's bed should be single, approachable from both sides, and sufficiently high to make attendance on the patient by physician and nurses capable of performance without strain to the back. The mattress should be firm and comfortable and protected by rubber and draw-sheets. The bed clothing should afford sufficient protection against cold, but should not be heavy enough to impede respiration or produce sweating. Short woolen nightshirt or pajamas are desirable. The apparel should afford ready access for examination

and the covering for the chest should be slit up the whole length of the front and fastened with buttons or other means.

Directions for Nurses.—The patient's strength must be spared by every possible means. He should not feed himself, but should be fed by the nurse with as little exertion on his part as possible. During the feeding he should remain in the recumbent position. Liquid nourishment or water may be taken from a glass by means of a bent glass tube. All unnecessary excitement, business or family cares and expressions of anxiety should be avoided. All unnecessary talking is to be avoided and even the most congenial visitors restricted to a short visit at stated intervals and cautioned not to tire the patient. The discharges should be passed into the urinal or bed-pan. Straining at stool is to be avoided. Surface bathing may be given once a day. The windows should be shut and the room warmed before the bath is given. Needless exposure during the process is to be avoided and a part of the body should be washed and dried before other parts are exposed. If bathing is followed by fatigue, it may be omitted. Hot-water bags or bottles or an electric heater may be used if necessary for warmth to the extremities. Careful attention to the arrangement of the pillows and bed-rest will assist the patient in securing a comfortable position, which should be occasionally changed to diminish the danger of hypostasis. The patient should not be allowed to sit up. Changes of position may be affected by moving the patient from his back to one or the other side. The twenty-four-hour amount of urine should be measured and recorded. Failure to pass urine after a period of eight hours should be reported to the physician. Sufficient sleep is important, and it is usually unnecessary to awake the patient for either food or medicine. Temperature, pulse and respiration should be recorded every four hours unless the patient is asleep. The temperature may be taken by rectum if the thermometer in the mouth is disturbing. A chart should be kept of the character and amount of nourishment. Patients with pneumonia should never be left alone. Sudden and unexpected delirium may induce the patient to injure himself or others.

Careful attention should be paid to the patient's mouth. The teeth should be brushed twice a day. A mouth wash consisting of boracic acid drams 4 (16 c.c.) and lemon juice and glycerin of each 4 ounces (128 c.c.) applied every four hours by means of a swab of cotton rolled on an orange-wood stick is of service. Dobell's Solution may also be used as a spray.

If necessary for a daily evacuation, a suds enema may be given.

The sputum should be disinfected. Sputum boxes should be burned. If the patient is too ill to expectorate into a special receptacle, small pieces of gauze or linen cloth may be used to wipe the sputum from the lips. These may be placed in a paper bag and burned. If disinfection of the expectoration is accomplished by means of carbolic acid or

other poisonous material, the solutions must be kept in some place which is inaccessible to the patient.

Diet.—There are no special restrictions and the patient may take as much of simple and nutritious food as he can digest. As the appetite is often impaired, the diet will usually consist of liquid and soft solid food, such as milk, ice-cream, custards, eggs, cereals, broths, milk toast, crackers, etc. Liquid food is best given every two hours, but the feedings may be omitted when the patient is asleep. While it is desirable to maintain the strength of the patient by nourishing food, it is unwise to surpass his inclinations in regard to quantity, and no anxiety need be felt if, as usually happens, the full number of calories needed by a person in health cannot be maintained. Attention must be paid to the effect of the diet on the gastro-intestinal tract. If there is vomiting or flatus, all food may well be omitted for a time. Tympanites may increase the dyspnea by elevation of the diaphragm and embarrassment of the respiration and the circulation.

An abundance of fluid should be supplied. Small quantities of water should be offered to the patient at frequent intervals. Iced water may be taken if preferred, and lemonade, orange juice, albumin water, grape juice, cocoa, tea or coffee.

After the fever has subsided and convalescence is established, the appetite returns and a liberal diet is allowed.

Treatment of the Special Symptoms.—*Chill.*—The patient should be put to bed between warm blankets and with hot-water bags or bottles at the feet. A hot drink may be given.

Herpes.—This does not usually require treatment. If troublesome, the lesions may be smeared with zinc-oxide ointment.

Fever.—This is the result of infection and toxemia and cannot be satisfactorily combated by any means at our disposal. The use of antipyretic drugs is now very generally abandoned. Hydrotherapy may be employed if it is found to afford symptomatic relief. There is no convincing evidence that it modifies or shortens the course of the disease in any way, but in some cases it seems to quiet the nervous system and diminish the sense of ill-being. Sponging with cool water (75° to 80° F.) limb by limb and the trunk by section, one part being dried and subjected to friction before proceeding to the next, may be used when the temperature is 102.5° or more, and repeated if agreeable to the patient every four to six hours. The windows should be closed during the bath.

Respiratory System.—Pain in the Side.—Local friction with the hand, the application of the ice-bag or Leiter's coil, hot-water bottle or electric heater, may be tried. Fixation of the side by means of a tight thoracic swathe may be successful. Strapping with adhesive plaster has the disadvantage of interference with chest examinations and may lead to irritation or infection of the skin. Local irritation with iodin, mustard or other means, and the use of wet and dry cups and leeches may only add to the patient's discomfort, and are to be

avoided. If simple measures do not suffice, a hypodermic of morphin may be given. Morphin is one of the most valuable drugs in pneumonia, and there should be no hesitation in its use in a disease which runs so short a course. As pain may prevent sleep, aggravate the dyspnea and harass and fatigue the patient, its relief is important to conserve his strength and enable him to withstand the infection.

Cough and Expectoration.—Cough is usually necessary for the expectoration of sputum, and an effort to control it should be made only for some definite indication. When harassing and unproductive cough disturbs sleep, aggravates the pain in the side or tires the patient, codein gr. $\frac{1}{4}$ (0.016 gm.), heroin gr. $\frac{1}{12}$ (0.005 gm.) or a subcutaneous injection of morphin gr. $\frac{1}{8}$ (0.008 gm.) may be given. When the bronchial secretion is abundant, it is usually best not to give morphin. If the expectoration is raised with difficulty, ammonium chlorid gr. 10 (0.650 gm.) repeated every four hours may be of service.

Serofibrinous and Purulent Pleural Effusions.—The differentiation between serofibrinous and purulent effusions must usually be settled by exploratory puncture and the decision concerning the appropriate treatment made after examination of the fluid. The indications for treatment are considered in the sections on Serofibrinous and Purulent Pleurisy.

Abscess and Gangrene.—Treatment of these complications is discussed in the section on Abscess and Gangrene.

Delayed Resolution.—It is important to exclude pleural effusion, pulmonary abscess or tuberculosis. Until the causes underlying delayed resolution are better understood, chief reliance must be placed on improvement of the general health and nutrition. An abundance of food, rest and fresh air are of most importance. External applications to the chest and drugs internally are probably ineffectual. Edsall and Pemberton[1] applied the *x*-rays with apparent success. Fibrolysin has been used in 2 cases by Krusinger,[2] and in 1 case by Brenner.[3] The results appeared to be favorable.

Cardiovascular System.—Cardiac Weakness.—This is but one feature of the general effect of the infection and toxemia on the vital organs of the body. The failure of the circulation is more readily apparent than that of other systems, and this has led to undue emphasis on cardiac failure as a cause of death in pneumonia. Cyanosis as a measure of failure of the circulation is uncertain on account of other factors as a cause. Extensive pulmonary involvement probably embarrasses the right side of the heart to some degree, but cannot be held accountable for cardiac failure in view of the tolerance which the heart shows in the presence of equal or greater interference with the pulmonary circulation in pleurisy with effusion, pneumothorax, pulmonary infarction, etc. and the usual absence of evidences of right-sided engorgement in pneumonia. In cases in which the pulse is rapid, weak and

[1] Amer. Jour. Med. Sci., February, 1907, p. 286.
[2] Münch. med. Woch., 1908, No. 14.
[3] Ibid., 1913, No. 28.

irregular, the second pulmonic sound of diminished intensity, the first cardiac sound enfeebled and the lung shows signs of pulmonary edema, it is desirable to support the circulation by every means in our power.

The measures already suggested under hygienic management and directions for nurses, especially those which spare the patient's strength, are more likely to prevent the development of cardiac weakness than any other means at our command. Cardiac stimulants are uncertain and far less important, but may be used for the purpose both of prevention and relief. Digitalis in doses of minims 10 (0.60 c.c.) of the tincture, gr. 1 (0.065 gm.) of the powdered leaves, or digipuratum may be administered as a routine, beginning on the second or third day of the disease. With the development of signs of cardiac weakness the amount of digitalis may be increased. Digipuratum may be administered subcutaneously or intravenously. Camphor, gr. $1\frac{1}{2}$ (0.0975 gm.) in 1 c.c. of sterile oil, may be given intramuscularly, and caffein in the form of caffein sodium benzoate, in one-grain doses, every two to four hours. Strophanthin intravenously in doses of a half to 1 mg. is useful in some cases. It should never be given in large doses or after digitalis has been administered. Strychnin, nitroglycerin, adrenalin chlorid, spartein sulphate, and musk are at times used. They are of doubtful value. Alcohol is used less and less and it would be better if it were not used at all, except in cases of chronic alcoholism. Persons previously accustomed to the excessive use of alcohol should not have their supply suddenly withdrawn during an attack of pneumonia for fear of precipitating delirium tremens.

Venesection is now seldom used, and only when the indications point to severe mechanical embarrassment of the heart. Extreme cyanosis, beginning pulmonary edema and dilatation of the right side of the heart justify its consideration. I have used it with apparent benefit in a few cases of pneumonia complicating mitral stenosis. From 300 to 500 c.c. of blood may be removed. As a means of combating toxemia, venesection is an irrational procedure, as it may as fairly be argued that abstraction of blood removes protective substances as circulating toxins.

Acute Endocarditis.—The patient should be abed as long as fever or any other evidence of activity of the endocardial infection persists, and for three to four weeks longer in order that the heart muscle may have time to adjust itself to the changed conditions. Even then he should be cautious about the resumption of customary exertion.

Pericarditis.—Treatment consists in the application of cold or the administration of morphin for the relief of pain. Thoracentesis should be performed when an effusion is present. Serofibrinous accumulations of fluid should be aspirated. With purulent fluid the pericardium should be opened and drained.

Phlebitis.—If, as usually happens, the leg veins are involved, the patient should be kept absolutely at rest to favor subsidence of the process and prevent the detachment of a clot and pulmonary embolism.

The affected limb should be supported comfortably on a pillow. Massage and all rough handling are to be avoided. The leg should be kept at rest for at least a month and longer if necessary.

Gastro-intestinal Tract.—If the bowels have not moved, it is wise at the outset to administer a mild cathartic, as sodium phosphate, gr. 45 (2.925 gm.) in half a tumbler of lukewarm water, a Seidlitz powder or saline cathartic water. If there is vomiting or flatus, it is well to largely restrict the amount of nourishment and albumin water alone may be given. Throughout the course of the illness it is important to prevent and, if necessary, to overcome tympanites. This may be accomplished by securing a daily evacuation, for which, if needed, a suds enema may be given. If tympanites is troublesome, restriction in the amount of food, turpentine stupes, enemata and the rectal tube may be employed. Acute dilatation of the stomach should be kept in mind as a cause of vomiting and abdominal distention. Treatment consists in passage of the stomach tube and the evacuation of gas and fluid contents and lavage until the wash-water returns clear. Food and drink by the mouth should be stopped. If the patient is turned on the right side or on the face, the tendency to mechanical obstruction of the duodenum may be prevented.

Peritonitis.—This should be treated on general surgical principles. The outlook in the diffuse form secondary to pneumonia is very unfavorable. Recovery may follow incision and drainage of circumscribed collections of pus.

Parotitis.—The local application of heat or cold may be used for the relief of pain. Morphin may be used if necessary. As soon as the presence of pus is established, the gland should be incised and drained.

Acute Nephritis.—This should be treated upon the same principles as apply to other forms of acute nephritis. The patient should be abed with flannel nightshirt and between blankets. The diet should be simple and contain milk to an amount not exceeding a quart to a quart and a half a day. Cream, cereals (oatmeal, rice, tapioca and sago), bread, macaroni and custards in limited amount may be given. The diet should be arranged so as not to contain more than 50 grams of protein during the acute stages of the disturbance. A moderate diminution in the amount of salt is desirable. Elimination by the bowel should be favored by the use of saline cathartics, but active purgation is unnecessary if dropsy and uremic symptoms are absent. Elimination by the skin may be secured by the hot pack or hot-air bath. Water is the best diuretic and may be given in sufficient amount to satisfy the thirst of the patient.

Nervous System.—Headache is usually troublesome only in the early stages of the disease, and may then be treated with the ice-cap, or, if severe, with phenacetin gr. 5 (0.325 gm.) combined with caffein gr. 1 (0.065 gm.). Insomnia due to pain or harassing and unproductive cough may be relieved with morphin. Sulphonal, trional, or veronal may be used in the absence of cardiac weakness. If these measures

fail, hyoscin hydrobromate gr. $\frac{1}{100}$ to $\frac{1}{200}$ (0.00065 to 0.00032 gm.) may be tried. Delirium of a mild type, unassociated with cardiac weakness and beginning pulmonary edema, has usually been treated with morphin or other opium derivative or chloral, bromid or hyoscin hydrobromate. Alcoholic cases should not have their alcohol omitted during pneumonia. In cases in which inanition is a cause, especially in the postcritical delirium, every effort should be made to build up the general strength with nourishing food and rest. Forcible restraint should not be practised. Depressant drugs should as far as possible be avoided.[1]

Meningitis due to the pneumococcus has thus far invariably proved fatal. The success obtained in the treatment of meningitis due to the meningococcus of Weichselbaum by means of intraspinal injections of antimeningococcic serum has led to the similar use of antipneumococcic serum in meningitis due to the pneumococcus. No favorable results have thus far been reported. This seems the most rational procedure to recommend, and, until further advances have been made in the treatment of pneumococcic meningitis, deserves a further trial.

Acute Otitis Media.—This is common, especially in children, and is frequently overlooked. Investigation of the ears should be made a part of the routine physical examination in pneumonia. Suppurative otitis media should be treated by puncture and drainage of the cavity. Early detection and prompt treatment may prevent extension to the meninges and fatal meningitis.

Acute Arthritis.—Simple immobilization with or without aspiration may be sufficient with serofibrinous effusions. In cases in which the fluid is purulent, the joint should be incised and drained. All unnecessary manipulation of the joint structures should be avoided.

Pneumonia and Diabetes.—The development of acidosis is to be feared, and it is probably safer to modify or abandon the restriction of carbohydrates at once with the onset of symptoms. Milk to the amount of 250 c.c. every two hours or oatmeal gruel may be given. Sodium bicarbonate should be administered in sufficient quantity if possible to keep the urine alkaline. If a severe grade of acidosis is present, as much as 100 grams a day may be taken. The intake of water should be pushed and, if necessary, enemata of salt solution given by the drop method. If coma develops, an enema of 10 per cent. glucose and the intravenous injection of 500 c.c. of $3\frac{1}{2}$ to 4 per cent. sodium carbonate in sterile water may be administered. From 200 to 400 c.c. of blood should be removed from the vein before the intravenous injection is made.

[1] Gregg (Boston Med. and Surg. Jour., September 18, 1913) reports the mortality in delirium tremens in five large general hospitals where restraint and depressant drugs were used as 26 per cent. At the Psychopathic Hospital in Boston with eliminative treatment by continued baths and packs, Southard (ibid., December 25, 1913) finds the mortality 3 per cent. in 64 cases. These results apply only to uncomplicated cases, but suggest the possibility of applying similar methods of treatment to complicated cases and among them pneumonia with delirium.

Crisis.—The crisis is usually the indication of a decisive victory won by the patient against the disease and little more need be expected of the physician than appropriate words of congratulation. But unfortunately it does not always happen that the patient emerges unscathed from the conflict. In some cases his strength is spent, and he may die of exhaustion or linger for a time between life and death. The watchfulness of those in attendance must therefore not be relaxed at this period of the illness, and the patient's strength must still be spared and, if necessary, supported. All exertion is to be avoided. Hot drinks, warmed blankets, the application of hot-water bags or bottles and cardiac stimulation may be necessary. Complications, especially pleural effusion, must be carefully sought during the epicritical period. The patient should not be allowed to sit up. An abundance of food, rest and sleep are important.

Convalescence.—Rules cannot be formulated for the management of convalescence. If the patient's strength permits, he may be allowed to get up at the expiration of about a week after the termination of the disease. Attention to the diet, suggestions as to the amount and character of the mental or physical effort permitted, the length of time which should elapse before the resumption of customary activities, vacation, change of climate and other matters must be considered with due regard to the needs of the individual.

CHAPTER XI.

FRIEDLÄNDER'S BACILLUS PNEUMONIA.

Friedländer's bacillus is also known as Friedländer's bacillus of pneumonia, the pneumobacillus, and bacillus mucosus capsulatus. Friedländer[1] in 1883 reported the discovery in pneumonic exudates of an organism which he termed the pneumococcus. Further studies, especially those by Weichselbaum,[2] showed this to be an encapsulated bacillus. This organism is occasionally found in suppurative lesions in various parts of the body, in the sputum from patients with simple bronchitis and in the sputum and pulmonary exudate from cases of bronchopneumonia. In rare instances it is found as the apparent sole cause of genuine lobar pneumonia.

Occurrence.—Of 94 cases of croupous pneumonia in Weichselbaum's series, this organism was found in 5, in 4 of these cases by culture. In three of the four it was mixed with other organisms. E. Fränkel[3] found two Friedländer pneumonias among 77 cases of pneumonia. Of 192 cases of lobar pneumonia coming to autopsy at the Massachusetts General Hospital, this organism was the only apparent cause in 6. (Autopsy 224, 328, 883, 1519, 2811, and 3329.)

Etiology.—In smears made from the sputum or exudate from the lung, the pneumobacilli appear as moderate-sized rods of variable length. They are usually two to three times as long as broad, with rounded ends. At times they are found in pairs or short chains. A thick, oval capsule can be demonstrated about the organism by appropriate methods of staining. The capsule is more easily demonstrable in fresh material than in cultures. The organisms decolorize by Gram's method of staining. On *blood serum* after twenty-four hours in the incubator, translucent, moist, colorless, confluent, mucus-like colonies appear. The colonies are viscid and can be drawn out into threads with the platinum wire. The water of condensation may be cloudy and viscid in consequence of the growth. *Bouillon* is clouded and a thin pellicle may form. The organism is non-motile. Spore formation is not observed. *Glucose agar stab cultures* show growth along the track of the inoculation and gas production. *Gelatin* shows a grayish white growth along the line of inoculation and a knob-like growth at the surface. Liquefaction of the gelatin does not take place. *Litmus milk* is acidified and coagulated. On *potato* a thin, colorless, viscid growth

[1] Die Mikrokokken der Pneumonie, Fort. d. Med., 1883, Bd. i, No. 22.
[2] Med. Jahrbücher, 1886, p. 483.
[3] Apelt, Münch. med. Woch., April 21, 1908.

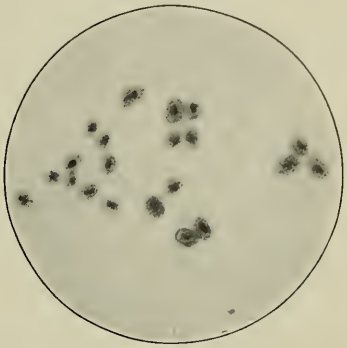
takes place. Growth occurs both at room temperature and in the incubator.

Inoculation of rabbits, guinea-pigs and white mice usually causes fatal septicemia. Subcutaneous inoculation of rabbits may give rise

Fig. 33

Friedländer's bacillus culture.

Fig. 34



Friedländer bacillus, smear from culture.

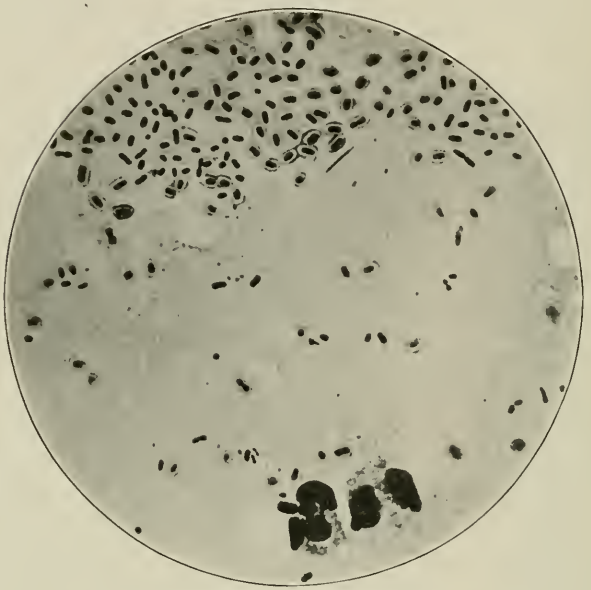
to local suppuration without septicemia. Attempts to produce experimental lobar pneumonia in animals have usually failed. Friedländer[1] produced focal pneumonia and pleuritis in mice by injection into the lung and inhalation of bacilli in suspension. Intrathoracic injection of guinea-pigs and dogs gave similar results, but these animals proved less susceptible. Rabbits proved insusceptible. In one dog intrathoracic injection gave rise to typical lobar pneumonia. Similar experiments have since been made with practically the same results.

Relation of Friedländer's Bacillus to Pneumonia.—The importance of this organism as a cause of lobar pneumonia has been questioned. It is not very uncommon to find it mixed with pneumococci in the sputum during life and in the pneumonic exudate after death in cases of lobar pneumonia, and in such instances the pneumococcus may be regarded as the probable primary cause and the pneumobacillus as a secondary invader. Reported instances of lobar pneumonia in which this organism is found as the apparent sole cause, comprise for the most part autopsy cases in which it may be assumed that the infection is terminal and secondary to the pneumococcus. The well-recognized tendency of the pneumococcus to die out or be overgrown by secondary

[1] Die Mikrokokken der Pneumonie, Fort. d. Med., 1883, Bd. i, p. 715.

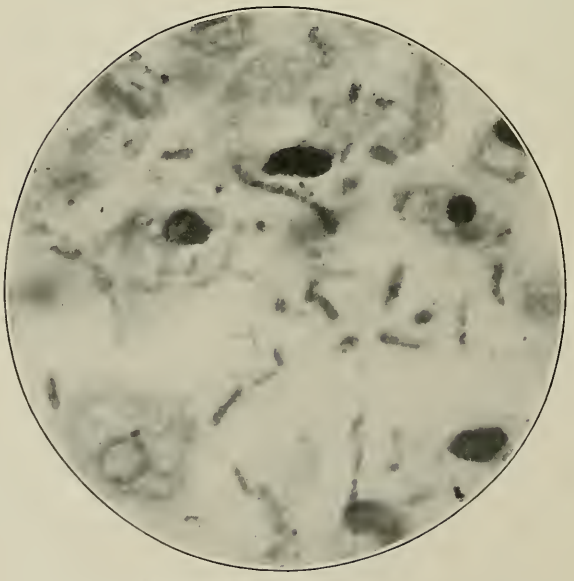
invaders lends support to this point of view. That secondary invasion with this organism may take place is suggested by one of the Massa-

FIG. 35



Friedländer's bacillus in sputum.

FIG. 36



Friedländer's bacillus in pulmonary exudate. × 1500.

chusetts General Hospital cases (542-54). Organisms resembling pneumococci were found in enormous numbers in the sputum on the eighth day of the disease, while on the next day enormous numbers of Friedländer's pneumobacilli were present. No autopsy was obtained.

While the matter cannot yet be regarded as settled, the following considerations tend to uphold the independent existence of primary lobar pneumonia due to this organism. In one case at the Peter Bent Brigham Hospital,[1] a woman (No. 2226), aged sixty-six years, was admitted in the afternoon with a history of having worked as a domestic until noon of the same day. She complained of having had a "cold" all day, pain in the side during the day and cough only that afternoon. Blood culture taken the same afternoon was negative, but the sputum showed a practically pure culture of Friedländer's pneumobacilli. Death occurred the following day at 1.30 P.M. At autopsy three hours later, the right upper lobe was found to be completely consolidated, with scattered nodules of consolidation in other lobes of the lungs. Pure cultures of Friedländer's pneumobacillus were obtained from the lung, heart's blood, spleen and liver. In this case the symptoms had lasted only little longer than twenty-four hours. Weichselbaum had one case of primary lobar pneumonia in which numerous encapsulated pneumobacilli were present in the sputum and were found also, on the second day of the disease, in pure culture in the pneumonic exudate obtained by lung puncture. Death occurred on the fourth day. In one (No. 2) of Apelt's[2] cases, a blood culture taken on the second day of the disease and in another (No. 1) on the third day was positive. In one of the Massachusetts General Hospital cases (Autopsy 328) death occurred on the second day of the disease, too early to make a secondary infection probable, and at autopsy a pure culture of this organism was obtained from the lung and the heart's blood. In one of the Rockefeller Hospital cases[3] (No. 1919), a pure culture of Friedländer's bacillus was obtained by blood culture and lung puncture just before death on the fourth day of the disease. In one of the Massachusetts General Hospital cases (Autopsy 3329), this organism was obtained in pure culture from the blood during life on the sixth day of the disease. Death occurred on the seventh day. In addition, the gross and histologic character of the exudate and the clinical features and course, mentioned below, favor the independence of this form of pneumonia.

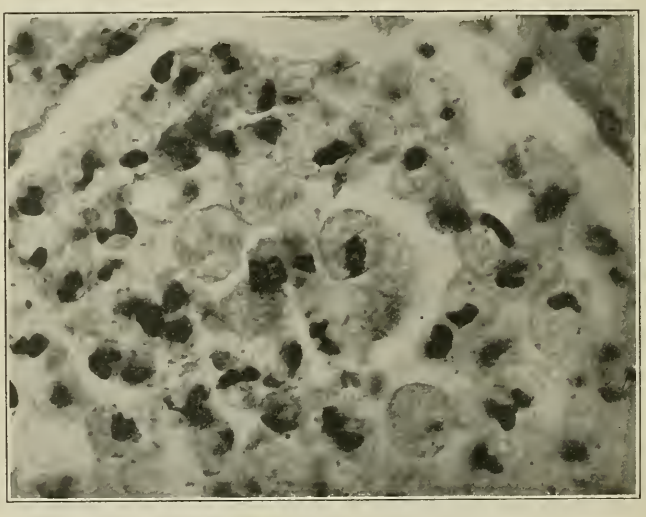
[1] I am indebted to Dr. Henry A. Christian for the privilege of using this case.

[2] Münch. med. Woch., April 21, 1908.

[3] I am indebted to Dr. Rufus Cole for the privilege of using his cases. Three cases of pneumonia with Friedländer's bacilli in the sputum have been observed at the Hospital of the Rockefeller Institute for Medical Research. In one case, Friedländer's bacilli mixed with other organisms were present in the sputum and the pus obtained from a lung abscess. Recovery followed operation by Dr. John A. Hartwell. In a second case a pure culture was obtained from the sputum, from material obtained by lung puncture and by blood culture. Death occurred on the fourth day. In the third case, Friedländer's bacilli, mixed with other organisms, were found in the sputum, but lung puncture and blood culture showed pneumococci and no Friedländer's bacilli. This case illustrates the danger of reliance on sputum examination alone for diagnosis.

Pathology.—Pneumonia seen in connection with infection with the pneumobacillus resembles that due to the pneumococcus in the lobar character of the process and the tendency of the infection to spare the pulmonary framework, as indicated by the absence of infiltration and thickening of the alveolar septa. It differs from ordinary pneumonia, however, in the less granular appearance of the section surface of the lung and the more viscid or mucoid exudate poor in fibrin. Softening of the pulmonary tissue with abscess formation occurs more frequently in this than in ordinary lobar pneumonia. Stühlern[1] noted abscess formation in the lungs in 2 (Cases 6 and 9) of 4 cases of pure infection with Friedländer's bacilli, Apelt[2] in 3 (Cases 1, 3, and 5) of 7 pure infections. Abscess formation was noted in none of the

Fig. 37



Friedländer's bacillus pneumonia. Alveolar exudate. × 1000.

6 pure infections at the Massachusetts General Hospital.[3] Thus abscess formation has been noted in 5 (27 per cent.) of 18 cases. It seems probable that such losses of pulmonary substance may be directly ascribed to the infection with the pneumobacillus. Other causes should, however, be excluded. In one case (Autopsy 1488) at the Massachusetts General Hospital, not included in this series, there was septicemia due to Friedländer's bacillus and organizing pneu-

[1] Centralbl. f. Bakt., 1904, 1te. Abth., 36, p. 493. [2] Loc. cit.

[3] Kokawa (Deut. Arch. f. klin. Med., 1904, lxxx, 39) found a cavity the size of a hazel nut in one of nine cases. The identity of the organisms in his cases was not established by culture. Isolated examples of abscess formation in connection with pulmonary infection by Friedländer's bacillus have been reported by Brinckerhoff (Med. and Surg. Rep. Boston City Hosp., 1901, S. 12), and Lenhartz (Nothnagel's Spec. Path. u. Ther., 1904, III, Bd. ii, 301).

monia with abscess formation involving parts of both lungs. J. H. Wright found actinomyces as a probable cause of the destructive pulmonary process. Anaërobic cultures should be made in these cases.

On histologic examination, the alveoli are found to contain an exudate of serum, red-blood corpuscles, pus cells and fibrin. The red-blood corpuscles are perhaps less numerous than in ordinary lobar pneumonia. The fibrin is less abundant. A striking feature of the exudate is the presence of varying and at times considerable numbers of large cells with a single, oval or round nucleus and vacuolated protoplasm. These cells are phagocytic for pigment, red-blood corpuscles, pus cells and the bacilli. In some parts of the sections these cells comprise a large part of the exudate. They are probably desquamated epithelial cells. Enormous numbers of encapsulated bacilli may be present in the exudate, both within and without the cells.

Symptoms.—In their symptoms of onset and course the cases present no distinctive clinical features. Herpes appears to be less frequent than in ordinary lobar pneumonia. An initial chill is usually absent. The onset is commonly acute with pain in the side, cough and dyspnea. Delirium is often observed. The sputum is blood-streaked, or rusty, or consists of almost pure blood. Its mucoid character is striking in some cases. Smear preparations of the sputum may show enormous numbers of Friedländer's bacilli and only few cells. The white count at entrance numbered 3400, 5000, 10,000 and 11,000 in four of the Massachusetts General Hospital cases, 28,000 in the case at the Peter Bent Brigham Hospital. In Brinckerhoff's[1] case it was 33,800. In the Rockefeller Hospital case (No. 1919) it was 21,900. As all these cases proved fatal, the white count cannot be regarded as having an important prognostic significance. The temperature is remittent or continuous. In general it may be said that the course of the disease is more severe than that of ordinary lobar pneumonia. A fatal termination may occur on the second or third day of the disease, which is unusual in ordinary pneumonia.

Complications.—Fibrinous pleuritis is constantly present. A serofibrinous or purulent effusion may be added. Meningitis, pericarditis, or endocarditis may occur as complications. The frequency of pulmonary abscess has already been mentioned. Septicemia occurred in all the Massachusetts General Hospital cases.

Diagnosis.—This cannot be made with certainty from examination of the sputum alone. Friedländer's bacilli may predominate in the sputum and yet the pulmonary process may be due to another cause. A pure culture of the organism obtained from material secured by lung puncture is the most conclusive clinical evidence of Friedländer's bacillus pneumonia. Positive blood cultures indicate a general infection.

[1] Loc. cit.

Prognosis.—The mortality is very high. No well-established instance of lobar pneumonia due to pure infection with Friedländer's bacillus is known to have recovered.

Treatment.—This is the same as for ordinary lobar pneumonia. Pulmonary abscess complicating Friedländer's bacillus pneumonia should be treated on the principles outlined in the section on Abscess and Gangrene.

CHAPTER XII.

PSITTACOSIS.

Psittacosis (from ψίττακος parrot) is a term applied[1] to severe acute infections occurring for the most part as house epidemics and thought to be due to transmission from diseased parrots to man. In parrots the disease is characterized by the occurrence of chronic enteritis with diarrhea and foul odor to the fecal material. The birds become apathetic and somnolent, the wings droop, the appetite is lost and death occurs with convulsions. Pneumonia is not observed. In man the disease has been characterized as a severe typhoidal condition with atypical pneumonia. No conclusive evidence of transmission from parrots to man has yet been produced. Bacteriologic studies have not served to establish any direct relation between diseased birds and infection in man, and the independence of this disease is doubtful. Leichtenstern[2] critically reviewed the literature.

Bacteriology.—Eberth[3] in 1880 found micrococci in the internal organs of a gray parrot. Wolff[4] in 1883 investigated 12 parrots for the purpose of explaining the high mortality among the birds imported into Europe in large numbers from the West Coast of Africa. Micrococci were found in almost all the organs. Nocard[5] in 1893 constantly succeeded in isolating a bacillus from the bone-marrow of parrots which had died on the way from Buenos-Ayres to Havre. This organism he described as a short, rather thick, motile bacillus, with rounded ends. Growth took place on all the usual solid and fluid media of a neutral or slightly alkaline reaction under aërobic and anaërobic conditions; lactose was not fermented, milk was not coagulated, and gelatin was not liquefied. The bacillus decolorized by Gram's method of staining. Feeding experiments and subcutaneous inoculation of parrots, pigeons, hens, mice, rabbits and guinea-pigs caused death from "hemorrhagic septicemia." Pure cultures of the organism could be recultivated from all the organs. Three years later Gilbert and Fournier[6] found a bacillus similar to that described by Nocard, in the heart's blood, the spleen, and the bone marrow in one parrot dying after several days of abundant diarrhea.

[1] Morange (De la psittacose ou infection spéciale déterminée par les perruches, Thèse de Paris, 1895).

[2] Centralbl. f. allg. Gesundheitspflege, 1899, xviii, 241.

[3] Virchow's Arch., 1880, Bd. lxxx, p. 311.

[4] Ibid., 1883, Bd. xcii, p. 252.

[5] Conseil d'hygiène publ. de la Seine, 24 mars, 1892, Annexe, B., p. 14.

[6] Sur un mémoire de MM. les Drs. Gilbert et Fournier (Contribution à l'étude de la psittacose) au nom d'une Commission composée de MM. Nocard et Debove, rapporteur, Bull. de l'Acad. de Méd., 1896, 3 S., 35–36, 429.

In one instance Gilbert and Fournier demonstrated Nocard's bacillus in the heart's blood at autopsy in one of Mathieu's[1] patients with psittacosis. Examination of the sputum, pleural fluid and blood obtained by puncture of the spleen, three days before death, had previously been negative. According to their observations, Nocard's bacillus resembled the colon and typhoid bacillus, but differed from the latter in the appearance of the growth on potato and gelatin and its extreme virulence for laboratory animals. The organism was agglutinated, but without loss of motility, by the serum of a patient with typhoid in a dilution of 1 to 10. Nicolle[2] found that in one case the blood serum of a patient with psittacosis agglutinated Nocard's bacillus in dilutions of 1 to 50 and 1 to 60. This same serum was active against the typhoid bacillus at 1 to 30, but inactive against the colon bacillus. In a second case the blood serum agglutinated Nocard's bacillus on one occasion in a dilution of 1 to 10, but was inactive against the other organisms. In a third case, the serum produced no agglutination with the three organisms. Others[3] have failed to confirm Nocard's and Gilbert and Fournier's findings.

Investigation by Netter of the pneumonic exudate from patients with the disease showed the diplococcus pneumoniæ. Rendu and Triboulet found the diplococcus pneumoniæ and staphylococci in the pneumonic sputum. Hallé found colon bacilli in the sputum of one patient and diplococcus pneumoniæ in another by mouse inoculation. Weinberg demonstrated diplococcus pneumoniæ and staphylococcus in the sputum (quoted from Leichtenstern.). Czaplewski investigated Leichtenstern's fatal case, finding streptococcus mixed with other organisms in the lung. He came to the conclusion that the parrot did not die from infection with Nocard's psittacosis bacillus, and that no conceivable etiologic connection could be recognized between the disease of the parrot and the illness of those in the house. He adds however, that the possibility of an infectious disease of parrots transmissible to man cannot be denied.

Epidemics.—Small outbreaks affecting several members of a household and ascribed to contagion from parrots were reported by Ritter,[4] Ost,[5] and Wagner.[6] In Paris, during the year 1892, following a large importation of parrots from Buenos-Ayres, there were 49 cases with 16 deaths. In 1893, there were 7 cases with 5 deaths; in 1894, 2 cases both of which recovered; and from 1895 to 1896, 12 cases with 3 deaths. In the winter of 1894 and 1895, house epidemics, described by Banti

[1] Gaz. des Hôp., 1896, 13 et 15 août.

[2] Sérodiagnostic de la psittacose, Mém. de la Soc. de Biol., 1898, p. 1171.

[3] Achard and Bensaude (Presse méd., 25 Nov., 1896, p. 639) found an organism identical with Nocard's bacillus in the urine from a patient with a condition suggesting typhoid, and in another case in the purulent contents of an inflammation of the right sternoclavicular joint.

[4] Correspondenz-Blatt f. Schw. Aerzte., 1879, 9, p. 576.

[5] Ibid., 1883, p. 424.

[6] Deut. Arch. f. klin. Med., 1884, xxxv, 191, and ibid., 1888, xlii, 411.

and Malenchini and by Palamidessi,[1] occurred in Florence and Ponto. In 1896, Haedke[2] observed a house epidemic in Stettin. In 1897,[3] cases were reported in Genoa, and in 1898[4] in Bernay in the North of France. Leichtenstern observed house epidemics in Cologne during 1898. In one epidemic there were 10 cases with 4 deaths, and in a second 8 cases with 1 death. In 1904, Vickery and Richardson[5] reported 3 cases of probable psittacosis with recovery.

The usual experience has been that several members of a household in close contact with a sick parrot have been taken ill almost simultaneously, the explosive character of the outbreak thus suggesting contagion from a common source rather than from person to person. The occurrence of outbreaks in numerous houses to which parrots had been delivered in different parts of Paris during the epidemic of 1892 lends support to the view that the infection was transmitted from them to man. The infrequency of the disease compared with the innumerable opportunities for contagion among ship's crews, bird handlers and lovers of pets is against it.

Pathology.—The number of cases in which postmortem findings are reported is too small to permit of a conclusion concerning the type of the pneumonic process. In Ritter's[6] 3 cases, the condition was described as "lobular, serous-croupous pneumonia." Gastou[7] found total lobar pneumonic infiltration. The cut surface was of firm consistency, dark bluish red, moist and smooth. In Leichtenstern's case the pneumonia was cellular and fibrinous.

Symptoms.—The incubation period appears to be from one to three weeks. The onset is usually acute, at times insidious. A chill or chilliness commonly initiates the attack. The temperature is quickly elevated and continuous or remittent, lasting from eight days to three weeks. Defervescence is usually by lysis, at times by crisis. At onset there is severe prostration. Headache is constant. The appetite is lost. Vomiting is seldom observed. Constipation is more common than diarrhea, in contrast to the disease in parrots. Cough is present from the outset. Delirium, apathy, and stupor were frequent among the Paris cases. Dyspnea, pain in the side, and cyanosis are likely to occur with pneumonia, the development of which is usually insidious, but may be acute, as in typical croupous pneumonia. The sputum may be absent, mucoid or rusty. On examination there are signs suggestive of lobular or lobar pneumonia. In some cases evidences of consolidation may be lacking. Herpes is absent. In rare instances a roseola-like eruption and petechial spots have been noted. The spleen is usually enlarged. In Leichtenstern's cases, delirium was usually absent, diarrhea was noted in several cases and the spleen was not found to be enlarged. Convalescence was protracted.

[1] Leichtenstern, loc. cit.
[2] Deut. med. Woch., 1898, xiv.
[3] Lancet, 1897, p. 1058.
[4] Leichtenstern, loc. cit., p. 271.
[5] Trans. Assoc. Amer. Phys., 1904, xix, 364.
[6] Loc. cit.
[7] Quoted from Leichtenstern, loc. cit., p. 264.

Diagnosis.—Aside from the occurrence of atypical pneumonia from apparent contact with diseased parrots, there are no distinctive features. The clinical aspects and course are similar to those seen in bronchopneumonia and atypical lobar pneumonia at times observed without relation to possible infection from birds.

Prognosis.—Among 91 reported cases there were 29 deaths, a mortality of 31.8 per cent. The pneumonia appears to be principally concerned in the fatal termination.

Prophylaxis.—The connection between disease in parrots and man can neither be affirmed nor denied. Intimate contact with diseased parrots must, however, be regarded as highly undesirable and is to be avoided by preventing their sale and their removal from the house, if they become ill after purchase. In addition, it is desirable that recently imported parrots be held in quarantine before they are offered for sale.

Treatment.—This is that of ordinary pneumonia.

CHAPTER XIII.

BRONCHOPNEUMONIA.

In this form there is an inflammation of the bronchi, the terminal bronchioles and the adjacent or the terminal air vesicles, hence the term *bronchopneumonia*. Because of its almost constant origin in bronchial catarrh, it is also called catarrhal pneumonia. Involvement of the lobules rather than the entire lobe, justifies the term lobular in contradistinction to lobar pneumonia. Inasmuch as capillary bronchitis is invariably associated with inflammatory changes in the lung, it cannot be regarded as having an independent existence, and is included among cases classed as bronchopneumonia. Tuberculous bronchopneumonia represents an important group.

Historical Note.—Bronchopneumonia was not sharply differentiated from other affections and given an independent place by the older writers. The failure to describe it as an important complication of measles indicates, as Jürgensen[1] suggests, that it was not well understood. Even Laënnec[2] did not definitely separate bronchopneumonia from other affections, but refers to small, scattered areas of pneumonic infiltration complicating "suffocative catarrh," and cites as an example a case of Andral's.[3] Barthez and Rilliet[4] were the first definitely to separate catarrhal from croupous pneumonia. Bartels'[5] description of the gross pathologic findings and clinical features of catarrhal pneumonia complicating measles was an important contribution.

Frequency.—This varies with the age of the patients. In infancy and up to about two years of age a great majority of the cases of *primary* pneumonia are of this type. Thus, of 322 cases of primary pneumonia observed by Holt[6] during the first two years of life, there were 242 (75 per cent.) of bronchopneumonia and 80 (25 per cent.) of lobar pneumonia. In later childhood and in adult life the frequency of bronchopneumonia diminishes, while that of lobar pneumonia increases. Of 2459 cases of pneumonia at the Massachusetts General Hospital, where children form only a small proportion of the total admissions, the clinical diagnosis of bronchopneumonia was made 339 times (13 per cent.) during the seventeen years from 1897 to 1914, while the cases of lobar pneumonia number 2120

[1] Handb. d. spec. Path. u. Ther. Ziemssen., 1874, v, 184.
[2] Traité de l'auscultation méd., T. i.
[3] Clin. méd., T. ii, observ. 46.
[4] Traité clinique et pratique des maladies des enfants, Paris, Baillières, 1853, 2d éd.
[5] Virchow's Arch., 1861, Bd. xxi, p. 65.
[6] Diseases of Infancy and Childhood, 1903, 2d ed., p. 525.

(86 per cent.) during the same period. During both childhood and adult life nearly all the cases of *secondary pneumonia* are of this type, and the disease is actually much more frequent than figures based on clinical statistics alone seem to show. Among 3000 autopsies at the Massachusetts General Hospital the number of cases showing bronchopneumonia outnumber those with lobar pneumonia, there being 273 of the former and 211 of the latter.

Etiology.—The two sexes are about equally affected. As with lobar pneumonia, cases of bronchopneumonia are more frequent during the colder months of the year. The previous condition of the patients is a variable factor, but it may in general be said that the disease is more common among the poorer classes, in patients who are undernourished and where there is overcrowding and bad ventilation. Premature infants, the inmates of infant asylums, and the subjects of rickets, syphilis, or infantile diarrhea are not infrequently attacked.

The influence of exposure is difficult to estimate, and while it cannot be regarded as a cause of the disease, yet in patients with an existing respiratory infection, it seems probable that sudden chilling of the surface of the body may be a contributing factor in aggravating the infection and leading to invasion of the lung.

Primary acute bronchopneumonia is essentially a disease of childhood and the first three years of life, and may attack children in previous good health or debilitated subjects. Of 443 cases of bronchopneumonia observed by Holt in infants and young children, 164 were primary. After the age of four, primary bronchopneumonia must be very uncommon. Of 195 cases of bronchopneumonia which have come to autopsy at the Massachusetts General Hospital,[1] only 14 represent the primary form of the disease, and all were four years of age or under. I have never seen a case in which a healthy adult has been stricken with pneumonia unpreceded by bronchitis in which at autopsy the condition was proved to be uncomplicated bronchopneumonia.

Secondary bronchopneumonia occurs more frequently during childhood than in adult life, but is met at all ages, and is not infrequent in the aged. The conditions to which the bronchopneumonia is secondary may be divided into three groups.

1. *Cases Complicating or following the Acute Infections.*—In childhood, measles, whooping cough, and diphtheria are responsible for the largest number of cases, and a considerable proportion of the deaths in these diseases is due to bronchopneumonia. Infection of the lungs secondary to bronchitis of the larger tubes is also a common method of origin. Bronchopneumonia also occurs as a complication of infantile diarrhea, scarlet fever, smallpox, erysipelas, and varicella.

In adults, the disease is most commonly secondary to a preexisting infection of the air passages and is not infrequent in the more

[1] Where children comprise only a small proportion of the total admissions.

severe types of acute bronchitis. It also occurs as a recurrent infection in bronchiectasis, chronic interstitial pneumonia and pulmonary abscess. Empyema breaking through into the lung may also be a cause. Lobar and bronchopneumonia at times coexist as found at autopsy in six of the present series. Bronchopneumonia may complicate pulmonary tuberculosis.

Abdominal suppuration is frequently complicated by bronchopneumonia which may arise by direct extension or by metastasis. In fatal cases in adults, peritonitis occupies a prominent place as a cause and was found in 35 out of 195 cases. The source of the peritonitis is probably of little moment, and may be local or general. Bronchopneumonia may arise in the course of all forms of meningitis, in endocarditis, pericarditis, otitis media, endometritis, metritis, salpingitis, parotitis, infections of the urinary tract, and other infections. It occurs in typhoid and usually as a terminal event.

Obstruction of the bronchi by pressure from without of malignant growth or aneurysm may lead to the retention of bronchial secretion, secondary infection and purulent bronchitis, bronchiectasis, and bronchopneumonia. Partial occlusion of a bronchus by a new growth springing from the bronchial wall may lead to similar changes. In one of the present series (Autopsy 2503), a small adenocarcinoma of the left primary bronchus gave rise to bronchiectasis and chronic inflammatory changes with abscess formation in the left lung and acute bronchopneumonia of the right lower lobe.

2. *Cases Occurring in Debilitating Conditions.*—Debilitating conditions of various sorts are often complicated by bronchopneumonia, especially as a terminal infection. The later stages of malignant disease, broken cardiac compensation, chronic nephritis, cerebral hemorrhage, brain tumors, pernicious and severe secondary anemia, leucemia, exophthalmic goitre, diabetes, and other diseases may be thus complicated.

3. *Aspiration Pneumonia.*—The experiments of Traube[1] showed that the pulmonary changes following section of both vagus nerves were due to the entrance of buccal secretion into the air passages. The consequent insensibility of the larynx results in the inhalation of food, drink or septic material into the lungs, and an intense and even gangrenous bronchopneumonia. Such an aspiration or deglutition pneumonia may occur when the larynx is insensitive, as in intoxication with alcohol, ether, or chloroform, in the stupor or unconsciousness of apoplexy, uremia, meningitis, cerebral hemorrhage or submersion. The danger is increased when there is already an infection of the respiratory tract, when vomiting occurs in a semiconscious patient, or when following an abdominal operation there is a suppression of expulsive efforts to free the air passages of foreign particles. This form of pneumonia is not uncommon following operations about

[1] Ges. Beitr. z. Path. u. Physiol., 1846, Bd. i.

the nose or mouth, the removal of adenoids, with cancer of the larynx or esophagus, and after intubation or tracheotomy. The aspiration of a foreign body into the lung is almost invariably followed by bronchopneumonia unless the body is at once removed.

Bronchopneumonia may follow the aspiration into near-by or remote parts of the lung of pus from a bronchiectatic cavity, a focus of abscess or gangrene or an empyema rupturing into the lung. A tuberculous bronchopneumonia may follow the inhalation of blood during hemoptysis.

Bacteriology.—One organism was found as the apparent sole cause of the primary or secondary bronchopneumonia in infants or adults, usually in more than one-half of the cases, by Weichselbaum,[1] Karlinski,[2] Neumann,[3] Queisner,[4] Netter,[5] Wright and Stokes,[6] Kreibich,[7] Dürck,[8] Wollstein,[9] and others. The pneumococcus and streptococcus were the most common single invaders and a smaller number of cases showed the staphylococci and Friedländer's bacillus. The influenza bacillus may readily be overlooked unless carefully sought. The micrococcus catarrhalis has received little attention, but is apparently also the occasional sole cause of bronchopneumonia as in the cases reported by Ghon, Pfeiffer and Sederl.[10] When these organisms are taken into account, it seems to be true of bronchopneumonia, both in infancy and adult life, whether primary or secondary, that mixed infections are the rule, and that to no one infecting agent can the disease be especially ascribed. Pure cultures, even when the sputum is collected with great care, are relatively uncommon, and although now one and then another organism may predominate in single specimens, yet in the presence of a mixed infection, the observer must remain in doubt as to the relative importance of any one group of bacteria. The diphtheria bacillus is to be reckoned with in the bronchopneumonia secondary to diphtheria, and was found in 52 of 128 cases of bronchopneumonia by Pearce.[11] It was unassociated with other organisms in 17 cases. Pulmonary infection with diphtheria bacilli may also be primary. Persistent infection of the lung with diphtheria bacilli may occur. Petruschky[12] found diphtheria bacilli in the expectoration of one patient three years after diphtheria. Physical examination was negative. In Schmidt's[13] case in which the original infection probably occurred ten years previously, organisms morphologically and culturally like diphtheria bacilli were present in the mucopurulent sputum in pure culture. Examination of the

[1] Wiener. med. Jahrb., 1886, lxxxii, 483.
[2] Fort. d. Med., 1889, vii, 681.
[3] Jahrb. f. Kinderh., 1889–90, xxx, 233.
[4] Ibid., p. 277.
[5] Arch. de méd. exp., 1892, iv, 28.
[6] Boston Med. and Surg. Jour., 1895, No. 14, vol. cxxxii.
[7] Beiträge z. klin. Med. u. Chir., 1896, H. 13.
[8] Deut. Arch. f. klin. Med., 1897, vol. lviii.
[9] Jour. Exp. Med., 1901–05, vol. vi.
[10] Zeit. f. klin. Med., 1902, vol. xliv.
[11] Boston Med. and Surg. Jour., December 2, 1897.
[12] "Gesundheit," 1912, Nos. 1 and 2.
[13] Münch. med. Woch., January 7, 1913.

lungs suggested chronic interstitial pneumonia. The organisms were avirulent. Infection with pest bacilli also occurs.

Thus far the attempt to correlate the clinical picture with the cultural findings has failed, and in their symptoms of onset, clinical course and termination, there seems to be no striking or constant difference in the various single or multiple groups of infection.

A general infection is present in a majority of the terminal bronchopneumonias.

Experimental Bronchopneumonia.—Wollstein and Meltzer[1] find that intrabronchial insufflation of dogs with pure cultures of the streptococcus or of the influenza bacillus produces bronchopneumonia and not lobar pneumonia. Pneumococci produce lobar pneumonia, as shown by Lamar and Meltzer,[2] and Wollstein and Meltzer.[3]

Pathogenesis.—Atelectasis was regarded by Bartels as an important feature of the origin of bronchopneumonia, but it is difficult to understand how it can play any essential part in the production of the disease, and it seems to be regarded rather as a consequence than as a cause. Its frequent occurrence may be ascribed to occlusion of the bronchial lumen by swelling of the mucosa. The air imprisoned in the involved region is then partly absorbed and partly expelled by succeeding expirations with or without the favoring influence of expulsive efforts with cough, while its renewal is prevented by the bronchial obstruction and the deficient force of inspiration. The essential factor in the disease, irrespective of the occurrence of atelectasis, seems to be the direct extension of an infective agent downward, along or through the walls of the bronchi. Collapse of the alveoli may precede or accompany the process, or it may be absent.

Pathology.—Gross Appearance.—Atelectasis is a frequent forerunner or accompaniment of bronchopneumonia in infants. In the early stages of the disease, the posterior inferior margins of the lungs are involved, and later the anterior and upper marginal portions as well. In some cases an airless strip of lung tissue from 1 to 2 inches wide is found to extend from the base toward the apex on the posterior aspect of the lung, and bounded both toward the spine and the axilla by air-holding tissue. In rare instances, a considerable part or even the whole of one lobe or one lung may be atelectatic. Collapsed areas are bluish, dark blue, blue black or violet in sharp contrast to the pale red of the neighboring and uninvolved parts, of diminished volume, and hence depressed below the level of the neighboring pulmonary surface, firm to the touch, and on section, are found to contain only a small amount of dark blood. Crepitation is absent. If the collapse is recent and still uninflamed, it is capable of reinflation by means of a blow pipe inserted into the bronchus, and then resumes the normal pale red color and former volume. But

[1] Jour. Exp. Med., 1912, xvi, 126.
[2] Ibid., 1912, xv, 133.
[3] Ibid., 1913, xvii, 353.

if already the site of bronchopneumonic infiltration, it is at first only partially and later not at all reinflatable.

Bronchopneumonic areas are usually bilateral, often symmetrically placed and commonly involve the lower lobes, although they may be found at any place in the lung. Of 85 cases studied at the Massachusetts General Hospital,[1] the lower lobes were predominantly affected, the left lobe being involved 45 and the right 54 times. In the superior lobes, the process was found on the right side in 30 cases and on the left in 24. The middle lobe of the right lung showed the smallest number of infections being involved in 14 instances.

Infiltration of an atelectatic region may be indicated by a dark red color, the presence of a dark red serum and greater difficulty in reinflation. Patches of bronchopneumonia may appear within the collapsed tissue or in parts of the lung not so involved, and atelectasis is not a necessary feature of the process. The bronchopneumonic patches can be felt as hard, solid, round or nodular areas within the tissue. Crepitation is absent. They are usually multiple, and when discrete, vary in size from that of a pin's head to a pigeon's egg or larger, and are at first reddish brown and firm, later, grayish red or pale gray and friable. Over peripheral areas, the pleura may be slightly turbid and granular and show minute hemorrhages. On section, the bronchopneumonic patches project slightly above the level of the neighboring lung, are more or less sharply circumscribed about a central bronchus from which a small amount of tenacious purulent fluid can be expressed, and present a smooth non-granular surface. The section surface exudes a white or gray purulent fluid on pressure. When the ramifications of the bronchi are cut and followed into the involved territory, the patches of bronchopneumonia are found to be lateral or terminal in respect to their relation to the bronchial divisions. Early in their development, scattered areas of bronchopneumonia may appear as minute grayish-yellow, tubercle-like granulations when seen through the pleura. Isolated larger areas are separated by uninflamed tissue, but confluent bronchopneumonia may lead to tolerably compact, homogeneous infiltration, resembling lobar hepatization. The infiltration is, however, less uniform than in croupous pneumonia, dark bands of collapsed tissue or strips of air-holding and crepitant alveoli may intervene between the infiltrated areas, the section surface is smooth rather than granular, fibrin is scanty or absent, and on microscopic examination a less uniform appearance is presented.

Emphysema is frequently found at the margins of the lung or in the neighborhood of the infiltrated areas. Subpleural and interstitial emphysema is only rarely seen. In acute cases, the bronchial mucous membrane is reddened, injected and swollen. The bronchi contain

[1] Lord. Infections of the Respiratory Tract with Influenza Bacilli and Other Organisms. Their Clinical and Pathological Similarity and Confusion with Tuberculosis, Boston Med. and Surg. Jour., May 11 and 18, 1905.

a mucopurulent or purulent secretion, and the evidences of bronchial inflammation can be followed to the finest ramifications of the air passages. In long-standing and severe cases, the bronchi and bronchioles may be dilated. The pleura is much less frequently involved with bronchopneumonia than with lobar pneumonia. Over atelectatic areas the pleura may be normal or slightly clouded. Overlying bronchopneumonic areas there may be fibrinous, serofibrinous or purulent pleurisy. The bronchial glands are usually enlarged, soft and red.

Microscopic Examination.—In the centre of the involved area is a bronchus or bronchiole with its lumen plugged with pus cells. Its wall is swollen and partially or wholly stripped of epithelium, and may be irregularly dilated. In the absence of epithelium, the bronchiole may be recognizable as such only from the presence of isolated circularly disposed muscle fibers and elastic tissue. The wall of the bronchiole is infiltrated with leukocytes. The walls of the neighboring alveoli are swollen, the capillaries are distended with blood, and the alveolar lumen contains leukocytes and desquamated and swollen epithelium. Red blood corpuscles are absent or present only in small numbers. Fibrin is present, but much less abundantly than in croupous pneumonia. The inflammatory process is most intense in the immediate neighborhood of the bronchial ramifications, while toward the periphery of the infiltrated area the exudate is less cellular. In older processes the cellular elements may show fatty degeneration. Softening of isolated alveolar spaces may lead to the production of small miliary abscesses, and infiltration of the involved parts with connective-tissue cells may give rise to focal or diffuse induration.

Pathologic Similarity of the Different Infections.—Most cases of bronchopneumonia are due to mixed infection with two or more organisms, as is shown by the results of cultures taken at the autopsy and the staining of sections for bacteria. Neither in the cases of mixed infection with different organisms, nor in those in which one group of bacteria predominates, is it possible to note any striking or constant difference in the character, extent or intensity of the bronchopneumonic process.

Results of Bronchopneumonia.—In many cases, the exudate is absorbed or expectorated, and the condition ends in symptomatic recovery. The conclusion is not always so favorable, and the pathologic study of fatal cases offers an explanation of the occasional persistence of symptoms and physical signs after the acute infection has subsided. Gangrene may develop but is uncommon. Abscess formation is not infrequent in fatal cases. Both abscess and gangrene occur more frequently in the aspiration and deglutition forms of bronchopneumonia.

Among 85 cases of bronchopneumonia coming to autopsy, abscesses of varying extent were present in 16 (macroscopic in 10, microscopic in 6). Doubtless in many instances small losses of pulmonary substance are capable of complete cicatrization. There is a compensatory

expansion of adjacent parts and restoration of the lung to complete functional integrity. In other cases, small pulmonary defects may never be fully repaired and remain as permanent pockets for the development of bacteria. An increase in the interstitial tissue is a frequent finding in the more subacute or chronic cases of bronchopneumonia. The formation of fibrous tissue takes place from the interalveolar septa, the interlobular, peribronchial, and perivascular tissue. In this series, pulmonary induration was found in 31 cases (macroscopic in 12, microscopic in 19). In 8 of the 85 cases there were well-marked localized abscesses, pulmonary induration or both.

The superior lobes or the apices are not infrequently the site of abscess formation, fibrous induration or both, in consequence of prolonged or recurrent bronchopneumonia, and the clinical aspect may then closely resemble tuberculosis. Thus, in 4 of the 8 cases, the superior lobes were involved. In one case there was an area of fibroid tissue at both apices, the left apex containing an irregular cavity about 1 cm. in greatest diameter, with trabeculated walls lined with mucous membrane, which was apparently continuous with a small bronchus. In a second case, the greater part of the anterior portion of the superior lobe of the left lung was transformed into an irregular cavity containing dirty, reddish-brown, foul material, lined with a firm membrane and surrounded by indurated tissue. In a third case, the superior lobe over a large part of its extent, especially the superior and posterior part, was resistant, diminished in size and extensively transformed into a blackish, grayish, fibrous-like tissue of a very tough consistency, and showing on section an increase of connective tissue and obliteration of the alveoli. In the last case, the right superior lobe was of almost board-like hardness, and on section, finely granular, pale and grayish. On microscopic examination, a small abscess cavity was found in one of four preparations and increase of connective tissue. In all of these cases, on gross inspection of the involved regions, the inspection of thin sections made with the knife and microscopic examination of material from the abscess wall or the areas of most advanced interstitial changes, there was no evidence of tuberculosis.

Cylindrical bronchiectasis may develop early in the course of bronchopneumonia as a result of infection of the bronchial wall and violent expulsive efforts with cough. This is more likely to occur in whooping cough. Bronchiectasis develops more frequently, however, in association with abscesses and chronic interstitial changes in the lung after long-standing infection. Dilatation of the terminal bronchioles may occur in connection with bronchitis, bronchiolitis, and bronchopneumonia. In some cases the condition may be fitly described as "honey-comb" lung.

A tuberculous bronchopneumonia may develop in the course of simpler infections of the respiratory tract, and is not very infrequent following measles or whooping cough. It is, of course, possible that

a tuberculous process may be engrafted on a simpler infection, but it is more probable that such processes are tuberculous from their inception, a latent and inactive pulmonary or glandular tuberculosis becoming active under the stimulus of the acute infection.

Symptoms.—The *primary* form of bronchopneumonia is common in infants, but is rarely seen in adults. The onset is abrupt and may be accompanied by a chill, a convulsion, by vomiting or pain in the side. Cerebral symptoms may be a prominent feature. A history of antecedent bronchitis is lacking. The temperature remains constantly high and usually terminates abruptly by crisis. Examination of the lungs may be negative or there may be signs of catarrh of the finer tubes, or of consolidation. The disease is rarely fatal. Recovery is prompt and there is no tendency to relapse. The clinical features are those of lobar pneumonia.

In the *secondary* form of bronchopneumonia, the onset is rarely abrupt or with a chill. The child is perhaps convalescing from measles or whooping cough, but the bronchial catarrh still persists, and after a day or two of indisposition and indefinite symptoms, has fever, rapid pulse, and very rapid respiration. There are copious sweats and marked prostration. The progress of the affection is then rapid, and the cough becomes more and more frequent, hard, painful, and exhausting. The child is sleepless, restless, and fussy. The pulse may rise rapidly and be scarcely perceptible at the wrist, and the respirations become 80 or more to the minute. The child's face and hands are very hot and the tongue is dry. The thirst is extreme. Vomiting is not infrequent and there may be constipation or diarrhea. Dyspnea soon becomes a most prominent and distressing feature. The child may rapidly become apathetic and rouses himself and cries only during a paroxysm of cough or in a momentary effort to breathe. As the urgency of the initial symptoms abates, and the apathy deepens, paroxysms of cough and spasmodic efforts to breathe are less frequent. Signs of deficient aëration become manifest and progressively increase. The face, lips, and fingers become more and more cyanotic. The pulse becomes more and more feeble, the respiration more shallow. Pallor may give place to cyanosis. The extremities become cool, tracheal rales are heard, and death from asphyxia may occur within twenty-four hours of the onset. Death may occur in coma or with convulsions or come more slowly. In infants dying within twenty-four hours of the onset, atelectasis alone may be found in the lungs. Older children succumb less rapidly and a fatal termination may be delayed for some days to several weeks. In more favorable cases, recovery may slowly take place, but convalescence is likely to be interrupted by relapses and the patient may be much reduced in weight and strength.

In adults and in the milder types of infection in children, the lungs are usually invaded by extension from the bronchi. The initial symptoms are those of an acute bronchitis on which the pulmonary process

is insidiously engrafted or its onset is indicated by an accession of existing symptoms. A chill is uncommon, and the pleural pain of lobar pneumonia is often absent. The pulse and respiration may become more rapid and there may be an increase in the intensity of the cough, dyspnea or cyanosis. Herpes is rarely observed. The sputum presents no characteristic features and may become more or less abundant after the onset of the pneumonic process. It is usually made up of discrete, greenish-yellow, purulent masses surrounded by mucus and is at times streaked with blood, but the rusty sputum of lobar pneumonia is not observed.

The temperature curve is not characteristic. Fever is usually present and may be higher than its previous level. In any case with the clinical features of bronchitis in which the fever persists beyond a few days, the presence of bronchopneumonia should be suspected even though there are no signs of solidification. The temperature may be only slightly elevated, is often irregular with morning remissions and evening exacerbations. A range of from 102° to 104° is not uncommon. It may be normal in the morning and elevated at night. In severe cases it may remain elevated for weeks, and its persistence may always be taken to indicate that the infection is still an active one. Defervescence is usually by lysis. Sweating is frequently noted during the disease. The temperature may remain normal for a few days, to be followed by a recurrence of fever for a variable period.

The blood usually shows a leukocytosis.

Physical Signs.—There may be no positive indications whatever of involvement of the lung. This is more especially the case in rapidly fatal infections in children and in the later terminal bronchopneumonias in debilitated subjects in whom death may take place before any definite physical signs appear. A severe diffuse bronchitis may so mask the signs of bronchopneumonia, as to make it impossible to detect, or the process may be so small as not to be discoverable even under the most favorable circumstances.

On inspection, in severe cases with extensive involvement, respiratory motion is frequent, short, and superficial, and may be noted to be restricted locally over those parts most affected. Thus when one or both lower lobes are the site of the process, the upper portions of the lungs on the same or on both sides may be more mobile. With wide-spread collapse or with capillary bronchitis and bronchopneumonia, especially in infants with elastic thoracic walls, there may be marked inspiratory retraction of the lower sternal region and the costal margin in consequence of the deficient expansion of the lower lobes. The cervical veins may be swollen from congestion in the pulmonary circuit. Pulmonary collapse in the neighborhood of the heart may increase the area of visible cardiac pulsation, or pulmonary inflation may diminish it.

The recognition of an initial collapse of the lung is difficult or

impossible. A change in the contour of the lower boundary of the lung outlined by percussion, relative dulness with a slightly tympanitic quality and diminished respiration without rales are suggestive evidence. A disappearance of these signs with the appearance of fine crepitations after a deep inspiration is the only positive indication.

On auscultation, rales are the most constant finding in cases with bronchopneumonia, and vary in their character and distribution with the nature and extent of the process. An accompanying bronchitis of the larger or smaller tubes may be indicated by sonorous or sibilant dry rales, or by fine, medium or coarse non-consonating moist rales. Involvement of the lung may modify the character of the moist rales and make them more clear cut, sharp, and distinct, of the so-called consonating quality, from which alone and without other signs, the existence of pulmonary invasion may be suspected. This distinction between the non-consonating rales of bronchitis and the consonating rales of pulmonary consolidation is sufficiently obvious in certain cases to make it of value in diagnosis, but it is often difficult or impossible of appreciation. The persistence of rales at one place in the lung may also be taken as probable evidence of pulmonary changes in the involved region.

Bronchial breathing may be present without dulness if the consolidation is centrally placed. It may be necessary to ask the patient to cough, and thus free the bronchi of secretion in order to bring it out. The whisper may be increased and have a bronchial quality. Increase of voice and tactile fremitus may also be noted.

Dulness may or may not be present. Owing to the resonance of the chest in children, slight changes in the note may be difficult of appreciation. Light percussion with a short, sharp, quick stroke is more likely to lead to the detection of changes from superficial areas, while heavy percussion may be needed for central areas. The percussion note over different parts of the chest in the neighborhood of a suspected area should be carefully compared as well as over symmetrical parts of the two sides in order to avoid error in case the consolidation is bilateral.

Considerable variation in the physical signs is observed from day to day. Plugging of the bronchi with tenacious secretion may lead to the apparent disappearance of a small focus, which later reappears. The invasion of new and nearby or remote territory is not infrequent. The extent of the process varies from areas no larger than the bell of the stethoscope to the involvement of the greater part or the whole of one or more lobes. With numerous and closely aggregated or confluent areas the dulness, bronchial breathing, increase of voice, whisper and tactile fremitus may be as marked as with lobar pneumonia.

Complications and Sequelæ.—Bronchopneumonia is invariably accompanied by bronchitis, and laryngitis is not uncommon, especially when the disease complicates diphtheria or measles. There may then

be hoarseness, aphonia, and severe dyspnea of the inspiratory type. A fatal laryngeal stenosis may be the result. Croupous pneumonia may coexist, and even at autopsy it may be difficult to differentiate between confluent bronchopneumonia and lobar pneumonia. A slumbering tuberculous process may be awakened into activity. Pleuritis is less common than with lobar pneumonia, but fibrinous, serofibrinous or purulent forms occur and may be difficult of recognition. Pneumothorax is rare, as are also pericarditis and endocarditis.

It is not very uncommon for an acute bronchopneumonia to initiate a persistent pulmonary infection, as already mentioned under Pathology. A persistent cough, with or without purulent sputum, may be the only symptom, and physical examination may fail to detect the site of the pulmonary process. Emphysema is likely to complicate the chronic infections.

The subsequent course of a persistent pulmonary infection is very variable. It may slowly subside and end in full recovery, or slowly progress, interrupted at longer or shorter intervals by acute symptoms as the disease lights up in previously uninvolved parts of the lung. In some cases, relapses occur irregularly at intervals of days, weeks, months or years, and the patient then usually presents the evidences of a persistent infection during the intervals of freedom from the acute exacerbations. The clinical features are those of chronic interstitial pneumonia with bronchiectasis or abscess formation, and the influenza bacillus may be found in the sputum. It is uncertain, however, whether this organism is to be regarded as more than a contributing factor in the presence of mixed infection. The lower lobes are usually the site of the infection and should be examined with special care. Examination by means of the *x*-rays may lead to the detection of a process not otherwise to be found.

As compared with lobar pneumonia, the physical signs of bronchopneumonia subside much more gradually. Even after a long period of slow resolution, complete symptomatic recovery may yet occur. In one case of influenza bronchopneumonia, the bronchial breathing disappeared only after six months, and yet finally the cough, expectoration and physical signs completely disappeared.

Types of Bronchopneumonia.—In Children.—The primary form of bronchopneumonia is seen as a rule only in children. Whether primary or secondary, the disease is characterized by its severe course, and the younger the child, the more serious is it likely to be. This is to be ascribed to the greater readiness with which the finer bronchi become occluded in youth, and the lack of muscular strength to expel the exudate. Sputum is usually absent in children under three years of age.

In the Aged.—The bronchopneumonia is almost invariably secondary, and the pulmonary features are likely to be insignificant. Cough, expectoration, dyspnea, and fever may be absent. The condition is likely to be terminal and of short duration. It is frequently overlooked during life and first discovered at autopsy.

Following the Infectious Fevers.—The younger the child, the greater the danger of the development of bronchopneumonia as a complication of *measles*. In Bartels' series of 573 cases of measles, 68 (12 per cent.) had pulmonary complications. Of those under one year, nearly 20 per cent. were affected, while only 13 per cent. of those from one to five years, and only about 10 per cent. of those from five to ten years. Death was due to this cause in nearly 80 per cent. of all fatal cases. The mortality is higher the younger the child, and may reach 100 per cent. in patients under one year. Bronchopneumonia develops at any stage of the disease, but most often during or after the disappearance of the efflorescence. In rare instances, an interval of some weeks may elapse. The patients may be apparently well with the exception of a persistent bronchial catarrh. The clinical aspect does not differ from that in other types of the disease. Convalescence is at times much prolonged. A smouldering tuberculous process may be lighted into activity by the infection.

Bronchopneumonia complicating *whooping cough* develops most often in young subjects, and most commonly during the spasmodic stage of the disease. It is likely to run a long course, and may end in recovery or a chronic and persistent infection with permanent changes in the lung.

Bronchopneumonia complicating *diphtheria* usually arises by aspiration of infected material from the upper parts of the respiratory tract, but is at times due to direct extension of the disease from the bronchi. The diphtheria bacillus alone may be concerned, but mixed infections are common, and other organisms than the diphtheria bacillus may be wholly responsible.[1] Fibrinous casts of the bronchi are at times expectorated. Necrosis leading to abscess formation is not infrequent. Recovery may occur, but convalescence is usually slow, and chronic interstitial pneumonia, abscess, gangrene or bronchiectasis may follow the infection.

Plague Pneumonia (*The Black Death*).—The black death of the middle ages is to be regarded as plague pneumonia. True plague pneumonia may be primary or secondary. It is fortunately uncommon, comprising usually only about 5 per cent. of the cases, but is highly contagious. Plague bacilli may be disseminated into the surrounding air during attacks of cough, as shown by Strong,[2] and the wearing of masks by those exposed and the sterilization of infected clothing are important preventive measures. Whether primary or secondary, the occurrence of pneumonic plague may have an important bearing on the character of an epidemic and increase the incidence of the pulmonary form among those attacked.

The pulmonary infection is lobular, and disseminated areas vary in

[1] Wright and Stokes (Boston Med. and Surg. Jour., April 4, 1895) found the diphtheria bacillus in 18 of 19 cases, in 8 in pure culture; Pearce (ibid., December 2, 1897) in 63 of 73 cases, and in pure culture in 17.

[2] Jour. Amer. Med. Assoc., October 14, 1911.

size from that of a pea to an egg, while confluent foci may embrace the greater part of a lobe. The involved regions are likely to be intensely hemorrhagic and contain pest bacilli in large numbers. Hemorrhages may be found in other parts of the body, especially in the pleura. Bronchitis of varying degrees of intensity accompanies the process. The bronchial glands are enlarged, soft, edematous and hyperemic, and are to be regarded as secondary buboes. The spleen is enlarged. Death is due to toxemia.

Primary pest pneumonia is an infection of the lung as the primary seat of the disease, and is unpreceded by primary buboes or a primary carbuncle. Only a few cases have been accurately recorded. It arises by inhalation of the organisms and has been produced experimentally by Wyssokowitsch and Zabolotny[1] by insufflation of pest bacilli into the trachea of a monkey, and by Goss[2] by forcing guinea-pigs to inhale a fine spray containing the organisms. In the unfortunate case of Dr. Screiber, reported by Berestnew,[3] pulmonary infection was thought to have taken place by the aspiration of organisms through a pipette. The incubation period is probably one week or less, and the disease usually begins suddenly with a chill or chilliness followed by fever. Malaise, headache, and vomiting are of varying degrees of intensity. The fever is continuous or remittent. Distressing and frequent cough, constant and increasing dyspnea and cyanosis are important symptoms. Pleural pain is often present. The sensorium is usually undisturbed, but in some cases there is delirium. Conjunctivitis may be present as in the bubonic form. Herpes is absent. The sputum may be absent, scanty or abundant, mucoid or mucopurulent, blood-streaked or frankly hemorrhagic. Frothy, liquid, bloody sputum is the most striking single feature of the disease and lacks the tenacious quality of ordinary pneumonic sputum. On examination, there may be only the signs of bronchitis, but in some cases more obvious evidences of infiltration as in other forms of bronchopneumonia. The spleen is usually palpable to two or more fingers' breadth below the costal margin. Pest bacilli may be found in the expectoration in enormous numbers and also in the circulating blood. There are no authentic cases of recovery from plague pneumonia, and death usually occurs from the fourth to the sixth, but may come as early as the second or as late as the fourteenth or fifteenth day of the disease. The diagnosis may be made by establishing a source of contagion, by the bloody sputum, presence of plague bacilli in the blood and expectoration, and the rapid and fatal course. The complement-fixation test is positive in pest, but may not appear until late in the disease.[4]

Secondary pneumonia in plague may be lobar and due to the pneumo-

[1] Recherches sur la peste bubonique, Ann. de l'Inst. Past., 1897.

[2] Arch. d. sc. biologiques, St. Petersburg, 1908, vol. xiii.

[3] Sur les cas de peste survenus au laboratoire du fort Alexandre 1er. à Cronstadt en fevrier, 1907, Arch. d. sc. biologiques, St. Petersburg, 1908, vol. xiii.

[4] Amake, Centralbl. f. Bakt., 1 Orig., Bd. li, H. 6.

coccus, but bronchopneumonia is the usual type and may be caused by pest bacilli or other organisms. True secondary plague pneumonia may result from the lodgment in the lung of infected emboli or the aspiration of material containing pest bacilli dislodged from an ulcerated tonsillar bubo. As with bronchopneumonia complicating other grave infections, secondary plague pneumonia is usually undetected during life, and is first discovered at the postmortem examination. In some cases it may be suspected from the cough, dyspnea, and cyanosis or established on physical examination. The sputum usually lacks characteristic features and is like that in ordinary bronchopneumonia. It may be bloody, but the frankly hemorrhagic expectoration of the primary form is rarely seen. The embolic form may occur early in the disease and involves any part of the lung, while aspiration plague pneumonia is a late manifestation and predominately affects the lower lobes. The outlook is grave, but recovery occasionally occurs.

Diagnosis.—The insidious onset, irregular course and frequent absence of definite physical signs make the diagnosis of bronchopneumonia difficult and at times impossible. Bronchopneumonia practically always complicates capillary bronchitis and may therefore be assumed to be present in this disease in the absence of more definite signs. A bronchopneumonia may be suspected also in the presence of a simple bronchitis, when the fever persists longer than a few days, when in the acute attack rales are localized over one lobe or one lung, or persist in one place longer than elsewhere, or when without change in the local signs there is a sudden increase in toxic symptoms and elevation of the temperature, pulse, and respiration. Urgent dyspnea and cyanosis are rarely present in simple bronchitis.

The distinction between bronchopneumonia and lobar pneumonia is usually not difficult. It is to be remembered that primary bronchopneumonia is very uncommon in adults, and occurs chiefly in children under three years. At this age, the symptoms of primary bronchopneumonia and lobar pneumonia are the same, but the former is much more frequent, and physical signs, if present, may indicate bilateral and multiple areas of consolidation. A primary confluent bronchopneumonia can hardly be distinguished from lobar pneumonia. Whether in adults or in children, secondary bronchopneumonia occurring in the course of or during convalescence from another affection, of insidious onset, without chill, absence of herpes, slow course, lack of rusty sputum, presence of bilateral and multiple areas of consolidation, defervescence by lysis, slow resolution and tendency to relapse is usually readily differentiated from lobar pneumonia.

Bronchopneumonia may be confused with an encysted pleural exudate when the bronchi leading to the consolidated area are plugged. There may then be dulness, diminished or absent breathing, voice, whisper and tactile fremitus, but the heart is not displaced, Grocco's paravertebral triangle of dulness is absent, the percussion note is

dull rather than flat, and the presence of air-holding tissue may be established all about the involved region, an uncommon event with pleural exudates, which usually reach to the inferior margin of the pleural cavity. A change in the signs after the bronchi are freed of the obstruction by cough may make the situation clear. An exploratory puncture should not be delayed in doubtful cases.

A simple bronchopneumonia may be closely simulated by the pulmonary form of miliary tuberculosis, which also at times follows measles and whooping cough, and is accompanied by cough, mucopurulent and at times blood-streaked sputum (usually without tubercle bacilli), dyspnea, cyanosis, and signs of bronchitis. Evidence of tuberculosis in the family or the past history, fever preceding the onset of the pulmonary symptoms, the presence of a local tuberculous lesion in the apex of the lung, in the glands, the choroid or elsewhere, dyspnea and cyanosis out of proportion to the local signs, or cerebral symptoms may suggest the tuberculous nature of the affection. As the two diseases may be associated, the diagnosis is not infrequently difficult or impossible without definite evidence of tuberculosis.

It is especially in the more persistent or relapsing types of the simpler infections that the question of tuberculosis arises. Bronchopneumonia due to other organisms than the tubercle bacillus shows a tendency in a small proportion of the cases to end in permanent damage to the pulmonary substance, and the patient then presents himself with a history of cough and expectoration for a few weeks, or it may be for months. There may be suggestive points in the history. Tuberculosis in the family or known opportunity for contagion, a history of primary pleurisy or of hemoptysis out of a clear sky may suggest tuberculosis. If the cough began without preceding catarrhal symptoms, it is also suggestive, but, on the contrary, little evidence against tuberculosis can be ascribed to the history of a "cold" which leaves the patient with a persistent cough. Many cases of tuberculosis begin in this way, a previously inactive or slowly advancing lesion being thus excited to more rapid progress. Concerning the course of the disease, it may be said that the chronic non-tuberculous infections seldom tend toward a fatal termination, but rather remain stationary or slowly progress with exacerbations and remissions, but without serious impairment of the general nutrition. The progress of the tuberculous cases is more rapidly downward, and loss of weight and strength, night sweats, and evening rise of temperature are more common. On general examination, the finding of phlyctenular conjunctivitis, corneal scars (if trauma, gonorrhea or syphilis can be excluded), enlarged cervical glands or scars of previous trouble, ischiorectal abscess or fistula are significant. On the part of the lungs, the non-tuberculous infections more frequently involve the inferior lobes, while the tuberculous invasion is commonly apical. Clinical and postmortem experience indicates that apical lesions are so rarely due to other causes than the tubercle bacillus, that they should be regarded as tuberculous

until they can be proved otherwise, and no clinical diagnosis of non-tuberculous apical disease can safely be made until this diagnosis is confirmed by negative tests with tuberculin.

Prognosis.—This is very difficult to estimate because of the large number of cases in which the condition is overlooked. In the primary form in children the outlook is favorable. The mortality in secondary bronchopneumonia is highest at the extremes of age. In children it varies in different series from 30 to 75 per cent. of the cases, and is highest in those who are poorly nourished, or enfeebled by rickets, syphilis, diarrhea, or prolonged febrile disease. Fat children are said to stand bronchopneumonia badly. In adults with such debilitating conditions as malignant disease, broken cardiac compensation, chronic nephritis, cerebral hemorrhage, brain tumor, pernicious and severe secondary anemia, leukemia, exophthalmic goitre, diabetes, etc., bronchopneumonia is extremely fatal. The outlook is more unfavorable with an extensive process, very rapid respiration, marked cyanosis, apathy, and cerebral symptoms. Aspiration or deglutition pneumonia is a very fatal form. Among 339 cases of bronchopneumonia at the Massachusetts General Hospital where children comprise only a small proportion of the admissions, there were 89 deaths, a mortality of 26 per cent., which is higher than that for lobar pneumonia during the same period. The duration of the disease is longer than with lobar pneumonia. No definite statement concerning the duration can be made, but the acute symptoms seldom subside within less than two weeks, and an equal period may elapse before resolution is complete in favorable cases. For the persistent and relapsing forms, no time limit can be set.

Prophylaxis.—As undernourishment is a predisposing factor, proper and abundant food and fresh air may be expected to diminish the incidence of the disease. If there is an infection of the respiratory tract, special care should be exercised to avoid exposure to cold or draught when insufficiently clad, and rapid cooling of the body when overheated. Pure air free from dust, and an equable temperature should be secured in the house. The child should not be taken out on windy and dusty days, and as a precaution, when out, it is well for the child to wear a veil. Measures directed toward limiting the spread of the infectious fevers will do much to diminish the number of cases of bronchopneumonia. Careful cleansing of the mouth and teeth during the fevers or in serious illness of any sort, and preceding general anesthesia and the postponement, when possible, of anesthesia when the patient has tonsillitis, bronchitis or other respiratory infection, will diminish the number of cases of aspiration pneumonia. The stomach should be empty before the patient is anesthetized. In stupor or unconsciousness from any cause, the patient should be carefully fed, the head should be turned so that saliva and mucus may escape freely from the mouth, and when vomiting occurs the patient should be turned on the side so that the vomitus may be expelled. Special care should be exer-

cised to avoid the aspiration of infected material during operations on the nose, mouth or larynx. In all conditions in which atelectasis is known to be present, or likely to develop, the position of the patient should, if possible, be frequently changed.

Early and careful attention to bronchitis, especially in infants, will do much to prevent the development of bronchopneumonia. All cases of respiratory infection should be regarded as presenting the possible danger of contagion, and isolation should, as far as possible, be secured.

Treatment.—There is no specific treatment, and reliance must be placed principally on rest, fresh air, and proper feeding. The patient should be abed and absolutely at rest while there is fever. Frequent changes of position, as already mentioned, may favorably influence atelectasis. The patient's room should be well lighted and well ventilated and an open fire-place improves the circulation of air. An abundance of fresh air should be secured by night as well as by day by throwing the windows open, care being taken, however, not to have the patient directly exposed to a strong current of air and that the bed clothes are not thrown off. In infants at the breast, the dyspnea may prevent breast feeding, and the milk may then be pumped from the breast and fed with a spoon. To infants who are artificially fed, properly modified milk should be given. There are no special indications concerning the diet, and the patient should be given as much of simple and nutritious food as he can digest, the effort being made in poorly nourished patients to improve the general condition. In the early stages of the disease, while there is fever and toxemia, the diet may well be limited to milk and milk preparations, broths and albumin water. The child should be encouraged to drink water freely.

In mild cases such simple measures suffice. Attention should be paid to the bowels, and if necessary, rectal enemata or mild laxatives may be given. If there is pain, distressing dyspnea and incessant and unproductive cough, opium may be given in the form of codeine gr. $\frac{1}{20}$ (0.0032 gm.), heroin gr. $\frac{1}{100}$ (0.00065 gm.), or paregoric m. 3 to 5 (0.2 to 0.3 c.c.) to an infant of six months, but should not be used unless there is some special indication, and then only cautiously. Local applications to the chest are now little used. Flax-seed meal or ice poultices, oil silk or cotton batting jackets, or Priessnitz's applications, by constricting the chest and diminishing the respiratory motion, may do more harm than good. Counterirritation with dry cups, mustard paste or other means irritates the skin, and may add to the discomfort of the patient. If the pulse shows signs of weakening, digitalis, camphor, and caffeine may be used. With distressing cough, mucus rattling in the bronchi, increasing dyspnea and restlessness, aromatic spirits of ammonia may be used as an expectorant in infants and ammonium chloride in older children. When the secretion is abundant and the cough feeble, syrup of ipecac may be used as an emetic to aid

in the expulsion of the mucus, but should not be given if the child is greatly prostrated. Inhalations of oxygen may also be useful.

Attacks of cardiac weakness with cyanosis and mucus rattling in the bronchi may be combated with a hot mustard bath (four tablespoonsful of powdered mustard to four gallons of water), digitalis, camphor, caffeine, and inhalations of oxygen. For nervous symptoms with hyperpyrexia, the cold bath or cold pack may be used. When the cold bath is used, the temperature of the water should be gradually lowered for children, from tepid to 75° or 80°, the peripheral circulation being maintained during the bath by massage of the extremities and the body and the application of heat to the extremities after the bath. If the prostration is extreme, it is best not to use cold applications, and the hot mustard bath may be substituted.

In protracted and relapsing types of bronchopneumonia, every effort should be made to improve the general health. This is usually best done by treating the patient as if for tuberculosis by rest, fresh air, and extra feeding.

CHAPTER XIV.

SUBACUTE AND CHRONIC INDURATIVE PNEUMONIA.

Conditions termed cirrhosis of the lung, pulmonary sclerosis, fibroid phthisis, cirrhotic or fibroid pneumonia are also included under this heading. By it is understood a fibroid change starting about the bronchi or the bloodvessels, in the interlobular, the interalveolar or the subpleural tissue. Subacute and chronic types are at times described separately, but as the causes are for the most part the same, and the two forms represent but different stages in the same pathologic process, their separate consideration would entail needless repetition. A useful division may be made into diffuse and local induration.

Etiology.—The causes are many and difficult to classify. In individual cases it is often difficult to determine the character of the initial process, and in many instances the condition seems to have had an insidious onset. The essential factor is probably a subacute or chronic infection, the exact nature of which it may be impossible to determine, since the infecting organisms may die out, leaving only scar tissue as an indication of their previous presence. Secondary invasion with other organisms may take place, and thus mask the original nature of the process.

The histologic study of postmortem specimens shows connective tissue formation most frequently in process of formation about tuberculous areas, in organizing bronchopneumonia and lobar pneumonia, and in parts of the lung adjacent to an infected pleura, and it is therefore reasonable to refer an already established induration in many instances to such causes.

Diffuse induration is commonly due to organized croupous or bronchopneumonia or to the extension of an infection from a purulent pleuritis. In clinical cases, the development of induration after croupous pneumonia is observed only in rare instances. Among 1000 cases of genuine croupous pneumonia, Fränkel[1] had the opportunity to observe at autopsy a termination in induration and contraction in only seven. Among 210 cases at the Massachusetts General Hospital showing genuine croupous pneumonia at autopsy, or referring their pulmonary symptoms to what may be interpreted as lobar pneumonia, there were 16 instances of organizing or indurative pneumonia. Bronchopneumonia is a more frequent cause, pulmonary induration being noted macroscopically (as mentioned in the section on Bronchopneumonia) in 12 of 85 cases coming to postmortem exami-

[1] Spec. Path. u. Ther. d. Lungenkrankheiten, 1904, p. 452.

nation. Bronchiectasis may occur as a consequence of the infection which gave rise to the induration, but once established, is likely to lead to an extension of the indurative process from the retention of infectious material within the dilated tubes. Partial occlusion of the bronchi by aneurysm, enlarged bronchial lymph glands, syphilitic ulceration of the bronchi, newgrowths or foreign bodies leads to infection and indurative pneumonia in parts supplied by the occluded passages. Atelectasis may be followed by induration, but the connective tissue changes are here to be ascribed rather to a complicating infection than to this condition alone. Interstitial changes occur in the so-called brown induration of chronic passive congestion. The syphilitic pneumonia of infants may also lead to induration. Dust inhalation is of itself alone probably not an adequate cause (see Pneumonoconiosis).

Local and circumscribed induration may be found at any place in the lung, but is most frequent at the apices where it is usually due to relatively inactive or healed tuberculosis, bacterial invasion in connection with the inhalation of dust, or to extension from an inflamed pleura. Among other causes may be mentioned abscess and gangrene, actinomycosis, gumma and infarction, and provided there is also a complicating infection, primary and secondary newgrowth, hydatids, foreign bodies, and injuries.

Pathology.—The appearances vary with the cause and extent of the process and the stage of development. Three principal forms may be recognized, the massive or lobar, insular or bronchopneumonic, and pleurogenous interstitial pneumonia.

1. **Massive or Lobar Form.**—The condition is usually unilateral and involves the lower somewhat more often than the upper lobes. Bilateral involvement is not infrequent, or parts or the whole of one lung may be affected.

In the early stages of organizing croupous pneumonia, the affected parts differ from ordinary red or gray hepatization in a less granular or smooth section surface and greater firmness of the tissue (red induration). Later stages show a change in color from grayish-red to grayish-yellow (yellow induration), or gray (gray induration), a diminishing amount of moisture in the cut surface and increasing toughness until finally the lung is transformed into a pale gray or slate colored (slaty induration) and contracted mass of scar tissue, which can be cut only with difficulty. These various appearances may all be present in one and the same lung. The change in color and the increasing firmness are due to replacement of the infiltrated parenchyma by connective tissue. Inhaled pigment scattered through the lung may give the appearance of polished granite, and fatty degeneration of the alveolar epithelium may impart dots of yellowish color to the section surface. Microscopic examination shows the development of connective tissue within the alveoli in the form of plugs of tissue connected by means of a pedicle with the alveolar wall. These plugs contain usually a net-

work of coarse fibrin in the meshes of which polynuclear leukocytes, round and spindle-shaped cells are found. The crescentic interval between the free margin of the plug and the alveolar wall contains swollen epithelial cells and red blood corpuscles. Bloodvessels enter the plug from the alveolar wall by way of the pedicle. Isolated threads or bundles of fibrin may be seen here and there to pass through the alveolar wall from one to another and neighboring plugs. These communicating fibers were first described by Kohn[1] and explained on the ground that there were small openings in the alveolar wall through which the fibers could pass, and were regarded as the framework on which the connective tissue formation was built. Hansemann[2] later showed that the stomata are normally present in the lung of animals. Organization of the alveolar plugs obliterates the alveoli, and the alveolar walls are thickened and infiltrated with round and later with spindle-shaped cells. The peribronchial, perivascular, interlobular and subpleural tissue are more or less involved. The affected parts of the lung are transformed into a homogeneous, translucent connective tissue in which it may be difficult or impossible to recognize any remains of the normal parenchyma.

Bronchopneumonic Form.—Here also in the more subacute or chronic cases the alveolar exudate becomes organized, and fibrous tissue is formed in the interalveolar septa, the interlobular, peribronchial and perivascular tissue. The indurative process is predominantly peribronchial, and abscess formation and bronchiectasis are frequently associated with it. The site of the process is very variable. The lower lobes are more frequently affected. The condition may, however, be confined to the upper lobes, or there may be scattered foci throughout one or both lungs. Confluence of numerous bronchopneumonic areas of induration may lead to the involvement of an entire lobe or the whole of one lung.

Pleurogenous Interstitial Pneumonia.—This is a well defined form. Persistent collapse of the lung in consequence of an accumulation of fluid, air or solid material in the pleural sac leads to inflammatory changes in the lung. In typical instances, broad bands of grayish-white connective tissue extend from the thickened pleura by way of the interlobular septa into the lung tissue. Infectious material travels by way of the lymphatics from the pleura to the lung. An opposite relation may obtain, and interstitial changes starting in the lung may later lead to involvement of the pleura.

These three forms represent the principal types of the disease, but are recognizable in only a small proportion of the cases. In most instances of interstitial pneumonia which come to postmortem examination, the onset appears to have been insidious or too ill defined to

[1] Zur Histologie der indurirenden fibrinösen Pneumonie, Münch. med. Woch., 1893, No. 3.

[2] Ueber die Poren der normalen Lungenalveolen, Sitzungsberichte der KGL. Preuss., Akad. d. Wissenschaften, 1895, Bd. xliv, p. 199.

admit of a definite statement concerning the method of origin. The pathologic picture is complicated by the coexistence of old and recent lesions. Together with the indurative changes, bronchiectasis, pulmonary abscess and gangrene may be found. Acute bronchopneumonia and lobar pneumonia are frequent intercurrent and terminal events. Pleuritis is practically a constant feature. Thus it is often difficult to decide between primary and secondary processes.

Pulmonary abscesses appear to occur with about equal frequency in interstitial pneumonia secondary to bronchopneumonia and lobar pneumonia. Bronchiectasis seldom complicates an indurative process following unresolved lobar, but is frequent after bronchopneumonia.

In the final stages of an extensive induration, the affected lung may be much reduced in size and lie close to the spine as a firm, hard, airless mass which cuts with the resistance of cartilage. The section surface is smooth and grayish-white or slate colored. An abundance of pigment may give a blackish mottling or coal-black, even coloring to the tissue. The contracted lung is intersected by bloodvessels and contains the terminations of more or less dilated bronchi. An extreme degree of bronchiectasis may exist and the lung then be transformed into a series of cavities. Ulcerative degeneration may lead to the development of abscess cavities, and if the process has reached an extreme grade, isolated and intercommunicating bronchiectatic and abscess cavities may comprise the greater part of the involved region with only little indurated tissue between.

Microscopic examination in the less extensive involvements shows the development of connective-tissue about the bloodvessels and the bronchi, and between the lobules and in the subpleural region. The alveolar walls are thickened and the air spaces contain recently formed and nuclear connective-tissue rich in bloodvessels or older and fibrillated tissue. If the transformation is far advanced, it may be impossible to recognize the alveoli. Here and there in the midst of the dense connective-tissue, dilated alveolar or infundibular spaces, lined with cubical epithelium and resembling glandular structures, may be found.

Thick dense adhesions may bind the lung to the thoracic wall, and its removal may be effected only with the knife. In other instances, and more often when the indurative process is of bronchopneumonic origin, the pleura may be only slightly involved. The unaffected parts of the same or the other lung are usually emphysematous. The heart frequently shows hypertrophy and dilatation, affecting principally the right ventricle.

The necessary interval which must elapse between the onset of the infection and the development of induration, probably varies within wide limits in different cases. The shortest period between the sudden onset of pulmonary trouble in patients previously free from symptoms referable to the lung, and the finding of an organizing pneumonia at postmortem examination in the Massachusetts General Hospital

series was seven days in one instance. In a second case the interval was nine days. Intervals of thirteen, fifteen, sixteen, and seventeen days are recorded in 4 other cases. According to Charcot,[1] red induration is observed after an interval of one month to six weeks, while the stage of gray induration may be established after two to three months; and a true fibrous metamorphosis is produced in the space of four to five months, a year or even longer.

Symptoms.—There is no typical clinical picture, and the symptoms are usually due to complications rather than to the induration itself. In many instances, the interstitial change represents the final result of an inflammatory process which has healed, not by resolution, but by replacement with scar tissue. If the arrest of the disease is complete, as it may be in pulmonary tuberculosis, inflammatory changes in connection with dust inhalation, in the induration complicating pleurisy, in the scarring of the lung which takes place following the healing of unresolved bronchopneumonia, abscess or gangrene, gummata, infarction and other processes of limited extent, there may then be no residual symptoms. The involved region remains functionally inactive, but the loss of a small area of lung tissue is of little moment to the individual. On examination there may be no evidence of the indurative process, which may, however, be suspected from the previous history, or remain entirely latent and be first discovered at postmortem examination. Areas of small extent are more likely to be detected at the apex than at other places in the lung, and may be indicated by retraction of the apical region, narrowing of the isthmus, slight dulness, bronchial breathing, increase of voice, whisper, and tactile fremitus. In time these signs may become less striking and finally disappear, owing to the development of emphysema.

Incompletely healed lesions leading to pulmonary induration as an incidental feature are accompanied by symptoms which are due principally to bronchial catarrh, bronchiectasis, abscess, or pleurisy. The symptoms and physical signs in these cases are those which are described in the sections on these conditions.

Finally, pulmonary induration may be a principal feature and extensive enough to present characteristic clinical aspects. In this type the onset may have been insidious or with the symptoms of lobar pneumonia or pleuritis. The opportunity is occasionally offered of observing the development of the condition. Thus induration may follow recurrent lobar pneumonia, affecting the same pulmonary region and usually without complete absence of pulmonary infection in the intervals between the attacks. Induration is more commonly observed following a lobar pneumonia of ordinary or severe course in which the fever continues elevated after its expected decline, or falls by crisis or lysis only to rise again after a few days. The leukocytosis continues, and the rusty tenacious sputum becomes mucopurulent.

[1] Maladies des poumons et du système vasculaire, 1888, p. 187.

Bleeding from fresh granulation tissue may give a bloody sputum at times. The signs of solidification persist, and a continuous or remittent fever lasts for weeks or months, There is loss of weight, strength and appetite, and tuberculosis is suspected. A fatal result may occur after a variable interval, but it is more common for the fever gradually to subside, the sputum to become less abundant, and the pulmonary signs to recede. The nutrition slowly improves and may again become normal, but the signs of localized trouble in the lung continue. With the progress of time, the signs become less evident owing to contraction of the affected region and emphysema of the neighboring parts of the lung.

It is more common to be confronted with the interstitial changes already well developed. There is then a history of chronic cough, more or less abundant sputum, dyspnea, and pain. The general health may or may not be disturbed, depending on the degree of toxemia from the persistent infection. In some cases, there is little change in the symptoms and physical signs over a period of many years. Patients with interstitial pneumonia, complicated by bronchiectasis and single or multiple pulmonary abscesses, are subject to recurring attacks of bronchial catarrh. Extension of the infection into neighboring or remote parts of the lung is likely to give rise to acute or subacute bronchopneumonia, bronchiectasis, and pulmonary abscesses. An elevation of temperature for a short period is common. Coincident diminution in the amount of sputum may suggest that a collection of pus has failed to find exit by way of the bronchi. A chill may precede such attacks. Rapid subsidence of the fever may follow an increase in the amount of sputum. Pleuritis is common. Pneumothorax is rare. Pulmonary gangrene may occur. Lobar pneumonia is a frequent terminal event. Death may also be due to septicemia, pyemia, malignant endocarditis, cerebral abscess or acute nephritis.

The sputum presents no characteristic features and is due to the complicating bronchiectasis, pulmonary abscesses, bronchopneumonia or gangrene. It is absent in interstitial pneumonia only when the condition is uncomplicated and the induration represents a healed pulmonary lesion. It is of variable amount, mucopurulent or purulent, oftentimes of bad odor, and consists of thin pus or thicker mucopurulent masses. Its color is yellowish or greenish. Admixture of coal dust may give it a blackish or coal-black color. If ulceration of the lung tissue is taking place, masses of pulmonary parenchyma may be found. Elastic tissue may be demonstrated by appropriate methods of examination (see Pulmonary Abscess and Gangrene). Microscopic examination shows pus cells, occasional alveolar epithelium, at times containing pigment and various bacteria.

Hemoptysis is frequent. Small amounts of blood may come from recently formed granulation tissue. Frank bleeding may be due to erosion of bloodvessels lining the walls or traversing the lumen of pulmonary cavities, or the rupture of varices in the bronchial wall. A

severe attack of cough or sudden exertion may initiate the hemorrhage. The amount of blood is usually small, but large and even fatal bleeding may occur. The bleeding usually lasts several days, and is commonly unaccompanied by fever in non-tuberculous cases.

Physical Signs.—Single or multiple areas of interstitial pneumonia if small and centrally placed or surrounded by emphysematous lung, may give no definite signs on examination. Superficial areas are more readily detected.

Inspection.—Diminished expansion of the involved part of the lung is often a striking feature. Contraction of the chest is frequently to be noted, and is greater in the more extensive unilateral involvements, as after unresolved lobar pneumonia, following bronchostenosis, and with pulmonary induration complicating empyema. Thoracic deformity may reach its most extreme grade when the interstitial process has occurred in childhood at a period when the chest is less rigid than in later life. If the disease begins in adult life, contraction of the lung may be largely compensated by the displacement of internal organs and with relatively little retraction of the thorax. Asymmetry may be accentuated by a considerable degree of emphysema in the otherwise unaffected parts of the lung. The shape of the chest depends on the site of the process. Involvement of the apical region is likely to lead to marked depression of the supra- and infra-clavicular fossæ and depression of the cervicohumeral line seen in profile, while involvement of the lower lobe leads to retraction of the side and narrowing of the intercostal spaces. The diminution in size may be confirmed with the tape. The shoulder on the affected side droops, and there may be atrophy of the shoulder girdle, the pectorals and serrati. There is frequently a variable degree of scoliosis with the convexity of the spinal curvature toward the affected side and with compensatory curves above and below.

Percussion.—The percussion note varies with the site and extent of the process. Small, central areas may give no change in the note. Superficial areas must reach a few centimeters in diameter to be detected by percussion. The note is dull over small and may be flat over large areas. If the interstitial process is complicated by considerable dilatation of the communicating bronchi or a cavity in the lung, the dull note may have a tympanitic, cracked-pot or metallic quality, and may change with the mouth opened and closed, during inspiration and expiration and on changing the position of the patient. Emphysema of the neighboring lung may obscure the findings on percussion. Hyperresonance from emphysema may be noted in the otherwise uninvolved parts of the same or the opposite lung. In consequence of pulmonary inflation the inferior margin of the opposite lung may be abnormally low and change its level relatively little during full inspiration, and the sternal border may be found by percussion to project several centimeters beyond the median line toward the affected side.

Auscultation.—The breathing may be feeble and vesicular, broncho-vesicular or bronchial. Dilatation of the bronchi or cavities in the lung may give the breathing an amphoric quality. Rales of a consonating or non-consonating quality, and fine, medium or coarse, are practically constantly present in cases complicated by bronchitis, bronchiectasis or cavities in the lung. They may be present in mild cases only in the morning before the accumulated excretion is expelled. In patients with small and circumscribed or scattered areas, centrally placed, persistent rales over the involved regions may be the only finding on physical examination. An increased loudness of the cardiac sounds may frequently be observed over areas of interstitial pneumonia, especially when the left upper lobe is involved. Increase in the intensity of the voice and whisper may be found over the consolidated areas. Loud vesicular breathing with some prolongation of expiration may be heard over uninvolved or emphysematous parts of the lung.

Palpation.—Diminished respiratory motion, and narrowing of the intercostal spaces may be confirmed by palpation. An increase in tactile fremitus is observed over infiltrated areas of sufficient extent provided unobstructed bronchi communicate freely with the involved region.

Displacement of the Viscera.—The heart may be greatly displaced toward the affected side. When the cirrhotic process affects the left lung, and especially with retraction of the left upper lobe, there is likely to be visible pulsation in the parasternal region in the second, third, and fourth interspaces. The apex beat may be seen and felt a considerable distance beyond its normal position toward the left axilla. Careful outlining of the heart by percussion will be of assistance in deciding between displacement and enlargement. With right-sided pulmonary processes the displacement may be far to the right and congenital dextrocardia may be suspected. In extreme degrees of pulmonary cirrhosis, it may be difficult or impossible to be sure of the position of the heart. Systolic murmurs are not infrequently heard over displaced hearts, and are probably due to dislocation or compression of the pulmonary artery.

As a result of pulmonary contraction, the diaphragm may be drawn upward far beyond its normal position on the involved side, as can be demonstrated by *x*-ray examination. An appreciation of this is of especial importance in cases of pulmonary induration complicated by pleurisy with effusion, pulmonary abscess or gangrene in which surgical exploration is contemplated. It is always well to determine the position of the diaphragm by means of the *x*-rays before interference is attempted.

Elevation of the diaphragm on the left side elongates the area of tympany from the stomach and intestines over Traube's semilunar space, and a tympanitic percussion note may be obtained upward as far as the fifth rib or higher.

Clubbing of the fingers is frequently observed in cases with interstitial pneumonia complicated with pulmonary suppuration. From four to six months is usually necessary for the development of the changes in the fingers.

Diagnosis.—It is often impossible to obtain definite signs from limited areas of pulmonary induration even when situated at the periphery of the lung. Numerous scattered foci centrally placed may also readily escape detection. With long standing cough and expectoration, signs of pulmonary solidification and contraction of the chest or displacement of the viscera, the diagnosis may be made. Post-mortem examination of patients long subject to pulmonary infection seldom fails to disclose an increase in connective-tissue as an incidental or principal lesion, and the condition may therefore be regarded as probable, even if its exact site cannot be determined, in those who have suffered from the expectoration of purulent sputum for weeks or months. The site of the process may be suggested by the finding on repeated examinations of rales persistently localized at one or more places. The determination of the cause is often difficult.

An origin in lobar pneumonia, though uncommon, is suggested when, preceding the evidences of induration, there is a history of single or recurring attacks of acute illness of sudden onset, with chill, rapid rise of fever, cough with rusty sputum and pain in the side, lasting about a week and ending by crisis or lysis. Great caution must be observed, however, to exclude pulmonary abscess, empyema and tuberculosis which are much more common causes of an apparent delay in resolution than indurative pneumonia. A confusion between empyema and indurative pneumonia is the most common error. Collections of pus between the lobes of the lung or between the diaphragm and the base of the lung are to be considered as well as the more common accumulations between lung and chest wall. Sacculated exudates, interposed little or not at all between lung and chest wall, are most difficult of differentiation, and owing to the retraction of the neighboring lung, may exhibit typical signs of pulmonary solidification, with dulness, loud bronchial breathing, and increase of voice and whisper. A peculiar ægophonic quality to the voice, marked diminution or absence of the tactile fremitus and an abnormal degree of dulness or even flatness on percussion are suggestive of pleural effusion. Pleural exudates which are situated in the paravertebral region give dulness along the edge of the spinal column, a region usually resonant in uncomplicated pneumonia. More extensive exudates may so far exceed the limits of the pulmonary boundary as to cause dulness in the opposite paravertebral region (Grocco's paravertebral triangle.). Dislocation of the heart is a valuable differential sign. With uncomplicated pulmonary induration, contraction of the affected region dislocates the heart toward the affected side, while accumulations of pleural fluid tend to dislodge the heart in the opposite direction. A persistent leukocytosis suggests pus. In doubtful cases, examination by means of the *x*-rays

and exploratory puncture must be used. Exploratory puncture should not be done unless the position of the diaphragm is known, and this can best be determined by *x*-ray examination.

Of the different forms of pleurisy, it is especially the purulent variety which is likely to lead to interstitial pneumonia. In cases in which pleurisy is a cause, there is likely to be a history at onset of pain aggravated by cough and long breath, and symptoms of sepsis are a prominent feature. There may be a scar of operation or the history of the withdrawal of pus. A neglected empyema may rupture into the lung and a large amount of pus be expectorated at one time. Such obvious perforation is less common than the slow invasion of the lung with multiple areas of suppuration and induration and the expectoration of small amounts of purulent sputum at frequent intervals. Owing to the frequency with which pleurisy complicates interstitial pneumonia, some care must be taken in deciding from the patient's story alone whether the pleurisy is primary or secondary. An apical site of the indurative process is against purulent pleurisy as a cause, but sacculated empyema over an upper lobe occurs in rare instances.

An origin in bronchopneumonia may be suspected when an indurative process occurs after a primary pneumonia in children under two years, since at this period bronchopneumonia is the more common type. Bronchopneumonia may also be suspected as a cause when the condition follows measles, whooping cough and diphtheria, bronchitis, the extension of an infection from the pleura or abdomen, obstruction of the bronchi by new growths within or compression from without, the aspiration of foreign bodies or inhalation of food, drink or septic material. Induration complicating abscess or gangrene is usually due to bronchopneumonia which arises by extension or the inhalation of septic material into nearby or remote parts of the lung.

In the determination of the cause, tuberculosis is always to be considered, and its exclusion is often difficult and at times impossible. Certain factors of importance in the differentiation between the more chronic types of tuberculous and non-tuberculous pulmonary infection are discussed under the diagnosis of bronchopneumonia, and need not be repeated. An apparent lobar pneumonia which terminates in tuberculosis is usually tuberculous from its inception, but tuberculosis may be engrafted on non-tuberculous induration. A certain proportion of the cases of pleurogenous interstitial pneumonia are tuberculous, but purulent pleurisy is less commonly due to the tubercle bacillus than the primary fibrinous and serofibrinous forms. The absence of tubercle bacilli from the sputum is of less moment in cases with interstitial pneumonia than in the more acute pulmonary processes, since an abundant development of scar tissue may wall off the tuberculous foci and prevent expectoration of bacilli. A final decision against tuberculosis may not be possible until tuberculin has been given and the tests have proved negative in increasing doses up to and including 10 mg.

In cases of indurative pneumonia not otherwise to be explained, bronchostenosis is to be considered. A foreign body, syphilitic ulceration and new growth arising from the bronchial wall and compression from without of aneurysm, tumor or enlarged glands are possible causes. More marked dyspnea than can be explained by the physical findings, attacks of suffocation, stridor, diminished or absent respiratory motion and breathing, and sibilant or sonorous rales over the site of the obstructed bronchus may be suggestive. There may be little or nothing of moment in the history, and physical examination may offer no additional evidence. In some cases, however, a foreign body may be known to have been inhaled. A history of syphilis may be obtained, or late lesions of this disease may be present elsewhere. Tracheoscopic examination may reveal ulcerations, or the Wassermann test may be positive. New growths of small size arising from the bronchial wall and without metastases and isolated enlargement of the bronchial glands can hardly be diagnosed unless some indication of their presence is found on *x*-ray examination. Malignant disease of the mediastinum or aneurysm may be detected after a careful history, and physical examination aided by the *x*-rays.

In some instances, tumor of the pleura or the lung may simulate pulmonary induration from the signs of pulmonary solidification and contraction of the side. Stridor, inequality of the pupils or the pulses, enlargement of the cervical or axillary glands, dilatation of the superficial veins of the thorax, dulness over the anterior or posterior mediastinum, and recurrent laryngeal paralysis may be suggestive.

Actinomycosis of the lung and pleura is to be considered in the presence of pulmonary induration, and may occur as a primary or secondary infection. The tendency of the infection to extend to the soft parts of the thorax is a striking and characteristic feature, but in the early stages there are likely to be no outward manifestations, and the diagnosis can be made only by finding actinomyces in the sputum.

Prognosis.—The outlook depends on the cause of the induration and the complications. Actinomycotic and aspiration pneumonia are very fatal forms. Unresolved lobar pneumonia may last for weeks or months, and finally end in functional efficiency of the lung and the gradual disappearance of physical signs. In individual cases, the patient's chances must be estimated by the severity of the infection and the general condition. The prospects of complete recovery are less good when the induration follows bronchopneumonia, because of the damage to the bronchial wall. In all types of the disease, the induration itself may represent a slowly progressive lesion in which the defensive action of the body is inadequate to repel the progress of the infection, or a more or less complete cure. Unfortunately in many cases, though the patient survives, the infection lurks persistently in dilated bronchi or pulmonary cavities. Dyspnea, cough, and expectoration then continue. Recurrent bronchopneumonia is common and is followed by extension of the indurative process. In tuberculosis

the indurative process is conservative, and complete encapsulation of caseous masses may effect an arrest of the disease. Death may occur from hemoptysis or from gradual failure of the right heart. In cases of fibroid induration due to tuberculosis, amyloid may be partly responsible for a fatal termination.

Prophylaxis.—Preventive measures must be directed against the causes of pulmonary induration. The avoidance of dust, the prevention of tuberculosis, syphilis, actinomycosis, aspiration and bronchopneumonia and pleurisy, and the early removal of foreign bodies from the bronchi are some of the problems. Care in the treatment of existing pulmonary or pleural disease is important. Improvement of the general nutrition, rest in bed while there is fever, avoidance of exposure to cold and draughts when overheated or insufficiently clad, the early and complete drainage of empyema, and the evacuation of pulmonary abscesses in properly selected cases may prevent the development or extension of induration.

Treatment.—Little or nothing can or need be done for pulmonary induration which represents a healed lesion of the lung without complications. In cases in which an infection persists with cough and expectoration, such general measures as are applicable to tuberculous patients should be advised. An occupation or life in the open air, in an atmosphere free from dust and in an equable temperature is desirable. An improvement of the nutrition by an abundance of food, fresh air and rest should be sought in patients whose general condition is below par. A cool morning bath or shower, followed by a hard rub with a coarse towel, may assist in improving the general tone. For patients with means and inclination for travel, the winters may be spent in the South.

In non-tuberculous cases, with little or no persistent infection and with developing or established contraction of the side, pulmonary gymnastics may be recommended. In tuberculous lesions, such exercises are contra-indicated for fear of aggravating an active lesion or exciting a slumbering process to activity. In suitable cases, deep inspiration and expiration for a number of times in the morning and afternoon may first be tried. More vigorous exercises may be added. Thus the patient, standing upright and lightly clad, may raise the arm on the affected side, laterally, through the horizontal to the vertical position at the side of the head. Deep inspiration may accompany this motion. With both arms outstretched in the lateral position, lateral bending of the trunk away from the affected side or torsion of the trunk with the pelvis fixed, may be practiced. Various simple exercises may also be prescribed with dumb-bells or pulley-weights. In regulating the daily life of patients with pulmonary induration, attention must be paid to the condition of the heart and, mindful of the strain which an impeded pulmonary circuit puts on the right ventricle, caution should be suggested against overexertion.

CHAPTER XV.

PNEUMONOCONIOSIS.

This term (from πνεύμων lung and ἡ κόνις the dust) was applied by Zenker[1] to a condition arising in consequence of the inhalation of dust. Since the changes formerly ascribed to dust are probably in large part, if not entirely, due to bacteria, the subject would not deserve separate consideration were it not that dust undoubtedly disposes to pulmonary disease.

Historical Note.—Different views have been held concerning the nature and source of pulmonary pigment in normal and pathologic conditions of the lung.

Origin from Without of Pigment in the Lung.—In 1703, Ramazzini[2] stated that certain stone cutters became asthmatic and phthisical from the inhalation of pointed and angular fragments of stone.

Pearson[3] first suggested that black pigmentation of the lung and bronchial glands was due to the inhalation of carbon and soot. Laënnec[4] made a distinction between the constant black mottling of the normal lung, the matière noire pulmonaire, and melanosis, suggesting that the black color may in part come from the smoke of lamps and combustible bodies. This simple explanation did not go unchallenged. Virchow[5] denied it and maintained that the so-called normal pigmentation was due to extravasated blood pigment.

Gregory[6] was the first to publish a case of pathologic pigmentation, and additional evidence through the publications of Erdmann,[7] Thompson,[8] Marshall,[9] Graham,[10] Hamilton,[11] Gibson,[12] Andral,[13] Rilliet,[14] Stratton,[15] who proposed the name anthracosis, and Brockmann[16] indicated that this pigmentation occurred to a much greater degree in occupations in which the workers were exposed to an atmosphere rich in carbon particles, as in coal miners, or in persons otherwise exposed to coal dust. Christison (in Gregory's case), Graham and Lecanu (in Rilliet's case) confirmed Pearson's observation on the identity of the substance with carbon.

[1] Deut. Arch. f. klin. Med., 1866–67, vol. ii.
[2] De morbis artificum diatribe Ultrojesti, 1703.
[3] Philosophical Transactions, 1813, ii, 159.
[4] Traité de l'auscultation médiate, 1813, 2d ed., Paris, 1826, T. ii, p. 34.
[5] Virchow's Arch., 1847, Bd. i.
[6] Edinburgh Med. and Surg. Jour., 1831, xxxvi, 389.
[7] Hufeland and Osann, Jour. f. prakt. Heilkinde, December, 1831, p. 4.
[8] Medicochirurgical Trans., 1857, xx, 230, and 1838, xxi, 340.
[9] Lancet, May 17, 1834.
[10] Edinburgh Med. and Surg. Jour., 1834, xlii, 323.
[11] Ibid., p. 297.
[12] Lancet, 1834.
[13] Laënnec, Traité de l'auscultation médiate, 1837, 4th ed., pp. 258 and 501, Pl. B.
[14] Arch. gén. de méd., June, 1838, p. 160.
[15] Edinburgh Med. and Surg. Jour., 1838, xlix.
[16] Hannov. Annalen f. d. ges. Heilk., Jahrg., 1844, N. F. iv, and Die metallurg. Krankheiten des Oberharzes, 1851, p. 116.

The inhalation of carbon was accepted as a cause of the condition in England, but this explanation was contested in Germany, and especially by Virchow, on the ground that if the pigment came from without, its presence in the lung itself between the elastic fibers and in the connective tissue must be ascribed to the penetration of solid particles through sound mucous membranes, and the possibility of such an invasion he was not disposed to accept. Then, too, not all coal miners were affected with the disease, and in two instances, reported by Barthelmess[1] and Begbie,[2] an outspoken melanosis was observed in persons unexposed to the inhalation of coal dust. Virchow[3] regarded the rare presence of the pigment in the alveolar wall and its more common position in the interlobular and subpleural connective tissue as against the inhalation theory. He also emphasized the lack of resemblance between the black granules in the lung and the rather brown than black particles of carbon and soot. He regarded the pigmentation of the "miner's lung" like the pigmentation of the normal lung, as due to great respiratory efforts of the workers and the consequent catarrh and extravasation of blood.

An important step in establishing the inhalation theory was made by Traube[4] who found small black particles, some of which showed one or several regularly circular openings in their centres or semicircular defects of varying size at the margin, in the sputum of a patient who had handled charcoal for about twelve years. Traube recognized these as inhaled charcoal particles, and examination of the dust in the place where the patient had worked, showed similar particles. At autopsy, the cut surface of the lung was a homogeneous black color. On pressure, a black ink-like fluid could be expressed. No trace of new-formed connective tissue or tuberculosis could be demonstrated. In the sputum and in the lung were large cells resembling alveolar epithelium, containing black, angular particles. No microscopic examination of the lung was made, but in a later case reported by Traube,[5] Cohnheim found carbon particles in the alveolar epithelium, in the interstitial tissue in places in such abundance as to surround the alveoli like black rings, and in the bronchial glands. Nowhere, however, was the interstitial tissue increased in amount. An accompanying ulcerative process was due to tuberculosis Traube's observations, together with cases reported by Maurice,[6] Kuborn,[7] Villaret,[8] Crocq,[9] and others established the origin from without of pigmented particles, and the invasion, not only of the lung, but also the bronchial glands.

Zenker's[10] report of a case of siderosis pulmonum established the invasion of the lung by metallic dust. In this case, the patient, a woman, aged thirty-one years, had worked for seven years in a

[1] Diagnose der Lungenmelanose, Erlangen, Inaug. Diss., Abh., 1855.
[2] Monthly Journal. [3] Edinburgh Med. Jour., September, 1858, iv, 204.
[4] Deut. Klin., 1860, Nos. 49 and 50. [5] Berl. klin. Woch., 1866, No. 3.
[6] Gaz. méd. de Paris, 1862, vol. vii. [7] Presse méd., 1862, p. 27.
[8] Cas rares d'anthracosis, Paris, 1862. [9] Presse méd., 1862, pp. 37–44.
[10] Deut. Arch. f. klin. Med., 1866–67, vol. ii.

small, unventilated room, preparing blotting paper for small books, between the leaves of which fine leaf gold was placed. The blotting paper was impregnated with finely pulverized English red and the atmosphere of the room was filled with dust. At autopsy, the exterior and section surface of the lung showed an intense brick-red color. Several large cavities and numerous firm, fibrinous nodules were scattered through both lungs. The two lungs weighed 1500 grams and contained about 21 to 22 grams of oxide of iron. Four girls worked in the room. Of the others, none complained of pulmonary symptoms. One had "colored" for ten years and her respiratory organs were sound.

Zenker proposed the name siderosis pulmonum (from σίδηρος iron) for this, and for the whole group pneumonoconiosis.

Virchow,[1] influenced by such reports and having convinced himself that the soot particles from the miner's lamp could not be distinguished microscopically from the black-pigment granules in the lung, relinquished his earlier opinion and accepted the existence of a true pulmonary anthracosis.

The Intestinal Theory.—Villaret's[2] opinion that inhaled dust particles, especially carbon, were swallowed and reached the lungs indirectly after absorption from the stomach and intestines, has recently been supported by Vansteenberghe and Grysez.[3] Arnold's[4] classical studies, however, showed that while following inhalation experiments in animals, carbon particles were constantly found in the lumen of the intestines, they were not found in the intestinal wall, the chyle vessels or the mesenteric glands. The experiments of Aschoff,[5] Schultze,[6] Cohn,[7] and Beitzke[8] show that foreign particles injected into the abdominal cavity are distributed by way of the lymph stream and the thoracic duct to the circulating blood and lodge principally in the spleen, liver, and bone marrow. It is well recognized that spontaneous pulmonary anthracosis is not uncommon among adult animals, and it is evident that the aspiration of foreign particles may take place while animals are being fed with a tube. Schultze and Beitzke failed to find anthracosis in animals fed through a gastric fistula. In Beitzke's experiment, an animal allowed to inhale soot after occlusion of a principal bronchus showed soot only in those parts of the lung not supplied by the occluded bronchus. The evidence is therefore, strongly against an intestinal origin.

[1] Virchow's Arch., 1866, xxxv, 186.

[2] Cas rare d'anthracosis suivi de quelques considerations physiologiques et pathologiques, Paris, 1862.

[3] Sur l'origine intestinal de l'anthracose pulmonaire, Annal. Past., 1905, Bd. xix, p. 787.

[4] Untersuchungen über Staubinhalation und Staubmetastase, Leipzig, 1885.

[5] Experimentelle Untersuchungen über Russinhalationen bei Tieren, Beitr. z. Klinik d. Tuberkulose, Bd. vi, H. 2, p. 147.

[6] Gibt es einen intestinalen Ursprung der Lungenanthrakose? Münch. med. Woch., 1906, No. 35, p. 1702.

[7] Die Lungenanthrakose und ihre Entstehung vom Darm aus., Berl. klin. Woch., 1906, No. 14, p. 1429.

[8] Ueber den Ursprung der Lungenanthrakose, Virchow's Arch., 1907, clxxxvii, 183.

Etiology.—Relation Between Dust and Pulmonary Disease.—As dust is a normal and necessary constituent of the atmosphere, without which there would be no rain, fog or clouds, it is inhaled by everyone in varying amounts. The amount of dust is greater in thickly settled regions and in certain occupations. Under healthy conditions most of the inhaled particles are caught in the upper parts of the respiratory tract and swept outward by the ciliated epithelium. The normal defenses of the body, however, are insufficient to protect those constantly exposed to an atmosphere heavily laden with dust, as is shown by the constant presence of coal dust at autopsy in the lungs of adults who have lived in the city.

It has long been recognized, however, that workers in factories and trades where the atmosphere is heavily laden with dust, more often suffer from diseases of the respiratory tract than others not so exposed. According to the statistics of Weyl,[1] among 292,536 persons receiving insurance for illness (1896–1899), there were 82,101 instances of disease of the respiratory organs, including 38,926 cases of pulmonary tuberculosis. Thus, of the whole number, about 28 out of every 100 patients suffered from disease of the respiratory tract, and about 13 of these from pulmonary tuberculosis. According to the United States Census Report for 1900, consumption caused 14.5 per cent. of all deaths for all occupied males. With these statistics for comparison, the incidence of respiratory disease and of phthisis among workers in dusty occupations may be noted.

Hirt[2] finds that out of every 100 patients among workers in dusty occupations, of those inhaling mineral dust about 51 suffered from respiratory disease and about 25 of these from phthisis; of those inhaling vegetable dust about 46 suffered from respiratory disease and about 13 of these from phthisis; of those inhaling animal dust about 44 suffered from respiratory disease and about 20 of these from phthisis; of those inhaling metal dust about 43 suffered from respiratory disease and about 28 of these from phthisis.

Later figures, as those given by Sommerfeld,[3] likewise indicate that tuberculosis is more common among workers in dust.

	Deaths from tuberculosis among 1000 living.	Mortality from tuberculosis in 1000 deaths.
Occupations without dust	2.39	381.0
Occupations with dust	5.42	480.0
Average	5.16	478.9
Corresponding male population in Berlin	4.93	332.3
Occupations with the development of		
A. Metallic dust	5.84	470.6
1. Copper trades	5.31	520.5
2. Iron trades	5.55	403.7
3. Lead trades	7.79	501.7
B. Mineral dust	4.42	403.4
C. Organic dust	5.64	537.04

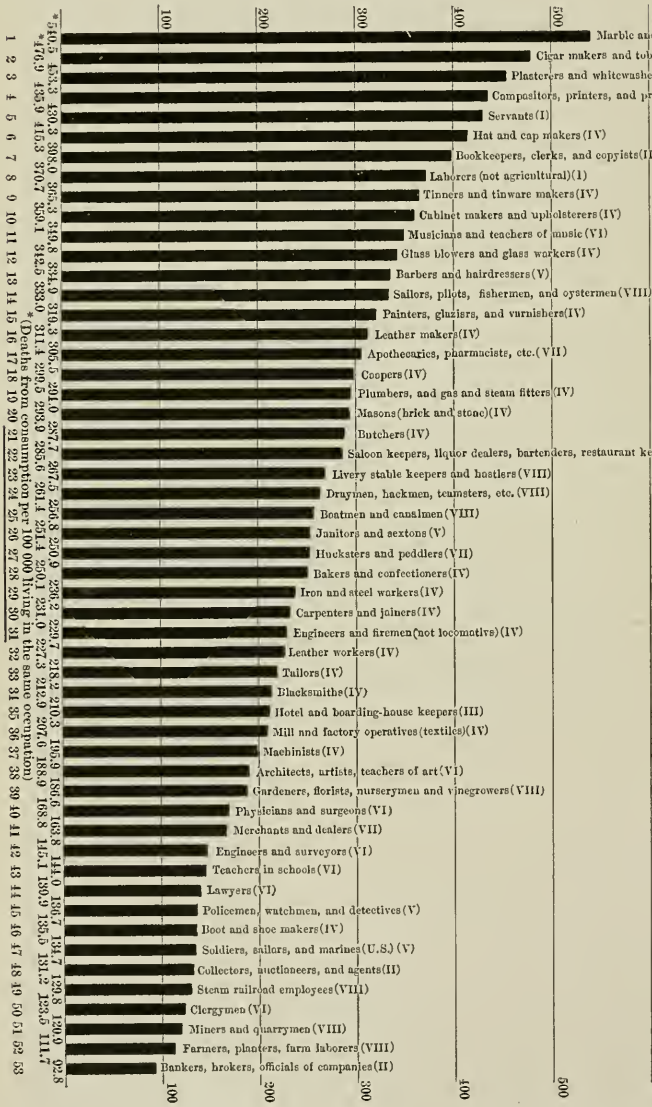
[1] Handbuch der Arbeiter Krankheiten, 1908, p. 39.

[2] Die Krankheiten der Arbeiter, Erster Theil, Die Staubs-inhalations-Krankheiten, 1875, p. 1.

[3] Handbuch der Gewerbekrankheiten, 1898, p. 344.

The statistics bearing on occupation and mortality from consumption compiled by Miss Lillian Brandt, from the United States Census Report for 1900, and graphically shown in the accompanying diagram are reproduced from the *Handbook on the Prevention of Tuberculosis* and show in greater detail the death rate from consumption in fifty-three specific employments or small groups of employment more or less alike:

FIG. 38



Death rates from consumption, of men in fifty-three occupations, in the registration states of the United States, 1900. (Brandt.)

It is to be noted that marble and stone cutters head the list. The high rate of tuberculosis among them has usually been ascribed to the irritation of the respiratory tract by fine particles of stone dust. A striking exception to the danger of dust in occupation is the relative freedom of miners and quarrymen who hold a position so near the bottom of the list.

The frequency of tuberculosis among miners varies widely according to the material mined and the locality, but among coal miners it is generally recognized that the mortality from this disease is low. Thus Arnold,[1] Parry,[2] Tatham,[3] Seltman,[4] Goldman,[5] Dirksen[6] and others agree in regarding tuberculosis as relatively uncommon among coal miners. Coal dust has even been regarded as preventing the development of phthisis, and it has been proposed to treat the disease with the inhalation of coal dust. Wainwright and Nichols[7] in an investigation of the causes of death among 857 anthracite mine workers, at Scranton, Pennsylvania, found that 23.45 per cent. died of pulmonary disease, and of this number only 3.37 per cent. of pulmonary tuberculosis, while in 2656 deaths among other occupied males at Scranton, 27.86 per cent. were due to pulmonary disease. and of these 9.97 per cent. to pulmonary tuberculosis. Tuberculosis is thus about two-thirds less frequent among these miners than among all other occupied males.

A greater incidence of pulmonary disease can be shown in towns than in country districts, and Asher[8] contends that as Germany has become more industrial, the death rate, especially in acute pulmonary disease, has risen, and in explanation the increasing amount of smoke may be held responsible. The larger the town, the higher the mortality curves for tuberculous and non-tuberculous disease of the lung.

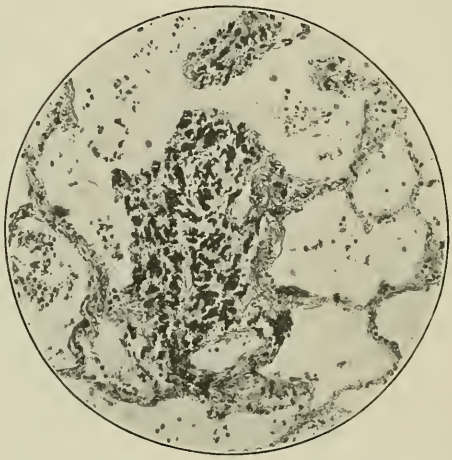
These and many other inquiries have shown that the incidence of and the mortality from pulmonary disease is usually greater among workers in dusty occupations than in those engaged in occupations without dust and in the population at large. The infrequency of pulmonary disease among coal miners is a striking and significant exception which has been vaguely and unsatisfactorily ascribed to a protective influence from coal dust and soot. While it must be granted that under certain conditions, dust is a factor in causing pulmonary disease, yet it must be regarded as only one of many factors in this relation. Among workers in dusty occupations, not only dusty air,

[1] Untersuchungen über Staubinhalation und Staubmetastase, Leipzig, 1885.
[2] Risks and Dangers of Various Occupations, London, 1900.
[3] Oliver's Dangerous Trades, London, 1900.
[4] Burger, Der Beziehung der Tuberkulose zu der Anthrakose, Marburg, 1903.
[5] Die Hygiene der Bergmanns, Halle, 1903.
[6] Arch. f. Hyg., 1903, No. 11.
[7] The Relation Between Anthracosis and Pulmonary Tuberculosis, Amer. Jour. Med. Sci., 1905, p. 130.
[8] Der Einfluss des Rauches auf die Atmungsorgane, Stuttgart, Enke, 1905.

but close confinement in overcrowded and badly ventilated rooms, long and irregular hours, overheating, sudden exposure to extremes of heat and cold, dampness, excessive physical exertion, constrained positions at work, a low rate of wages, insufficient clothing, poor nutrition, and not infrequently chronic alcoholism, must also be considered. Of far greater importance is the influence of bacteria which deserves separate consideration.

Dust and Bacteria.—Not all exposed to the inhalation of dust present symptoms during life or show pathologic changes in the lungs after death as a result of the infiltration of the tissue with foreign particles. The occurrence of pulmonary pigmentation from coal dust and soot with such frequency as to constitute a normal appearance of the lung is against the view that particles of dust are alone capable of

FIG. 39

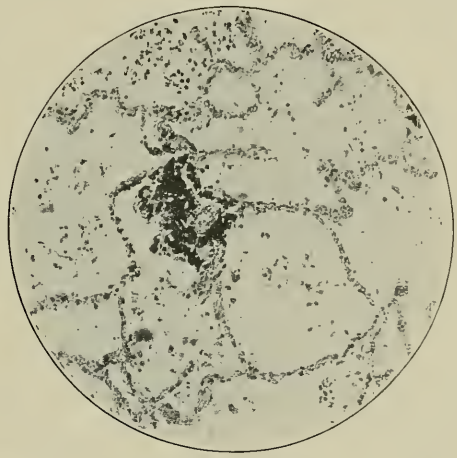


Pneumonoconiosis. Foreign pigment in lung tissue with slight if any reactive inflammation about it.

giving rise to serious disturbances. Even when the exposure has been long and severe, as in Traube's first case of charcoal inhalation, there may be no indication of reactive inflammation by the formation of connective tissue. In Zenker's report it is noted that long exposure to the inhalation of English red gave rise to respiratory symptoms in only one of the workers. The tolerance for dust by a great majority of the workers in dusty occupations is a matter of common experience. In one instance at the Massachusetts General Hospital (Autopsy 2953) a man, aged sixty-one years, who in youth had worked as a stonemason and later as a crossing-tender on the railroad, gave no history of cough, and examination of the lungs was negative. He died in consequence of cancer of the intestines, and microscopic examination of the lungs (Figs. 39 and 40) showed marked infiltra-

tion of the interalveolar and perivascular tissue with pigment, but no inflammatory changes. Invasion of the lung by dust alone therefore, does not necessarily give rise to pulmonary disease. There must then be some other factor. The reports of pathologic changes due to dust were for the most part made before the importance of bacteria was appreciated, and antedate the discovery of the tubercle bacillus. Pulmonary lesions when present are those consistent with the results of bacterial invasion, and the almost constant and parallel increase in the incidence of pulmonary disease and of tuberculosis among workers in dusty occupations suggests that the combination of dust and bacteria is an important factor. The various conditions which can be regarded as having an influence on pulmonary disease among workers in dusty occupations are so complex that it is impossible

FIG. 40



Pneumonoconiosis. Foreign pigment in lung tissue with slight if any reactive inflammation about it.

accurately to estimate the importance of any single factor, and yet it seems more reasonable to ascribe a greater importance to bacteria than to a difference in the irritating qualities of marble and stone dust and coal dust in the incidence of pulmonary disease among marble and stone workers and coal miners. Marble and stone-cutters are, for example, frequently at work within doors, and during the colder months of the year in small, crowded, unheated, and dusty spaces. The workers are likely to be occupied in the midst of dust and expectorated material, representing an accumulation extending over a considerable period. Such conditions are favorable for the spread of infection from one worker to another. Coal miners, on the other hand, work underground where the dampness and the constant invasion of new territory lessen the danger of the spread of infected material.

Kinds of Dust.—Workers in dusty occupations inhale material which varies according to the character of the trade. Mixed dust is, however, common in all occupations.

Coal and Soot.—Dwellers in cities, where numerous factories fill the air with smoke, are exposed to a much greater degree than those who live in the country. Choremen, chimney-sweepers, coal-heavers, coal-trimmers, charcoal-burners, and coal-miners are especially subject to the inhalation of coal or soot. Lung disease resulting from the inhalation of coal dust is known as anthracosis, melanosis, phthisis melanotica, coal miner's lung, "black spit," etc. As already stated, coal-miners are not, however, more affected with pulmonary disease than the community at large and in many statistics even less so.

Metallic Dust.—Occupations involving the finishing of metal implements are dusty, and the grinders of cutlery and other steel products may suffer from pulmonary disturbances which have been termed "steel-grinder's phthisis," "grinder's asthma," and "grinder's rot." The dust is composed of particles of steel and stone and is most abundant in the process of "dry" grinding. In the hafting of knives by means of an emery wheel, the dust is made up of particles of bone, steel, and stone. In file cutting by hand, owing to the practice of strapping the file to a bed of lead, the dust of the work shops contains lead, which adds the danger of poisoning to that from the inhalation of dust. To the invasion of the lung by iron dust Zenker gave the name siderosis, which in his case was due to the inhalation of English red. The manufacture, filing, turning and polishing of copper, and the extraction of zinc from the ore are dusty occupations. In the mining of such metals as tin and gold, much dust may be generated in the process of drilling, blasting, shovelling, and breaking the stone, especially when this is done by hand. Oliver[1] called attention to the high death rate from phthisis among gold-miners working on the Rand.

Stone Dust.—The dust of railways and streets set in motion by automobiles and street cars is a possible source of danger. In subways there is the mixture of street and subway dust, and in the latter, fine particles of iron ground from the brake-shoes of the cars and the rails. The blasting, breaking and crushing of stone, the manufacture of millstones and the making of china and earthenware are dusty occupations, and may give rise to such pulmonary conditions as the so-called "stone-mason's phthisis," "ganister disease," and "potter's phthisis." Lung disease due to the inhalation of stone dust is known as chalicosis or lithosis.

Organic Dust.—Such textile manufacture as the making of goods from cotton, hemp, flax, wool, silk, hair, and jute, rope-, carpet-, and felt-making, fur-brushing, rag-sorting and rag-cleaning, flour-milling

[1] Lancet, June 14, 1902.

and cigar and snuff manufacture, may be dusty occupations. Pulmonary disease in consequence of the inhalation of cotton fiber has been called byssinosis, that following tobacco inhalation tobaccosis.

Pathology.—Aside from the invasion of the tissue by the kind of dust to which the individual has been exposed, there are no special pathologic features. The foreign particles may excite no changes whatever and merely lie within the tissue as an inert and indifferent substance. Considerable variation in the appearance of the lung is presented in those who have apparently been similarly exposed. An unusual degree of invasion in certain individuals may be ascribed to weakening of the protective force of the ciliated epithelium, owing to bronchial catarrh and the blocking of the pulmonary lymph spaces by previous inflammatory processes, thus preventing the migration of dust from the lung to the lymph glands. The influence of chronic inflammation in the arrest of pigment can be seen in the accumulation of pigment masses about areas of induration, giving them a slaty color.

In extreme cases of anthracosis, a black fluid can be expressed from the bronchi or the section surface, parts or the whole of the lung may show on section a black mottled appearance, and underlying the visceral pleura may be seen a network of black pigment which outlines the lobular septa. Pigment is also seen at times in the costal pleura in the form of lines running parallel with the lower border of the ribs. Pigmentation of the costal pleura is probably due to the absorption of particles which have escaped from the visceral pleura into the pleural cavity. According to Merkel[1] in cases of siderosis the color is either black (magnetic oxide of iron and phosphate of iron) or red (oxide of iron), depending on the character of the inhaled dust. In chalicosis, byssinosis, and tobaccosis the lungs present no special features. In rare instances, in the lung of coal workers and more commonly in those exposed to the inhalation of iron and stone dust, numerous very hard nodules, varying in size from that of a hemp seed to a pea, have been described. These nodules grate on section with the knife, have a gray-yellowish color, and show punctiform and linear markings. In many of them a lumen the size of a pin point may be seen. These nodules, as Rindfleisch[2] maintained, are probably areas of localized tuberculosis.

Other changes in the lungs correspond to the features already described under subacute and chronic indurative pneumonia. Bronchial catarrh is usually present. Bronchiectasis and abscess cavities are not infrequent. Emphysema and adhesive pleurisy are common. The bronchial glands are often black and indurated.

Dust Metastases.—Dust is found not only in the lungs, tracheobronchial and cervical glands of those exposed to the inhalation of dust, but at times, especially in older persons, in the mesenteric

[1] Handbuch der spec. Path. u. Ther., Ziemssen, Bd. i, p. 513.
[2] Lehrbuch d. path. Gewebelehre, Leipzig, 1873, 3 Auflage.

glands and also in the spleen, liver, and kidney. Soyka[1] was the first to establish this, finding anthracotic pigment in the spleen, liver and kidneys of a patient, aged seventy years, with emphysema. He believed that the pigment passed by way of the tracheobronchial glands to the thoracic duct and thence into the blood-stream. Weigert[2] suggested an entrance to the circulation by rupture into the blood-stream of anthracotic glands adherent to bloodvessels at the hilus of the lung. Arnold[3] suggested such a degree of atrophy in the wall of the branches of the pulmonary artery that particles of dust at first lying in the adventitia might later reach the subendothelial layer of the intima and thus gain entrance to the circulation. Weintraud[4] ascribed the invasion of the abdominal organs to retrograde transport of particles through the lymph stream. Attempts to solve the problem by animal experimentation have thus far proved unsuccessful. The evidence at hand seems insufficient to decide on the way in which these metastases occur, but transportation by way of the blood-stream is the most probable explanation. For a discussion of the question, reference may be made to Roth,[5] Gärtner,[6] Askanazy,[7] Ohkubo,[8] Beitzke,[9] and Lubarsch.[10] No harmful affects are known to follow the deposit of pigment in the internal organs, but the matter is of some importance from its bearing on the manner in which bacteria enter the body.

Results of Changes in the Tracheobronchial Glands.—Induration, necrosis, cavity formation, and periadenitis may be seen in connection with invasion of the glands by dust. Adhesion of the glands to neighboring structures may have serious consequences. Traction diverticulum of the esophagus may thus arise. In Leichtenstern's[11] case there was stenosis of the esophagus. Rupture into the trachea or bronchi may cause aspiration pneumonia or gangrene. Perforation of the pericardium may give rise to pericarditis. A communication may be established between the esophagus or the great bloodvessels and the air passages, with fatal hemoptysis as a result. Compression of the trachea or bronchi may be followed by bronchiectasis in the territory supplied by the partially occluded passages. Tiedemann[12]

[1] Ueber die Wanderung korpuskulärer Elemente im Organismus, Prager med. Woch., 1878, No. 25.

[2] Ueber den Eintritt des Kohlenpigments aus den Atmungsorganen in den Kreislauf, Fort. d. Med., 1883, No. 14.

[3] Staubinhalation und Staubmetastase, Leipzig, 1885.

[4] Untersuchung über Kohlenstaubmetastase, I. D. Strassburg, 1889.

[5] Ueber Metastasen von Kalk, Fett and Kohlenstaub, Korrespondenzblatt f. Schweizer Aerzte, 1884, vol. xiv.

[6] Ueber die Beziehung der schwarzter Pigment in der Leber, Milz und Niere f. d. Kohlenstaubablagerung, I. D. Strassburg, 1885.

[7] Zur Staubverschleppung und Staubreinigung in den Geweben, Zeit. f. allg. Path. u. path. Anat., 1906, Bd. xvii.

[8] Ueber die Intravasation der anthracotischen Pigmentes in die Blutgefässen der Lunge, Virchow's Arch., 1908.

[9] Verhandl. d. deutsch. path. Gesellsch., Jena, 1908, xii, 237. [10] Ibid., p. 241.

[11] Deut. med. Woch., 1891, No. 15, p. 534.

[12] Ueber d. Ursachen u. Wirk. chron. entzündlichen Proz. im Mediast., Deut. Arch. f. klin. Med., Bd. xvi, p. 575.

reported narrowing of the superior vena cava and obliteration of the azygos vein. Immermann[1] noted a late systolic murmur continued into early diastole, of variable distribution and intensity, but most constant over the base of the heart, and at times heard also between the scapulæ. Autopsy showed a stricture of both primary branches of the pulmonary artery in consequence of interstitial pneumonia. In Fränkel's[2] case there was a systolic murmur continued into diastole, of maximum intensity in the third right intercostal space beside the sternum, and heard also inside the spine of the right scapula. Autopsy showed folding of the principal branch of the right pulmonary artery in consequence of an adhesion of an indurated gland with it and the bronchus. In Sewall's[3] case a systolic murmur in the back, inside the right scapula, was due to pressure on the right branch of the pulmonary artery. Adhesion of indurated glands to the vagus or its branches may give rise to tachycardia and recurrent laryngeal paralysis.

Symptoms.—In many cases there are no symptoms whatever which can be ascribed to the inhalation of dust. Patients may inhale dust for long periods without pulmonary symptoms, and even persons who show large amounts of dust in the lungs and bronchial glands after death, may have had no pulmonary disturbance during life. Symptoms when present are similar to those observed in cases with bronchitis, bronchiectasis, emphysema, subacute, and chronic indurative pneumonia and pulmonary tuberculosis. The presence in the expectoration of particles of foreign material only deserves special consideration. Workers in coal dust expectorate black sputum in which minute particles of a coal-black color can be seen. Gritty particles may prevent close application of slide and cover-glass. On microscopic examination hard coal appears as fine granules of an irregular shape, polygonal plates, or less commonly spear-, lancet- or needle-shaped splinters varying in length and thickness. The particles are free or enclosed in epithelial cells or leukocytes. In Traube's case the microscopic appearance of the particles indicated their origin from charcoal. In siderosis the color of the sputum varies according to that of the inhaled dust, being black as in anthracosis when magnetic oxide or phosphate of iron has been inhaled and red if the individual has inhaled the oxide of iron. The inhalation of stone dust or organic dust usually has no influence on the color of the sputum. At times, patients who have been exposed to stone dust expectorate stone-like concretions.

Inhaled particles of foreign material usually persist in the sputum only until those particles clinging to the walls of the air passages or

[1] Striktur beider Hauptäste der Lungenärt. u. ihrer erst. Verzweig. infolge chron. interstit. Pneum., Deut. Arch. f. klin. Med., Bd. v, p. 235.

[2] Spec. Path. u. Ther. d. Lungenkrankheiten, 1904, p. 512.

[3] An Extraordinary Case of Anthracosis, Trans. Amer. Climatological Assoc., 1905, vol. xxi.

ingested by phagocytic cells are expectorated. Particles which have become imbedded in the tissue are expectorated only when there is ulceration of the parenchyma of the lung. Elastic tissue is also then present in the sputum.

In uncomplicated cases of pneumonoconiosis, examination of the lungs is negative.

Diagnosis.—Varying amounts of dust are found in the lungs of all persons exposed to dusty atmosphere, its amount varying with the degree and duration of the exposure. Unless complicated by inflammatory changes, the absence of distinctive clinical features may prevent a clinical diagnosis, but its presence may be suspected from the history of exposure. If masses of disintegrated lung tissue are expectorated the foreign particles may be detected. As it is doubtful if dust alone and without the presence of bacteria is capable of giving rise to serious pulmonary lesions, the establishment of the presence of dust in the pulmonary tissue is of little if any importance. It is probable that most, if not all, cases classed as pneumonoconiosis are more properly placed under subacute or chronic pulmonary infections. The most important question in diagnosis is whether the pulmonary disturbance is due to infection with tubercle bacilli or other organisms.

Prophylaxis.—In the prevention of pulmonary disease incident to the inhalation of dust, other factors than dust itself must be taken into consideration. Measures for the relief and control of patients with pulmonary tuberculosis must be enforced. Persons subject to pulmonary infection with other organisms than tubercle bacilli are also a source of danger and should be instructed as to the proper care of the expectoration. Individuals suffering from tuberculous or non-tuberculous infection should be excluded from dusty occupations. Sufficient air space, proper ventilation, regular, and not unduly long hours of employment, avoidance of sudden exposure to extremes of heat and cold, and excessive physical exertion, an adequate wage, nourishing food, sufficient and proper clothing, and abstinence from alcohol will do much to diminish the incidence of pulmonary disease. Until the so-called dusty occupations no longer deserve the name, physicians should pass upon the fitness of candidates, and no person under eighteen years should be allowed in such employment. The dangers of dust need especially to be appreciated by workers in dusty occupations, and it is doubtful if the conditions obtaining in many workshops and factories would long be tolerated by the workers, or the business continue to be profitable to the owners if the workers were better informed. The distribution of circulars of information among the workers and owners would do much to correct unhealthy conditions. The introduction of electric lighting in place of gas and kerosene, inlets of sufficient size for the admission of fresh air, effective means for the removal of dust, such as exhaust fans with strong draught away from the workers, daily

sprinkling and sweeping of floors, and when necessary, the wearing of respirators will diminish the danger.

Home dust, that of public meeting places, and churches may also be dangerous. Dark, dirty, and ill-ventilated rooms may harbor tubercle bacilli and other organisms and prove a danger to those who inhale dust in such places. Dusting with a damp cloth, sweeping with a damp broom, and the use of the vacuum cleaner diminish the chances of infection. The substitution for carpets of rugs which may be cleaned outdoors will diminish the amount of house dust. The use of soft material in the making of streets is responiible for a large amount of the dust which gains entrance to city houses. In streets where there is much travel, especially by the automobile, the amount of dust may be enormous. In thickly settled regions asphalt with a hard, smooth, and easily cleaned surface should be substituted for macadam. Sprinkling with crude petroleum or the use of one of the various preparations of tar on the surface of soft streets should be more generally adopted. The use of soft coal for heat and power fills the air of cities with smoke, which pours in black clouds from the chimney tops. The use of suitable smoke-consuming devices should be required by law.

Treatment.—There are no means by which the dust which has invaded the lung can be eliminated. Persons already subject to pulmonary disease should avoid dusty places, and bronchitis, bronchiectasis, indurative pneumonia, emphysema, and other disturbances should be appropriately treated.

CHAPTER XVI.

PULMONARY ABSCESS AND GANGRENE.

The clinical distinction between abscess and gangrene is often difficult or impossible. It may be uncertain even at autopsy. Typical examples of the two affections may be easily differentiated, but pulmonary abscess may later develop into gangrene, the two processes may be combined, and it may be hard to say where the one stops and the other begins.

Etiology.—In general the same etiologic factors obtain in both groups. Although in a considerable proportion of the cases the onset is insidious, and the clinical findings fail to disclose the character of the underlying pulmonary disturbance, it is improbable that either abscess or gangrene is ever actually primary and unpreceded by pulmonary changes. In many cases, pulmonary abscess and gangrene may be recognized as secondary to infection of the lung, the neighboring regions or more remote parts of the body.

1. **Pulmonary Infections.**—*Lobar Pneumonia.*—Abscess is a clinical complication only in rare instances. Fränkel[1] observed a termination in abscess in scarcely 2 per cent. of 1200 cases. Special search for pulmonary abscesses at autopsy on cases of lobar pneumonia shows that they are not infrequent in fatal cases. In 51 cases of lobar pneumonia coming to postmortem examination at the Massachusetts General Hospital, abscesses of variable size were found either macroscopically or microscopically in 14, and doubtless capable of spontaneous resolution in a considerable proportion of the cases. The conditions in fatal cases are probably more favorable for their development. Debility, alcoholism, and general or local circulatory disturbances may be in part responsible. Traube[2] suggested emphysematous degeneration, to which pressure of the pneumonic exudate is superadded, as a predominant factor in diminishing the blood-supply to an extent incompatible with survival of tissue. Less commonly he believed that hemorrhage into the inflamed region may precede and in conjunction with the exudate cause sufficient compression to induce the necrosis. Hemorrhagic infarction following local thrombosis may thus be a cause. Lobar pneumonia is the most easily recognized and appears to be the most frequent single cause of pulmonary abscess. Of 50 cases of pulmonary abscess at the Massachusetts General Hospital, 14 could be traced to this.

[1] Deut. med. Woch., Vereins Beilage., 1903, p. 204.
[2] Gesammelte Beiträge z. Path. u. Physiol., 1871, Bd. ii, p. 537.

In Tuffier's[1] series of 49 operated cases of pulmonary abscess, lobar pneumonia was a cause in 23. Gangrene appears to be less frequent than abscess after pneumonia. Aufrecht[2] did not observe a termination in gangrene in 1501 cases of croupous pneumonia. Among Fränkel's[3] 85 cases of gangrene only 3 could be traced to genuine fibrinous pneumonia. Of 50 cases of gangrene at the Massachusetts General Hospital, 8 were apparently due to this cause.

Bronchopneumonia.—Owing to the difficulty of detecting small areas of bronchopneumonia its importance is hard to estimate in clinical cases. In a series of 85 cases of bronchopneumonia coming to autopsy at the Massachusetts General Hospital, pulmonary abscesses of varying size were found in 16 (macroscopic in 10, microscopic in 6).[4] The cases represented for the most part infection with two or more organisms, among which pneumococci, the pyogenic cocci and influenza bacilli predominated. The prevalent belief that abscesses are more frequent after infection with influenza bacilli is not borne out by these cases. Of 13 postmortem cases of bronchopneumonia, with influenza bacilli and other organisms, small abscesses were present in only 2. Many of the cases of pulmonary abscess with an insidious onset should be classed in this group. Those which follow bronchitis, bronchiectasis, etherization, and the inhalation of foreign bodies are usually due to the breaking down of areas of latent or obvious bronchopneumonia. Gangrene as well as abscess may thus arise. Abscess formation may precede the development of gangrene. Putrid bronchitis and bronchiectasis are specially likely to give rise to gangrene. Among 60 cases of gangrene noted by Lenhartz[5] 9 cases (15 per cent.) were due to bronchiectasis.

Aspiration.—The inhalation of infected material into previously sound parts of the lung undoubtedly plays an important part not only in initiating pulmonary abscess or gangrene, but also in the development of multiple from single foci. The character of the aspirated material may determine the formation of abscess or gangrene in the infected region. The inhalation of foreign bodies, of a solid, semisolid, or fluid consistency, and pathologic products of suppurative lesions are very likely to give rise to destructive pulmonary lesions. Submersion is not infrequently followed by abscess or gangrene. Food on its way to or from the stomach may be drawn into the lungs. This may occur in health. It is more common during unconsciousness and sometimes happens in the insane. Of pathologic products, those arising in the course of diphtheria of the pharynx or larynx, cancer of the tongue or jaw, ulceration, new

[1] Chirurgie du Poumon., Paris, 1897.

[2] Nothnagel's Encyclopedia of Practical Medicine, Diseases of the Bronchi, Lungs, and Pleura, 1902, p. 760.

[3] Spec. Path. u. Ther. d. Lungenkrankheiten, 1904, p. 546.

[4] Lord, Boston Med. and Surg. Jour., May 11 and 18, 1905.

[5] Kissling, Jahrbücher der Hamburgischen, Staatskrankenanstalten, Jahrgang, 1905–06, Bd. x, p. 10.

growths or traction-diverticula of the esophagus and softened bronchial lymph glands perforating the trachea may be mentioned. The accident may happen spontaneously, during narcosis for operation, or in the case of the esophageal lesions during the passage of a stomach-tube or esophageal bougie. It may follow tonsillectomy or adenoid operation. Gangrene is more likely to follow the entrance of putrefying material into the lungs.

2. **Origin by Extension from Neighboring Organs.**—Extension from the bronchi is the most common source. This has already been considered. Infection of the pleura usually arises by extension from the lungs, but a purulent pleurisy may in turn cause pulmonary reinfection, with the formation of pulmonary abscesses or fistulous tracts connecting the pleura and bronchi. In some instances the adjacent lung is honeycombed by the suppurative lesions. It is often difficult to determine whether the pulmonary abscesses are primary or secondary. Suppuration in the lesser peritoneum, the retroperitoneal space or the liver may perforate the diaphragm and cause pulmonary abscesses, provided, as is often the case, the visceral and diaphragmatic pleuræ have previously become adherent. Carious vertebræ, suppurating bronchial glands and perforation of the esophagus may likewise give rise to pulmonary abscesses by extension. In rare instances surprisingly little pulmonary damage may follow the formation of a fistulous tract between an outlying collection of pus and the bronchi. Gangrene is less common than abscess in this method of origin.

3. **Embolic Form.**—The clinical picture in this group may be that of pyemia. The detachment of infected thrombi from any part of the venous circuit may give rise to pulmonary abscesses; in rare instances to pulmonary gangrene. Pulmonary infarction may coexist. At times, infection from the bronchi may invade an area of pulmonary infarction due to a bland embolus. Ulcerative endocarditis, septic puerperal thrombosis and thrombosis of the sigmoid sinus complicating suppurative disease of the ear may be mentioned as among the most frequent causes. Bacteria or even very fine emboli may at times traverse the capillaries. Endocarditis of the left side of the heart and pylephlebitis may thus at times cause pulmonary infection. A certain proportion of the pulmonary destructive lesions of obscure origin which follow various operative procedures, especially abdominal operations, are probably due to the detachment of infected thrombi from regional veins.

4. **Trauma.**—Among 50 cases of pulmonary abscess, trauma was a cause in 2. In an equal number of patients with gangrene it was a cause in only 1. Pulmonary infection is not common even after chest injuries of considerable violence. Fracture of the ribs and contusion pneumonia may lead to these conditions. Infection may arise by extension from without, as in penetrating wounds or from the air passages. Laceration of the lung substance may occur without external evidence of thoracic injury.

5. **Special Causes.**—Abscesses of tuberculous origin are not under consideration in this section, but it should be noted that the tubercle bacillus, the action of which is usually if not always reinforced by other organisms in the production of pulmonary suppuration, is the most common and important cause. Actinomyces bovis, like the tubercle bacillus, produces pulmonary destructive lesions and usually in association with other bacteria. More or less closely related branching, filamentous organisms variously described as pseudotubercle bacilli, cladothrix or atypical actinomycetes, and described in the section on Streptothricosis, are also capable of giving rise to similar pulmonary lesions. Fungi of the genus Oïdium or of the genus Aspergillus, amebæ, the lung fluke, and bacillus mallei are rare causes. Syphilitic pulmonary lesions and new growths of the lung may in rare instances become necrotic with the formation of abscesses. Echinococcus disease of the lung or neighboring organs may likewise be a factor. In all destructive processes in the lung, such organisms as the pneumococcus, the pyogenic cocci, the influenza bacillus, etc., are more or less constantly present as secondary invaders singly or combined. How far they may be concerned as principal factors in inducing pulmonary suppuration is difficult to estimate.

Gangrene has been ascribed to different organisms, none of which can as yet be regarded as having a specific etiologic relationship with the disease. In the present state of our knowledge, gangrene may be regarded either as dependent on the one hand upon serious interference with the blood-supply, it may be from unusually extensive thrombosis in connection with infection with pathogenic bacteria, or, on the other, as due to infection with one or more organisms singly or in combination capable of causing a special type of destructive and putrefactive pulmonary lesion. Attention has been directed toward spirochætæ as a cause. Feldmann[1] found spirochætæ by Levaditi's method of staining at the margin of the necrosis. Buday[2] finds a large number and great variety of organisms in the gangrenous parts, and among them cocci, bacilli, filamentous organisms, comma bacilli, fusiforms, and spirochætæ. In bronchogenous, acute gangrene, especially in those of progressive character, fusiforms, comma bacilli, and spirochætæ were present in the tissue in the great majority of the cases and in increased numbers at the margin of the necrosis. Identification of the type of spirochæta is hardly possible on morphologic grounds alone.

Pathology.—On inspection, pulmonary *abscesses* appear as circumscribed, grayish, yellowish, yellowish-green, greenish, or reddish-brown areas, from which pus, with or without shreds of pulmonary tissue, can be expressed. The pus may be odorless or foul. Single cavities are usually more or less round and vary greatly in size from beyond the limits of unaided vision to losses of pulmonary substance

[1] Wiener klin. Woch., 1906.
[2] Beitr. z. path. Anat. u. z. allg. Path., 1910, xlviii, 70.

involving the greater part of one lobe. They may be single or multiple. The walls of fresh abscesses or those actively progressing are likely to be soft, uneven, and necrotic, with but little if any line of demarcation between the abscess proper and the surrounding tissue. The walls of older and more quiescent abscesses may be grayish-white or gray, brown or even almost black in color, smooth or uneven and trabeculated, and dense from the formation of connective tissue. The connective-tissue envelope may be thin or thick, well- or ill-defined. Confluence of neighboring areas may give rise to irregularly shaped excavations. In recent cases the surrounding lung tissue is always inflamed. In older processes, organization may have taken place with the formation of grayish, smooth, tough, airless tissue. Under favorable conditions, the contents of the cavity may be expectorated, contraction of scar tissue leads to gradual diminution in size, and in rare instances, the walls of small excavations may thus be brought together with final obliteration of the cavity. Fibrinous or purulent pleurisy may complicate pulmonary abscesses at the periphery of the lung. Pyopneumothorax may also occur.

The microscopic study of sections from cases of lobar or bronchopneumonia not infrequently shows in isolated regions the disappearance of the normal alveolar arrangement and its replacement by pus cells representing the beginnings of small abscesses. Such microscopic areas of suppuration are probably capable of restoration to functional integrity. In more advanced abscess formation, the contents of the cavities may be found to consist of well-preserved or disintegrated pus cells, detritus, and bacteria of various kinds, with elastic fibers and shreds of pulmonary tissue. The walls of the abscess cavity and the neighboring pulmonary tissue are infiltrated with pus cells. In the more subacute and chronic cases, the formation of new fibrous tissue from the neighboring interalveolar septa, the interlobular, peribronchial, and perivascular tissue may be noted.

Laënnec first accurately described pulmonary *gangrene* and recognized a diffuse and a circumscribed form. Diffuse gangrene is rare. Laënnec saw but two cases in twenty-four years. The greater part or the whole of one lobe may be involved and converted into a greenish-black, pulpous, foul-smelling mass, with ill-defined boundaries. In the more common circumscribed variety, single or multiple areas are found. They vary in size from a bean to an apple, at first are dry and greenish-gray in color, later moist, softened, greenish-brown or black, extremely offensive, and in places disintegrated with the formation of cavities. The cavities contain a brownish or greenish, offensive fluid, and are lined with uneven, shreddy walls. Evacuation of the contents may show bronchi and bloodvessels, especially arteries, lining their walls or traversing the lumen. The bloodvessels are usually extensively thrombosed. If erosion of a vessel precedes its occlusion, severe and even fatal hemorrhage may result. The gangrenous area may be sharply differentiated from the surrounding

tissue by a zone of intense hyperemia or more firmly consolidated tissue, beyond which there is pulmonary edema for a variable distance. In slowly progressive or stationary lesions, a pyogenic membrane may form outside the gangrenous region. In favorable cases, the necrotic and disintegrated material may be absorbed or expectorated, organization and connective-tissue formation take place, the cavity slowly diminishes in size and may finally heal. In less favorable instances, it remains. In chronic cases, induration of the neighboring tissue is an invariable accompaniment, in spite of which, however, the process may continue slowly to extend. In long-standing disease, bronchiectasis occurs in the bronchi communicating with the diseased region. Fibrinous, serofibrinous, purulent or putrid pleuritis, and pyopneumothorax may complicate acute pulmonary gangrene situated near the periphery of the lung. Extensive pleural adhesions are likely to form in the course of more chronic cases. Multiple gangrenous foci are common and arise by extension or aspiration. The bronchial mucous membrane is reddened and swollen in consequence of irritation from contact with the decomposing material. The bronchial lymph glands are usually enlarged. Single or multiple cerebral abscesses may arise from the detachment of infected thrombi from the pulmonary veins.

Microscopic examination of sections from acute cases of pulmonary gangrene shows serum, scanty fibrin, occasional leukocytes, and desquamated epithelial cells, and usually an abundance of red blood corpuscles within the alveoli. In places, fibrin and pus cells may be more abundant. Connective-tissue formation may be noted in the neighboring lung as already mentioned in connection with pulmonary abscess.

Certain pathologic features of abscess and gangrene, such as (1) the site of the lesions, (2) their number, (3) the occurrence of pulmonary induration, and (4) the condition of the pleura, deserve special mention. In this connection the two processes may well be considered together.

1. **The Site of the Lesions.**—Abscess or gangrene may be found in any part of the lung. The lower lobes, and especially the right, are more frequently involved. Proximity to the pleura is in general a striking feature. Of 30 cases coming to postmortem examination at the Massachusetts General Hospital the lesions were just beneath or extended into the pleura in 28. In one of the remaining cases, with multiple processes, their relation was variable, some near and others distant from the pleura, while in the last case they were deep within the substance of the lung. Their deep or superficial site varies somewhat with the cause. Foreign bodies lodged in the larger bronchi are likely to lead to deep-seated processes. Following trauma, they may be found at the seat of the injury. Extension from neighboring extrapulmonary regions affects the nearby parts of the lungs.

2. **The Number of the Lesions.**—Pulmonary destructive processes are more often multiple than single. Thus of 38 cases of abscess or

gangrene coming to autopsy a single focus was found in 13, multiple foci in 25. The cause of the process bears an uncertain but somewhat suggestive relation to the number of the lesions. Bronchopneumonia, aspiration pneumonia, and embolism are more likely to lead to multiple and widely separated lesions. Croupous pneumonia is likewise more often followed by multiple foci, as in 2 of 3 cases in the series, but limitation to one lobe may be more often observed. The duration of the process is of greater importance. This is strikingly illustrated in 11 operated cases at the Massachusetts General Hospital. Of 6 patients with a history of from three weeks to two months the findings at operation and the rapid subsidence of cough and expectoration thereafter in 5 indicate that the evacuated pus was probably from the only important focus. Of 5 other cases with symptoms for from nine months to four years, the pulmonary lesions were certainly or probably multiple in 4. In general, it may be said that acute abscess or gangrene is single or predominantly confined to one region. But the longer the process has lasted, the greater is the opportunity for the formation of multiple foci, by extension into contiguous territory or aspiration into neighboring or remote parts of the lungs. Chronic processes are thus almost invariably multiple.

3. **Pulmonary Induration.**—Here, too, the duration of the disease is a most important consideration. In the acute cases the affected regions are not sharply limited from the surrounding and always inflamed pulmonary tissue. In the more subacute and chronic cases the adjacent zone of reactive pneumonia is gradually transformed into granulation tissue, which later gives place to connective tissue. Pulmonary induration may be diffuse or confined to the immediate neighborhood of the destructive process. Bronchiectasis and multiple lesions are frequently observed. It is impossible to state the necessary interval for the development of induration, since it varies in different cases. In one of the hospital series, marked interstitial pneumonia was found about a large abscess cavity three and one-half weeks after an apparent lobar pneumonia.

4. **The Condition of the Pleura.**—The frequent peripheral site of pulmonary abscess and gangrene is responsible for pleural involvement in a majority of cases. The proportion varies in different series. Tuffier's figures are usually quoted. He noted pleural adhesions in 87 per cent. In 35 cases coming to postmortem examination at the Massachusetts General Hospital the visceral and parietal layers were firmly adherent in the region of the pulmonary process or over a wider area in 13, purulent pleuritis was present in 5, weak adhesions or a few bands of connective tissue were found in 12, and the lungs were free in the remaining 5. The cause of the pulmonary lesions may determine the condition of the pleura. Croupous pneumonia and extension of suppuration from without never spare the pleura. If the disease is due to bronchopneumonia, aspiration pneumonia, or embolism the pleura may be free.

Symptoms.—The symptoms of abscess differ from those of gangrene principally in degree. Abscess is a much milder and simpler process. The clinical features of abscess will first be considered, but it must be constantly in mind that a sharp distinction between them cannot be made. In some instances, the two diseases may represent in a single case a beginning as abscess, which later develops into gangrene; in others, the opposite relation may obtain.

1. **Abscess.**—When lobar pneumonia terminates in abscess, the first intimation may be a persistence of fever after the time of its expected decline, an accession of cough, a more abundant purulent sputum, and the failure of resolution in the affected lung. The temperature is usually irregular, but often shows marked morning remissions and evening exacerbations. It may be remittent or intermittent and is sometimes absent. The cough, aside from becoming more frequent and harassing, may lack distinctive features. The sputum changes from rusty, tenacious, to mucopurulent, and later to purulent; from scanty to an increasingly more abundant expectoration. There may be frequently recurring chills. The patient is likely to become pale and lose in weight and strength. There may be no distinctive physical signs, and for some days to a week or more the suspicion of caseous pneumonia, empyema, pulmonary induration or abscess may be entertained. In typical cases, however, a more severe paroxysm of cough may be followed by the sudden expectoration of a large amount of pus, after which the physical signs of cavity may be found and the symptoms immediately improve. The purulent sputum continues, but may gradually diminish in amount. Small cavities may com-completely heal.

The symptoms of abscess following bronchopneumonia or aspiration pneumonia present little that is characteristic. To the clinical features of these conditions may be added a more severe cough, fever of a septic type, and the sudden expectoration of abundant sputum. The embolic form of abscess is likely to be masked by the severity of the underlying general infection. When pulmonary suppuration supervenes on hemorrhagic infarction the bloody sputum becomes mixed with or changes to pus. Evacuation may occur suddenly as in other forms. The symptoms of pulmonary abscess arising by extension from without are often obscure. The pus may invade the lung in many small areas over a considerable territory, with only a gradual increase in already existing pulmonary symptoms. Obvious perforation may, however, occur. It may be followed by evident relief and insignificant symptoms. In some instances serious symptoms of suffocation and even death may quickly follow.

The most suggestive single symptom of pulmonary abscess is the sudden expectoration of a large amount of pus. The patient is often conscious of the sudden relief of pressure and may even indicate its site. With the development of a cavity communicating with the bronchi, paroxysmal cough, and the evacuation within a short period

of considerable amounts of sputum is often a striking feature. It is especially common in the more subacute or chronic cases, and the patient may be almost or quite free from cough in the intervals. Such periodic evacuation depends on imperfect drainage, and is more often seen with abscesses in the lower lobes of the lungs. The assumption of certain positions, such as lying on the unaffected side, may constantly induce a paroxysm, while maintenance of the cavity in a dependent part of the lung may insure the greatest relief. Patients with cavities in one or the other lower lobes may thus be most comfortable in a sitting or half-sitting position and inclined toward the affected side. Similar paroxysmal evacuation may be seen with bronchiectasis. The breath may have a disagreeable odor. Pain from pleurisy is frequent. Dyspnea is not a striking feature from abscess alone.

Sputum.—This is mucopurulent or purulent. It is very variable in amount and may reach several hundred to five hundred cubic centimeters or more in twenty-four hours. The color is a varying shade of green. Admixture of blood may give a brownish tinge. Pure blood may be expectorated in streaks or as frank hemorrhage. The sputum may be odorless or disagreeable and variously described as stale, musty, sweetish or even fetid, but not horribly offensive as in pulmonary gangrene. The odor alone is not a safe means of distinguishing the two processes. If the disease is of short duration, putrid sputum suggests gangrene. Putrefaction of shreds of pulmonary tissue lining the walls of abscesses or the purulent contents of the cavity may likewise give rise to a foul odor. In chronic abscesses and in bronchiectasis, putrid sputum is occasionally observed from the latter cause. The gross appearance of the sputum may suggest its source. Pus from large and single abscesses or from outlying suppuration is likely to be homogeneous and little mixed with mucus. Sputum from multiple abscesses, on the contrary, may show little tendency to confluence, each mass being covered with mucus. Too much reliance should not be placed on such features, however, for the abscess may communicate imperfectly or not at all with the air passages and mucus covered masses of sputum may come from inflamed bronchi. An almost pure purulent sputum with little admixture of mucus may occur in advanced bronchiectasis, with loss of the bronchial mucous glands. A conclusion as to the size of the cavity from the amount expectorated at one time is uncertain, as the cavities may be multiple and a portion of the sputum may also come from other parts of the inflamed lung or the bronchi.

After standing the sputum may separate into three layers: a sediment of pus at the bottom, a layer of foamy mucus more or less intermixed with mucopurulent masses at the top, and thin, cloudy fluid, mostly saliva, in the intervening space. Similar stratification of the sputum on standing may be seen in bronchiectasis or the evacuation of pus through the bronchi from without, as from empyema.

Careful examination of the sputum, if necessary in a flat glass dish

on a black background, may disclose shreds or masses of pulmonary tissue. If the specimen has been standing the sediment is most likely to contain them. They vary from microscopic dimensions to masses an inch or more in length, at times of a reddish color, but more often yellowish-white or greenish-gray from infiltration with pus. Their origin from the lung may be determined, on microscopic examination, by the presence of elastic tissue. They may also contain fatty acid crystals, pigment, and abundant bacteria. Small grayish-white or yellowish particles or granules may be found in the sediment of pus. They can be differentiated from actinomyces granules only by the microscope. When crushed between cover glass and slide, they are found to consist almost exclusively of bacteria. They are smaller than Dittrich's plugs.

Elastic Tissue.—This may be found in the shreds of pulmonary tissue. Smaller particles of elastic tissue, visible only with the microscope, are more common. Its presence is a certain indication of a destructive lesion. It may be demonstrated by Sir Andrew Clark's method as recommended by Osler. The thick purulent sputum is poured upon a glass plate 15 x 15 cm., flattened into a thin layer by means of a second plate 10 x 10 cm. and examined over a black background. Elastic tissue appears as grayish-yellow spots and may be identified under the low power of the microscope. Only the larger masses can be recognized in this way. Smaller fibers must be sought under the high power.

Elastic tissue appears under the microscope as intensely refractive fibers or bundles of fibers, with a sharply defined, wavy outline. The fibers are of varying but usually small diameter and frequently branch. Their ends are often curled and frayed. An origin from the lung can be determined with certainty only when an alveolar arrangement can be shown. Destructive processes in the larynx, trachea, bronchi or pleura may also give rise to single or interlacing filaments of elastic tissue.

For the discovery and identification of small fragments of elastic tissue I have generally used the following method of sedimentation and staining: From 0.5 c.c. to 1 c.c. of the thick, purulent sputum is placed in a small Erlenmeyer flask and diluted with 15 to 20 volumes of distilled water. A few drops (3 to 5) of KOH are added and the mixture gently warmed over the Bunsen flame until the sputum is dissolved. As small an amount of KOH as possible should be used in order to keep the specific gravity low. Elastic tissue is insoluble[1] in KOH. The solution is then sedimented by means of the centrifuge, the supernatant fluid decanted and smears made on coverglasses by means of the platinum loop from the small amount of sediment which remains. The smears are dried in the air or over the Bunsen flame, fixed by heat, as for tubercle bacilli, and covered with Weigert's

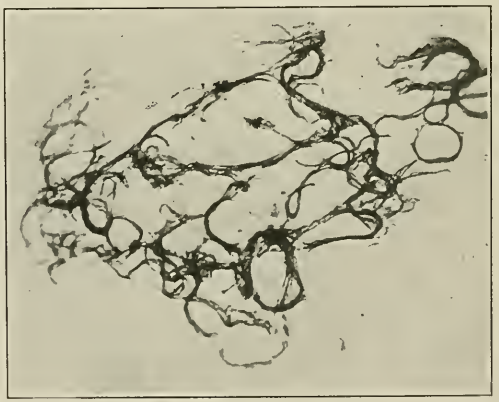
[1] In acids and alkalis.

elastic tissue stain.[1] A convenient method is to slip the cover-glass into a large test-tube containing enough of the stain to cover it. The action of the stain can be accelerated by heat, but a water bath must be used or the alcohol in the preparation will ignite. Immersion of the end of the test-tube containing the cover-glass and stain in boiling water for about five minutes is usually sufficient. The preparation is decolorized in alcohol (95 per cent.), dehydrated with absolute alcohol, cleared with xylol and mounted in Balsam. The elastic fibers appear dark blue or almost black. If cells are present their shadowy outline may be seen.

Fig. 41

Fig. 42

Fig. 43



Elastic tissue in sputum, stained with Weigert's elastic tissue stain. An alveolar arrangement is best shown in Fig. 43.

By the use of this method, confusion of elastic tissue with connective-tissue, fatty acid crystals, leptothrix, chains of bacteria, fragments of cells, and vegetable fibers may be avoided. Elastic tissue from food is a possible source of error, which may be prevented by careful collection of the sputum.

[1] Centralbl. f. allg. pathologie, 1898, ix, 289, or Mallory and Wright's Pathologic Technique.

2. **Gangrene.**—What has been said of the symptoms of abscess applies also to gangrene. The constitutional depression may be more severe, the loss of flesh and strength more rapid. The gross and microscopic character of the sputum is much the same. It is much more offensive than in acute abscess. Blood, usually much altered, is more often present, in consequence of which the sputum is likely to be reddish, dirty brown, or chocolate in color. Severe and even fatal hemoptysis may occur both in abscess and gangrene. Shreds of pulmonary parenchyma are more often found in sputum from gangrene than from abscess. Traube[1] regarded the absence of elastic tissue from the shreds of pulmonary tissue as a characteristic feature of gangrene and in striking contrast to its abundance in abscess. Von Leyden[2] in general agreed with this opinion, but noted the presence of elastic fibers in the sputum of cases of gangrene in exceptional instances. In my experience, elastic tissue is present in about the same proportion of cases with gangrene as with abscess. Dittrich's[3] plugs may also be found in the sputum. They are soft and mushy or putty-like masses, varying in size from a millet-seed to a bean, of an extremely offensive odor, and composed principally of bacteria, with fatty acid crystals, free fat, and debris. They are not characteristic of gangrene, being found also in bronchiectasis and occasionally in abscess.

Physical Signs.—In a considerable proportion of cases, examination fails to disclose the site of the abscess or gangrene even when this is circumscribed and of some extent.

In the acute cases of abscess or gangrene the persistence of rales at one place may suggest the site of a developing process. A friction rub may be heard. Slight variation from the normal in the breathing, voice, and fremitus may be present. Dulness on percussion is common to the largest number of cases. It is usually due to consolidation of neighboring lung, at times to a complicating pleurisy with exudation. In cases in which there is a collection of fluid in the lung and before a communication is established with the bronchi in addition to dulness, there is diminished breathing, voice, whisper and tactile fremitus over the involved region. As the destructive lesion progresses and after communication with the bronchi has been established, changes in the findings from day to day or after a paroxysm of cough may be noted. A variation in the auscultatory signs is most important and depends on the amount of pus retained in the cavity. If the contents has been evacuated, the breathing may be distinctly bronchial. Amphoric breathing and metallic rales may also be heard, but less often in acute than in subacute and chronic cases.

Over well-developed and superficial cavities the signs may be quite typical. The most striking feature may be bronchial breathing over an area tympanitic on percussion. Cracked-pot note or a variation

[1] Ges. Beiträge zur Path. u. Ther., 1871, Bd. ii, p. 454.
[2] Volkmann's klinische Vorträge, 4 Ser., pp. 91–120.
[3] Ueber Lungenbrand in Folge von Bronchialerweiterung, Erlangen, 1850.

in the percussion sound with the mouth open and closed, during inspiration and expiration and on changing the position of the patient may be noted. On auscultation there may be coarse, bubbling or fine, ringing metallic rales, bronchial, and amphoric breathing, loudly increased bronchial whisper and voice, with an amphoric quality. In doubtful cases it is well to ask the patient to cough and again examine suspected areas.

The smallest cavity detected as such during life, in the hospital series measured at autopsy 3 x 2 cm. and was situated just under the pleura in the posterior aspect of the left inferior lobe. Larger cavities are often missed, especially if deeply placed or without free communication with the bronchi.

Complications.—Pneumonia of the neighboring region is invariably present. Bronchopneumonia or aspiration-pneumonia are not infrequent and may give rise to multiple areas of abscess or gangrene. Pulmonary induration is induced by the more subacute or chronic destructive processes. Bronchiectasis frequently follows long-continued pulmonary suppuration.

Hemoptysis is frequent. The amount of blood is usually small. Severe and even fatal hemorrhage may occur both in abscess and gangrene. It occurs both in acute and chronic processes and comes from arteries lining the walls or traversing the lumen of cavities. Fatal bleeding is more common in gangrene. Of 50 cases of gangrene at the Massachusetts General Hospital 1 was fatal from this cause. There was an enormous hemorrhage on the twentieth day of the disease and death occurred from a recurrence of the bleeding two days later. Nordmann[1] has collected the instances of grave hemoptysis found in the literature. An important distinction, I believe, may be made between the cases in which hemoptysis precedes by a longer or shorter interval the development of abscess or gangrene and those in which it occurs during their course. In the former group the suspicion of tuberculosis should be strongly entertained, provided other pulmonary symptoms are insignificant or absent, while in the latter a destructive process of a different etiology is a sufficient cause.

Infection of the pleura may lead to fibrinous, serofibrinous, purulent, or putrid pleuritis. The milder forms are more common. Purulent or putrid exudates are more often seen with gangrene. An exudative pleuritis complicated 10 (11.8 per cent.) of Fränkel's[2] 85 cases of gangrene. A pneumococcus empyema was present in 1 and a putrid exudate in the remaining 9 cases, 3 of which were associated with pneumothorax. As Fränkel states, the putrid empyema may be present before the gangrene becomes apparent. Reactive inflammation about the gangrenous area and compression by the pleural exudate may effectually close a communication with the bronchi. Disintegration of the bronchial wall may finally lead to evacuation of the gangrenous

[1] Gaz. des Hôp., 1906, p. 1034.
[2] Spez. Path. u. Ther. d. Lungenkrankheiten, 1904, p. 559.

cavity and the empyema through the bronchi. Pericarditis may also occur. Clubbing of the fingers may complicate chronic pulmonary abscess or gangrene. (See Bronchiectasis.)

Cerebral abscess complicates pulmonary abscess or gangrene in rare instances. Virchow[1] first noted its association with gangrene. Sir William Gull[2] specially emphasized the complication. Many cases arising in the course of suppurative pulmonary and pleural disease have since been reported. Martius[3] in 1891, collected 22 cases with autopsy, including 7 reported by Nacther[4] and 2 of his own. Cameron,[5] in 1907, analyzed 17 cases. The cerebral lesions are probably due to the detachment of infected emboli from thrombi in the pulmonary veins. They may be secondary to empyema, gangrene, abscess, bronchiectasis or purulent bronchitis. An interesting feature is the apparent infrequency of metastatic abscesses in other regions than the brain. Among Martius' 22 cases of pulmonary cerebral abscess, metastases were found elsewhere (liver, heart, kidneys, and spleen) in only 6. The cerebral abscesses were multiple in 13 and single in 9 of the 22 cases. The left side of the brain was alone affected in 13 (7 single, 6 multiple). In a large proportion of the cases the infection is carried to the cortical distribution of the middle cerebral artery and leads to the complex of symptoms known as cortical or Jacksonian epilepsy. Hemiplegia or monoplegia may also occur. The right side of the body is more often affected. In some instances there are no symptoms which can be ascribed to cerebral abscess.

Diagnosis.—The distinction between abscess and gangrene in clinical cases rests principally on the uncertain evidence obtained from the odor of the sputum.

The more important features in the diagnosis of abscess or gangrene may be briefly summarized. The history may be suggestive. Pulmonary destructive lesions may follow lobar pneumonia, the inhalation of foreign bodies, submersion, etherization, operation about the upper respiratory tract, or on an individual known to be the subject of bronchial or pulmonary inflammation, after trauma or in the course of suppuration anywhere in the body, especially in the pleura or abdomen. The general symptoms are those of sepsis. Cough is practically constant. The sputum is purulent. In typical cases there may be the sudden expectoration of a large amount of pus. The presence in the expectoration of shreds of pulmonary tissue or elastic tissue with an alveolar arrangement establishes the diagnosis.

The physical signs may be those of pulmonary consolidation and cavity formation. Only the signs of cavity are typical of abscess and gangrene. If the case is seen when there is a circumscribed collection

[1] Virchow's Archiv, 1853, Bd. v, p. 275.
[2] Guy's Hosp. Rep., 1857, S. III, vol. iii.
[3] Deut. Militarärztl. Zeitschrift, 1891.
[4] Deut. Arch. f. klin. Med., 1884, vol. xxxiv.
[5] Guy's Hosp. Rep., vol. lxi; S. III, vol. xlvi.

of pus within the substance of the lung and before a communication is established with the bronchi the signs are like those over centrally placed fluid due to other causes. If air-holding pulmonary tissue intervenes between the involved region and the chest wall there is dulness (not flatness), diminished but not absent breath sounds, voice, whisper and tactile fremitus.

The more frequent location of areas of abscess or gangrene in the lower lobes, and especially the right, should lead to the examination of these regions with special care in suspected cases, but in the absence of physical signs indicating the position of the process no reliance can be placed on its probable site as a possible point for surgical intervention. The lesions are usually near the periphery of the lung and more often multiple than single. Both the site and number vary somewhat with the cause, and a careful consideration of this relation may be of diagnostic importance. The probability of multiple lesions and complicating pulmonary induration increases with the duration of the disease.

A determination of the condition of the pleura is of special importance. An adherent pleura eliminates one source of danger in operative interference. As already mentioned, about one-half the cases of abscess and gangrene coming to autopsy at the Massachusetts General Hospital showed adhesive or purulent pleurisy over the affected pulmonary region. A previous history of empyema which had been opened and drained would indicate with practical certainty that the pleural space was obliterated. Exceptions, however, have been noted in rare instances. From a previous history of fibrinous or serofibrinous pleurisy no certain conclusions can be drawn as to the condition of the pleura. There is, of course, much greater chance of obliteration of the pleural sac than in an individual not so affected. A consideration of the cause of the abscess or gangrene may be of value. Lobar pneumonia practically always involves the pleura. When the disease follows bronchopneumonia, aspiration-pneumonia, or embolism, the pleura is less often affected. The occurrence of pain is always suggestive of pleural involvement and may indicate the site of a developing process. Narrowing of the intercostal spaces from spasm of the intercostal muscles may be an important early sign. More than normal inspiratory retraction of the intercostal spaces may be suggestive. Diminished or absent pulmonary excursion, as shown by percussion of the lower pulmonary margin at the end of inspiration and expiration, may furnish valuable evidence concerning the condition of the pleura. The absence of the diaphragm shadow on the affected side may indicate an adherent pleura. The disappearance of pleural friction under observation may have a similar value. In the absence of more definite and typical signs of thickened pleura or pleural effusion, however, occasional mistakes in the diagnosis of pleural involvement are inevitable. The surgeon, therefore, should always approach the pleura as if it were free or he will occasionally create artificial pneumothorax

or evacuate a pulmonary abscess or gangrene into an intact pleura. An artificial empyema will then add to the gravity of an already serious condition.

An encysted empyema may simulate abscess or gangrene. If the pleurisy is primary, cough and expectoration may be insignificant or absent. Pain is likely to be a prominent symptom of onset. The sacculated pleural exudate is usually bounded on one side by the thoracic wall, and the signs are those of pleural fluid. The signs of uncomplicated abscess or gangrene are those of pulmonary consolidation and cavity. If the case first comes under observation after the empyema has ruptured into the lung and communicates freely with the bronchi, the signs of pyopneumothorax may be present.

Encapsulation of pus between the lobes of the lung or between lung and diaphragm presents special difficulties of differentiation from pulmonary abscess and gangrene. Interlobar empyema may be suggested by a position corresponding to that of the interlobar septa and the absence of signs above and below this region. Encapsulation of pus between lung and diaphragm, without contact with the chest wall, may begin with the symptoms of diaphragmatic pleurisy. Examination may disclose the process several inches above the base of the lung.

Perforation of the lung may be the first objective sign both of interlobar and diaphragmatic empyema. The gross character of the sputum is seldom of much assistance in the diagnosis. The finding of elastic tissue, with an alveolar arrangement, is conclusive evidence of pulmonary destruction, but does not exclude a complicating empyema. The presence of one kind of bacteria in the expectorated pus such as the pneumococcus or streptococcus is rather in favor of ruptured empyema than abscess or gangrene, in which mixed infection is more common.

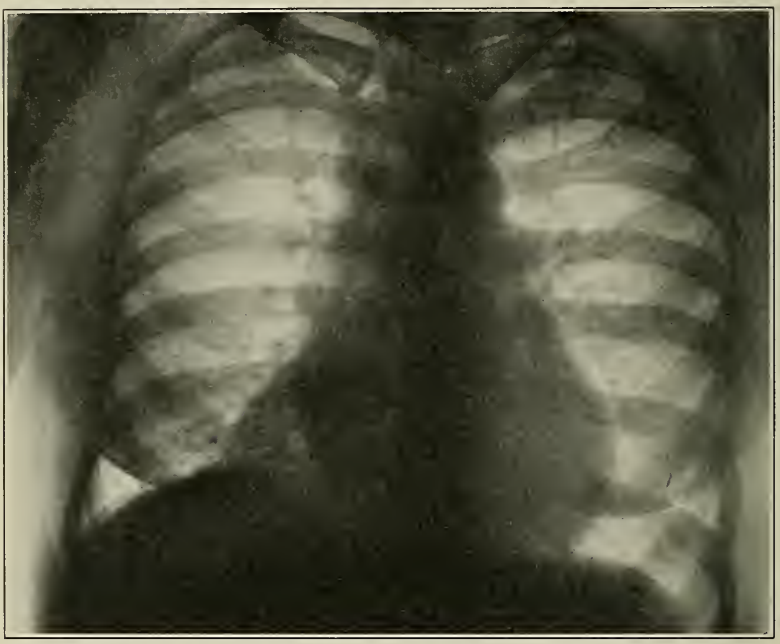
Involvement of the pleura early in the course of abscess or gangrene may suggest a primary pleurisy rather than pulmonary disease. The odor of the sputum or the breath and the presence of elastic tissue in the expectoration may suggest the diagnosis.

The differential diagnosis between chronic abscess and bronchiectasis can hardly be made. The two processes are usually combined and thus in the presence of one the other may be suspected.

Pulmonary tuberculosis must always be considered in the presence of abscess or gangrene. It is more likely to be a cause when the pulmonary disease appears to be primary rather than in cases obviously secondary to pulmonary or other disease. A family history of tuberculosis or opportunity for contagion, a history of hemoptysis early in the course of an apparently mild pulmonary affection, progressive loss of flesh and strength, and evening rise of temperature preceding the onset of abscess or gangrene, are especially suggestive of tuberculosis. Tuberculous processes are more often at the apex than at the base of the lung. Hemoptysis is a frequent symptom in the course of

non-tuberculous abscess or gangrene, and cannot be regarded as specially suggestive of tuberculosis in the presence of destructive lesions which may come from other causes. The location of the process is merely one of many factors to be taken into consideration in weighing the possibility of tuberculosis. Non-tuberculous as well as tuberculous destructive lesions may occur at the apex. In 1905, I reported 4 cases[1] in which cavities were found at autopsy in the superior lobes of the lung, but without gross or microscopic evidence of tuberculosis. On the other hand tuberculous lesions are not very infrequent at the

FIG. 44



Pulmonary abscess. Dense shadow at base of right lung in cardiophrenic angle. (No. 191,543.)

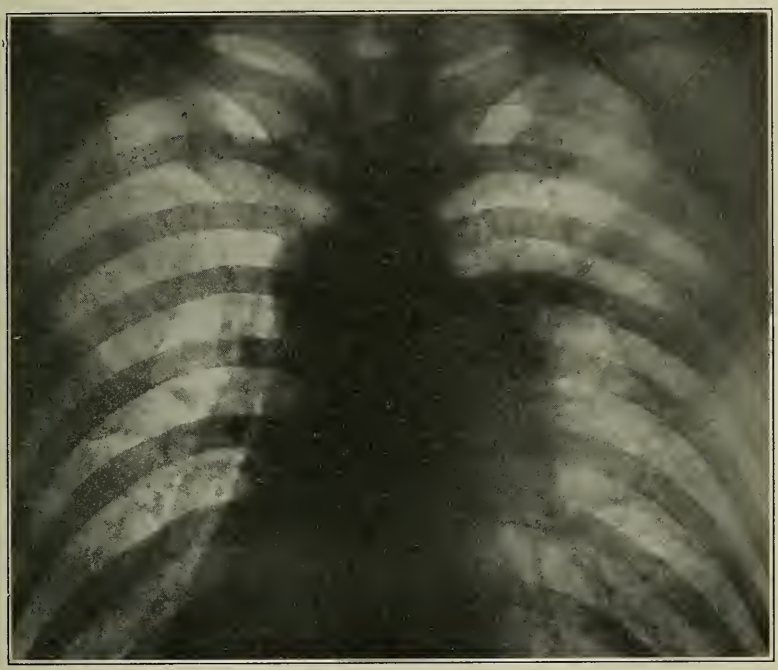
bases. Repeated negative examinations of the sputum do not positively exclude tuberculosis. A pulmonary destructive process which has progressed to the stage of producing an abundant purulent sputum containing elastic tissue, however, and fails to show tubercle bacilli after diligent and repeated search, is not likely to be tuberculous in origin. In the more subacute or chronic and afebrile cases, the subcutaneous use of tuberculin in ascending doses up to and including 10 mg. may be used as a final resort in diagnosis.

The occasional presence of so-called pseudotubercle bacilli in the

[1] Boston Med. and Surg. Jour., May 11 and 18, 1905.

sputum from cases of abscess or gangrene demands a careful study of doubtful organisms. This group is considered elsewhere. No examination of the sputum from cases of abscess or gangrene is complete without a search for actinomyces.

Fig. 45



Pulmonary abscess. Lodgment of fishbone in esophagus four weeks ago. Dense shadow in region of root of right lung. Foul sputum containing elastic tissue. (No. 192,934.)

X-ray Examination.—This may confirm the results of physical examination, disclose the presence of multiple areas, only one of which has been detected, or locate a focus not otherwise to be found. Lenhartz[1] states that the *x*-rays first disclosed the site of the disease in about ten of his cases and led to operative interference. The *x*-ray plate is an important guide to the surgeon if operation is undertaken. An area of abscess or gangrene is usually seen as a dense shadow. Its extent is always greater than that of the destructive lesion from the constant presence of inflammatory changes in the surrounding tissue. In rare instances an empty cavity may appear as a relatively less dense shadow within the involved region. Careful comparison of the physical findings with the *x*-ray plate assists in the interpretation of the latter. The *x*-rays in conjunction with the history and physical signs may make it possible to differentiate an encapsulated empyema from pulmonary

[1] Verhandl. d. Deut. Röntgengesellschaft, Bd. i, p. 55 u. ff.

abscess or gangrene. An otherwise doubtful etiology may be established as in a case seen with Dr. J. S. Stone. The shadow of a tack, thought to have been swallowed five years before, was disclosed.

Exploratory Puncture.—The diagnosis of abscess or gangrene has often been made in this way. The procedure may lead to an erroneous diagnosis or to dangerous and even fatal consequences. It is an unjustifiable method and cannot be too strongly condemned. Exploration may result in a dry tap if the operator fails to find the cavity with the aspirator. The cavity may be reached, but its contents may be too viscid to flow. Removal of the purulent contents of a bronchus may be regarded as the contents of a cavity. The withdrawal of an infected instrument through an uninfected pleura may lead to empyema. A troublesome superficial abscess may follow infection of the soft parts. Injured bloodvessels, lining the wall or traversing the lumen of pulmonary cavities or fresh granulations have been the source of fatal bleeding. Exploratory incision is a safer procedure in cases in which abscess or gangrene is suspected. Exploratory puncture of an adherent pleura after thoracotomy is performed is a useful means of diagnosis and is described under Treatment (p. 314).

Prognosis.—This is difficult to estimate in individual cases. Complete recovery may spontaneously occur both in abscess and gangrene. The greater frequency of abscess at autopsy on cases of lobar or bronchopneumonia than might be expected from their clinical course, as already mentioned, suggests that the repair of small losses of pulmonary substance is often effected. Small single or multiple abscesses are probably frequently overlooked in clinical cases. In severe and prolonged diffuse or localized bronchitis, without signs of pulmonary involvement, elastic tissue may occasionally be found in the sputum, and yet the case may finally end in complete recovery. In one of the hospital series, with an acute onset of cough following a cold, as much as an ounce of purulent sputum mixed with blood and containing elastic tissue, was raised at each paroxysm of cough. There were signs of pulmonary consolidation over an area the size of the palm below the angle of the left scapula, but no cavity was detected. The patient was discharged well after a stay of two months in the hospital, and when seen four years after the attack there were no symptoms or signs of the previous trouble. Anders and Pfahler[1] report an instance of complete recovery in a case with cavity at the angle of the right scapula. The sputum contained elastic tissue. Rieder[2] made a diagnosis of pulmonary abscess in 2 cases by means of the *x*-rays. Elastic tissue was found in 1. Both recovered. Strauss[3] reports similar cases.

Laënnec,[4] Leyden,[5] Wasmer,[6] and Kausch[7] have reported sponta-

[1] Pennsylvania Med. Jour., 1905–06, ix, 425–427.
[2] Münch. med. Woch., April 24, 1906.
[3] Berl. klin. Woch., 1913, i, 509.
[4] Laënnec on the Chest, Trans, from 3d French ed. Johns Forbes, 1838.
[5] Volkmann's klin. Vorträge, 1st S., No. 26, p. 210.
[6] Ueber Spontanheilung von Lungenabscess und Lungengangrän Inaug., Diss. Kiel., 1903.
[7] Verhandl. d. Berliner med. Gesellsch., 1912, xliii, 77.

neous recovery from pulmonary gangrene. Of Leyden's 8 cases of pulmonary gangrene, 6 were discharged well, 1 left the hospital with a putrid cavity, and the last was still in the hospital at the date of writing. Wasmer reports 4 cases of abscess and 2 of gangrene, which he regards as spontaneously cured. Elastic tissue or shreds of lung substance were demonstrated in 5 of the series. A survey of his table shows that recovery appears to have been complete, as judged by the absence of sputum in 2, one of whom had had evident signs of cavity, the other of gangrene.

Incomplete recovery is commonly observed. The acute attack subsides, but the patient continues to cough and raise abundant purulent sputum. Chronic multiple abscesses, bronchiectasis and interstitial pneumonia may remain as the result of an acute abscess or gangrene. In the chronic stage, the patient is liable to recurrent attacks of bronchopneumonia and the loss of more pulmonary substance from abscess or gangrene.

In general, various factors influence the prognosis of abscess and gangrene. They are, unfortunately, of only very limited value in estimating the chances of the individual case. The prognosis of abscess is much more favorable than that of gangrene.

The etiology has a bearing on the outcome. Destructive lesions following trauma and lobar pneumonia appear to be relatively favorable. In the case of trauma this is due to the development of suppuration in previously healthy tissue capable of repair. With lobar pneumonia the single or circumscribed nature of the process and the short viability of the pneumococcus may be of importance. An origin in bronchopneumonia is less promising. The lesions are more likely to be multiple and due to a variety of organisms. I have never seen any convincing arguments in support of the prevalent belief that the course of abscess due to the influenza bacillus is especially unfavorable. This organism is to be found in a large proportion of all respiratory lesions, both benign and malignant. Solid foreign bodies, not immediately removed from the bronchi, are likely to give rise to severe disturbances and an almost invariable chronic course. Abscess or gangrene arising as a complication of putrid bronchitis or bronchiectasis and developing in indurated tissue is usually severe and long continued. The prognosis of abscess or gangrene following the extension of suppuration from neighboring regions, or the aspiration of fluid material varies with the amount and quality of the fluid, the development of single or multiple areas, the previous state of the lung, and the general condition of the patient. Such processes are in general severe. Metastatic pulmonary abscess or gangrene, as a pyemic manifestation, is likely to run a severe and fatal course.

The prognosis is better with single or circumscribed than with multiple and widely distributed processes. Apical localization may be more favorable if the relation with the bronchi is such that gravity can assist in the evacuation of pus. The size and number of the foci

must also be taken into account in estimating the gravity of the situation. The occurrence of complications may be of greater significance than the original process. An hemoptysis or cerebral abscess may prove fatal. Perforation of the pleura is of itself a serious event, but may lead to early detection and evacuation by operation.

The clinical aspect is important above all else in estimating individual chances. The general appearance of the patient and the degree of sepsis as indicated by the fever, pulse, sweats, and chills, are valuable guides. Careful observation for a time, with a record of the daily amount of sputum, may furnish important data for the estimation of progress. A persistence of septic symptoms with an increasing amount of sputum and elastic tissue indicates an advancing lesion. The duration has an important bearing on the outcome. If an active process has existed for as long as six to eight weeks, the presence of irreparable pulmonary damage is to be feared. Multiple lesions, bronchiectasis and pulmonary induration are then almost inevitable.

Mortality.—The mortality of abscess without operation cannot be accurately indicated. That of gangrene is also uncertain. It is said by Verneuill[1] to be 80 per cent. Lenhartz[2] referred to the statistics of three large municipal hospitals in Berlin from which exact figures concerning pulmonary gangrene were available. The mortality was not below 57 per cent., and for the most part rose over 70 per cent. Many of the recovered cases have persistent cough and expectoration.

Baron[3] collected seven cases of abscess in infants. The disease was fatal in all. He adds one case with recovery after evacuation of the abscess cavity by operation.

The surgical mortality of abscess and gangrene, in collected cases, is given by Garré[4] as follows:

Abscess	182 cases;	Cured, 148;	Died, 34;	(18.5 per cent.)
Gangrene	281 "	" 197;	" 84;	(29.3 " "

The experience of individual operators is of greater value. Lenhartz,[5] acting in the double capacity of internist and surgeon, had operated on 85 cases of pulmonary gangrene in the ten years preceding 1907. Of this number 53 were cured and 32 died. If 4 cases with tuberculosis and 12 in poor general condition be excluded the results are more favorable. Of 69 cases, 53 (76.8 per cent.) recovered and 16 (23 per cent.) died. Among the cured cases a large number would have died without operation. Körte[6] has performed pneumotomy on 28 patients with pulmonary gangrene or abscess. Of this number 20 recovered and 8 (28.5 per cent.) died.

[1] Ann. de la Soc. Belge de Chir., 1900, viii, 148.
[2] Verhandl. d. Deut. Röntgengesellschaft, 1905, i, 56.
[3] Ueber Lungenabscess bei Säuglingen, Berl. klin. Woch., January 20, 1908.
[4] Garré and Quincke. Lungenchirurgie 2 aufl., 1912, p. 127.
[5] Verhandl. d. Deut. Gesellschaft f. Chir., 1907, xxxvi, 60.
[6] Arch. f. klin. Chir., 1908, lxxxv, 2.

An important difference in the results of operation exists between acute and chronic cases. This is strikingly indicated in 11 operated cases at the Massachusetts General Hospital.[1] Of 6 cases of abscess or gangrene (3 abscess, 1 gangrene, and 2 either abscess or gangrene) operated within three weeks to two months of onset 5 showed immediate improvement and were later discharged relieved; 3 were in perfect health after four to twelve years; 2 could not be traced; 1 died soon after operation and multiple abscesses were found at autopsy. Of 5 cases of abscess or gangrene (3 abscess and 2 either abscess or gangrene), with symptoms for from nine months to four years, 3 died soon after operation, 1 failed to be relieved after several operations, and the last case recovered.

Treatment.—(1) **Medical.**—In the acute cases the patient should be abed and remain there as long as there is fever or foul expectoration. Means similar to those for pulmonary tuberculosis should be instituted to improve the general condition. The food should be abundant and easily digestible. Extra feedings are to be advised, if they can be taken. An abundance of fresh air, by night as well as by day, will help. If treatment is carried out indoors a large sunny room should be chosen and the windows kept open constantly. Free ventilation lessens the effect of an offensive expectoration on the patient and the attendants.

The patient must be cautioned not to swallow the sputum. This should not be expectorated into cloths or handkerchiefs, but into a special receptacle. Care should be taken not to soil the beard or clothing. The sputum cup should be emptied as frequently as possible. A mouth wash may be used at regular intervals and also after each paroxysm of cough.

An effort should be made to favor the evacuation of pus by position. The patient may instinctively assume the most favorable posture. If the disease is in the lower lobes, evacuation may be favored if the patient lowers his head over the edge of the bed during the paroxysm of cough. At intervals, during the day, the patient may lie with the affected side uppermost, in an effort to drain the pus into the trachea. Elevation of the foot of the bed, on which the patient lies at full length on the back or abdomen, may also be tried. Quincke[2] has specially emphasized position in the treatment of bronchiectasis. Fränkel[3] has had an adjustable bed frame constructed by means of which the patient can be placed in any desired position.

No reliance can be placed on drugs in the treatment of abscess or gangrene. An effort to check the cough, if successful, may aggravate the condition by increasing the retention of pus. The use of narcotics should be restricted to the relief of a dry and harassing cough, which

[1] Lord. Internat. Clinics, 1906, vol. ii, 16th S. Scudder (Bost. Med. and Surg. Jour., October 1, 1914) has collected 16 subsequent cases at the Massachusetts General Hospital, of whom 5 died, 3 were unimproved, and 8 were relieved or cured.

[2] Berl. klin. Woch., 1898, No. 24, p. 525.

[3] Spez. Path. u. Ther. d. Lungenkrankheiten, 1904, p. 566.

prevents sleep or exhausts the patient. Such derivatives of opium as morphin, gr. $\frac{1}{8}$ (0.008 gm.), codein, gr. $\frac{1}{2}$ (0.032 gm.), or heroin, gr. $\frac{1}{12}$ (0.0054 gm.), may then be used and preferably only at night. Various expectorants may be tried. Ammonium chloride, gr. 10 (0.65 gm.), or the inhalations of simple or medicated warm vapor may be useful. For the offensive odor of the sputum and breath, oil of turpentine, oil of eucalyptus, or myrtol in doses of 3 to 5 drops, in gelatin capsules or in milk, is recommended. Injections into the site of the pulmonary lesions cannot be advised.

2. **Surgical.**—*Indications for Operation.*—*Acute Cases.*—Acute pulmonary abscess and gangrene are surgical affections. The best results can be expected only when the physician and surgeon work together. The site of the process must be known. No reliance can be placed on its probable position as a possible point of attack. The chances of success are infinitely better when the process is single, but multiple areas are not necessarily a contra-indication. The assistance of the *x*-rays in determining the site and single character of the process is almost indispensable. It must be constantly in mind that the chances of cure diminish with the lapse of time.

Spontaneous and complete recovery occurs both in abscess and gangrene, and the attendant's judgment will often be taxed to its utmost to decide whether an expectant policy or operation is the wisest course. The knowledge that in many of the recovered cases there is permanent and distressing pulmonary damage may influence the decision. Lobar pneumonia as a cause may be considered of favorable moment in estimating the probable outcome. The clinical features are of more importance.

In the presence of a small process, without marked symptoms of sepsis, a pure, purulent sputum (not foul) and without a large amount of lung tissue, an expectant policy may be followed. An estimate of progress may be made from the amount and character of the sputum and the temperature chart. If recovery or marked improvement does not occur within three to four weeks, operation should be considered. Operation is indicated, on the other hand, in the presence of a large cavity, marked sepsis, putrid sputum and abundant lung shreds. If empyema is present in any case it should be opened and drained. An accessible abscess, elsewhere, which has invaded the lung should also be opened.

Multiple areas of abscess or gangrene may usually be considered a contra-indication to operation. This is more particularly the case when the lesions are widely separated. Multiple and circumscribed foci may be successfully operated, in acute cases. A complicating cerebral abscess makes operation inadvisable. Hemoptysis is not necessarily a contra-indication. If recent there is, of course, the danger of inducing a second attack by the manipulations of the lung. This may also occur spontaneously and end fatally. Much depends on the certainty with which the site of the bleeding can be found. The absence of pleural adhesions is not a contra-indication.

Chronic Cases.—The exigencies of the individual case determine the propriety of surgical intervention in cases which have lasted for months or years. In general, operation is not to be advised. The chances are much in favor of a multiple even though circumscribed process. Induration of the affected region may prevent the closure of the cavity. More extensive costatectomy, pneumolysis, and pulmonary resection rather than simple incision are then likely to be necessary. There is greater danger of hemorrhage. The chance of aspiration-pneumonia during prolonged narcosis increases the operative risk. The likelihood of effecting a cure is also far less favorable. (See Bronchiectasis.)

A careful history of the case may indicate that the destructive pulmonary process in question is of more recent origin than might otherwise be supposed, and hence more favorable for operation. If situated in normal lung tissue, the situation may be little different from that in an uncomplicated and acute case. In the subacute and chronic cases I believe that a progressive lesion affords a better chance for cure than one in which the disease is quiescent. The continued presence of elastic tissue in the sputum may be of value in estimating a progressive character.

Technic of Operation.—The focus of abscess or gangrene should be as nearly as possible empty before operation is undertaken. The patient should therefore be urged to cough and evacuate the cavity. An attempt should also be made to assist the evacuation by position. Local anesthesia is to be preferred, especially for patients in poor condition and those in whom an abundance of secretion endangers sound parts of the lung by aspiration. General anesthesia must often be used. It is necessary in children and nervous individuals. The patient should be only lightly anesthetized. Whether local or general narcosis is employed the patient may well be given morphin subcutaneously before the operation. After the operator has completed the pulmonary incision the anesthetic may be removed, as the pulmonary pleura and lung are insensitive.

The position of the patient during the operation is of importance. He should be placed so that the affected region is dependent, the unaffected lung thus being given full play and the danger of aspirating pus minimized. Körte[1] recommends a slight inclination toward the sound side for operations on the anterior thorax. When operating on the lateral or posterior regions he places the patient on the sound side in the full lateral position.

Thoracotomy.—The incision should be made over the site of the lesion and parallel with the ribs. The soft parts are retraced. About 6 cm. of two or more ribs are subperiosteally resected. Inside the ribs and intercostal muscles lies the thin endothoracic fascia beyond which is the costal pleura.

[1] Arch. f. klin. Chir., 1908, vol. lxxxv.

Pleurotomy.—Is the pulmonary adherent to the costal pleura or free? If adherent, the operation is relatively simple. If free, it may be very difficult. The respiratory excursion of the pulmonary pleura may be plainly visible through the thin partition which remains after removal of the ribs. The condition of the pleura may be doubtful. Palpable induration of the underlying structures suggests an obliteration of the pleural sac at this point, but it is easy to be deceived in this matter. Consolidated pulmonary tissue may give the same feeling. To be sure, the pleura is *likely* to be adherent when induration is present but one never can be quite certain. Then, too, adhesions, though present, may be insecure or limited to a small area, while the neighboring region is free. In all cases, therefore, it is wisest to proceed as if the pleural sac were free.

The parietal should be sutured to the costal pleura, including the lung and intercostal muscles (costopneumopexy). A continuous suture with a round and curved needle is used and each stitch locked by introducing the needle between the entrance and exit of the preceding. The field of operation should thus be enclosed. If the pleura is free, such fixation cannot be relied upon with certainty to prevent collapse of the lung, as the stitches may tear away. The operator may be influenced by the conditions in his further course. If delay is dangerous or pleural adhesions are present, the operation may be continued. If interference is not urgent or the condition of the pleura doubtful, it is best to perform the operation in two stages, waiting now for six to ten days in the hope that adhesions will form. Silk is probably the best suture material. Medicated suture material (silk soaked in turpentine (Karewski), juniper-iodoform catgut or iodine-catgut (Körte)) has been recommended. Many other methods, such as injections (tincture of iodine, mercuric nitrate), applications (zinc chloride paste, iodoform gauze), cauterization, or electrolysis have been suggested, but have never come into general use.

Pneumotomy.—Difficulty may be experienced in finding the cavity. Palpation may disclose an indurated area with a central depression. Exploratory puncture with the aspirating needle or air-tight trocar, contra-indicated in the presence of an unopened throax and free pleura, may now be of great service. Introduction of the instrument further than 2 to 3 cm. into the lung may injure important vessels and cause dangerous hemorrhage. If the focus is not at first discovered, puncture should be made in other nearby places. The prevailing peripheral site of abscess and gangrene demands a careful search of this region before a deeper location is suspected. If necessary the lung tissue may be incised to a depth of 2 to 3 cm. within the field of operation. Failing in this a blunt instrument may be introduced to a greater depth, but not without danger. If pus is reached, the cavity should be opened with the cautery passed alongside the instrument with which it was discovered. The knife or scissors may also be used, but the cautery is to be preferred, especially for the incision of hyperemic tissue.

Lenhartz[1] stated that sometimes one must go 16 to 20 cm. into the lung with the cautery to find the gangrenous area. If pus cannot be found the wound should be packed in the hope that, as sometimes happens, it may later drain into the field of exploration.

Pulmonary tissue overlying an area of abscess or gangrene should be freely opened to secure constant, free drainage. The contents of the cavity should be absorbed with gauze sponges, pulmonary arteries traversing the lumen ligated and the ends of open bronchi discharging pus widened with a blunt instrument or cautery. Körte[2] recommends the use of a head- or cystoscope-lamp for illumination. A good-sized rubber drainage tube, about which gauze is lightly packed, should reach from the thoracic surface to the bottom of the cavity. Washing out the cavity is too dangerous to recommend. It may carry infectious material through the open bronchi into sound parts of the lung. Lejars[3] removed a large sequestrum, measuring 7 x 4 x 5 cm., from a cavity representing the right upper lobe. The patient recovered.

Pneumectomy.—Resection of a lobe of the lung for pulmonary abscess was successfully performed by Krause.[4] The patient recovered.

Dangers and Accidents.—Partial or complete pneumothorax may occur during operation. Sudden collapse of the lung may be followed by severe dyspnea, cardiac weakness, and collapse. Murphy[5] has shown that the cause probably lies in the consequent relaxation and oscillation of the mediastinal curtain, the fixation of which with forceps or a pull on the collapsed lung serving to relieve the symptoms. Gerulanos[6] has demonstrated that collapse more often follows operative pneumothorax on the right than on the left side. This is probably due to the larger size of the right lung. The accident is more to be feared with normal lung and intact mediastinum than in the presence of pulmonary or pleural disease which may limit the collapse of the lung and the elasticity of the mediastinum. Garré[7] emphasizes the important relation which the size of the thoracic opening into the pleura bears to the symptoms. A pleural opening smaller than the glottis still permits even the fully collapsed lung to take some part in respiration. A large pleural opening not only excludes the collapsed lung from participation in the respiratory act, but greatly embarrasses the sound lung. Inspiration is followed by dislocation of the mediastinal curtain toward the sound side, thus limiting pulmonary inflation. Forced expiration, with consequent positive intrathoracic pressure on the sound side, dislocates the mediastinum toward the diseased side and causes insufficient deflation.

[1] Lenhartz and Kissling, Verhandl. d. Deut. Röntgengesellschaft, Bd. i, S. 55, u. ff.
[2] Loc. cit.
[3] Bull. et mém. Soc. de Chir. de Paris, 1911, xxxvii, 749.
[4] Seit 11 Jahren geheilter Fall von Resektion einer Lungenlappens bei Lungenabszess, Münch. med. Woch., 1911, lviii, 2418.
[5] Jour. Amer. Med. Assoc., July, 1898.
[6] Deut. Aerzte Zeit., 1902, Heft 9 und 10.
[7] Garré and Quincke. Lungenchirurgie, 2 Aufl., 1912, p. 22.

The pleural sac may be accidently opened during the removal of the ribs or in the process of fixation by suture. Körte then attempts to close the defect by including a gauze compress, applied to the affected region in a wider stitch tied over the gauze. If the lung collapses, it should be quickly grasped with the dressing forceps, drawn into the pleural opening and there fixed by suture. Artificial pneumothorax occurred in six of Körte's cases. It was thus remedied and was not followed by unfavorable results which could be ascribed to the accident. A small amount of air within the pleura is of itself harmless and is quickly absorbed. After costatectomy and during difficult breathing the lung may "flutter" to and fro, even when the pleural sac is obliterated. The respiration may be much embarrassed. Withdrawal and fixation of the lung to the edges of the incision may be attempted. The operation may need to be discontinued. In one of Körte's cases, death during a second operation was apparently due to this cause.

Empyema may follow exploratory puncture or pneumotomy, when the pleural sac is free or incompletely obliterated. It is usually associated with partial or complete pneumothorax when it follows operation. It is a dangerous complication and must be carefully guarded against, but may occur even when the utmost care is taken. Lenhartz[1] lost two patients from empyema.

Hemorrhage may occur from the intercostal or pulmonary arteries. It is especially to be feared during exploratory puncture of the unopened thorax, as the bleeding vessel may then be inaccessible. Capillary bleeding may be controlled by the cautery or tampon. Arterial bleeding may be stopped by securing the bleeding point with hemostatic forceps and the ligature. Hemoptysis may occur during operation as in one of Körte's cases, with a bronchiectatic cavity of the upper lobe. A long blood clot, lodged in the larynx, caused severe respiratory disturbance, but was finally removed from the pharynx without the necessity of tracheotomy. Air embolism may follow the entrance of air into veins in the midst of indurated tissue.

Finally, sudden respiratory disturbance, collapse and death during or immediately after the operation, may occur in uncomplicated cases. Postmortem examination may fail to disclose the cause. Reflex cardiac inhibition is a probable explanation.

Results of Operation.—In successful cases the amount of sputum rapidly diminishes. The foul odor to the breath and sputum subside. The appetite improves. The fever gradually falls to normal. Incomplete recovery may be due to bronchopneumonia, multiple cavities, or a complicating pleurisy. Complete recovery may follow the operative closure of even large losses of pulmonary substance. No evidence of the previous disease may be disclosed by *x*-ray examination.

Lenhartz[2] reports the case of a man, aged forty-nine years, in whom a fist-sized gangrenous cavity of the right lower lobe was evacuated.

[1] Mitth. a. d. Grenz. d. Med. u. Chir., Bd. ix.

[2] Loc. cit.

Death occurred about two and one-half years later from gastric cancer. At autopsy thick pleural adhesions were the only evidence of the pulmonary trouble.

After-treatment.—This is usually simple. Impaired drainage may be due to more rapid closure of the thoracic wound than of the pulmonary cavity. It is well, therefore, to pack the pulmonary cavity loosely with gauze, while the thoracic wound is tightly filled. The drainage tube should be gradually shortened so that healing will occur from within. More extensive costatectomy may be needed. A complicating empyema may have to be opened. Postoperative bleeding occurred in two of Körte's cases. In one, ligature of a bleeding vessel in the incised pulmonary tissue was necessary eight days after the operation. In the second case, a fatal arterial hemorrhage occurred twenty-one days after operation. At autopsy, a small aneurysmal dilatation in the cavity was found to have ruptured. In still another patient a similar accident was probably prevented by the ligature of a large pulsating vessel in the gangrenous cavity.

Positive and Negative Pressure Apparatus.—Sauerbruch's negative pressure chamber, Brauer's positive pressure method or their modification have as yet been applied in the surgery of pulmonary abscess and gangrene only in isolated instances. Their use would not obviate the necessity of pleural fixation. They would greatly lessen the danger of pneumothorax and agitation of the lung from forced respiration during the operation. Postoperative pneumothorax would still as readily occur. Positive pressure may increase the danger of aspiration-pneumonia.

Intratracheal Insufflation.—Meltzer and Auer's[1] method consists in the introduction deep into the trachea of a flexible elastic tube of suitable size. A nearly constant stream of air is driven through this tube and returns by way of the space between the tube and the walls of the trachea. The danger of artificial pneumothorax in the performance of thoracic operations is overcome by this means, since the process of ventilation can be efficiently carried on without any aid of the respiratory mechanism. The method is simple, has proved satisfactory, and may be used in cases in which there is danger of pneumothorax during thoracic operations. If desired, insufflation anesthesia, also, may be used.

Artificial Pneumothorax.—Forlanini[2] treated a case of putrid pulmonary abscess of the right lung secondary to croupous pneumonia by means of artificial pneumothorax. The abscess had lasted almost six years. The patient was practically well at the time of the last report three years after treatment was begun.

[1] Jour. Exp. Med., 1909, xi, 622; see also Meltzer, Jour. Amer. Med. Assoc., August 12, 1911.

[2] Münch. med. Woch., January 18, 1910.

CHAPTER XVII.

CIRCULATORY DISTURBANCES.

Pulmonary Congestion.—In the lungs, as elsewhere, active and passive congestion may be considered. The two forms are not infrequently combined and sharp distinctions between them cannot be made. Both soon lead to the escape of fluid from the pulmonary vessels.

Active Congestion (*Active Hyperemia*).—Engorgement of the pulmonary vessels with an increased amount of arterial blood occurs in the initial stage of all inflammations of the lung, such as pneumonia, tuberculosis, and pleurisy. A zone of hyperemia likewise surrounds all circumscribed inflammatory pulmonary lesions. Inflammatory hyperemia too slight in degree to be termed pneumonia may be seen in the course of influenza and in typhoid fever. The inhalation of irritating substances may also be a cause. In the presence of an intrathoracic lesion such as pneumonia or a pleural effusion which limits the pulmonary space, the pulmonary vessels outside the affected region may be overdistended as a compensatory process. This collateral hyperemia or fluxion, as it is called, is of little if any importance. Pulmonary congestion accompanying malaria has been ascribed to the malarial plasmodia, and is said to appear during the febrile period and to disappear during the intervals of apyrexia. Although pulmonary congestion associated with malaria may be aggravated during the paroxysms, the malarial origin of the congestion itself is doubtful.

French writers recognize a primary and independent pulmonary congestion under the name of Woillez's disease. There may be an initial chilliness, rapid rise of temperature, pain in the side, and cough with mucoid or mucopurulent but not rusty sputum. On physical examination there is slight dulness, diminished tactile fremitus, diminished breathing with prolonged expiration and subcrepitant or moist rales. The disease lasts only four to five days, defervescence occurring by lysis. The outcome is almost invariably favorable. The condition has been specially studied by Carrière,[1] who demonstrated pneumococci alone, or more often mixed with other organisms in the sputum in 9 of 14 cases. Pneumococci were also found in material obtained by lung puncture in 8 of 10 cases. Inoculation of rabbits seemed to indicate that the organism was of attenuated virulence. The disease does not present sufficiently distinctive

[1] Revue de méd., 1898, pp. 765 and 951; and 1899, p. 54.

characters to justify its inclusion as a special form of pulmonary congestion and seems rather to be an abortive pneumonia.

Hyperemic parts of the lung are dark red in color, of increased volume, more resistant and less elastic than normal. The cut surface exudes an increased amount of dark red fluid. The tissue is still air holding. The whole lung is rarely affected. The dependent parts are most often the site of the process.

On microscopic examination, the pulmonary capillaries are found engorged with blood. The alveolar spaces contain serum, desquamated epithelium, and a few mononuclear and polynuclear leukocytes.

Simple congestion may give rise to dyspnea. Physical signs are lacking unless the congestion is accompanied by exudation. Rales may then be heard over the affected region.

Active congestion of the lung hardly deserves consideration apart from the diseases to which it is secondary. The outlook and treatment are those of the underlying conditions.

Passive Congestion.—This arises in consequence of obstruction to the return of blood from the lungs to the heart. It is most often cardiac in origin, and due to disease of the mitral valve or insufficiency of the left ventricle. The passive congestion is especially marked in long-standing cases of mitral stenosis with hypertrophy of the right ventricle. In this condition, blood is strongly forced into the pulmonary circuit already overfilled because of the impeded outflow through the mitral valve. When in consequence of aortic valve disease, arteriosclerosis or chronic nephritis, a left ventricle previously capable of carrying on the circulation begins to give way, pulmonary congestion also arises. Although the lungs are the first to feel the effect of the stasis, yet in the absence of hypertrophy of the right ventricle, the lungs suffer far less than in mitral stenosis. The congestion is distributed beyond them to the right auricle and the systemic veins, thus relieving the lungs of a part of the burden. Compression of the pulmonary veins from intrathoracic tumors or thrombosis of the pulmonary veins may also be a cause.

Brown Induration.—In the most extreme grade of passive congestion as seen in long-standing cases of mitral disease, the lungs are voluminous, heavier than normal, firm and inelastic, and cut or tear with resistance. The color is brownish or russet brown, due to the increased amount of blood and the deposit of blood pigment in the interstitial tissue and the alveolar cells. Small parenchymatous hemorrhages may give to the tissue an uneven coloring. The bloodvessels of the lung and bronchi are dilated and tortuous. On microscopic examination, the pulmonary capillaries may be found dilated to several times their normal width and the interstitial tissue is increased in amount. Pigment granules may be present in the interstitial tissue and within the alveolar cells. Pigmented epithelial cells ("Herzfehlerzellen") may also be found in the sputum.

Pulmonary stasis from cardiac insufficiency causes dyspnea, cyanosis,

and cough. These symptoms are likely to be intensified in those cases of cardiac insufficiency in which the force of the left ventricle suffers relatively greater impairment than the right. They are likely to make their appearance early in the course of mitral stenosis in which the outflow from the lungs is not only obstructed, but the stasis is increased by the hypertrophied right ventricle. Likewise in other conditions of cardiac failure in which, with insufficiency of the left ventricle, the right ventricle still continues to force blood strongly into the lungs, the pulmonary symptoms are likely to be pronounced. When, however, the right ventricle gives way, the venous stasis is distributed back through the systemic veins and the pulmonary symptoms are likely to be less marked.

The dyspnea of passive pulmonary congestion has been ascribed to various factors. It has led to much discussion and difference of opinion, and a satisfactory explanation cannot yet be offered. Obstruction of the outflow of blood from the lungs to the heart leads to overfilling of the pulmonary capillaries, slowing of the pulmonary blood stream, and distention and diminished elasticity of the lung. The mechanical changes in the lung limit the amplitude of pulmonary excursion, overburden the respiratory muscular system, and dyspnea results. Inasmuch as the freedom with which the lungs can expand is limited by the structures which surround them, the pulmonary alveoli are probably narrowed, as maintained by Traube, and the respiratory surface thus diminished in extent. A diminished amount or impairment in the quality of the blood supply to the respiratory centre may be regarded as contributing factors.

A striking feature of cardiac dyspnea is the frequency with which it is intensified in the reclining position. Ability to breathe more easily in the upright position (orthopnea) may be due to increased thoracic space from the descent of the liver and the diaphragm, diminished venous stasis in the medulla and relief of the pulmonary congestion from slowing of the venous circulation in the territory drained by the inferior vena cava, in the sitting position.

Cough is a frequent symptom. Expectoration may be absent. When present in uncomplicated cases, the sputum is usually scanty and mucoid. Blood is frequently present, as bloody streaks, small bloody masses or a frothy bloody mucus. In rare instances, small blood clots are expectorated. Frank hemorrhage of small amounts of blood may occur, probably from the rupture of dilated vessels in the walls of the bronchi. Bronchitis is not infrequently engrafted on the pulmonary congestion and then aggravates the pulmonary symptoms.

Uncomplicated passive congestion gives rise to no physical signs. When associated with the extravasation of fluid into the air passages, rales may be heard. Fever is absent. If the stasis reaches the systemic venous circuit, swelling of the liver and edema of the feet may complicate the situation.

The symptoms of passive pulmonary congestion are subject to

remissions and exacerbations which depend on the establishment or failure of cardiac compensation.

Cardiac Asthma.—Rapid loss of power in the left ventricle may be quickly followed by severe thoracic oppression, intense dyspnea, orthopnea, cyanosis and cough with scanty, mucoid, blood-tinged sputum. The lungs may be negative with the exception of fine, non-consonating rales at the bases. The term "cardiac asthma" has been applied to this condition.

Hypostatic Congestion.—In long-standing passive congestion, the effect of gravity may largely determine the location of the process, which is then most marked in the dependent parts, as at the bases posteriorly with the patient lying in bed. The term "hypostatic congestion" is applied to this condition.

Hypostatic Pneumonia.—Bacterial invasion may be superimposed on hypostatic congestion and lead to "hypostatic pneumonia." The pneumonia may be lobar, but is more commonly lobular. Owing to the debilitated condition of the patient and the coexistence of edema in the affected region, the symptoms and physical signs are likely to be atypical. Fever may or may not be present. Existing dyspnea and cyanosis may be aggravated. Signs of pulmonary consolidation, consonating rales, bronchial breathing, increase of voice, whisper and tactile fremitus may be present if the pulmonary process is sufficiently extensive and reaches the periphery of the lung. An intense edema, however, may mask the signs. The complication adds gravity to an already grave situation and is not infrequently first discovered at postmortem examination.

Diagnosis.—Passive hyperemia of the lung may be suspected in the presence of cardiac insufficiency involving the left ventricle and in uncompensated mitral stenosis. Some confirmation of its presence is afforded by the expectoration of mucoid sputum mixed with blood, if pulmonary infarction and pneumonia can be excluded.

Prognosis.—Passive congestion of the lung is responsible for the earliest symptoms indicating cardiac decompensation. The outlook is that of the disease to which the passive congestion is secondary. Hypostatic pneumonia is an unfavorable complication and is likely to hasten a fatal termination.

Treatment.—Treatment should be directed to the cardiac affection upon which the passive congestion depends. With hypostatic pneumonia, an expectorant such as ammonium chloride may be tried.

Pulmonary Edema.—In this condition there is an escape of fluid from the pulmonary vessels into the pulmonary tissue, the alveoli, the bronchioles, and frequently into the bronchi also. It is a very common postmortem finding and often precedes death by only a short interval. It is then spoken of as a terminal or final edema. It may also occur as a transient condition in the course of mild or severe pulmonary or other lesions. Its gravity varies much with the extent of the process, the cause and the rapidity with which it occurs. In

general, it may be said that pulmonary edema is a relatively unimportant event, patients dying with rather than of it. In some instances it is a contributing or principal cause.

Chronic Form.—As already noted, long-standing, passive congestion of the lung is likely to be most marked at the bases. Such hypostatic congestion is likely soon to be followed by the escape of fluid from the vessels in the affected region. The condition is then spoken of as "hypostatic edema," which varies in degree from a slight excess of moisture to an airless and solid lung. Hypostatic congestion and edema are bilateral or unilateral, depending on the prevailing position of the patient on the back or on one or the other side. A half or more of one or both lungs may thus be affected. Rales may be heard over the site of the process. If the edema is marked, there is dulness, diminished or absent breathing, voice, whisper and tactile fremitus. It may be difficult or impossible to differentiate this condition from hydrothorax without exploratory puncture. Pleural effusion, however, may complicate the edema.

The treatment of hypostatic edema is that of the cardiac affection upon which the edema depends. When the patient is confined to the bed, an effort should be made to avoid the development of hypostatic congestion and edema by frequently changing the position from one side to the other and the back. If his strength permits the patient may also be propped up with pillows or a bed rest.

Acute Form.—This is associated with a variety of pathologic conditions.

1. *Cardiac Disease.*—Cardiac weakness, whether from diseases of the heart itself or secondary to arteriosclerosis or renal disease, must be regarded as one of the chief causes of pulmonary edema.

2. *Renal Lesions.*—Chronic Bright's disease and arteriosclerosis are common findings in cases of pulmonary edema. The nephritis is commonly only indirectly a cause, through its effect on the heart and aorta. It is possible, however, that both edema of the lungs and edema of the glottis may be due to toxemia.

3. *Arteriosclerosis.*—This is frequently present. The arteriosclerosis may affect the aorta alone or may be general. Huchard[1] regards the pulmonary edema as due to extension of the aortitis and periaortitis to the cardiopulmonary plexus with consequent disturbance of innervation in the pulmonary vessels. It seems more probable, however, that here also the arteriosclerosis is responsible for the edema through its effect on the heart.

4. *Infectious Disease.*—Acute pulmonary edema may be observed in the course of typhoid fever, tuberculosis, rheumatic fever, scarlet fever, smallpox, influenza, and pneumonia. Cardiovascular or renal disease is frequently present and diminished resistance to infection from passive congestion may be in part responsible. In some instances

[1] Bull. de l'Acad. de Méd., 1897, xxxvii, 509; and Bull. méd., 1897, xi, 400.

the edema is the initial stage of an inflammatory process which has progressed beyond a simple active hyperemia, and yet is not outspoken enough to be classed as pneumonia. The pneumococcus is most frequently found in the affected regions. Streptococci and other organisms are also found.

5. *Paracentesis of the Thorax and Abdomen.*—In rare instances, acute pulmonary edema and the expectoration of albuminous fluid follow the removal of pleural effusion. The cause of the edema cannot be stated. It is improbable that it is due to injury of the lung by the trocar. The albuminous expectoration may follow the withdrawal of small amounts of fluid, but in general, it has occurred after the removal of large quantities. The postmortem reports on the fatal cases suggests that pulmonary inelasticity from pleural adhesions or complicating cardiac, pulmonary or mediastinal disease is an important contributing factor. The condition may be due to congestion of the expanding lung, and the ready escape of serum from vessels rendered more permeable by reason of long compression. Riesman[1] has termed this "congestion by recoil." It is also possible that the condition is an "edema ex vacuo," undue negative tension in the aspirator serving to forcibly expand an inelastic lung and thus withdraw fluid from the vessels. Pulmonary edema has also followed withdrawal of abdominal fluid.

6. *Doubtful Causes.*—Isolated examples have been reported of pulmonary edema during pregnancy, in the course of tabes dorsalis, in hysteria, as a manifestation of angioneurotic edema and after anesthesia. Such cases probably belong among the groups previously mentioned.

Pathogenesis.—The pulmonary edema accompanying infections and following paracentesis need not be further considered.

Concerning the edema arising in the course of cardiorenal or cardiovascular disease, it may be assumed that it is due to increased pressure within the pulmonary capillaries or an increase in their permeability singly or combined.

It is probable that the escape of fluid from the vessels is for the most part mechanical and cardiac in origin. Myocardial weakness is commonly present, but weakness of the heart as a whole, frequently fails to cause pulmonary edema and is thus not a sufficient explanation. Welch's[2] experimental production of pulmonary edema in rabbits by squeezing the left ventricle seems to offer the true explanation. Partial paralysis of the left ventricle resulted from the mechanical irritation while the right ventricle still continued to beat. Incapacity of the left ventricle to expel the blood onward diminishes the outflow from the lungs. Persistent action of the right ventricle overfills the pulmonary circuit, and serum escapes from the distended capillaries.

[1] Amer. Jour. Med. Sci., April, 1902.

[2] Virchow's Arch., 1878, vol. lxxii; and also Meltzer, Amer. Med., 1904, viii, 19, 59, 151, and 191.

Acute pulmonary edema, according to Welch, is thus due to "a disproportion between the working power of the left ventricle and the right ventricle of such a character that, the resistance remaining the same, the left ventricle is unable to expel in a unit of time the same quantity of blood as the right ventricle."

Arterial hypertension may be suspected to underly the condition. The left ventricle, already taxed nearly to its limit, is still further burdened, it may be by undue physical effort or excitement, and suddenly gives way under the strain. Further observations on the behavior of the blood pressure in such cases are needed. A disturbance in the coronary artery leading to insufficiency of the left ventricle is also a possible explanation. Kraus[1] finds that an intense pulmonary edema may be obtained in rabbits injected intravenously with 200 to 300 c.c. of normal salt solution if both vagi are cut in the neck following the injection. He ascribes the edema to loss of vasomotor tone in the pulmonary vessels.

While inequality in the capacity of the two ventricles from whatever source seems the most important factor in acute pulmonary edema, yet an increased vascular permeability cannot be excluded as a contributing cause.

Pathology.—The appearance of the lungs depends upon the association of the edema with active or passive hyperemia. The essential addition to these conditions is the presence in the alveoli, the bronchioles and the bronchi also, of an abnormal amount of serous fluid, which exudes from the cut surface of the lung. The fluid may be foamy from admixture with air. Pulmonary edema arising in consequence of inflammatory processes is usually limited to the neighborhood of such conditions, and may thus be local and circumscribed, or general in a part or the whole of one or more lobes of the lungs. Depending on the intensity of the inflammatory process, the fluid is more or less tinged with blood. It is rich in albumin and is found on microscopic examination to contain desquamated alveolar epithelium, red blood corpuscles, varying numbers of polynuclear leukocytes and bacteria. When the edema is due to stasis, it is bilateral. It may be confined to the lower lobes or involve the whole of both lungs, in which case it is most marked at the bases. The fluid may be blood tinged. Desquamated alveolar epithelial cells are present in varying and usually small numbers.

Symptoms.—Pulmonary edema is usually only a relatively unimportant event in the course of active hyperemia or of stasis, and is commonly indicated only by an aggravation of already existing dyspnea and cough, with the presence of rales over the involved region. At times, the sudden occurrence of an intense and widespread edema may prove rapidly fatal. In such cases the patient may die of suffocation, and before he has had time or strength to expectorate the fluid.

[1] Berl. klin. Woch., 1913, i, 1035.

Pulmonary edema due to an acute infection of the lung is seldom sudden in onset, is accompanied by fever, and the expectoration is usually only moderate in amount.

In some instances the expectoration of a large amount of serous fluid is a prominent feature. These cases are usually associated with cardiovascular or renal disease or both. The onset is usually sudden. The attack is likely to occur at night or after unusual exertion or excitement. It may wake the patient from sleep. There is a sense of severe thoracic oppression which increases rapidly to a feeling of impending suffocation. The breathing is labored and accompanied by audible rattling noises. Speech is difficult or impossible. The dyspnea becomes intense. Orthopnea is present. The face and extremities become cold and cyanotic and the skin may be bathed in sweat. A constant and harassing cough accompanies the paroxysm. The expectoration is pale or slightly reddish, thin watery fluid, intimately mixed with air, which gives it a foamy appearance. It may at times actually gush from the mouth and amount to as much as one to two quarts during the attack. The paroxysm usually lasts for several hours. The patient may die in the first attack. More often he recovers, but recurrences are common. Lissamen's[1] patient, a woman, aged forty-five years, had seventy-two attacks, all nocturnal, within two and a half years.

Examination during the attack shows coarse bubbling rales throughout the lungs, usually most marked at the bases, where there may also be slight dulness. The cardiac sounds may be obscured or inaudible in consequence of the rales. In some instances, weakness of the cardiac impulse and feeble pulse have been noted. Fever is absent in uncomplicated cases. Manifestations of dropsy elsewhere than in the lungs may or may not be present. In all but one of Stengel's[2] five cases the blood pressure was high. Aphasia, monoplegia, hemiplegia, delirium, stupor, coma or convulsions may be observed during the attack.

Diagnosis.—Attacks of so-called cardiac or uremic asthma, like attacks of pulmonary edema, are probably due to cardiac weakness, and especially to failure of the left ventricle. The difference between them and pulmonary edema may be regarded largely as one of degree in the disproportion between the working power of the two ventricles. The acute passive congestion of cardiac asthma is unaccompanied by the outpouring of an abundant serous fluid as in pulmonary edema.

Acute pulmonary edema should be distinguished from bronchial asthma in which, however, the dyspnea, while affecting both phases of respiration, is especially expiratory. The expectoration is scanty and mucoid, rather than abundant and watery. The thorax is distended. Sibilant and sonorous rales are heard on auscultation. Cursch-

[1] Lancet, February 8, 1902.

[2] Paroxysmal Pulmonary Edema and its Treatment, Amer. Jour. Med. Sci., January, 1911.

mann spirals and Charcot-Leyden crystals in the sputum and an increase of eosinophiles in the sputum and the blood may be helpful features. The presence of cardiorenal or cardiovascular disease, with arterial hypertension, may be established in pulmonary edema.

Prognosis.—This is grave. The patient may die in the first attack. More commonly he recovers, but recurrences are frequent at long or short intervals, between which there is likely to be a progressive failure of cardiac compensation.

Treatment.—The pulmonary edema arising in the course of infections of the lung is to be treated as for the underlying condition.

The treatment of acute pulmonary edema which occurs in consequence of cardiorenal or cardiovascular disease presents a difficult problem. In the present state of our knowledge the attacks may be regarded as due to cardiac insufficiency of such a character that the relative power of the two sides of the heart is disturbed, the essential feature being a loss of strength in the left ventricle. Arterial hypertension or disease of the coronary arteries, or both, may underly the condition. The indication is to reëstablish cardiac efficiency as a whole and to equalize the work of the right and left ventricles. The situation is complicated, is not well understood, and the treatment so far as the giving of drugs is concerned, is largely empirical.

Complete mental and physical rest is of chief importance, and should as far as possible be secured. The patient should be abed. He is usually more comfortable propped up with pillows or a bed-rest. Morphin has been strongly recommended and as strongly condemned. It is chiefly of value through its quieting effect on the nervous system. Though it is said by some to increase the danger of suffocation, this is probably overestimated, and it may be used with advantage in cases in which there is much nervous excitement, in doses of grs. $\frac{1}{8}$ or $\frac{1}{4}$ (0.008 or 0.016 gm.) subcutaneously. Oxygen inhalations are harmless and may do good. Counter-irritation to the skin may be followed by improvement. A half dozen or more dry cups may be applied to the back and an equal number to the front of the chest. A mustard poultice or plaster may be applied to the front of the chest and allowed to remain until the skin is well reddened, but not longer. Hot hand and foot baths with or without the addition of mustard may also be used.

The attempt to stimulate the heart by means of drugs should be made only after careful consideration of the circulatory condition. It is quite possible to do more harm than good. It seems best to rely on the simple measures already suggested unless for special reasons it seems wise to do more. In considering the advisability of cardiac stimulation, the probable disproportion in the action of the two ventricles must be borne in mind. It is important to know whether the failure of the left ventricle is due to arterial hypertension or to some other cause. If arterial hypertension has been the cause, strophanthin, given intravenously, combined with the use of nitroglycerine or amyl

nitrite may be of service. When other measures fail digitalis, camphor, and caffein, may be used.

Emerson[1] recommends artificial respiration for pulmonary edema due to cardiac insufficiency, believing that the flow of blood through the lungs will thereby be promoted and the right heart relieved. In desperate cases, with deep cyanosis and increase in the cardiac dulness to the right, venesection may be done.

[1] Arch. Int. Med., 1909, iii, 368.

CHAPTER XVIII.

PULMONARY THROMBOSIS, EMBOLISM AND INFARCTION.

Thrombosis.—By pulmonary thrombosis is understood the formation during life from the constituents of the blood of a solid mass or plug within the pulmonary vessels. Such plugs or thrombi may be formed in the pulmonary veins, the pulmonary arteries or their branches. Thrombosis of the pulmonary veins may give rise to emboli in the systemic arterial circulation.

Embolism.—Pulmonary embolism may arise in consequence of the detachment of a part or the whole of a thrombus from the pulmonary artery, the systemic veins or the right side of the heart.

The two processes may well be considered together.

Occurrence.—Pulmonary thrombosis and embolism are of infrequent occurrence. Among 3000 autopsies at the Massachusetts General Hospital, pulmonary thrombosis or embolism is recorded in only 60 instances. The condition is somewhat more frequent than these figures indicate, since cases may be unrecognized during life and followed by recovery.

Etiology.—The factors which lead to thrombosis in any part of the body apply also to its occurrence in the pulmonary vessels. Certain alterations in the blood itself undoubtedly play an important part in the predisposition to thrombus formation, but as yet are little understood. Mechanical interference with the circulation is an important predisposing cause. Lesions of the walls of the vessels also play an important part. Such lesions may be bacterial, toxic or mechanical in origin. The various factors are often combined. Similar causes influence the occurrence of pulmonary embolism, as a secondary manifestation, but all thrombi are not equally likely to give rise to emboli.

In the majority of cases in which plugs are found in the pulmonary arteries or their branches, venous thrombi are present also in other parts of the venous circuit. Thus of the 60 cases in this series, thrombosis of other venous channels was found in 36, including 9 instances in which 2, 4, and 3 other channels were involved. In cases with multiple plugging of vessels, the different veins affected are usually those in the line of the blood current from the involved region. Unrelated tributaries in the venous circuit were plugged in only one instance in the series. It is probable, therefore, that in the majority of cases, plugging of the pulmonary arteries or their branches is due to embolism rather than to thrombosis, although it is often difficult to make the distinction from the character of the plug found in the pulmonary vessel.

Thrombosis of the veins of the lower extremities is the most common source of pulmonary embolism. Thrombosis of the right side of the heart, the iliac, uterine and ovarian veins and the cerebral sinuses are frequent sources. The hemorrhoidal, prostatic, innominate and jugular veins and those of the upper extremities are among the numerous occasional sources of pulmonary emboli.

Of the various diseases with which pulmonary embolism is associated those in which venous thrombosis is a frequent complication naturally occupy an important place. In general, pulmonary embolism arises more frequently from septic than from bland thrombi.

Cardiac disease from its effect on the circulation is an important predisposing cause of pulmonary thrombosis and embolism. In this series, plugging of the pulmonary arteries complicated cardiac hypertrophy and dilatation in 28 instances, in five of which thrombi in the right auricle or ventricle were a possible source. In nine of the cases there was valvular endocarditis. The places of election for intracardiac thrombi are the auricular appendices and the region between the columnæ carneæ at the apices of the ventricles. It is possible that an open foramen ovale may furnish the channel through which emboli may pass from the left to the right auricle and finally lodge in the pulmonary artery. I know of no instance in which such an occurrence has been reported. In one case (Autopsy 733) in this series, two openings in the foramen ovale, measuring about 2 and 4 mm. respectively, were occluded by thrombi which passed through the openings. These plugs projected at either side into the right and left auricles and united to form one continuous thrombus. The right auricle and ventricle also contained thrombi, while the left side of the heart was free.

Pulmonary thrombosis or embolism is not very infrequent as a terminal event in many cachectic conditions. Venous stasis and terminal infections undoubtedly play an important part in their production. They are of little clinical interest and need not be considered in detail. Malignant disease occupies a prominent place and is represented by ten instances in this series.

Venous thrombosis complicating the puerperium is not uncommonly a cause of pulmonary embolism. The venous thrombosis may occur during pregnancy, but is much more frequent within the first few days after delivery. The veins of the lower extremity are apparently prevailingly involved. In many instances, the process has arisen by extension from the pelvic veins, the invasion of which may in turn come from the uterine sinuses.[1] Herff[2] estimates the occurrence of venous thrombosis at about 2 per cent. of all lying-in women. Pulmonary embolism occurs in from 15 to 20 per cent. of those with venous thrombosis. The mortality is estimated at about 50 per cent.

[1] Sperling, Zur Kasuistik der Embolie der Lungenarterie, etc., Zeit. f. Geburtshülfe und Gynäkologie, 1893, vol. xxvii.

[2] Handbuch der Geburtshülfe, III, ii, 974.

In a small proportion of cases, pulmonary embolism may occur without previous symptoms of venous thrombosis. Such emboli probably come from thrombi in the pelvic veins.

Thrombosis occurring in typhoid fever may give rise to pulmonary embolism, as in four cases in this series. Thayer[1] mentions only one case of pulmonary plugging in 38 instances of venous thrombosis among 1458 cases of typhoid fever.

Thrombosis of the pulmonary artery complicated pneumonia in only one case. This was the only thrombus found. The incidence of this complication may be estimated from the statistics of Musser and Norris.[2] They found peripheral thrombosis in 17 (0.72 per cent.) of 2360 and pulmonary thrombosis in 5 (0.27 per cent.) of 1830 collected cases of pneumonia. Steiner[3] reported on 41 cases of peripheral thrombosis complicating pneumonia, finding it more common during convalescence. Death was due to pulmonary embolism in 5 cases. Thrombosis of the pulmonary veins is a constant feature of pneumonia and may give rise to emboli in the systemic arterial circuit.

Pulmonary tuberculosis is complicated by venous thrombosis in rare instances. Dodwell[4] observed it in 20 of 1300; Ruge and Hierokles[5] in 19 of 1778 cases. It usually occurs in the last few weeks or months of life, and is probably due to cardiac weakness and terminal infection in most instances. The thrombus is commonly in the peripheral veins, but the pulmonary artery was involved in two of Ruge and Hierokles' series.

In pleurisy with effusion, thrombosis or embolism is one of the most frequent causes of sudden death. In a series of 500 cases with serofibrinous effusion, sudden death before tapping occurred in 3, and autopsy showed the cause of death in 2 to be pulmonary embolism. One patient had a double effusion, the second a large unilateral accumulation. Of 14 cases with pleurisy with effusion coming to autopsy, thrombosis or embolism of the pulmonary artery was a cause of sudden death in 5. Of the 5 cases, 3 had pleurisy with serofibrinous, 2 with purulent effusion. Bacterial infection may play a part in causing this complication. Venous stasis from the pleural fluid is probably also an important factor. The most common sources of emboli in patients with pleural effusion are from thrombi within venous channels not far distant from the lung, as the pulmonary arteries, the right auricle, the superior and inferior vena cava, the iliac and femoral veins. The large size of the vessels involved increases the danger of a fatal termination from the large size of the detached embolus. If life is prolonged, pulmonary infarction is favored by the existing pulmonary stasis.

[1] Johns Hopkins Hosp. Bull., October, 1904.
[2] Osler's Mod. Med., vol. ii, p. 611.
[3] Johns Hopkins Hosp. Bull., June, 1902.
[4] Amer. Jour. Med. Sci., June, 1893.
[5] Berl. klin. Woch., 1899, No. 4.

Chlorosis may be complicated by thrombosis and pulmonary embolism. According to Eichhorst (quoted from Leichtenstern), venous thrombosis was present in 4 (1.6 per cent.) of 243 cases. Von Noorden[1] observed it in 5 (2 per cent.) of 230 and Leichtenstern[2] in 11 (0.66 per cent.) of 1653 cases. Involvement of the lower extremities (48 cases) and the cerebral sinuses (29 cases) comprised 77 of the 86 cases in Leichtenstern's table. He found that of 52 instances of chlorotic thrombosis of the extremities, pulmonary embolism occurred in 10, ending fatally in 9. Welch[3] collected 13 instances (25 per cent.) of pulmonary embolism among 52 cases with venous thrombosis in other regions than the venous sinuses. All but 2 ended fatally. This frequency of pulmonary embolism gives an unusual gravity to this form of thrombosis. Its occurrence has been ascribed to peculiar brittleness of the chlorotic thrombi.

Venous thrombosis, followed by pulmonary embolism, may complicate various operative procedures.

According to Clark,[4] venous thrombosis was observed 35 times in 3000 abdominal sections at the Johns Hopkins Hospital. The thrombosis involved the veins of the legs and occurred from the eighth to the thirtieth day after operation, being most frequent about the fifteenth day. In an analysis of 1196 laparotomies at the Munich Surgical Clinic, Gebele[5] found 77 (6.43 per cent.) with pulmonary complications. Fourteen (1.17 per cent.) were due to pulmonary embolism. Eleven of these were fatal and the diagnosis was confirmed by autopsy. The complication may occur without infection of the wound of operation or the peritoneum as in 6 of his cases.

Sonnenburg[6] reported 50 cases (5 per cent.) of thrombosis and embolism among 1000 operations for appendicitis. Haward's figures are somewhat lower, with venous thrombosis 34 times among 3774 cases of appendicitis. A little less than one-eighth of the cases with thrombosis were followed by pulmonary embolism. Clark believes that the usual femoral thrombophlebitis which occurs as a sequel to celiotomy starts from a primary thrombus in the deep epigastric veins, slowly propagated along the vessel until it reaches the external iliac, where it gives rise to a retrograde thrombus in the femoral veins. The thrombosis may be due to trauma alone, or follow latent or obvious infection.

Pulmonary embolism may similarly follow gynecologic operations, the reduction or radical cure of hernia, fractures, dislocations, lacerations, and trauma. The trauma may induce venous thrombosis which may remain latent for a time and be discovered only after pulmonary embolism has occurred. The original injury may be mild or severe.

[1] Berl. klin. Woch., 1899, No. 4. [2] Münch. med. Woch., 1899, No. 48.
[3] Allbutt's System of Medicine, vol. vi, p. 202.
[4] Univ. of Penna. Med. Bull., 1902–03, xv, 156.
[5] Beiträge z. klinischen Chirurgie, Tübingen, 1904, vol. xliii.
[6] Ueber Lungenkomplikationen bei Appendicitis, 31 Kongr. d. Deutsch. Ges. f. Chir., 1902.

The detachment of venous thrombi with consequent pulmonary embolism may occur without obvious cause, and during sleep. It may follow massage, a change from the reclining to the sitting position, an attack of cough, deep inspiration, straining at stool, and especially bending the affected limb, as at the knee or hip. It is possible that elevation of the pelvis, too long maintained in the course of laparotomies for operation upon the pelvic organs, may induce cardiac dilatation in patients with weak hearts, and thus favor thrombosis as suggested by Trendelenburg.[1]

Pathology.—1. **Thrombosis and Embolism.**—Thrombosis of the pulmonary artery does not differ essentially from a similar process elsewhere. Displacement of a thrombus in the pulmonary artery or its branches may give rise to embolism of the same vessel or its branches beyond. McPhedran and Mackenzie[2] have reported an unusual instance of pulmonary thrombosis. The smaller pulmonary vessels were the site of an extensive endarteritis and were everywhere thrombosed. In some places the thrombi were organized.

Owing to the large size of the right pulmonary artery, emboli more frequently lodge in it than in the left. The lower are more frequently affected than the upper lobes. This is probably due to the larger size of the branches to these regions. Gravity may also favor this location. Those factors which diminish the blood-supply to the right lung, such as previous thrombosis or embolism, contraction of the lung, the pressure of pleural effusion or position may dispose to left-sided embolism. The size of the embolus naturally varies with the caliber of the vessel from which it comes, although folding may increase the diameter of an elongated mass and result in the occlusion of a larger vessel. Elongated emboli riding on the bifurcation of the pulmonary artery are not uncommon. Pulmonary emboli are often multiple. The pulmonary artery, the right side of the heart and the venous tributaries are likely to be engorged, at times markedly dilated with blood.

Secondary thrombus formation takes place about the embolus if life is prolonged after the accident. This may result in the occlusion of a previously incompletely closed vessel. Both thrombi and emboli may be converted by a process of organization into solid or cavernous fibrous tissue. In rare instances, a partial restoration of the vessel lumen may take place.

2. **Pulmonary Infarction.**—The gross appearance of pulmonary infarcts was first carefully described by Laënnec, who termed the condition "pulmonary apoplexy." Although the association of arterial plugging with pulmonary infarction was later noted, it was not until Virchow's[3] important researches on thrombosis and embolism that

[1] Prakt. Ergebn. d. Geburtshilfe u. Gynäkologie, 1911, iii, 68.
[2] Trans. Assoc. Amer. Phys., 1903.
[3] Virchow, Ges. Abhandl. z. wissensch. Med., Frankfurt, a, M, 1856, p. 374.

emboli were suspected as a cause. The investigations of Panum[1] and Cohnheim and Litten[2] showed that in only a small proportion of the experiments on artificial embolism did infarction of the lungs occur. The manner of its production has been the subject of considerable discussion. Küttner's[3] and Litten's[4] work has thrown much light on the condition.

(*a*) *The Relation of Thrombosis and Embolism to Pulmonary Infarction.*—The pulmonary arteries are terminal arteries, as Cohnheim believed, but a free and extensive anastomosis doubtless exists between their finer branches through the pulmonary capillaries. The bronchial arteries also supply the pulmonary tissue. Their importance in maintaining the blood supply to the territory of the pulmonary artery is indicated by Küttner's experiment. After ligation of the pulmonary artery and the injection of cinnabar into the jugular vein, he found this substance not only in the branches of the bronchial arteries, but also in the pulmonary capillaries and even in the branches and trunk of the ligated pulmonary artery. Under ordinary conditions following occlusion of a branch of the pulmonary artery, the pulmonary circulation is probably sufficiently maintained by the neighboring pulmonary capillaries and the bronchial arteries to prevent infarction. In the presence of an impaired pulmonary circulation, however, hemorrhagic infarction is likely to follow such an occlusion. The source of this hemorrhage is difficult of explanation. Cohnheim believed it to be due to a backward flow from the pulmonary veins, but Litten's observations indicate that it comes from the bronchial arteries. In his experiments, ligation of the pulmonary artery and veins, the bronchial arteries remaining intact, was constantly followed by pulmonary infarction, thus excluding the pulmonary veins as a necessary factor. Ligation of the pulmonary and the bronchial artery, with its collaterals (the tracheo-esophageal, pericardiacophrenic and pleuromediastinal arteries), was not followed by infarction. In this experiment, in which the pulmonary veins were free, the absence of infarction excludes them as a probable source.

In clinical cases, as in these experiments, an important relation obtains between pulmonary infarction and the condition of the pulmonary circulation. When infarction follows pulmonary thrombosis or embolism, it is usually associated with stasis in the pulmonary circuit. Thus of 60 cases of pulmonary thrombosis or embolism, coming to autopsy at the Massachusetts General Hospital, pulmonary infarction was found in 28. In all but one of these 28 cases, there was some serious intrathoracic complication sufficient to cause embarrassment of the pulmonary circulation. In 22 cases, 11 of which were complicated by an accumulation of pleural fluid, disease of the endocardium, myocardium or pericardium was present. Two of the 28

[1] Virchow's Archiv, vol. xxv, pp. 308 and 433.
[2] Ibid., vol. lxv, pp. 99–115.
[3] Ibid., vol. lxxiii, p. 1878.
[4] Zeit. f. klin. Med., Bd. i, pp. 131–227.

cases were complicated by lobar pneumonia, one by pulmonary tuberculosis, and one by pleurisy with effusion. In one instance there was cancer of the stomach with extensive metastases and a large amount of fluid in the pleural sacs. Of 32 cases with pulmonary thrombosis or embolism, but without infarction, only 17 were similarly complicated. Usually under normal conditions and at times even when the pulmonary circulation is embarrassed, the anastomosing pulmonary capillaries and the bronchial arteries are capable of maintaining the circulation in the affected territory. Other factors may prevent the occurrence of infarction. The arterial plugging may be incomplete, the affected vessel may supply too small an area, or death may take place too quickly after the accident.

It has been thought that pulmonary infarction could occur from other causes than pulmonary embolism or thrombosis, but this is improbable. The arterial plugging can be demonstrated in a great majority of the cases. This has been regarded as a result rather than a cause of the infarction, but venous rather than arterial plugging is likely to be a consequence of infarction. An unobstructed lumen in the affected artery may intervene between the plug and the area of infarction. This is in favor of its primary rather than secondary origin. Then, too, the character of the plug or the appearance of one of its extremities may definitely indicate its origin by fracture from a thrombus in a more remote vessel. The prevailing situations for pulmonary infarctions correspond to the areas of distribution of the pulmonary vessels most commonly affected by thrombosis or embolism. In their sharp limitation from the surrounding tissue, their situation, shape, consistency and microscopic appearance, pulmonary infarcts resemble similar processes elsewhere. Finally, pulmonary infarction may be experimentally produced by artificial occlusion of the pulmonary arteries.

(*b*) *Appearance of Pulmonary Infarcts.*—Pulmonary infarcts are almost invariably hemorrhagic.[1] The lower are more frequently involved than the upper lobes and the right side more often than the left. The situation of pulmonary infarcts thus corresponds to that of pulmonary emboli. They are more often multiple than single, are usually peripheral, and on section conical or wedge shape, with the apex of the cone toward the root of the lung, the base, more or less circular in outline, appearing beneath the pleural surface. They may rarely be found entirely within the substance of the lung, and are then likely to be more nearly spherical. In general they vary in size from a cherry-stone to a hen's egg. Smaller and larger areas may be found, and in rare instances more than a half of one lobe may be involved.

[1] Freyberger (Trans. Path. Soc., London, 1898, xliv, 27) has reported a rare instance of an anemic pulmonary infarct. Cardiac weakness may account for this occurrence. Welch (Allbutt's System of Medicine, 1899, vi, 265) states that in two or three instances he has seen nearly white or pale-red, fresh anemic infarcts in densely consolidated lungs.

In recent cases the overlying pleura may be normal in appearance but with older infarcts it is likely to be turbid and covered with a thin layer of fibrinous exudate. Careful search will usually disclose a plug in an artery at or near the apex of the infarction. The cut surface of recent infarcts is elevated, smooth or slightly granular, dark red or even almost black in color, airless, and on pressure exudes only a small amount of bloody fluid. Infarcts are usually hard and their boundaries sharply defined, thus differing from ordinary hemorrhages into the pulmonary tissue from ruptured vessels. The neighboring tissue may be edematous. A zone of hyperemia may also bound the infarcted area, its brighter color in sharp contrast to the dark red of the infarct itself.

On microscopic examination of a recent hemorrhagic infarct the capillaries, alveoli, interstitial tissue, and bronchi are found crowded with red-blood corpuscles. A small amount of fibrin may be present, but this is usually more abundant in older infarcts. The capillaries also contain hyaline thrombi. In older infarcts, and especially toward the central part of the involved region, the alveolar walls almost constantly show coagulation necrosis, as Willgerodt[1] emphasized. Disintegration of the red cells may also take place.

It is probable that in some cases in which the pulmonary infarction involves only a small area the circulation may be at least partially reëstablished. Necrosis of tissue, however, is an almost invariable result, and complete resolution can hardly be expected. Organization takes place, the infarct is finally converted into connective tissue and remains as a puckered and pigmented scar.

Infection of the infarcted area may arise from infected emboli or by extension from the bronchi or lung. Suppuration, extensive necrosis, abscess formation, and gangrene may then occur. A sequestrum may form in the infarcted area. Multiple pulmonary abscesses, interstitial pneumonia, and empyema may follow.

Symptoms and Course.—Pulmonary embolism would less often occur if it were always possible to recognize venous thrombosis. Involvement of the superficial veins of the extremities is usually easily determined from the presence of pain, palpable and tender veins, and edema. Dilatation of veins tributary to the venous channels suspected of thrombosis may be suggestive. Unfortunately, thrombosis of deep veins may be unaccompanied by any symptoms whatever. Mahler[2] regards a step-like rise of the pulse, the temperature still remaining low, as an important sign of thrombosis and most marked following pulmonary embolism. This sign is at times of value, but is often absent, and its interpretation difficult from the presence of complications.

It is convenient for purposes of description to consider the symptoms

[1] Ueber die hämorrh. Inf. d. Lungen, Arb. aus d. path. Inst. in Göttingen, Berlin, 1893, pp. 100–120.

[2] Thrombose, Lungenembolie und plötzlicher Tod, in Leopold, Geburtshilfe und Gynäkologie. Arbeiten aus der kgl. Frauenklinik im Dresden, 1895, Bd. ii, pp. 72–120.

of (1) pulmonary embolism, or the "embolic act," as Gerhardt[1] termed it, and (2) pulmonary infarction, separately.

1. **Pulmonary Embolism.**—Various factors have a bearing on the clinical features. Sudden and complete occlusion of a pulmonary artery is followed by more obvious and more serious results than gradual and incomplete closure. The symptoms naturally vary also with the number of the emboli. Embolism of infected material has little bearing on the immediate symptoms, but exerts an important influence on the subsequent course. The patient's condition is a factor. Embolism is of graver consequence in those already weakened by disease, and especially in those with cardiac disease. The clinical picture also presents important differences according to the size of the occluded vessels and the nature of the embolus. A division is therefore made into (*a*) embolism of the pulmonary artery or its main divisions, (*b*) of medium-sized and smaller branches, and (*c*) capillary embolism. In the following pages, embolism of blood-clot is discussed. Air embolism, fat embolism, mercury embolism, cell embolism, and hydatid embolism will be considered under separate headings.

(*a*) *Embolism of the Pulmonary Artery or its Main Divisions.*—The sudden and complete occlusion of the pulmonary artery, both its main divisions or their branches, is followed by death which occurs at once or within one to two minutes. Prolongation of life beyond this period is probably due to incomplete occlusion. Trendelenburg[2] in 9 cases noted an immediately fatal termination in 2, and an interval of ten, fifteen to twenty, about thirty, thirty to thirty-five, about forty minutes and one hour before death in the remaining 7 cases with embolism of the pulmonary artery. Of 4 cases in the Massachusetts General Hospital series, the fatal ending took place in ten, fifteen, twenty-five, and forty-five minutes respectively.

Occlusion of one main division may be less rapidly fatal. In three cases in this series, life was prolonged for forty-five minutes, nine hours, and two days respectively. In exceptional instances, life may last for an even longer period. Hart[3] has reported two cases with total occlusion of a main division of the pulmonary artery in which an advanced organization indicated a long previous duration.

In the rapidly fatal cases, death may actually be the first symptom. It may be preceded merely by a groan or an outcry. In other instances the patient is suddenly overcome with a sense of oppression and precordial distress, the face is pale or pale and cyanotic, the pulse rapid, weak, and irregular or imperceptible, and death takes place in coma or convulsions. If the course is more protracted, the sudden onset of thoracic oppression, intense dyspnea, orthopnea, distress, or pain referred to the shoulders, the chest, or upper abdomen, extreme appre-

[1] C. Gerhardt, Der Hämorrhagische Infarkt., Volkmann's Klinische Vorträge, 4th S., pp. 91–120.

[2] Deut. Gesellsch. f. Chir., Berlin, Verhandl., 1908, vol. xxxvii.

[3] Deut. Arch. f. klin. Med., 1905, lxxxiv, 449.

hension, restlessness, cold and clammy sweats, chills, syncope, delirium, involuntary urine and feces, and convulsions may be noted. Consciousness may be retained throughout. It may be lost at first, to be regained later with an improvement of the other symptoms. An interval of comparative comfort may be followed by a recurrence of symptoms. In one of the hospital cases the patient died in the last of three attacks, occurring within forty-five minutes. The pulmonary artery was occluded by a single, coiled clot 45 cm. long. The reappearance or exaggeration of symptoms may be due to displacement of a mass insecurely fixed, to fresh emboli, reflex causes or thrombus formation about the embolus. The contrast between the intensity of the dyspnea and the freedom with which air enters or leaves the lung may be a striking feature. During the attack, examination may show pallor followed by intense cyanosis. The cervical veins may be markedly dilated, and in some instances show independent pulsation. The pulse is usually rapid, of small volume and low tension, and may be irregular or imperceptible. An increased area of cardiac dulness to the right of the sternum and a displacement of the apex beat to the left, from dilatation of the right side, may be determined. The pulmonic second sound may be accentuated. The circulatory disturbances are largely due to the blocking of the pulmonary circuit with consequent anemia of the arterial, congestion of the venous system, and embarrassment of the right heart.

Distinctive physical signs on the part of the lung are lacking. Pulmonary edema may ensue in protracted cases. Litten[1] called attention to a rough murmur, and under favorable circumstances also a thrill, coincident with and outlasting systole for a variable period. The murmur is heard in the region of the upper border of the third left rib or second left costal cartilage, may also be audible over the whole anterior part of the thorax and in the interscapular region at about the level of the third dorsal vertebra. The narrowing of the pulmonary blood-stream accounts for it. Litten heard it in 4 cases, in which embolic occlusion of the pulmonary artery was found at autopsy. The diagnosis was made during life in three. Murmurs due to narrowing of the pulmonary blood-stream from other causes have been noted by Immermann,[2] Aufrecht[3] and Fränkel.[4] Litten made the further interesting observations in one case of a double apex beat and double first sound, probably due to increased resistance in the narrowed pulmonary circuit.

In cases in which the patient immediately loses consciousness and dies in syncope, death is usually ascribed to cerebral anemia. Interference with the coronary circulation is also a possible explanation. The experiments of Russell and Brodie,[5] and Capps and Lewis[6] on

[1] Berl. klin. Woch., 1882, Nos. 28 and 29.
[2] Deut. Arch. f. klin. Med., 1869, Bd. v, p. 235. [3] Ibid., 1876, Bd. xviii, p. 629.
[4] Spez. Path. u. Ther. der Lungenkrankheiten, 1904, p. 512.
[5] Jour. of Phys., 1900-01, vol. xxvi.
[6] Amer. Jour. Med. Sci., December, 1907.

pulmonary and pleural reflexes suggest that reflex cardiac inhibition may also be a factor. In the more protracted cases, in which dyspnea is a striking feature, death has been ascribed to asphyxia.

Pulmonary infarction is relatively uncommon as a consequence of embolism of the pulmonary artery or its main divisions. In the cases in which it occurs, the plugging in the artery or its main branches may be incomplete, and a plug in a smaller branch may be responsible for the infarction.

(*b*) *Embolism of Medium-sized and Smaller Branches of the Pulmonary Artery.*—The symptoms following total occlusion of all branches from one of the main divisions of the pulmonary artery do not differ from those described above. The plugging of single branches of one of the main divisions may also be followed by similar but usually less intense symptoms. In patients already weakened by disease, the symptoms may be marked and the termination fatal. Embolism of medium and smaller pulmonary arteries is more often latent than obvious. It is more common and of special interest because of its important relation with pulmonary infarction.

(*c*) *Capillary Embolism.*—The lodgement of foreign substances in the finer ramifications of the pulmonary arteries and the pulmonary capillaries gives rise to symptoms of embolism only when there is mechanical obstruction of a large territory. Air embolism, fat embolism, mercury embolism, and cell embolism may be mentioned as examples of this type.

So-called *parasitic emboli* embrace the largest group. Their invasion of the lungs is unaccompanied by symptoms of embolism, and they are of chief importance because of the pulmonary conditions to which they give rise. Infected venous thrombi, and endocardial vegetations may transport bacteria into the lung with consequent metastatic pulmonary abscesses. Invasion of the venous system by tubercle bacilli, actinomyces, and streptothrix may cause secondary pulmonary infection.

The transport of malignant tumor cells may give rise to metastatic new growths in the lungs.

2. **Infarction.**—This is often latent and discovered only at autopsy. This is more likely in patients already seriously ill, as with cardiac disease and broken compensation. The symptoms of embolism may accompany the attack, but this is unusual, as infarction is more particularly a feature of occlusion of the smaller pulmonary vessels.

Pain is the most constant and usually the first symptom of infarction. It resembles that from ordinary pleurisy, is usually unilateral, but may occur on both sides of the chest and is then probably due to simultaneous infarction of both lungs. It may at times be felt in the shoulder or upper abdomen. The pain may be sudden and severe in its onset, or begin as a slight discomfort on long breath or cough, gradually increasing in intensity during the first twenty-four hours. It may be the only symptom. A chill or chilliness may accompany the pain.

The breathing is likely to be rapid. There may be dyspnea from restricted respiration and a slight dry cough. During the first part of the attack the temperature is usually normal and examination of the lungs negative.

The expectoration of blood is an important symptom, but may be absent. When it occurs, it usually begins after the onset of pain. Its appearance is usually delayed for a few hours, and it may not come for two to three days. In typical and uncomplicated cases, it consists of homogeneous, viscid, tenacious, dark red masses of variable size. The tenacious quality is due to an admixture of mucus. The character of the sputum alone may be very suggestive of infarction. The total amount seldom exceeds a few drams in twenty-four hours. The expectoration of pure blood was never observed by Gerhardt[1] nor was it seen in any of my cases. The expectoration of large amounts of pure blood was noted by Laënnec, but I judge from his description that he confused other forms of hemoptysis with that from infarction. In one of Fränkel's patients the daily amount of dark red sputum repeatedly reached 300 to 500 c.c. If the infarction breaks down with the formation of cavities, copious bleeding may occur. In long-continued and complicated cases, bloody masses of sputum may be mixed with mucopurulent material. The expectoration of blood may continue for weeks, but in favorable cases gradually diminishes in amount. The sputum and also the breath may have a slightly musty or foul odor, even in cases which ultimately progress favorably. On microscopic examination, red-blood corpuscles and pigmented alveolar cells may be found. The blood pigment is in the form of amorphous brownish masses or crystals of hematoidin. The absence of bacteria in the stained specimens may be a striking feature, upon which, however, too much reliance should not be placed.

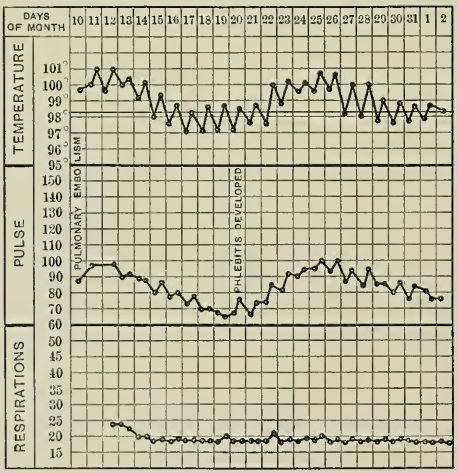
Physical signs are often lacking, because of the small size of the infarct, in rare instances because of its central position. When present, they usually appear coincident with or soon after the hemoptysis and are more often found over the inferior and posterior or lateral parts of the lung. According to Gerhardt, the right side between the angle of the scapula, the vertebral column and the diaphragm is most often affected. In rare instances the apex may be involved. The signs are those of pulmonary consolidation and are not distinctive of infarction. The interspaces may be narrowed on the affected side. The respiratory excursion of the involved lung may be diminished. Over the infarct, dulness, fine or medium, consonating or non-consonating rales, diminished vesicular or bronchial breathing, increased voice, whisper and tactile fremitus may be observed. The dulness has often been noted to have a tympanitic quality, the explanation of which is not clear. It has been ascribed to edema or relaxation of the neighboring lung or (and more plausibly) to the vibration of air in the open bronchi.

[1] Klin. Vorträge, Volkmann, 4 S., xci-cxx, 730.

A pleural friction rub is not uncommon and may be heard over a much larger area than the apparent size of the infarct itself. With small infarcts the pleural may be the only manifestations. It cannot be stated how large an infarct must be to give rise to physical signs. Gerhardt believed that in the majority of all cases in which it measures from one to four cubic inches (the size of a nut to that of an egg), obvious dulness may be expected. The prevailing subpleural position of the base of infarcted areas and the frequent edema and hyperemia of the neighboring lung favor its detection. It has nevertheless happened in the experience of many observers that infarcts of considerable size, undetected during life, have been found at autopsy. To judge from the hospital cases, pulmonary infarcts seldom lead to other than fibrinous inflammation of the pleura. In most cases complicated by more than small amounts of pleural fluid, coincident cardiac or other disease suggests another explanation for the pleural effusion.

The temperature may be normal throughout. Moderate fever, however, is not uncommon and usually begins, not with the pain, but with or shortly after the hemoptysis.

Fig. 46



Febrile reaction following pulmonary embolism. The source of the embolus could not be discovered until ten days later when phlebitis of the left leg became manifest. The second period of elevated temperature is due to the phlebitis. (P. C.)

The further course of pulmonary infarction depends more upon the seriousness of the underlying disease than upon the infarction itself, which is often only an incident in an otherwise serious affection. Numerous infarcts or those of large size may be a contributing or even a principal cause of death. Small and uninfected infarcts usually

run a favorable course. The temperature gradually falls. Bloody sputum and signs of pulmonary solidification usually persist for a longer period, but ordinarily they, too, subside in the course of a few weeks. Examination may then fail to disclose evidence of the previous trouble in the lung or pleura. The patient (P. C.), whose chart is shown above, has safely passed through five attacks of embolic pulmonary infarction arising from thrombosis of the saphenous veins. All his attacks have been accompanied by symptoms of pleurisy, three by hemoptysis, and two by evidence of pulmonary consolidation. Yet in spite of this, the lungs are negative and the pleural sacs free, as indicated by a wide excursion of the diaphragm shadow. The heart is negative, with a rate of about 80 beats per minute at rest, but exertion is followed by tachycardia which may amount to 100, 110 and even 120 beats per minute. An infected clot gives rise to more serious disturbances. Pneumonic infiltration may arise in the neighboring lung. Abscess formation or gangrene may develop at the site of the infarct. In the presence of such pulmonary complications, the sputum changes its character, and in addition to blood from the infarct, contains pus which may be foul, and elastic tissue. Empyema or pneumothorax may complicate the destructive pulmonary changes.

Diagnosis.—Thrombosis and embolism of the pulmonary artery or its branches can hardly be differentiated clinically. It is probable, as already mentioned, that in the majority of cases in which plugging of the pulmonary arteries occurs, the occlusion is due to embolism rather than to thrombosis. The apparent absence of thrombosis does not exclude embolism, for the thrombosis may be undemonstrable in an inaccessible vein or latent even in the extremities.

Embolism may be suspected when sudden and unexpected death or suggestive symptoms occur in the presence of a recognized thrombosis of a systemic vein, or in the course of diseases or conditions known to be frequently complicated by venous thrombosis. The suddenness of onset, the intensity of the dyspnea without evidence of respiratory obstruction, distress rather than pain, pallor followed by cyanosis, dilated and at times pulsating cervical veins, signs of cardiac weakness or dilatation and the appearance of a murmur over the base, such as that described, may be mentioned as more or less typical features.

The condition may be confused with coronary artery disease in which, although death may occur in the first paroxysm, there will usually be a history of previous attacks. Pain is a more prominent symptom, and dyspnea and cyanosis are less often present to such a degree as in pulmonary embolism. An acute cardiac failure in the course of chronic myocardial or valvular disease offers the greatest difficulty from the frequency with which such a condition is complicated by pulmonary embolism. The condition known as cardiac asthma may closely simulate pulmonary embolism, and in some instances cannot be distinguished from it. Here, too, the previous history will be of assistance, but it is probable that slowing of the pulmonary

circulation is largely responsible for the symptoms in both conditions. When embolism occurs as a late complication, not only of cardiac disease but also of other intrathoracic conditions accompanied by dyspnea, there may be no distinctive symptoms, and the first intimation of its occurrence come at the autopsy table.

The clinical picture of pulmonary infarction is variable. Its most suggestive features may be thus summarized: The attack begins with pleural pain, usually followed after an interval by bloody sputum of a peculiar character. The hemoptysis is in turn accompanied or succeeded by dry pleurisy and pulmonary consolidation with or without fever. Attention to the order in which the symptoms appear may suggest the diagnosis. Owing to the usual small size of the arteries affected, preceding symptoms of embolism are often lacking. In an attack of pleurisy alone in the course of such conditions as give rise to embolism, infarction should be suspected. In rare instances the pleurisy may be apparently primary. Such an attack during the puerperium is very suggestive of infarction. Tuberculosis must be excluded.

Pulmonary tuberculosis may simulate pulmonary infarction. A family history of the disease or opportunity for contagion, the expectoration of bright red and clear blood rather than dark red and tenacious masses, the absence of coincident pleurisy, prevalent involvement of the apices rather than the bases of the lungs, and the presence of tubercle bacilli in the sputum, may be distinguishing features. If necessary, tuberculin may be used. Nevertheless the differentiation is not always easy. Bloody sputum from tuberculous processes may resemble that from an area of infarction. Pleurisy may accompany and fever may follow the hemoptysis in both conditions. Tubercle bacilli are likely to be absent from the bloody sputum of tuberculous patient early in the disease. The order in which the different features appear in infarction, the site and gradual disappearance of the pulmonary lesion in favorable cases, and the finding of venous thrombosis as a source of emboli will usually establish the diagnosis. The exclusion of *lobar pneumonia* by the more constant initial chill, more immediate rise and more rapid fall of the fever, rusty sputum and more extensive yet more rapidly resolving pulmonary involvement is usually not difficult. The embolic character of a septic pneumonia, however, may be difficult or even impossible of detection, although it may be suspected if a primary source for venous infection can be found. The bloody sputum from *malignant tumors of the lung* may closely resemble that from pulmonary infarcts, but pleural pain coincident with its appearance is unusual, a primary tumor may be found elsewhere, and the further course of the disease is not that of infarction. It should be remembered that pulmonary infarcts are not very uncommon as a complication of new growths, and unless careful account is taken of the progress of the symptoms, may be mistaken for secondary malignant disease of the lung. Hemoptysis may occur as a symptom of *echinococcus cysts* of the lung. It is not uncommon before as well as after

rupture, and pleuritis is a frequent early symptom. In Gerhardt's[1] case, with bloody sputum, flatness and diminished breathing below the right nipple, infarction was suspected until the sputum became more fluid and more abundant and was found to contain cyst membrane. Hooklets may also be found in the sputum. In some cases echinococcus cysts elsewhere will suggest the diagnosis. Chronic *passive congestion* consecutive to cardiac disease is a common cause of bloody streaks or a frothy bloody mucus, which in the absence of pleural pain and signs of consolidation should not give rise to confusion.

Prognosis.—This varies with the number and size of the occluded vessels, the completeness of the closure, the character of the embolus and the previous condition of the patient. It may be said in review that the sudden and complete occlusion of the pulmonary artery itself, one of its main divisions or their branches is almost invariably fatal, regardless of the patient's previous condition. The prognosis of embolism of smaller vessels is apparently usually good so far as immediate consequences are concerned, provided the pulmonary circulation is unimpaired. It may, however, lead to infarction. Occlusion of these vessels complicating existing cardiac weakness may be fatal and is very likely to lead to infarction. Large infarcts may be fatal. Small and medium sized infarcts frequently end in recovery, but here also the general condition of the patient and the presence or absence of infection of the affected region are important factors.

Treatment.—The utmost care should be taken to avoid detachment of emboli from a recognized or suspected venous thrombus. The patient should be warned of the danger of pulmonary embolism and cautioned also against sudden movements, straining at stool or violent coughing. He should be in bed, with the affected part absolutely at rest. If an extremity is involved, it should be immobilized. The length of time which must elapse before the danger is past, varies with the severity of the process and cannot be definitely stated. Disappearance of local tenderness, diminishing edema and absence of fever are favorable indications. In cases which progress satisfactorily, absolute quiet for a month to six weeks may usually be considered a safe limit. Customary activities should only be gradually resumed.

In cases of *pulmonary embolism* with serious symptoms there is always a chance that the plug rides on the bifurcation of the pulmonary artery or only incompletely occludes a vessel. Displacement of such a clot may be fatal. The patient should therefore be quietly at rest in bed, and every unnecessary movement, even talking, avoided. Physical examination, if made at all, should be limited to accessible parts of the chest. Morphia may be given for pain or distress. Fränkel recommends hot hand-baths and sinapisms to the chest and calves to dilate the peripheral vessels and delay the venous return. Other

[1] Loc. cit., p. 735.

than such simple measures may do more harm than good. Cardiac stimulation is, if possible, to be avoided, since it may start a fresh embolus or transport a clot into a more dangerous site. The frequency with which plugging of the pulmonary arteries is associated with right-sided cardiac thrombosis, suggests great caution in pursuing other than such an expectant policy.

Trendelenburg[1] recommends the operative removal of emboli from the pulmonary artery. This has been accomplished in 4 cases,[2] but without preventing a fatal termination. Siever's patient lived fifteen hours, Krüger's five and a quarter days after the operation. The number of cases in which surgical interference can be considered is relatively small, and in view of the difficulty of diagnosis and the dangers of the operation, the chances for recovery at present are probably better without than with operation.[3]

With *pulmonary infarction,* the relief of pain is usually the chief indication. Absolute rest in bed will not only diminish the pain, but also lessen the danger of other infarcts from fresh emboli. Fixation of the side, an ice-bag, or hot water bottle may be sufficient. If not, morphin may be given. Examination of the lungs should be made, but with care not to disturb the patient. The hemoptysis does not require treatment. The blood effused into the bronchi must be expectorated. If it is not and the infarct has become infected, the aspiration of infected blood into sound parts of the lung may give rise to bronchopneumonia. It is doubtful if the various styptics commonly recommended have any control over hemoptysis, and if they did, it would be inadvisable to use them. The administration of calcium salts to increase the coagulability of the blood may do harm by inducing more extensive thrombus formation in the affected vessels. Pleural effusions complicating pulmonary infarction may be treated in general on the same principles governing the treatment of similar effusions from other causes. An empyema should be opened and drained.

[1] Operativ. Behandl. d. Emb. d. Lungenarterie, Deut. Gesellsch. f. Chir., Berlin, Verhandl., 1908, vol. xxxvii.

[2] Trendelenburg, ibid., and Deut. med. Woch., July 2, 1908, No. 27; Sievers, Deut. Zeit. f. Chir., 1908, p. 93; Krüger, Zeit. f. Chir., 1909, No. 21, p. 757.

[3] The skin is incised from the sternal margin for a distance of about 10 cm. along the second rib, and along the sternal margin, perpendicular to this incision, from the insertion of the first to that of the third rib. The two triangular flaps of skin are laid back and the sternal portion of the second rib resected. The pleura and the pericardium are opened with care not to wound the internal mammary artery or the phrenic nerve. By means of a sound, a piece of rubber tubing is passed behind the aorta and the pulmonary artery, through the pericardial sinus. With this the vessels can be drawn forward and partially or completely compressed. The pulmonary artery is opened, the embolus withdrawn, and the venous opening temporarily closed with forceps. The arterial opening is sutured above the blades of the closed forceps, with fine silk, including the intima. Cardiac pulsations may disturb this procedure, but they may be controlled for a few seconds at a time by constriction of the vessels with the rubber tube still left in place. Special instruments are used. They should be constantly ready for use. Artificial pneumothorax on the operated side is a disadvantage which might be overcome by the use of positive or negative pressure apparatus. Their inconvenience and the time consumed in preparation are as yet insuperable difficulties.

Large serofibrinous effusions or those causing pressure symptoms should be evacuated, but small or medium serofibrinous effusions may well be allowed to remain for a time at least for fear of dislodging pulmonary thrombi by their removal and in the hope that they will be absorbed. This applies particularly to the effusions which, from their appearance after the infarction, seem to arise in consequence of it. In the cases in which the relation is reversed and the pulmonary embolism complicates the pleural effusion, a more common condition, I believe, it is probable that the pleural effusion has played an important part in giving rise to the thrombus from which the embolus has come. Judgment as to the best course to pursue in these cases is difficult as one has to weigh on the one hand the danger of more extensive thrombosis if the fluid is allowed to remain and the possible detachment of fresh emboli by its removal. In such cases, if the symptoms from the effusion are not urgent, it is probably best to wait, keeping the patient meanwhile absolutely at rest, in the hope that loosely attached thrombi may become fixed.

Air Embolism.[1]—The first recognition of air embolism during operation as a cause of death appears to have been made by Beauchêne and reported in 1821 by Majendie.[2] Many cases have since been reported. The cause of death has been the subject of much discussion and experimentation.

Atmospheric air may enter the veins in the course of operations about large venous trunks, as in the neck, about the shoulder, the upper thoracic region, and the cerebral sinuses. It may take place through the uterine veins, after detachment of a placenta previa or following intrauterine injections for the production of abortion. Air embolism has followed attempts to produce artificial pneumothorax in a number of cases. (See Artificial Pneumothorax.) Welch and Flexner[3] have called attention to the possibility of mistaking gas formation after infection with the bacillus aërogenes capsulatus for air embolism, and unless a bacteriologic examination is made death can safely be ascribed to this cause only when it follows immediately or shortly after the known entrance of a considerable amount of air into the veins.

Animals vary in their susceptibility to air embolism, and experimental investigation of the lethal dose of air cannot safely be applied to man. The experience of surgeons shows that the entrance of a few bubbles of air into a vein is apparently harmless. The fatal quantity of air is probably at least several cubic centimeters.

The entrance of air may be indicated by a sound of suction, proceeding from the venous opening. Death may occur almost immediately. It may be preceded by great dyspnea, cyanosis, dilated pupils, syncope or convulsions. A cardiac murmur may develop. The pre-

[1] Reference to the principal articles on this subject may be found in Wolff's Experimentelle Studien über Luft Embolie, Virchow's Archiv, 1903, vol. clxxiv.

[2] Jour. de Phys., 1821, T. i, p. 80.

[3] Jour. Exper. Med., 1896, No. 1.

cordia may be tympanitic on percussion. The cervical veins may be much dilated and pulsate; the pulse rapid, irregular, and of small volume. Most cases end in death. Recovery occasionally occurs.

The pathologic findings vary somewhat. The right side of the heart is usually much dilated and contains frothy blood. Bubbles of air are usually found in the veins, especially in those near the heart, the pulmonary artery and its branches. It is doubtful if any amount of air reaches the pulmonary veins, the left side of the heart and the systemic arterial circulation unless through an open foramen ovale.

Death in air embolism has been ascribed to overdistention and paralysis of the right heart, unable to impel onward a medium more compressible than blood. It has also been ascribed to an arrest of the air in the pulmonary capillaries, thus blocking the venous circulation. This view is supported by the observations of Passet,[1] Hauer,[2] and Kose.[3] In their experiments, air embolism was followed by an increase of pressure in the pulmonary artery and a lowering of pressure in the systemic arterial circulation. It is probable that pulmonary embolism is the principal cause. Cardiac embarrassment and cerebral anemia from a depleted arterial circulation are probably also factors.

Fat Embolism.—The first observation on embolism of the pulmonary capillaries by fat, following an injury, was made by Zenker.[4] Wagner[5] also recognized the condition, but associated it with suppuration and the formation of metastatic abscesses. Many observations have since been made. Scriba's[6] studies are especially noteworthy. Fuchsig[7] suggests the term "traumatic lipemia." Connell[8] has reviewed the literature.

Pulmonary fat embolism may occur when, through injury or disease, liquid fat in the neighborhood of a ruptured vessel enters the systemic venous circulation. It probably takes place to some extent after all fractures of bone, but is more serious after the fracture of bones rich in fat marrow. Ribbert[9] has shown that it may follow the simple jarring or concussion of bone without fracture, and that following fracture it is often more extensive than can be explained by the fracture alone. It may occur from inflammation of and operations on the bones, especially brisement forcé[10] and from trauma, operative injury or inflammation of the subcutaneous tissue, although the readiness with which venous channels collapse in such regions is less favorable

[1] Ueber Lufteintritt in die Venen, Arbeiten a. d. Pathol. Inst. zu München., 1886, S. 293.

[2] Erscheinungen im grossen und kleinen Kreislaufe bei Luftembolie, Zeit. f. Heilk., 1890, vol. xi, S. 159.

[3] Experimentelle Studien über Lungenembolie, Wien. med. Woch., 1902, lii, 1934, 1989, 2038, 2091.

[4] Beiträge z. norm. u. path. Anat. d. Lunge, Dresden, 1862, p. 31.

[5] Arch. f. Heilk., 1862, iii, 241.

[6] Deut. Zeit. f. Chir., 1879, vol. xii.

[7] Zeit. f. Heilk., 1902, Abth. 1, xxiii, 80.

[8] Jour. Amer. Med. Assoc., February 25, 1905.

[9] Correspondenzbl. f. Schw. Aerzte., 24, 1894, and Deut. med. Woch., June 28, 1900.

[10] Payr, Zeit. f. Orthop. Chir., 1899–1900, vol. vii.

to its occurrence. Burns and scalds, contusions and lacerations of the liver, the brain, infection with subsequent fatty degeneration of organs and fatty degeneration of thrombi may also be mentioned as causes. It may follow the subcutaneous injection of oil as a vehicle for drugs or for nutritive purposes.[1]

The fat lodges in the smaller branches of the pulmonary arteries and the lung capillaries where it is recognized on microscopic examination in the form of drops and cylinders of oil. In severe cases it is quite generally distributed throughout the lungs. In cases of exceptional severity, Ribbert estimates that a half of all the capillaries may be thus obstructed. If the blocking of larger vessels tributary to the capillaries is taken into consideration, an exclusion from the circulation of far more than half of the lung tissue may take place. In one of Ribbert's cases, a clot in the right auricle was enveloped in a thick layer of solidified fat. The lungs may show numerous multiple ecchymoses. In some instances there are extensive hemorrhages and areas of pulmonary infarction. Pulmonary edema is an almost constant postmortem finding in the human being, but is not a striking feature in experimental animals, and is probably due to a terminal cardiac insufficiency.

Some of the fat passes through the pulmonary capillaries and is carried to other organs, among which the brain, the heart, and the kidney are predominately affected. Fat embolism of the cerebral vessels may lead to extensive multiple ecchymoses and may also cause infarction. Plugging of the coronary arteries is followed by patchy, fatty degeneration of the myocardium. The fat may be demonstrated in the glomeruli of the kidney and fatty degeneration of the convoluted tubules may be found. Welch[2] suggests that pulmonary fat embolism may be of medicolegal importance in determining whether injuries have been inflicted before or after death.

In a large proportion of the cases in which fat embolism is found at autopsy, it is merely an incident in an otherwise fatal condition. In a second and smaller group of cases it is probably a contributing cause of death, but it is difficult to estimate its importance in cases complicated by shock, hemorrhage and sepsis, or in patients with serious acute or chronic disease. Finally, cases are occasionally observed with extensive fat embolism without other grave lesions, and this condition can fairly be regarded as the principal cause of death. Such cases are for the most part those with accidental or operative injury of bone, of itself too slight to account for the fatal termination. In these cases it is not always easy to determine whether pulmonary, cerebral or cardiac embolism is the cause of death. In one of Ribbert's and in Czerny's[3] case, the enormous amount of fat in the pulmonary circulation seemed an adequate cause. In the cases in which fat is

[1] Fibiger. Nordiskt Medicininskt Arkiv, 1900, N. F. 11.
[2] Allbutt's System of Medicine, 1899, vol. vi.
[3] Czerny, Berl. klin. Woch., 1875, No. 44.

transported through the lungs to the brain, fat embolism of the cerebral vessels may be fatal. Scriba[1] regarded this as the principal cause of death. The cardiac lesions may be an important contributing factor.

Symptoms.—The symptoms which may be ascribed to fat embolism may come on at once after injury or operation. In such cases, characteristic symptoms are usually lacking. A most interesting and important feature in some cases, however, is an interval of freedom from any symptoms whatever. The patient appears to be doing well and the indications may be wholly favorable for several days to a week or more. The onset may be sudden or gradual. The respirations may then become rapid and there is likely to be dyspnea which may be extreme. Pain in the side, with or without the expectoration of frothy, blood stained or hemorrhagic sputum may accompany these symptoms. In consequence of cerebral invasion, there may be mental confusion, insomnia, delirium, coma or convulsions. In some cases there are paralyses indicating focal lesions. The pulse is likely to be feeble, irregular and rapid. Pulmonary and cerebral symptoms are likely to be combined. The temperature is variable. It may be elevated, normal or subnormal. Examination may show pallor or cyanosis, cold extremities, dilated cervical veins, Cheyne-Stokes respiration, rales suggestive of pulmonary edema, and fat in the sputum and urine. There is some justification for the belief that cerebral invasion is dependent to some degree on the maintenance of cardiac efficiency and that the pulmonary type of the disease predominates in patients weakened by disease or injury. A satisfactory explanation for the interval of freedom from symptoms cannot be given. The presence of fat in the urine and sputum may suggest the diagnosis in doubtful cases.

Prognosis.—The prognosis of fat embolism is very difficult of estimation. It is of itself alone probably only very rarely a cause of death.

Mercury Embolism.—The treatment of syphilis by the injection of insoluble salts of mercury is occasionally followed not only by general symptoms of poisoning, but by symptoms for the most part or exclusively referred to the lungs. Various mercury preparations, such as the salicylate or yellow oxide of mercury, gray oil, calomel, etc., suspended in liquid petroleum, mucilage of acacia, olive oil, or other oily vehicle, are commonly used.

Symptoms.—When pulmonary symptoms occur, they usually follow immediately or soon after the injection. In some instances they are delayed until the following day or later. The first indication may be a feeling of thoracic oppression or cough. Expectoration may be absent. If present, it may be tinged with blood. In rare instances, the sputum is dark red, bloody, and airless. Cyanosis, dyspnea, at times even orthopnea, and pain resembling that due to pleurisy are commonly present. A chill may precede the attack. The temperature is usually

[1] Loc. cit.

elevated. The pulse may be rapid. In the majority of the cases, examination of the lungs is negative. At times, rales, dulness, bronchial breathing, and pleuritic friction rub develop. Such signs are usually confined to a circumscribed area in the posterior and inferior part of one or both lungs.

The pulmonary features usually predominate. They may be accompanied by general malaise, weakness, insomnia, loss of appetite, nausea or vomiting, colicy abdominal pain, diarrhea, and sweating. The urine has occasionally been noted to be of high color and to contain a trace of albumin.

The attacks vary much in intensity. In some cases the ordinary occupation has been followed. More often in the reported instances the patient has been confined to his bed. Neubeck[1] collected 16 cases of fatal poisoning after the injection of mercury, adding one case of his own. No cases with pulmonary symptoms are included in his series, and so far as I know, no fatality from complications on the part of the lung has been reported. In the cases with pulmonary symptoms, recovery follows at times in the course of a few hours, usually within several days to a week, but some malaise and pallor may persist for a longer time.

No pathologic studies have been reported for man, but the intravenous injection of acetic acid thymol-mercury suspended in 10 per cent. liquid petrolatum, or in 10 per cent. mucilage of acacia, the injection of liquid petrolatum, or 10 per cent. watery solution of mucilage of acacia alone, in rabbits, was shown by Möller[2] to give rise to a disturbance of an embolic nature in the pulmonary circulation. The mercury salt in suspension caused the most intense reaction in rabbits. Examination of the lungs of animals injected intravenously with this substance showed, besides hemorrhagic infarction, intense irritation, with areas of pneumonia of variable size. Intramuscular injections of the same substance in animals failed to cause symptoms during life or demonstrable changes at autopsy.

The clinical picture is that of pulmonary embolism, which probably arises only in those cases in which the mixture containing mercury has been injected directly into a vein. In some of Möller's patients with this complication, it was observed that the customary reaction at the site of the injection was lacking.

Statistics vary as to the frequency of the accident. Möller[3] reported 3835 injections in 315 patients, observing this complication 43 times in 28 cases. Thus every eleventh patient was affected. The combined statistics of Epstein[4] and Voss[5] show 22 such complications in 21,963

[1] Quecksilbervergiftung mit tödlichem Ausgange, Dermatologische Zeitschrift, 1902, vol. ix.

[2] Ueber Lungenembolien bei Injection von unlöslichen Quecksilberpräparaten, Arch. f. Derm. u. Syph., 1896, vol. xxxvii.

[3] Loc. cit.

[4] Allg. med. Centralzeitung, 1897, Nos. 49 and 50, and Arch. f. Derm. u. Syph., Bd. xl.

[5] Ueber Hg., Paraffin Embolien, Derm. Zeit., 1904, vol. xi.

injections on 2281 patients; or one to every 103 cases or to every 998 injections.

The danger may be lessened by plunging the needle into the tissue and waiting to see if blood flows before the syringe is attached. After attachment of the syringe aspiration of blood should be attempted before the mercury is injected. If it is found by these means that the point of the instrument has entered a vessel, another site for the injection should be chosen. This is not always successful in preventing trouble. The least dangerous site for the injections is into the muscle in the upper and outer gluteal region.

Cell Emboli.—The presence within the pulmonary capillaries of giant cells from the bone marrow, liver cells, and placental (syncytial) giant cells has frequently been noted, but appears to be of no special clinical significance. In rare instances, masses of hepatic tissue and chorionic villi have been found in the branches of the pulmonary artery. The metastasis of cells from malignant tumors may take place by way of the venous circulation and lead to secondary deposits in the lungs.

The invasion of the lungs by cells resembling the megakaryocytes of the bone marrow is of special interest. Attention has been called by Foa and by Verson[1] to the prevailing absence of an intact protoplasm about such cells lodged in the lung. The nuclei of these cells, with or without a zone of protoplasm appears to be practically constant in the lung. Wright[2] has noted their ameboid motion, the projection of their protoplasmic processes far into the lumen of bloodvessels through an imperfect wall and the identity in morphology and staining reaction of this cytoplasm with the blood plates. All grades of transition could be observed between these bud-like processes and their division into blood plates. It is probable that after the detachment of a part or the whole of its protoplasm, the nucleus enters the circulation and is lodged in the pulmonary capillaries. Ogata[3] finds that pulmonary embolism of bone marrow tissue may normally be observed in rabbits. This may be ascribed to concussion of the bone marrow and is more marked following severe concussion, as from a fall.

In his study of the histology of typhoid lesions, Mallory[4] noted the presence of large, phagocytic, mononuclear cells in the larger and smaller bloodvessels and the capillaries of the lung. In one case of typhoid fever complicated by typical fibrinous pneumonia, he noted great numbers of these cells in the lung. MacCallum[5] found extensive multiple hemorrhagic infarctions of the lung in a case of typhoid fever.

[1] A propos des transports embolique de noyaux de megakaryocytes dans les capillairs du poumon, Arch. ital. de Biologie, 1906, vol. xlvi.

[2] The Origin and Nature of the Blood Plates, Boston Med. and Surg. Jour., June 7, 1906.

[3] Beitr. z. path. Anat. u. z. allg. Path., 1912, liii, 120.

[4] Jour. Exp. Med., 1898, vol. iii, No. 6.

[5] On the Transportation of Cellular Emboli through the Thoracic Duct into the Lungs, Amer. Med., Philadelphia, 1903, v, 452.

These were due to plugging of branches of the pulmonary artery with masses of cells of the type of lymphoid and larger mononuclear phagocytic cells. These cells probably reached the lungs by way of the thoracic duct, which was found to contain them in large masses.

Hydatid Embolism.—In rare instances, pulmonary embolism may follow the detachment or rupture, of hydatid cysts into the venous circulation. The most frequent site for the primary growth is in the liver or heart. Garnier and Jomier[1] collected twelve instances, with autopsy, from the literature, and added one case of their own. One or more branches of the pulmonary artery may be plugged by the cyst or daughter cysts. The symptoms do not differ from those in pulmonary embolism from other causes. The diagnosis may be suggested by the finding of hydatid disease somewhere in the body.

[1] Des embolies hydatiques de l'artère pulmonaire, La Presse médicale, 14 Juin, 1905.

CHAPTER XIX.

HEMOPTYSIS.

Expectorated blood may come from the mouth, nose, pharynx, esophagus, stomach, or respiratory passages. The term *hemoptysis* is usually applied only to blood from the respiratory organs and is restricted in the following discussion to an origin below the larynx.

The blood may consist of streaks on the outside of the sputum. In other cases there is an intimate admixture of the blood with the sputum which then presents a pink, red, rusty, purple, or even black color. Pure fluid or clotted blood may be expectorated. Blood-casts of the bronchi are rarely observed.

For convenience of description, hemoptysis may be classified according to the amount of blood lost in twenty-four hours as small (not exceeding 30 c.c.), moderate (from 30 to 100 c.c.), severe (100 to 250 c.c.), and profuse (exceeding 250 c.c.).[1]

Etiology.—The causes in the probable order of frequency[2] may be enumerated as follows:

1. **Pulmonary Tuberculosis.**—This is probably the most frequent cause. The well-known frequency of pulmonary tuberculosis and the occurrence of hemoptysis in about 60 per cent. of all cases during some part of their course supports this. The proportion of cases in which pulmonary tuberculosis occurs as a cause of hemoptysis differs according to the character and source of the material on which the statistics are based. Stricker[3] estimated that of 900 soldiers with hemoptysis, 699 (77.6 per cent.) were tuberculous. Of 909 patients with hemoptysis coming to the Out-patient Department of Brompton Hospital, Jex-Blake[4] regarded 497 (54.6 per cent.) as tuberculous. Of 134 autopsy cases with a record of hemoptysis in their past history or present illness at the Massachusetts General Hospital, pulmonary tuberculosis was a cause in only 14 (10 per cent.). The infrequency of tuberculosis in this series is due to the usual exclusion of patients with tuberculosis from the wards of the Hospital.

2. **Pneumonia.**—Lobar pneumonia probably stands next in frequency as a cause of hemoptysis. Rusty sputum is common. Frank hemor-

[1] Brown's (Osler, Mod. Med., 1907, vol. iii) classification.

[2] I know of no trustworthy statistics of the relative frequency of the various causes of hemoptysis. The causes are here arranged in the probable order of frequency.

[3] Ueber Lungenblutung in der Armee, Festschr. z. 100 jährigen Stiftungsfeier d. med.-chir. Friedrich Wilhelm Inst., Berlin, 1895.

[4] Practitioner, 1911, lxxxvii, 616.

rhage is rare. Pneumonia was a cause in 42 (31 per cent.) of 134 cases of hemoptysis with autopsy at the Massachusetts General Hospital. In bronchopneumonia, blood-streaked and blood-tinged sputum may be seen, but not the rusty sputum of lobar pneumonia, and frank hemorrhage is not observed in uncomplicated cases.

3. **Chronic Passive Congestion.**—The proportion of cases in which this is concerned apparently falls only little below that represented by pneumonia. The blood in the sputum is usually in bloody streaks, small bloody masses, or a frothy, bloody mucus. In some instances small blood-clots are expectorated. If the passive congestion is complicated by pneumonia, frank hemorrhage may occur. In one such case two ounces of blood were expectorated. Cardiac insufficiency is the common cause in this group. Chronic passive congestion was responsible for 40 (29 per cent.) of the 134 autopsy cases with hemoptysis at the Massachusetts General Hospital. The section on Passive Congestion may also be consulted.

4. **Pulmonary Infarction.**—This is a much more common cause than is generally believed. Passive congestion is a predisposing factor and is not infrequently associated. As in passive congestion, the blood is usually in streaks or masses; at times clots are expectorated. The color may be bright or dark red. Frank hemorrhage is rare. Tenacious, rusty sputum adhering to the inverted cup and resembling that seen in pneumonia may be observed without pneumonia at autopsy. Hemoptysis from pulmonary infarction may be an initial symptom —the so-called "premonitory hemoptysis"—of mitral stenosis. Stasis leads to the formation in the right side of the heart of thrombi, from which pieces may be detached with resulting pulmonary infarction. Previous symptoms of cardiac disease may be lacking and the hemoptysis may be regarded as tuberculous in origin. Infarction was a cause of hemoptysis in 23 (17 per cent.) of 134 cases in this series.

5. **Abscess, Gangrene, and Bronchiectasis.**—Blood-streaked and bloody sputum is more common than frank hemorrhage. The blood may come from capillaries, dilated veins in the bronchial wall, or the erosion of branches of the pulmonary artery lining the wall or traversing the lumen of a cavity. Fatal hemorrhage may occur. Pulmonary abscess was a cause of hemoptysis in 3 (2 per cent.) of 134 cases in this series and bronchiectasis in 1 (0.7 per cent.). Laënnec[1] reported 2 cases with frequent hemoptysis during life and with bronchiectatic cavities without tuberculosis at autopsy. The bleeding commonly lasts several days. Fever is usually absent in non-tuberculous cases. Foreign bodies expectorated from within may be a cause of hemoptysis.

6. **Aortic Aneurysm.**—This is among the less common causes of hemoptysis. Blood-streaked or bloody sputum may come from the trachea or bronchi as a consequence of pressure, and apart from any leak in the

[1] Traité de l'auscultation méd. et des mal. des poumons., Paris, 1837, 4 éd., par Andral.

aneurysmal sac. Frank hemorrhage is usually due to the escape of blood from the aneurysm, but is not always fatal. Osler[1] refers to a patient who lived for four years after a severe hemoptysis. The famous surgeon Liston[2] had in July, 1847, a feeling of constriction at the top of the windpipe and slight difficulty in swallowing. A profuse hemoptysis of thirty to forty ounces was almost fatal. Although Liston himself suspected aneurysm, neither Watson nor Forbes could discover anything in his chest. On December 6 he died in a paroxysm of dyspnea. The trachea was perforated, but the opening was blocked by firm laminæ of fibrin. Aneurysm was a cause of hemoptysis in 7 (5 per cent.) of 134 cases at the Massachusetts General Hospital. In three of these the initial bleeding was fatal.

7. **New Growths.**—Small amounts of blood in the sputum are not uncommon in patients with malignant disease of the bronchi or lung. Profuse bleeding is rare, but may occur in consequence of the erosion of a vessel of some size. Hemoptysis from malignant disease occurred in 2 cases (1 per cent.) in this series.

8. **Mechanical Injuries.**—Aspirated foreign bodies, penetrating injuries from without, a blow or fall upon the chest, with resulting fracture of the rib, may be a cause. Hemoptysis following contusion without rib fracture is uncommon, and when it occurs should lead to the suspicion of organic disease, especially tuberculosis. Blood in the sputum is occasionally observed in connection with lung hernia, and may be ascribed to mechanical injury of the lung at the hernial orifice. Severe physical exertion is not a sufficient cause, and when hemoptysis follows it is usually due to tuberculosis. A strikingly illustrative instance is found in the records of the Massachusetts General Hospital. In 1898 a man, aged forty-six years, died in the hospital of gastric cancer. The history states that twenty-four years before, after rowing a race, he coughed up a lump of blood as big as an egg. The hemoptysis was not preceded or followed by pulmonary symptoms. At autopsy (No. 274) the probable cause of the bleeding was found in obsolete tuberculosis of the lungs and bronchial lymph glands.

9. **Lesions of the Trachea or Bronchi.**—Ulcerative lesions are usually a cause of only slight hemoptysis, but erosion of a large vessel may result in fatal hemorrhage. Syphilis is probably the most common cause in this group, and is considered in the section on Syphilis of the Trachea and Bronchi. Tuberculous ulceration may be responsible. Melanotic or tuberculous bronchial lymph glands may ulcerate into the air passages and lead to erosion of branches of the bronchial or pulmonary arteries. Fatal hemoptysis may follow. Fibrinous bronchitis may lead to hemoptysis at the time of detachment of the cast from the bronchial wall. In acute bronchitis the sputum may be blood-streaked or blood-tinged. Hemoptysis in the course of chronic

[1] Mod. Med., vol. iv, p. 483. [2] Quoted from Osler, ibid.

bronchitis is usually due to disturbances in the lung to which the bronchitis is secondary. (See Chronic Bronchitis.)

10. **Actinomycosis** is a rare cause.

11. **Leprosy.**—Leprosy according to Sticker[1] may be a cause. Among 142 patients with leprosy seen by Sticker in India, leprous pulmonary infection was present in 4, of whom one had hemoptysis.

12. **Constitutional Diseases.**—Hemoptysis may be observed in diseases in which bleeding occurs elsewhere, such as hemophilia, leukemia, hemorrhagic purpura, and scurvy.

13. **Toxic Causes.**—Inhalation of irritating fumes from bromin, chlorin, ammonia, and sulphuric acid may lead to slight bleeding in consequence of injury to the tracheal or bronchial mucous membrane.

14. **Animal Parasites.**—The pulmonary distoma is an important cause in regions where this parasite prevails. The hepatic distoma is rarely concerned in hemoptysis. Echinococcus disease, filaria sanguinis, and filaria lymphatica may be mentioned in this group.

15. **Pulmonary Aspergillosis** is a rare cause.

Other causes of hemoptysis can for the most part be ranged under the groups already discussed. Vicarious menstruation is still occasionally mentioned, but there are no well-authenticated cases in the literature. The condition does not exist apart from some pulmonary lesion which is tuberculous in the majority of the cases. There is little basis for belief that disturbances of the nervous system (hysteria, epilepsy, psychoses) can give rise to hemoptysis. Feigned bleeding is sometimes encountered in hysterical patients. Sir Andrew Clark's[2] observations led him to believe that hemoptysis at times occurring in persons over fifty was due to changes in the walls of the pulmonary arteries. Persons of so-called "arthritis diathesis" were affected, and the hemoptysis was regarded as of arthritic origin. Betweeen 1875 and 1889 Clark observed about 20 such cases. Today such cases might be found to belong among those due to passive congestion in consequence of cardiovascular or renal disease. Similar instances have only rarely been reported, and I must confess to scepticism as to their classification in a separate group. When hemoptysis occurs in pregnancy the pregnancy cannot be held responsible. Malaria is not to be accounted a cause of hemoptysis.

In emphysema, blood-streaked sputum may come from ruptured capillaries; more abundant bleeding is probably due to passive congestion or occurs in connection with changes in the lung to which the emphysema is secondary.

Diagnosis.—It is at times difficult to determine the source of blood, whether from the lungs, mouth, nose, nasopharynx, pharynx, esophagus or stomach. If the blood comes up with cough and the sputum is blood-streaked for several days afterward there is little doubt as to

[1] Nothnagel's spec. Path. u. Ther., vol. xiv, Bd. ii, 1 Abth.

[2] Remarks on the Non-tubercular and Non-cardiac Hemoptysis of Elderly Persons, British Med. Jour., 1889.

its origin from the respiratory tract. A history of preceding pulmonary disturbance will help to fix upon the lungs as a source. In recent cases in which there is doubt as to its origin the nose, mouth and naso-pharynx, larynx, and trachea should be inspected. Blood may flow from above downward into the air passages and be expectorated with cough.[1]

In some cases the distinction between hemoptysis and hematemesis is difficult or impossible. Blood from the stomach or esophagus is usually preceded by gastric symptoms and expelled by vomiting. The presence of food elements mixed with the blood may help in the decision, but vomiting may accompany hemoptysis and be a cause of confusion or swallowed blood may be vomited. Dark chocolate-colored blood or blood resembling coffee grounds suggests a gastric origin. The absence of blood-streaked or bloody sputum following the initial attack may be of importance. A history of tarry stools or the persistent presence of occult blood in the dejections may be helpful.

In difficult cases a decision that the lungs are the source may be possible only after a most careful history and physical examination, the demonstration of a pulmonary lesion, and the exclusion of other sources of bleeding.

In the determination of the cause of the hemoptysis a distinction of value may be made between those hemorrhages which occur as an initial symptom, or early in the course of an otherwise apparently mild pulmonary disturbance, and those which are associated with more or less marked symptoms of pulmonary or other disease.

In cases in which *hemoptysis occurs out of a clear sky or when cough and scanty expectoration alone cloud it, the cause is almost invariably pulmonary tuberculosis.* Every effort should be made to obtain evidence for or against this diagnosis by a careful history and as soon as it can safely be done by a thorough physical examination. Repeated and careful search may establish this diagnosis by the finding of tubercle bacilli in the sputum. Examination by means of the *x*-rays may be helpful. A Wassermann test may also be necessary. Slight subsequent fever is suggestive of a tuberculous origin. Exceptions to the tuberculous origin of hemoptysis in this group are uncommon. Only one instance, *i. e.*, hemoptysis from syphilitic ulceration of the trachea, has come under my personal observation. In rare instances, however, cases with premonitory bleeding as a symptom of latent mitral stenosis are likely to be encountered. Unless care is exercised in taking the history that all symptoms are included, and it is established that the

[1] Van Swieten (Commentaria in Hermanni Boerhaave, §1198, 1773, p. 3) made the following interesting observation on himself. He felt a slight tickling sensation in the fauces and shortly afterward brought up bloody sputum. This was followed by an irritating cough and blood-tinged expectoration. By means of a mirror he recognized in the soft palate near the uvula a capillary vessel from which a drop of blood emerged about every two minutes. After a half-hour the bleeding ceased and in three hours the vessel had disappeared.

hemoptysis is in fact an initial and uncomplicated event, the situation may be wrongly interpreted. Latent venous thrombosis may, for example, lead to hemoptysis from pulmonary embolism, but the occurrence of other symptoms, such as dyspnea and pain in the side, may serve to suggest that the case may belong in the second group.

When hemoptysis occurs in connection with more or less marked symptoms of pulmonary or other disease the causes multiply and all enumerated in the foregoing list are included. Tuberculosis is here an important but not the predominant cause. Copious bleeding is uncommon apart from tuberculosis, ruptured aneurysm, occasional cases of abscess and gangrene, and ulceration of the trachea and bronchi. Insignificant hemorrhage and prominence of other symptoms and signs is usually seen in lobar pneumonia, chronic passive congestion, pulmonary infarction, abscess, gangrene, and new growths.

Hemoptysis in Pulmonary Tuberculosis.—This may occur at any period of life, but is uncommon at the extremes of age. It may be observed in infancy, as in the cases reported by Powell,[1] Hoffnung,[2] Hohlfeld,[3] Hinz,[4] and Kasten.[5] In the cases reported by Powell, Hoffnung, Hinz and Kasten the bleeding was fatal. Of Stricker's 900 cases the first hemoptysis occurred between the ages of twenty and twenty-four in 698. It is in general more frequent between the ages of fifteen and thirty, and is more common in men than in women. Aufrecht[6] reports fatal bleeding in a woman aged eighty-three.

Hemoptysis may occur in any pulmonary form of the disease, but is more often observed in chronic ulcerative tuberculosis, of which it may be the first manifestation or appear as a symptom at any part of its course. It appears to be more common in the earlier stages of the chronic ulcerative type and a higher blood pressure at this period has been suggested as a cause, but this is doubtful. In the majority of cases the bleeding occurs during ordinary activity, and is not infrequent in the early morning hours when the patient is abed. In a small proportion of cases hemoptysis follows some unusual physical exertion, mechanical injury, such as a blow or fall, excitement, or exposure to cold. In some instances an acute exacerbation of the tuberculous process precedes the hemoptysis. In women recurrent hemoptysis may be observed at the time of the catamenia. Hemoptysis may follow the removal of pleural effusion as in one of my cases.

Patients who have once had hemoptysis are very likely to have it again and numerous attacks are not uncommon. In some instances the sputum may be constantly blood-stained over a period of months or years.

[1] British Med. Jour., May 30, 1874.
[2] Ueber Hämoptoë bei Kindern., Inaug. Diss., Berlin, 1885.
[3] Monatsschr. f. Kinderheilk, 1903.
[4] Ueber profuse Hämoptoë im frühen Kindesalter bei der Lungentub., Inaug. Diss., Leipzig, 1903.
[5] Zur Lehre der Hämoptoë im Säuglingsalter, Beitr. z. Klinik d. Tub., 1906, v, 431
[6] Path. u. Ther. d. Lungenschwindsucht, 1913, 2 Auf., p. 203.

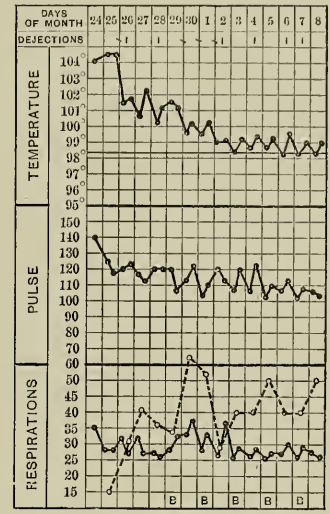
Pathology.—Blood-streaked, pink, red, or rusty sputum may come from capillaries in a congested bronchial mucosa or the pulmonary tissue by a process of diapedesis. Larger amounts of blood usually have their origin in rupture of an aneurysmal dilatation of a branch of the pulmonary artery, lining the wall or traversing the lumen of a pulmonary cavity. According to Kidd's[1] observations, aneurysmal dilatation of the vessel lying within a cavity is common and consists of a lateral expansion of the vessel on its exposed side. In rare instances an artery traversing the lumen of the cavity may be uniformly dilated to form a fusiform aneurysm. The aneurysms vary in size from a pin's head to a plum, but seldom exceed the size of a cherry. They are usually single, but may be multiple, and in one case Kidd found 22 in one lung. Rupture of the sac is the most frequent cause of profuse hemoptysis. In a series of 80 cases of fatal bleeding a ruptured aneurysm was found in 70. In a small proportion of cases erosion and ulceration of the wall of the vessel within a cavity, without the formation of aneurysm, may be responsible for the bleeding. At times a main branch of the pulmonary artery may be involved, but usually the bleeding comes from a medium-sized branch. In one instance West[2] found ulceration of a branch of the pulmonary vein as a cause of fatal bleeding.

Symptoms.—In tuberculous cases in which bloody sputum is expectorated there are usually no other special symptoms. When pure blood is suddenly expectorated the patient may be conscious during a coughing spell of a tickling sensation in the throat and then of a warm fluid with a salty taste in the mouth. Cough may be absent. Following the attack more blood is usually brought up on coughing or clearing the throat, and the sputum is commonly bloody for several days after the attack. In some cases the patient is wakened from sleep by the attack. He may be uncertain of the origin of the blood, and respiratory symptoms suggesting the lungs as a source may be absent, but this is uncommon. Slight fever is usually present for several days after the hemoptysis (Fig. 47), and may be due to absorption of aspirated blood, but is more often a consequence of extension of the tuberculous process by the aspiration of infected blood. The amount of blood lost is usually small and without appreciable affect on the course of the underlying tuberculous process.

If the hemorrhage is large, the blood may pour from the mouth and nostrils. Nausea and vomiting may accompany the attack and swallowed blood may be vomited. Anxiety and restlessness are likely to follow an initial or profuse hemoptysis. Acceleration of the pulse, elevation of the rate of respiration, and dyspnea may be observed in the more severe cases. A repetition of the bleeding is likely to follow on successive days or at longer or shorter intervals. Sufficient blood may be lost in one attack to exsanguinate the patient or profuse

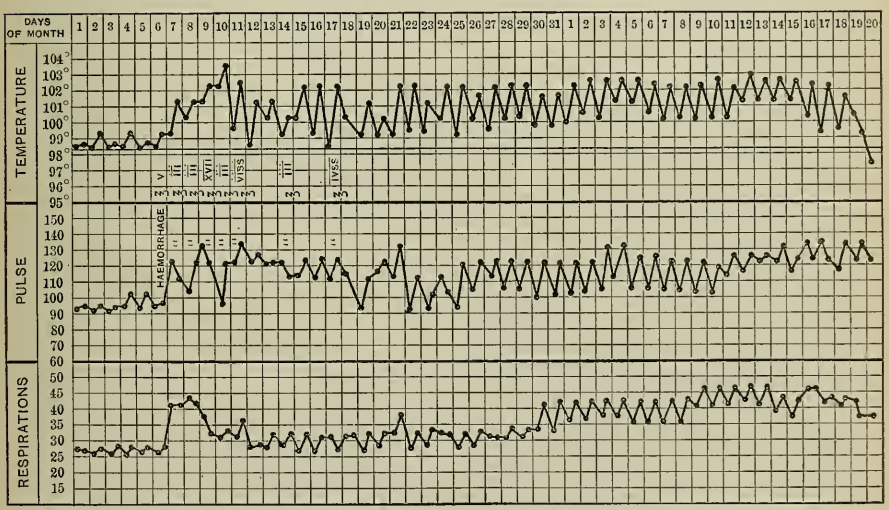
[1] Allbutt and Rolleston's System of Medicine, vol. v, p. 326.
[2] Diseases of the Organs of Respiration, 1902, i, 384.

FIG. 47



Febrile reaction following hemoptysis in pulmonary tuberculosis. (No. 145349.)

FIG. 48



Hemoptysis in an afebrile patient. Subsequent elevation of temperature and persistence until death six weeks later. Fatal termination due to rapid extension of the tuberculous process probably as a consequence of the hemorrhage. (V. Z.; C. H.)

bleeding may recur, as in West's[1] case, in which on the average a half-pint of blood was expectorated daily for forty-five days. In the last attack thirty-seven ounces were brought up and the patient died of suffocation. Death may take place suddenly from suffocation, cerebral anemia, and syncope, after an interval from exhaustion, or by rapid extension of the tuberculous process in the lung. The aspiration of infected blood into nearby or remote regions is likely to increase the extent of the pulmonary involvement. Tuberculous bronchopneumonia is the most common result of such aspiration, but acute miliary tuberculosis or acute pneumonic phthisis may occur. Dyspnea, rapid pulse, high fever, cyanosis and death may follow the more extensive invasions.

Physical signs on examination of the chest are usually those of the underlying disease. If the hemoptysis occurs at an early stage of the tuberculous process the examination may be negative. In some cases rales limited to the involved region or distributed over a wider area may be heard. They may be due to blood in the branches of the bronchi. At the time of the bleeding, physical examination, if attempted at all, should be cursory and limited to auscultation of the breath sounds, the voice and whisper and testing the tactile fremitus. Percussion should be avoided and the patient should not be allowed to attempt forced breathing.

Prognosis.—This is difficult to estimate and depends on many factors. There are cases in which hemoptysis as an initial symptom or early in the course of an apparently mild respiratory disturbance is the first intimation of the tuberculous nature of the disease and leads to a more immediate decision on adequate measures for relief. In such instances, success in securing an arrest of the tuberculous process may be largely dependent on this timely warning. But in the majority of cases, hemoptysis appears to influence the outlook little if at all. Brown[2] finds, however, in an analysis of 1810 cases from the records of the Adirondack Cottage Sanitarium that males with hemoptysis did not do as well during sanitarium residence as those without hemoptysis, and that of 1276 cases discharged from the institution two to twenty years previously a slightly larger number of deaths occurred among those who had hemoptysis. In females a similar result was not shown.

Outspoken tuberculosis does not necessarily follow hemoptysis, which may occur in patients with apparent good health and sound lungs. Of 329 instances of hemoptysis observed by Ware,[3] 62 (18 per cent.) recovered without subsequent symptoms to suggest pulmonary tuberculosis. The interval elapsing between the attack of hemoptysis and the last report was over ten years in 41 cases. In 1768 Goethe,[4] at the age of nineteen and then a student at Leipsig, had an attack

[1] Loc. cit., p. 388.
[2] Osler. Mod. Med., 1907, iii, 280.
[3] Hemoptysis as a Symptom, 1860.
[4] Aus meinem Leben., Dichtung und Wahrheit, 2 Th., p. 300.

as follows: "One night I waked with a severe hemoptysis and had enough strength and presence of mind to wake my room-mate. . . . For several days I wavered between life and death." For some months he thought he had pulmonary tuberculosis and must die young. At the age of eighty-two he had hemoptysis again and died at the age of eighty-three. His long and active life may serve as a comforting example to those who need encouragement. At the age of twenty-three or twenty-four, Rousseau[1] expectorated blood and gave up his work as a teacher of singing. He died at the age of sixty-six.

Hemoptysis *per se* is rarely fatal. Winsch[2] observed fatal bleeding only twice among 100 patients with hemoptysis. Death as the immediate result of bleeding occurred in only 1 of 76 patients with hemoptysis at the Channing Home and 2 of 142 patients at the Massachusetts General Hospital. Death as a consequence of extension of pulmonary infection for which the hemorrhage was probably in part responsible, occurred in 1 other case (See Chart, Fig. 48) at the Channing Home and 6 other cases at the Massachusetts General Hospital.

Treatment.—Blood-streaked or blood-tinged sputum is an indication for cessation of all exertion for a few days.

More abundant bleeding is an indication for the immediate adoption of such measures as tend to favor thrombosis at the point of rupture of the bleeding vessel and cessation of the hemorrhage. The chief danger is not that the hemoptysis will prove fatal from loss of blood, but that the tuberculous process will be extended into previously unaffected parts of the lung by the aspiration of infected blood. The excitement and anxiety attendant on the bleeding increase this danger by increasing the depth of respiration and inducing the patient to yield to unnecessary inclination to cough. It is first necessary to calm the fears of the patient and the family. Reassuring examples of recovery are not far to seek and can be drawn from every physician's experience. In a very large proportion of the cases the hemorrhage ceases spontaneously and careful nursing is all that is required.

The patient should be put to bed and kept absolutely quiet in a semi-recumbent position, cautioned not to speak unnecessarily, and then not above a whisper. Unproductive cough should, so far as possible, be suppressed. The patient should not be allowed to feed himself, and urine and stool should be passed into the urinal or bed-pan. The diet should be light and easily digestible. All food may well be withheld for a few hours after the bleeding. Fluids should be restricted to from one to one and a half quarts a day and given in small portions at a time to avoid overfilling of the bloodvessels. If the hemorrhage is severe, the amount of fluid should still further be restricted and the quantity of food limited for several days. Food should be given either

[1] Confessions, i, Livre 5. .

[2] Beiträge z. Kenntniss der Hämoptoë phthisicorum, Diss., Berlin, 1898, quoted from Sticker, Nothnagel's spec. Path. u. Ther., xiv, Bd. ii, 1 Abt.

cold or warm, and not hot. Tea, coffee, and alcohol should not be allowed. Acids may prolong coagulation time and should not be given. If the bowels fail to move an enema is to be preferred to cathartics. Increased intrathoracic pressure from straining at stool may dislodge an occluding thrombus and renew the hemorrhage.

The room should be well ventilated and cool, but chilling of the patient's body is to be avoided. Visitors should be excluded and the utmost quiet and serenity should prevail. Only a cursory physical examination should be made at the time of the hemorrhage and a thorough examination postponed until at least two weeks after the bleeding has ceased. The patient should be absolutely at rest in bed as long as there is fever and for at least a week after cessation of the hemoptysis. Tuberculin should not be used for diagnostic purposes until at least a month has elapsed. Only urgent reasons justify the removal of pleural fluid during or soon after hemoptysis.

The use of opium is a common practice in the treatment of hemoptysis, but it has both disadvantages and advantages. Cough is necessary for the expectoration of blood in many cases, and to prevent cough may only increase the danger of retention of infected material within the air passages. On the other hand, expulsive efforts with cough may dislodge a partially adherent thrombus and maintain or renew the hemorrhage. Morphine gr. $\frac{1}{8}$ (0.008 gm.) or codein gr. $\frac{1}{4}$ (0.016 gm.) may be used to quiet irritative and unproductive cough or extreme nervousness, but should not be used as a routine.

Of other measures, an ice-bag over the heart may be quieting. Pieces of ice in the mouth and salt on the tongue are popular remedies, and if not of value, are at least probably not harmful. Too much ice by mouth may unduly increase the volume of body fluid.

Of the following measures, none have been shown to have any definite effect in controlling the hemorrhage. Of the so-called *hemostatics*, gallic acid gr. 10 (0.650 gm.), tannic acid gr. 10 (0.650 gm.), mineral acids, especially dilute sulphuric acid, ♏ 10 (0.60 c.c.), alum gr. 10 (0.650 gm.), the perchloride of iron, Tr. ferri perchloridi ♏ 10 (0.60 c.c.), acetate of lead gr. 2 (0.130 gm.), and the fluid extract of ergot dram 1 (4 c.c.) are sometimes used. Calcium lactate may be given in doses of gr. 15 (0.975 gm.) three times a day for three days and then omitted for two days. *Astringent inhalations*, such as the vapor of turpentine (a teaspoonful of the oil on a handkerchief placed in front of the mouth), or tannic acid, or alum gr. 10 to 20 (0.650 to 1.300 gm.) to the ounce in the form of a spray are probably valueless.

Theoretical considerations have led to the use of *emetics*, such as tartar emetic gr. $\frac{1}{4}$ to $\frac{1}{2}$ (0.0162 to 0.032 gm.) every hour till nausea and vomiting is produced, ipecacuanha gr. 1 to 2 (0.065 to 0.130 gm.) every quarter to half hour, or apomorphin hydrochlorate gr. $\frac{1}{20}$ to $\frac{1}{16}$ (0.0032 to 0.0043 gm.) subcutaneously. Their purpose was to convert partial into complete rupture of the injured vessel in order that the severed ends might retract and thus favor cessation of the bleeding.

Dislodgement of an occluding thrombus and fresh hemorrhage is more likely to follow than any favorable action, and they should not be used. *Reduction of blood-pressure* in the pulmonary circuit by the use of sodium nitrate gr. 2 to 5 (0.130 to 0.325 gm.), amyl nitrite (3 to 5 drops in a glass perle) and nitroglycerin gr. $\frac{1}{100}$ (0.00065 gm.) presents theoretical advantage, but there is no evidence that diminution of pulmonary pressure takes place. Pituitary extract and atropin sulphate gr. $\frac{1}{100}$ (0.00065 gm.) have also been recommended. *Constriction of the pulmonary vessels* by means of the subcutaneous use of adrenalin is purely hypothetical, and if systemic blood-pressure were raised, might aggravate the hemorrhage.

Venesection was formerly a common practice for the purpose of lowering blood-pressure, stopping the pulmonary hemorrhage and preventing death from suffocation, but is now universally abandoned. A similar purpose is the basis of treatment by constriction of the extremities by an elastic ligature. The two thighs just above the knee, the two upper arms or all four extremities are so far constricted as to obstruct the return venous flow, without obliteration of the pulse, thus withholding blood in the extremities. The obstruction may be maintained on three limbs at a time and then gradually released, each limb in rotation, one ligature being changed every twenty minutes. This may be considered as a life-saving measure in the presence of profuse hemorrhage.

The subcutaneous injection of gelatin cannot be recommended. The use of fresh animal (rabbit) serum is said to control hemorrhage by increasing coagulation. Thirty cubic centimeters may be used subcutaneously. In one case of persistent hemoptysis in which I used it, no effect was obtained.

Limitation of motion of the affected side by application of the ice-bag, a sand-bag, the lateral decubitus, adhesive plaster or artificial pneumothorax has been recommended. Inasmuch as the tuberculous process is bilateral in a very large proportion of the cases, it is usually impossible to tell from which side the bleeding comes, and the immobilization of the unaffected side may throw an additional burden on the other and aggravate the bleeding. While successful limitation of motion of the affected side may favor the cessation of hemorrhage, it may prevent the expulsion of blood and thus increase the danger of infection. To judge from my cases, the hemorrhage itself is less menacing to life than spread of the infection by the effused blood. Artificial pneumothorax is more dangerous than hemorrhage. Attempts at immobilization may do more harm than good.

In the presence of an hemoptysis so profuse as to seem likely to be immediately fatal, the use of *intravenous normal saline solution* may be considered. In one case (No. 136,772) after a very abundant hemoptysis, the patient became unconscious, the pulse very weak and irregular, and the extremities cold. Consciousness returned after a saline infusion had been given, but the patient died within a few hours from a recurrence of the bleeding.

CHAPTER XX.

PULMONARY SYPHILIS.

Many of the older writers speak of phthisis due to lues. Little attention was paid to the condition, however, until Depaul[1] in France, and Virchow[2] in Germany, published more accurate anatomic studies. In spite of many recorded cases and of careful anatomic and histologic studies, there is still little agreement concerning the features of the disease. Syphilis only rarely affects the lungs. The diagnosis cannot be made with assurance during life, and is often uncertain at the postmortem. The chief difficulty lies in the exclusion of other diseases, especially tuberculosis, which may produce a similar picture. The literature to 1882 is collected by Hiller[3] and from 1879 to 1899 by Flockemann.[4] The literature is also reviewed by Herxheimer.[5]

Two clinical types of the disease are recognized: the *hereditary* and the *acquired* forms.

1. **Hereditary Form.**—As a result of congenital syphilis, there may be circumscribed pulmonary lesions or *gummata* and a diffuse invasion of the pulmonary tissue or *pneumonia*. The two lesions are frequently combined. They are usually associated with other manifestations of congenital syphilis, such as coryza, various syphilides, enlargement of the liver and spleen, and emaciation. If the infant lives, the respiratory involvement may be evidenced by cyanosis and dyspnea, but physical examination of the chest is practically always negative.

The pregnancy rarely proceeds to full term, and depending on the extent of the pulmonary and other lesions, the infant is stillborn or lives only a few hours or days. In very rare instances, there may be late manifestations of pulmonary syphilis.

(*a*) *Gummata.*—These are rare manifestations of congenital syphilis. They consist of circumscribed interstitial changes with some tendency to necrosis and cavity formation. Pulmonary gummata in the newborn have been described by Martineau,[6] Chiari,[7] Schinze,[8] Kokawa,[9] and others. The process does not differ from similar changes found in the acquired form with which it will be described.

(*b*) *Pneumonia.*—In this group may be included Virchow's *white pneumonia*, with which interstitial changes are often combined, or

[1] Soc. anatom., 1837.
[2] Virchow's Arch., 1847, vol. i.
[3] Charité Annalen., 1882, ix, 184.
[4] Zentralb. f. allg. Path., Bd. x, pp. 469 and 964.
[5] Ergeb. d. allg. Path. u. path. Anat., Lubarsch u. Ostertag, 1906, II.
[6] Soc. anat., 1862.
[7] Wien. med. Presse, 1895, p. 349.
[8] Beitr. zur congenit. Lungensyph. Inaug., Diss., Leipzig, 1902.
[9] Arch. f. Dermat. u. Syph., 1906, vol. lxxviii.

occur as a late stage of the more active process. Of the various pulmonary manifestations of syphilis, white pneumonia is the best established type. It is chiefly of anatomic interest, since the diagnosis of the condition cannot be made during life and the infants are stillborn or die soon after birth. One instance (Autopsy 2892) of congenital syphilitic pneumonia was found among 3000 autopsies at the Massachusetts General Hospital.

Parts or the whole of one or both lungs may be involved. The affected lung is enlarged and firm and may show the impressions of the ribs. The external and cut surface is dry and pale, yellowish, grayish or reddish-white in color, and may have a marbled appearance. Excised pieces sink in water. The cut surface has the appearance of white hepatization, but is more often smooth and without the granular appearance found in ordinary pneumonia. The condition has been called "pancreatization" from the resemblance to the cut surface of the pancreas. The pleura is usually free. The subpleural tissue may be thickened, vascular, and infiltrated.

On microscopic examination, both parenchymatous and interstitial changes are usually found. Cases in which the alveolar epithelium is desquamated, swollen and has undergone fatty degeneration represent the parenchymatous form or true pneumonia alba of Virchow. Cases with proliferation of the interstitial tissue alone without changes in the parenchymatous tissue are classed as interstitial pneumonia. Such a distinction between the two forms is maintained by Hiller,[1] Heller,[2] Stroebe,[3] Spanudis,[4] Fränkel,[5] and others. In most of the reported cases, however, changes in the parenchymatous and interstitial tissue have been associated, and it is questionable whether a sharp distinction between the two groups is justified. Heubner,[6] Birsch-Hirschfeld,[7] Ziegler,[8] Orth,[9] Schinze,[10] and Kokawa[11] believe that there is only one form of pneumonia. This is white pneumonia in its broader sense, and changes in the parenchyma and interstitial changes are combined. According to Kokawa, the interstitial changes are the more constant, being present in all of four cases which he studied, while the involvement of the epithelium was variable.

The interstitial tissue is increased in amount by proliferation of the fixed connective-tissue cells and infiltration with small mononuclear and occasionally with polynuclear cells. The interstitial changes vary in different cases and in different parts of sections from the same case.

[1] Charité-Annalen., 1882, ix, 184.
[2] Deut. Arch. f. klin. Med., 1884, xlii, 159.
[3] Zentralb. f. allg. Path. u. path. Anat., Bd. ii, p. 1009.
[4] Ueber kongenitale Lungensyph., Freiburg, 1891, Inaug.. Diss.
[5] Spez. Path. u. Ther. der Lungenkrankheiten, 1904.
[6] Gerhardt's Handbuch der Kinderkrankheiten, 1896.
[7] Lehrbuch der path. Anat., 1894.
[8] Lehrbuch der allg. Path. u. path. Anat., 1902, Bd. ii.
[9] Lehrb. der Spez. path. Anat., 1887, p. 447.
[10] Beitrag zur Kong., Lungensyph., Leipzig, 1902, Inaug. Diss.
[11] Archiv f. Dermat. u. Syph., 1906, vol. lxxviii.

Its increase may be noted in the interalveolar septa, but is especially marked about the bronchi and the bloodvessels.

The alveoli and smaller bronchi are wholly or partially filled with desquamated epithelial cells, leukocytes, and red blood corpuscles. The desquamated epithelium may be swollen, fatty or necrotic. The alveolar walls may be thickened.

The capillary bloodvessels are widened. The walls of the larger vessels are thickened. The adventitia is most affected, is infiltrated and vascular. Interstitial changes have been observed in the media. In rare instances thickening of the intima has been noted. From the observation of most advanced changes in the perivascular tissue, it has been thought that this represents the starting-point of the process.

The lymph spaces may be widened. Kokawa has noted that the elastic fibers are less developed in the lungs of the fetus with syphilitic pneumonia than in normal lungs at a corresponding age. The pleura may be thickened or unchanged.

The spirochæta pallida has been found in the pulmonary tissue by Levaditi,[1] Beriel and Favre,[2] Jambon,[3] and others. The organism is more abundant in the diseased tissue than elsewhere, but may also be found in the blood and in non-specific lesions in infected infants.

Relation of Congenital Pulmonary Syphilis and Tuberculosis.—It is stated that the two lesions may be combined in the same lung, and although this may be true, owing to the difficulty of differentiating syphilis and tuberculosis, proof of the syphilitic character of such combined lesions is thus far wanting. Infants with undoubted congenital syphilis in extrapulmonary regions may have pulmonary tuberculosis, and tubercle bacilli may be found in the lesions at the post-mortem examination. Caseous syphilitic pneumonia has been described but is not substantiated.

2. **Acquired Form.**—The pulmonary manifestations of acquired syphilis are rare. Fowler[4] could find only twelve specimens believed to illustrate syphilitic lesions in the lungs in the museums of the London Hospitals and the Royal College of Surgeons. Of these, two were doubtful. Osler[5] states that among 2500 autopsies at the Johns Hopkins Hospital, there were twelve cases in which lesions ascribed to syphilis were found. Among 3000 autopsies at the Massachusetts General Hospital, one case (Autopsy 29) with syphilitic ulceration of the trachea and indurative pneumonia with cavity formation was found. The syphilitic character of the pulmonary lesions is doubtful.

Bronchial catarrh may be an early manifestation of the secondary period of syphilis, corresponding to the cutaneous eruption of the same period. Gummata of the trachea and bronchi may occur as a late secondary or tertiary manifestation. Tracheal and bronchial stenosis

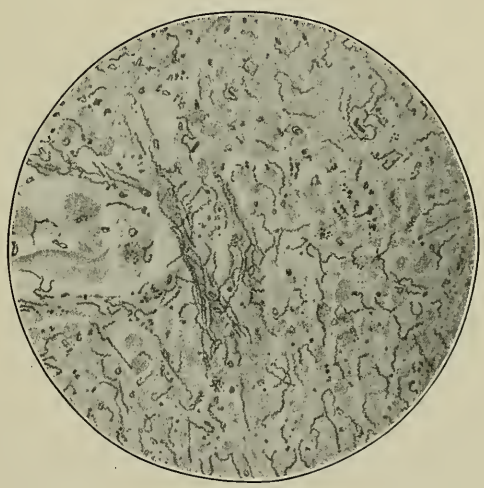
[1] Annales de l'Institut Pasteur, January, 1906.
[2] Soc. méd. des hôp., Lyon, 1906.
[3] Th. de Lyon, July, 1906, p. 134.
[4] The Diseases of the Lungs, Fowler and Godlee, 1898, p. 429.
[5] Osler. Modern Medicine, vol. iii, p. 471.

is not uncommon as a result of the contraction of the scar tissue. Pulmonary gummata and interstitial changes are usually late manifestations of acquired syphilis and occur during the tertiary period. They seldom appear until two years have elapsed, but may be found after eighteen to twenty years.

Pathology.—(1) *Gummata.*—These may be single or multiple, and vary in size from a hemp seed to a walnut. They may be found in any part of the lung, but are more commonly within than on the surface. They show a special disposition to develop at the root of the lung, but may at times be found in the lower lobes; least often at the apices. Diffuse fibroid induration is often associated with gumma.

In its early stages, a gumma is said to be soft, yellowish in color, irregular in shape and surrounded by pale red or grayish tissue. Later, it may be reddish, yellow, gray or white. Fatty degeneration and connective-tissue formation take place. Caseation may occur. Inflammation in the neighboring tissue may lead to the formation of a capsule. Necrosis with evacuation into the bronchi may result in cavity formation, but this is rare. Finally, tough connective-tissue scars of a white, gray or even black color, from the deposit of pigment, may be found. If at the periphery of the lung, these may lead to indentation or puckering of the pleura. Calcareous masses may arise from the deposition of lime salts.

FIG. 49



Spirochætæ in lung tissue. (Koch.)

On microscopic examination, proliferation of the connective-tissue cells about the bloodvessels, the bronchi or in the interlobular tissue is found. Necrosis may prevent the recognition of individual elements of the tissue. Connective-tissue outgrowths may proceed from the mass into the surrounding tissue. The adjacent alveoli and alveolar

walls contain an excess of proliferated epithelial cells. The histologic picture in gumma does not differ essentially from that in syphilitic interstitial pneumonia. The bloodvessels play an important part in the process. They may be thrombosed and their walls may be thickened.

The spirochæta pallida is difficult of demonstration in the syphilitic lesions of the lung as in similar lesions of other organs. It has been found in acquired syphilitic pulmonary lesions by Koch[1] and Schmorl.[2] The spirochæta pallida must be carefully differentiated from non-syphilitic spirochætæ, which may be present in the lung tissue.

2. *Diffuse Fibroid Induration.*—Interstitial changes of variable extent may occur independently of gummata or in association with them. The connective-tissue may spring from the perivascular, the peribronchial or the subpleural connective tissue. Parts or the whole of one lung may be involved. The changes are common at the hilus. Bronchiectasis frequently accompanies the fibrosis. Caseation is uncommon, and tubercle bacilli are absent. The microscopic picture is not distinctive of syphilis. It is to be remembered that in cases in which tracheobronchial syphilis is present. bronchostenosis may give rise to inflammatory and indurative changes in the pulmonary territory supplied by the stenotic bronchi, and that the virus of syphilis may not be immediately concerned in the pulmonary process.

3. *Bronchopneumonia.*—It is doubtful whether this can be ascribed to syphilis.

Symptoms.—There are no symptoms distinctive of pulmonary syphilis. Gummatous lesions alone are usually without symptoms. Even quite extensive interstitial pneumonia may fail to give rise to symptoms. When these occur, they are usually due to an accompanying bronchiectasis. Cough and dyspnea may be prominent features, their intensity varying with the extent of the lesions. The sputum presents nothing characteristic. It may be abundant, and purulent and at times is offensive. Hemoptysis may occur from the erosion of arteries lining the walls or traversing the lumen of pulmonary cavities. It is less common than in tuberculosis. Pain may be present, but is not a prominent feature from the infrequency with which the pleura is affected. Night sweats may occur. Emaciation may exist with extensive pulmonary disease. In the early stages the disease is afebrile, but hectic fever may be present later in its course.

Physical Signs.—Uncomplicated gummata usually fail to give rise to physical signs. With extensive interstitial pneumonia and bronchiectasis, the signs are such as may be present in similar processes from other causes. A location of pulmonary changes elsewhere than at the apices may be suggestive.

Diagnosis.—1. *Clinical.*—In the newborn the diagnosis cannot be made. The possibility of pulmonary syphilis in children who have

[1] Verhandl. d. deut. path. Gesellsch., 1907, p. 275. [2] Ibid.

suffered from hereditary syphilis should be borne in mind. The association of pulmonary symptoms with interstitial keratitis, Hutchinson's "notched teeth," labial fissures, nasal and palatal ulceration, depression of the bridge of the nose, tibial and cranial nodes and deafness may be suggestive. In the acquired form of the disease, the symptoms and signs will usually suggest pulmonary tuberculosis. The diagnosis cannot be made with certainty, but the following considerations may serve to suggest that the case is one of pulmonary syphilis and not tuberculosis. (*a*) Undoubted evidence of syphilitic infection, followed by secondary manifestations and the coexistence with the pulmonary process of other tertiary syphilitic lesions. Ulceration or stenosis of the trachea or bronchi is especially suggestive. (*b*) Absence of family history or opportunities for contagion of tuberculosis. (*c*) Positive Wassermann test. (*d*) The absence of tubercle bacilli from the sputum in repeated examinations. (*e*) Negative subcutaneous tuberculin injections in increasing doses up to and including 10 mg. (*f*) A pulmonary lesion outside the apices of the lungs, as determined by physical examination or the *x*-rays. Syphilitic processes are most often at the root or at the bases of the lungs. (*g*) Improvement of the pulmonary symptoms under antisyphilitic treatment. Little can be expected from this in an advanced stage of the disease.

2. *Pathologic.*—It cannot be said as yet that even at autopsy the syphilitic character of pulmonary lesions can be conclusively established.

In the distinction between congenital syphilitic and croupous pneumonia in the newborn, the histologic picture may be suggestive. Less abundant fibrin, less marked interstitial and vascular changes and involvement of the pleura are more characteristic of lobar pneumonia, while the presence of extrapulmonary signs of congenital syphilis and the discovery of the spirochæta pallida in properly stained sections of the lung tissue speak for syphilitic pneumonia. Pulmonary tuberculosis must also be excluded.

In the diagnosis of congenital or acquired gummatous or interstitial pulmonary processes, the following points must be considered. (*a*) The previously mentioned clinical features (*a* to *e* above) may furnish important evidence. (*b*) Caseation, necrosis, cavity formation and pulmonary aneurysms are more characteristic of tuberculosis than of syphilis. (*c*) When pulmonary cavities occur in syphilis, they are more likely to be bronchiectatic in origin. (*d*) Changes in the blood-vessels are more common in syphilis. Giant cells are more often seen in tuberculosis. (*e*) Demonstration of spirochæta pallida in the lesions. (*f*) Finally, the careful search for tubercle bacilli in stained sections and the inoculation of a guinea-pig with a piece of the suspected tissue must be negative.

Fibroid changes with or without bronchiectasis may follow pulmonary suppuration from other causes than syphilis and tuberculosis.

The cause of such changes may be sufficiently obvious from the history of the case. Neither on gross nor histologic examination can they be positively differentiated from interstitial changes due to syphilis. In such cases, reliance must be placed on the distribution of the lesions and the presence of associated syphilis with other factors in any given instance.

Prognosis.—This depends largely on the extent of syphilitic invasion of the lungs and other organs and on the early recognition of the disease. The complete recovery from pulmonary lesions, the syphilitic character of which is highly probable, has repeatedly been observed under antisyphilitic treatment. When the pulmonary disease has progressed to extensive fibroid changes and bronchiectasis, the prospects for recovery are hopeless, but some alleviation may be expected.

Treatment.—General measures similar to those for pulmonary tuberculosis should be instituted. These consist in rest, extra feeding and fresh air. Mercury and salvarsan are chiefly to be relied upon in syphilis of the lung as in syphilis of other organs. The earlier the treatment is begun, the better the results which may be expected. Alternating courses of the protiodid of mercury and of salvarsan intravenously are most efficient. Treatment should be controlled by the Wassermann test.

CHAPTER XXI.

PULMONARY ACTINOMYCOSIS.

Etiology.—Bollinger[1] first showed that the disease of cattle previously known as a form of sarcoma of the jaw was due to a vegetable parasite to which Harz[2] gave the name of "Actinomyces bovis" because of its radiate structure. Soon afterward, J. Israel[3] discovered the parasite in man. He includes in his publication an observation, making it apparent that the organism had been seen as early as 1845 by v. Langenbeck.[4] The identity of the human and bovine infections was first pointed out by Ponfick.[5]

The first extensive studies on the biology of the organism were made by Bostroem[6] and by Wolff and Israel.[7] Their widely different views are responsible for much of the confusion which has since obtained. It is now known that Bostroem and many subsequent investigators, beginning their experiments with material containing true Actinomyces, have in many instances cultivated therefrom a group of contaminating organisms properly classed among the Streptothrices. This confusing group is widely distributed in nature, being found not only as an occasional cause of suppurative lesions in man and cattle, but also on grains and grasses. Wolff and Israel, on the other hand, undoubtedly worked with true actinomyces. Their investigations have been confirmed by many investigators, notably by Wright,[8] whose painstaking research has finally placed the biology of actinomyces upon a firm foundation.

Actinomyces Bovis.—No difference has been established between the organism found in man and in animals. It is present in the lesions and in the pus in the form of spherical or irregularly rounded, grayish or yellowish granules, varying in size from minute particles to a diameter

[1] Cent. f. d. med. Wissensch., 1877, p. 481. [2] Ibid., p. 484.

[3] Virchow's Arch., 1878, lxxiv, 15.

[4] Hermann Lebert (Traité d'anat. path. gén. et spec., 2 vol. Text in Fol. 8, 2 vol. Atlas in Fol., Paris, 1857–61, i, 54. Atlas, vol. i, cl. ii, Fig. 16) speaks of "Corps particuliers trouvé dans le pus" and describes them. His figures show that they were actinomyces. The descriptions given by Rivolta (Sarcoma fibroso al bordo inferiore della brancha mascellare sinistra del bove, Medico veterinario, January, 1868, p. 125). Robin (Traité de microscopie, Paris, 1871, p. 576, Fig. 157), and Perroncito (Osteosarcoma della mascella anteriore e posteriore nel bovini. Article Pathologia dell' Enciclopedia agraria italiana, diretta dal Dottore Gaetano Cantani, 1875, iii, 599), show that the organism had also been seen by them.

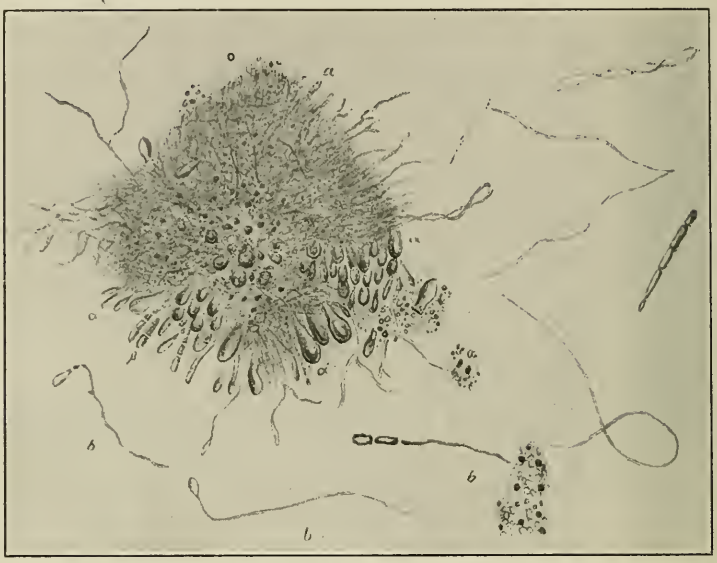
[5] Berl. klin. Woch., 1879, No. 23, p. 345.

[6] Beitr. z. path. Anat. u. z. allg. Path., 1890.

[7] Virchow's Arch., 1891, cxxvi, 11. [8] Jour. Med. Research, May, 1905.

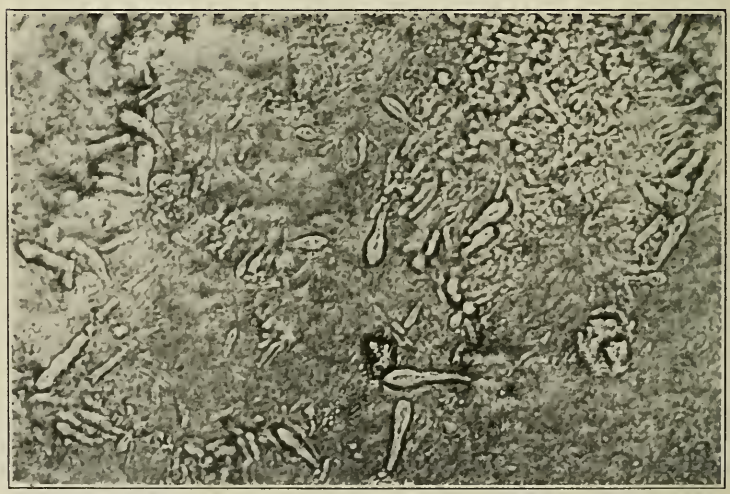
of 1 to 2 mm. These may be soft, tallowy and easily crushed or hard, resistant and even calcified. By the aggregation of small colonies

FIG. 50



Actinomyces granule. (J. Israel.)

FIG. 51



Crushed actinomyces granule from fresh sputum. Unstained. × 750.

a mulberry-shaped mass may be produced. In mucopurulent sputum, the granules may be found entangled in the mucus. In fluid pus,

they may gravitate to the bottom of the receptacle. They are more easily recognized if the specimen of sputum is poured into a glass dish containing water amounting to several times the volume of sputum. In this the more coherent masses of sputum may be teased apart by means of the platinum wire. The granules tend to sink to the bottom. Examination on a black background will facilitate the search.

When crushed between slide and cover glass, typical granules appear under the low power of the microscope as yellowish granular masses, relatively transparent in the central parts and with a narrow, denser, irregular margin. Under the high power, an indefinite mass of tangled fibers, debris and pus cells are found at the centre and at the periphery a dense network of interlacing filaments. At the extreme margin, are isolated branching filaments and radiating, hyaline, and refractive club-shaped bodies, thickest at or near the distal extremity. The "clubs" or rays are the distinctive feature of the granules. They are not always present, but in their absence the colonies cannot be identified with certainty in fresh specimens. In the report of cases as actinomycosis of the lung, a failure to record the fact that the granules are club-bearing may suggest the possibility of confusion with particles composed of streptothrix filaments. Club formation is probably a means of protection against the destructive action of the tissue cells and fluids.

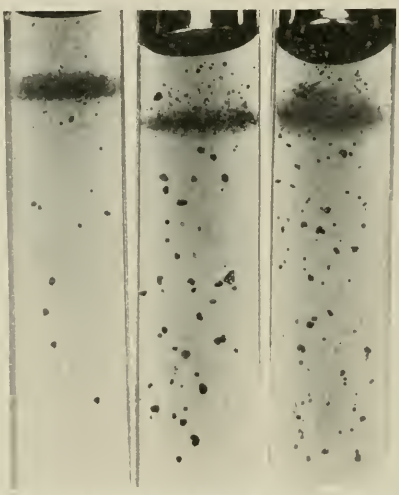
Smears may be made from the crushed granules and stained by Gram's method. After decolorization with alcohol, the specimen is washed in water, stained for a few seconds with a saturated aqueous solution of eosin, again washed, cleared with absolute alcohol and with xylol and mounted in balsam. The filaments then appear as Gram-staining slender-branched and unbranched wavy threads. Thicker filaments are occasionally seen. At times they increase in size toward one end, forming a slender club. These are not the true clubs, but appear to be simple variations in the morphology of the organism. A striking feature of some of the filaments is the presence of deeply staining points, giving them a beaded appearance. The true clubs are stained with eosin and can be readily recognized. Their number in stained smears made from the granules is usually less than in fresh specimens from the same material, suggesting that the clubs are washed away or dissolved in the process of staining. Their radial position at the periphery of the colony is also likely to be disturbed by the manipulations.

The organism may be isolated by the following method, employed by Wright:[1] Granules should first be thoroughly washed in sterile salt solution or bouillon, then crushed and disintegrated between two sterile glass slides. Only such masses as show an abundance of filaments should be chosen for cultivation. The disintegrated granule is transferred by means of a platinum loop to several test-tubes con-

[1] Jour. Med. Research, May, 1905.

taining 1 per cent. dextrose agar to a depth of about 7 to 8 cm. and cooled to about 40° C. An even distribution of the material through-

FIG. 52



Gross appearance of sugar-agar suspension cultures of actinomyces.
(Dr. J. H. Wright.)

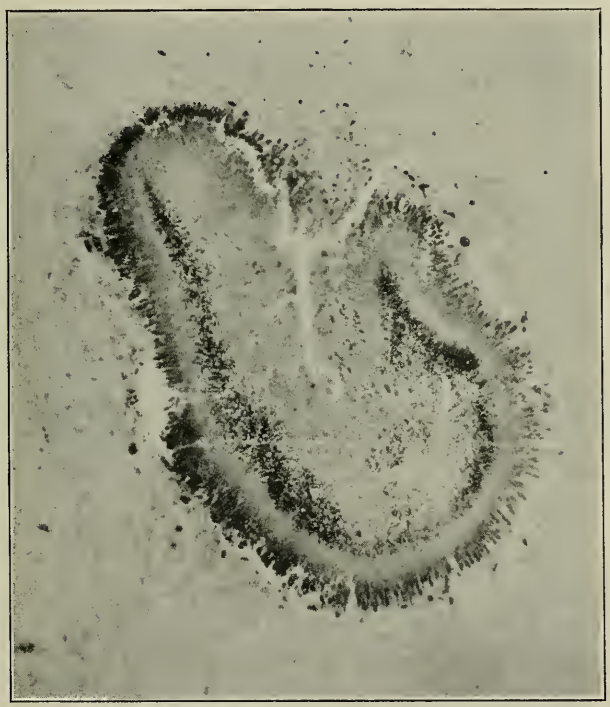
FIG. 53

A colony of actinomyces in a section of sugar-agar suspension culture.
(Dr. J. H. Wright.)

out the agar is accomplished by means of the loop and the tube placed in the incubator. At the same time a number of granules

should be placed on the sides of sterile test-tubes plugged with cotton and kept at room temperature in the dark. If there is little or no contamination of the material with other organisms, the colonies of actinomyces may be expected to develop within a few days to a week. A small portion of the agar containing colonies is removed, placed on a clean slide and examined under the low power of the microscope. By this means, a small section of the agar containing a single colony may be separated from the mass, thoroughly washed of adherent

FIG. 54



Colony of actinomyces with well-developed "clubs" at the periphery in a nodule in the peritoneal cavity of a guinea-pig inoculated with a culture of the organism. (Dr. J. H. Wright.)

bacteria in sterile bouillon, again transferred to melted agar and placed in the incubator. If many colonies of contaminating bacteria are present, isolation will probably be impossible by this means. An attempt may then be made to isolate the organism from the granules dried on the sides of the sterile tubes, in which it may be expected that a large number of the contaminating bacteria have been killed after a period of two to three weeks.

Actinomyces are anaërobic and grow well only in agar or bouillon.

In 1 per cent. dextrose or glucose agar suspension cultures after two to four days in the incubator, the growth is most abundant in a narrow zone from 5 to 10 mm. below the surface, while scattered colonies appear throughout the medium below. Colonies in cultures are in general similar to those in the lesions of the disease, and are composed of spherical masses of interlacing and branching filaments disposed in a more or less radiate manner. The growth in bouillon usually occurs in the form of whitish, coherent, spherical masses at the bottom of the tube, without surface growth or the production of cloudiness in the medium. In the other usual culture media and at room temperature, little or no growth takes place. Spore formation is not observed. Wright succeeded in reproducing the club-formation, so characteristic of the colonies in tissues, by growing actinomyces in such animal fluid as blood-serum and serous pleuritic fluid. The organism withstands drying at room temperature for fifty to eighty days.

The attempt to reproduce the disease experimentally in animals has failed to give rise to a progressive lesion comparable to the disease in man and cattle. The results of intraperitoneal inoculation of guinea-pigs and rabbits with bouillon cultures are inconstant. In some instances small connective-tissue nodules containing one or more cavities filled with pus are produced in or upon the omentum. These lesions in their anatomic and histologic appearance are identical with typical actinomycosis, but little evidence is thus obtained that the organism has multiplied within the animal body.

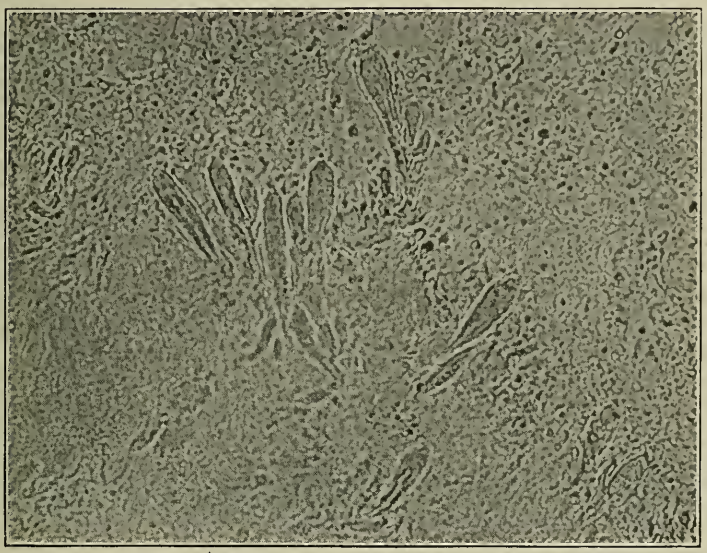
The practically constant occurrence of mixed infection with various bacteria in spontaneous actinomycotic lesions and the failure to produce a progressive infection in animals after inoculation with pure cultures suggest that contaminating bacteria play an important part in the disease. In explanation of the rare instances of spontaneous infection with actinomyces alone, an increased individual susceptibility may be assumed.

Mode of Infection.—The prevalent view that infection takes place through the inhalation of dust or local injury from dried grains or grasses is based on the assumption that the disease is due to organisms of the type described by Bostroem. The organisms of this group grow well on all culture media at room temperature and in the incubator. They grow even on sterilized water and can be demonstrated on grains and grasses. They have not been shown, however, to cause lesions like actinomycosis after experimental inoculation of animals.

There is no conclusive evidence that actinomycosis is contagious. Growth of true actinomyces in artificial media occurs only at about 37° C. and it is therefore unlikely that multiplication of the organism takes place under any ordinary conditions outside the human or animal body. Wright suggests that it is a normal inhabitant of the alimentary canal, gaining entrance to the tissues as do other bacteria through local wounds or abrasions. Foreign bodies have occasionally been

found within lung tissue the site of actinomycosis. In Balack's[1] case, a barley-grain was found in a pulmonary cavity. Israel[2] found a fragment of a carious tooth at autopsy in an abscess cavity of the left upper lobe. It is probable that actinomyces, as well as other organisms, may thus at times be implanted in the lung.

FIG. 55



Actinomycosis of the omentum in a guinea-pig forty-five days after intraperitoneal inoculation with material from the tonsillar crypts of a patient without actinomycosis. × 750.

That infection with actinomycetes arises from within the individual from organisms present in the buccal cavity is supported by my experiments.[3] The intraperitoneal inoculation of guinea-pigs with the contents of carious teeth and the tonsillar crypts from persons free from actinomycosis gave rise to omental tumors histologically identical with actinomycotic tissue and containing typical club-bearing actinomyces granules. In order to completely establish the identity of these organisms with actinomyces bovis, pure cultures should be obtained, and with such cultures it should be possible to produce in animals lesions similar to those obtained with pure cultures of actinomyces isolated from human or bovine actinomycosis. Attempts to isolate the organism in pure culture by various means have thus far failed. Its isolation from material obtained from the teeth and the tonsils

[1] Ueber Lungen-Aktinomykose, Inaug. Diss., Leipzig, 1893.
[2] Arch. f. klin. Chir., Bd. xxxiv, p. 160.
[3] Lord, Jour. Amer. Med. Assoc., 1910, lv, 1261.

and from the experimental lesions in animals is rendered especially difficult by the abundance of the contaminating bacteria. From these considerations, until proof is offered to the contrary, actinomycosis may be regarded with probability as arising from organisms harbored in and about the teeth and in the crypts of the tonsils.

Occupation appears to have no bearing on the development of pulmonary actinomycosis. Both sexes are about equally affected. The disease occurs most frequently between twenty and forty years of age.

Pathogenesis.—Infection of the lung may occur as a primary affection or secondary to the disease in neighboring or remote organs.

Primary Pulmonary Actinomycosis.—The disease is most frequent in the region of the head and neck. Infection of the lung or abdomen stands next in frequency. Of 105 cases collected by Rütimeyer,[1] the lungs were involved in 22 (20 per cent.). Of the 421 cases reported by Illich,[2] the lung was primarily affected in 58 (13.7 per cent.). The manner in which the organism gains entrance to the lung is uncertain. Aspiration from the buccal or pharyngeal cavity is a possible source.

Secondary Pulmonary Actinomycosis.—This is much less common. The disease may arise by *extension* from neighboring organs. Infection about the jaws or neck may descend along the prevertebral region to the mediastinum, and thence invade the lung. Extension may likewise occur from the esophagus or through the diaphragm from the abdomen. A subdiaphragmatic, hepatic, perinephritic or perityphlitic abscess may be the starting point of the disease. Infection of the pleural sac may be prevented if an adhesive pleurisy precedes the rupture. In a considerable proportion of all cases of actinomycosis, whether of the lung or other organs, *metastatic distribution* of the organism occurs in the later stages of the process. Invasion of blood-vessels may follow the softening of infected tissue and erosion of the vessel wall. The detachment of an infected thrombus thus formed may carry the organism into remote parts of the body by way of the arterial or venous circuit, the latter being most common. Rupture into the portal system results in secondary involvement of the liver, while invasion of the systemic veins leads to secondary deposits in the lung. Israel[3] noted metastatic distribution of actinomyces in one of his cases and many similar observations have since been made. In a few instances, the portal of entry into the circulation has been found. Thus Ponfick[4] found a mass projecting into the lumen of the jugular vein, and regarded this as the source of a soft tumor the size of an apple, containing actinomyces granules, in the right auricle. Hanau[5] noted perforation into the superior vena cava in a case of actinomycosis of the left lung and pericardium. Benda[6] has reported

[1] Berl. klin. Woch., 1889, Nos. 3 and 4.
[2] Beitrag. z. Klinik. d. Aktinomykose, Wien, 1892.
[3] Virchow's Arch., 1878, vol. lxxiv.
[4] Ueber Actinomykose, Berl. klin. Woch., 1880, No. 46, p. 660.
[5] Zwei Fälle von Actinomycose Correspondenzbl. f. Schw. Aerzte, 1889, xix, 165.
[6] Zwei Fälle von metastat. Aktinomykose, Deut. med. Woch., 1900, No. 13.

a case of actinomycosis of the liver leading to perforation of an hepatic vein, with secondary actinomycotic thrombosis of the inferior vena cava and death from pyemia. In a second case, actinomycosis of the heart wall and actinomycotic thrombi in a coronary vein were found.

Dissemination by way of the lymph channels occurs only in rare instances if at all. Slight inflammatory hyperplasia of the bronchial glands is common. Histologic examination, however, usually fails to show lesions characteristic of the disease or filaments which can with certainty be regarded as actinomyces. In Balack's[1] case, on the other hand, a gland at the tracheal bifurcation was enlarged to the size of a pigeon's egg and contained actinomyces granules within small areas.

Pathology.—Changes in the pulmonary tissue as a result of invasion by actinomyces closely resemble the lesions in chronic ulcerative pulmonary tuberculosis. Connective-tissue formation is more abundant, however; sinuous and communicating tracts are more common, and extension to neighboring organs and the thoracic wall is more often observed.

The gross appearance of the lung presents a variable and usually complicated picture. The more characteristic lesions comprise areas of bronchopneumonia and interstitial pneumonia, multiple abscesses and bronchiectasis. Bronchitis is almost invariably present. Lobar pneumonia, gangrene and tuberculosis occur as complications in rare instances. Pulmonary tuberculosis and actinomycosis were associated in Hebel's[2] and in one of the Massachusetts General Hospital cases (Autopsy 1488).

There is no pathologic evidence in favor of a purely bronchial form, but the terminations of the bronchi are almost invariably implicated in the process, and the infection spreads by extension and the aspiration of organisms into neighboring or remote parts of the lungs. The lower lobes are principally affected, the left somewhat more commonly than the right. The disease is usually unilateral. In Schlagenhaufer's[3] case, there was diffuse involvement of both lungs in the form of purulent bronchitis, peribronchitis, multiple bronchiectasis and bronchopneumonia and indurative pneumonia, with consecutive interstitial and vesicular emphysema. Primary invasion of the upper lobes has been noted, as in 9 of the 58 cases collected by Illich,[4] in 3 of which the apices were involved. Lindt's[5] case is noteworthy because of the finding at autopsy of actinomycotic cavities at the apices of both lungs. Other instances of apical localization have since been reported.

In its early stages the disease appears as scattered or circumscribed, isolated, grayish, yellowish or reddish-brown, resistant pulmonary areas, which on section are found to contain pus, the evacuation of which discloses cavities lined with grayish-yellow, brownish or reddish

[1] Ueber Lungen-Aktinomykose, Inaug. Diss., Leipzig, 1893.
[2] Ueber Aktinomykose, Virchow's Arch., Bd. cxlvi. p. 1.
[3] Virchow's Arch., 1906, clxxxiv, 491.
[4] Loc. cit.
[5] Korrespondenzbl. f. schw. Aerzte, 1889.

granulation tissue. Within the centre of the cavity a communicating and at times dilated bronchus may be found. The bronchial wall is usually reddened and contains pus. More extensive focal or lobar involvement results in the formation of dense inelastic, partially or wholly airless, grayish or reddish-gray areas of infiltration, in which are found larger or smaller cavities connecting with the bronchi and with each other by narrow, complicated fistulous channels. Extensive losses of substance are uncommon. At times, however, ulceration progresses to a marked degree. An abundant connective-tissue formation is usually a striking feature, and leads to contraction of the affected region. Within the cavities and also in the purulent contents of the bronchi, actinomyces granules are found.

Microscopic examination of the contents of the cavities shows pus cells, red blood corpuscles, free fat and fatty acid crystals, detritus and isolated or conglomerate masses of branching Gram-staining filaments, as well as the club-bearing actinomyces granules. The primary lesions probably consist of catarrhal desquamation of the bronchial mucous membrane through which the organism finds its way into the submucosa and peribronchial tissues. Here and in the neighboring alveoli, there is round-celled infiltration, proliferation of the alveolar epithelium and the interstitial connective tissue. Grayish-red nodules are thus formed, the centre of which soon undergoes necrosis and softening, while at the periphery an abundant, vascular connective-tissue proliferation more or less completely invests the process.[1] In stained sections, multiple, isolated or confluent abscesses are found, within few or many of which are radiating club-bearing actinomyces colonies. Between and within the pus cells, few or many isolated branching filaments may be seen. Serial section may be necessary to demonstrate the colonies.

There is no noteworthy difference between primary pulmonary actinomycosis and that secondary form of the disease arising by extension from neighboring organs. A distinction between the two forms may be difficult or impossible. In general, however, a more extensive destructive and indurative process may be expected at the site of the primary focus, although this is not invariably true, as the earliest lesions may be partially or wholly healed by replacement with scar tissue. In the early stages of metastatic pulmonary invasion, numerous scattered miliary nodules may be found throughout the lungs, or larger wedge-shaped subpleural areas, the further evolution of which takes place, as already described for the primary form of the disease.

The involvement of neighboring organs by direct extension is a striking feature of the disease. Invasion of the pleura is almost invariable, usually leading to the formation of adhesive pleurisy. Small and encysted serofibrinous, hemorrhagic or purulent pleurisy occa-

[1] Baumgarten, quoted from v. Korányi, Nothnagel Spec. Path. u. Ther., 1897, Bd. i, p. 108.

sionally follows. Invasion of the peripleural tissue is common. Erosion of the ribs, perforation of the intercostal spaces in one or more places, and superficial thoracic abscesses are often found. Invasion of the pericardium, the mediastinum with erosion of the vertebræ, extension downward through the diaphragm leading to subdiaphragmatic, hepatic and perinephritic abscesses are not infrequently observed. Infection of the heart muscle may also take place. Metastatic distribution may lead to abscess formation in any organ of the body, more especially in the spleen and kidney, less often in the brain. Amyloid may follow the long-continued suppuration.

Symptoms and Physical Signs.—The clinical picture is variable. The onset of the primary pulmonary form is usually insidious. The course is commonly chronic, acute only in rare instances.

The initial symptoms are those observed in other inflammatory affections of the bronchopulmonary system, and closely resemble tuberculosis. There is a history of cough with gradually increasing sputum. Dyspnea at first slight, but of gradually increasing degree, is common. Slight elevation of temperature is almost constantly observed. Pleural pain is a feature in a large proportion of the cases. As the disease progresses, the cough becomes more troublesome. The fever is more marked and irregular, intermittent or remittent. Loss of weight and strength, pallor, night sweats and emaciation gradually ensue.

The sputum presents no distinctive features, other than the actinomyces granules. In Rütimeyer's[1] case, the patient made the unusual observation of a sensation as if the mouth were full of sand and of grating between the teeth from the presence of the granules. The sputum is at first scanty, whitish and mucoid or mucopurulent. As the disease progresses, it becomes more purulent and of a yellowish or greenish color. It is commonly odorless, but may be fetid. In some instances, it is distinctly foul. The amount is variable and usually small throughout the course of the illness. The expectoration commonly takes place throughout the day, rather than in attacks at long intervals, as in ordinary bronchiectasis or pulmonary abscess. Large amounts are occasionally observed. and at times as much as one-half to one liter in the twenty-four hours. Blood in the sputum is mentioned in fully one-half of the more carefully reported cases in the literature. It may occur as bloody streaks or masses, and the sputum may in consequence be bright red, rusty, brownish or blackish in color. In rare instances the sputum resembles currant jelly. Small amounts of fresh blood are occasionally observed.

Large amounts of fresh blood have been recorded in rare instances. In Rieke's[2] case a hemorrhage amounting to one-third of a liter, after pulmonary symptoms had lasted for about three months, appeared

[1] Berl. klin. Woch., 1889, p. 68.

[2] Ein Fall von primärer Lungenaktinomykose mit tötlicher Blutung, Inaug. Diss., Kiel, 1903.

to hasten the fatal termination. In Bulling and Rullmann's[1] case hemoptysis was an early symptom. A recurrence, amounting to three-quarters of a liter, terminated an illness of about a year and a half. In one of the Massachusetts General Hospital cases (No. 169,915), three hemorrhages, each of a liter or more, occurred during the course of a primary pulmonary actinomycosis. The first bleeding took place during the second month of pulmonary symptoms. Club-bearing actinomyces granules were found in the sputum, but no tubercle bacilli. Hemoptysis as an initial symptom has not so far as I know been observed.

In Finckh's[2] case a primary pulmonary actinomycosis with thoracic perforation was complicated with fibrinous bronchitis, and in the fibrinous casts of the bronchi numerous actinomyces granules were found. Elastic tissue is occasionally found in the sputum, but apparently less often than in pulmonary tuberculosis.

Israel[3] has divided the clinical course of the diseases into three stages. In the first or *bronchopulmonary* stage, the process does not extend beyond the limits of the pulmonary tissue. Involvement of the pleura marks the beginning of the second or *pleurothoracic*, while invasion of the thoracic wall terminates in the third or *fistulous* stage. The classification presents a useful picture of the usual progress of the disease. In most clinical cases, however, the exact limits of the process cannot be accurately determined. This is especially true of the first two stages.

The disease is seldom recognized in the early part of its course. Such pulmonary symptoms as have already been described may be present. Physical examination may be negative or the physical signs of bronchial catarrh, pulmonary infiltration or cavity formation may be established. Canali's[4] case, often quoted as an instance of bronchial actinomycosis, probably belongs in the pulmonary group. The patient, a girl aged fifteen years, gave a history of cough and expectoration, with frequent febrile attacks for a period of eight years. The sputum was foul and contained actinomyces granules. Examination failed to show signs other than those of a diffuse bronchitis. Involvement of the pulmonary tissue cannot be excluded and the further course of the disease is unknown.

At times, the symptoms of pleural invasion are the first indication of the disease. This is more likely if the pulmonary process is peripherally placed. With central lesions, months may elapse before the pleura is reached. Pleural involvement may be latent. There may be only slight and occasional pain, or the pain may be severe and accompanied by high fever and chills. Pleural friction may be heard. Limitation of thoracic motion, retraction of the side, narrowing of the

[1] Ein Fall von Lungenaktinomykose, Berl. klin. Woch., 21 Okt., 1907.
[2] Beiträge z. klin. Chir. Tübingen, 1903–04, vol. xli.
[3] Klin. Beiträge z. Kenntniss der Aktinom. des Menschen., Berlin, 1885, Hirschwald.
[4] La broncho-actinomycosi nell' uomo., Rivista clinica, Bologna, 1882.

intercostal spaces, dislocation of the heart toward the lesion, and absence of the diaphragm shadow may indicate an adhesive pleurisy. Dulness, diminished breathing, voice, whisper, and tactile fremitus may be present as a result of thickened pleura. An accumulation of encysted or free serofibrinous, purulent or hemorrhagic effusion may be found. The small and circumscribed purulent exudates are more common. Retraction of the affected side is an important sign and may be observed with or without an effusion.

It is uncommon for the disease not to exceed the limits of the pleura and perforate the chest wall. Cases without perforation of the thoracic wall, have, however, been reported, among others by Ponfick,[1] Hebb,[2] Hanau,[3] Heusser,[4] Butler,[5] Kashiwamura,[6] von Graff,[7] Schlagenhaufer,[8] and Bulling and Rullmann.[9] An unusually early stage of the disease was observed at the Massachusetts General Hospital. The patient (Autopsy 1488), a man aged forty-six years, with a family history of tuberculosis and of cough and blood-tinged sputum for only twenty-two days, was found at autopsy to have an organizing pneumonia with abscess and cavity formation in the right upper and lower and left lower lobes. The pleural cavities were free from fluid. The lungs were bound to the parietal pleura by a few adhesions. In three of the pulmonary cavities, typical club-bearing actinomyces colonies were found in stained sections of the tissue. The right lung also showed tuberculosis.

Perforation of the chest wall is observed more commonly in this than in any other form of pulmonary disease. It was recorded in 82 of 100 cases collected from the literature. Its occurrence should never fail to suggest the diagnosis of actinomycosis. Rupture may occur at any part of the chest. The abscess may point in the neck as in Lindt's[10] case or it may first reach the surface in the abdominal wall. The abscess slowly makes its way from the peripleural space, between or through the thoracic muscles to the subcutaneous tissue. A flat, hard, elastic, circumscribed or diffuse tumor-like swelling appears. The overlying skin may be normal or dusky red. The superficial veins may be dilated. Owing to the abundance of the connective-tissue formation and the usual absence of large accumulations of pus, the mass is brawny and true fluctuation is seldom observed. Small areas of softening in the midst of indurated tissue may give rise to softer, fluctuating and harder, resistant areas side by side which on palpation make the surface appear uneven. The swelling may be tender. The inflammatory process is indolent, and a long interval

[1] Breslauer aerztl. Zeit., 1885, No. 3.
[2] Lancet, 1887, i, 313.
[3] Correspondenzbl. f. schw. Aerzte., 1889, No. 6, p. 165.
[4] Berl. klin. Woch., 25 Nov., 1895.
[5] Med. News, 1898, No. 17.
[6] Virchow's Arch., 1903, vol. clxxi.
[7] Zeit. f. Heilkunde, 1904, 25, Abt. path. Anat.
[8] Virchow's Arch., 1906, clxxxiv, 491.
[9] Berl. klin. Woch., 21 Okt., 1907.
[10] Ein Fall von primärer Lungenspitzenactinomykose, Korrespondenzbl. f. schw. Aerzte, 1889.

may elapse before rupture of the skin takes place. Perforation is likely to occur in several places. In the absence of extension from the neck, actinomycosis of the chest wall should always be regarded as proceeding from a primary pulmonary focus. Israel[1] reports an instance of subcutaneous emphysema in the course of pulmonary actinomycosis.

Extension may also take place into the prevertebral space, the pericardium or the abdomen. The patient's general condition gradually fails. Increasing pallor, fever of an irregular type and night sweats are commonly present. Chills may also occur. Metastases in the liver, spleen, heart and brain may be latent or take place with the clinical features of pyemia. Metastatic abscesses in the skin are occasionally observed and present the appearances already described for the thoracic phlegmon. Amyloid of the liver and spleen may cause palpable enlargement of these organs in the course of long-continued suppuration. Death may be due to progressive marasmus or to metastatic involvement of a vital organ.

Diagnosis.—Primary pulmonary actinomycosis is often unrecognized. During the period before perforation of the chest wall takes place, the disease closely simulates other more common pulmonary affections, and the diagnosis cannot be made without the demonstration of actinomyces in the sputum. It should therefore be an invariable rule to search for actinomyces granules in the sputum from all cases with pulmonary suppuration.

In the early stages of the development of the primary pulmonary form there are no distinctive clinical features. The gradually increasing cough, mucopurulent or purulent and at times bloody sputum, dyspnea, pleural pains, occasional fever, night sweats, failing health and strength, physical signs of local bronchitis, pulmonary infiltration, or cavity formation, with or without involvement of the pleura, naturally suggest pulmonary tuberculosis. Actinomycosis is usually basal, but attacks one and even both apices in rare instances. The absence of a family history of tuberculosis or known opportunity for contagion, the failure to find tubercle bacilli in the sputum after careful and repeated search and negative tests with tuberculin, make actinomycosis more probable, but actinomycosis and tuberculosis may coexist. The demonstration of the one, therefore, does not serve to exclude the other. Non-tuberculous lesions such as abscess, gangrene, bronchiectasis and interstitial pneumonia must also be considered, but whether they are due to actinomyces or to simpler infection cannot be determined without the sputum examination. A shorter and more stormy course, relatively less abundant sputum and more marked thoracic retraction is perhaps more common with actinomycosis, but such features cannot be relied upon in the differentiation.

The presence of a circumscribed thoracic swelling, of the character already described, is one of the most important physical signs of the

[1] Deut. Med. Woch., 1906, xxxii, 166.

disease, and with its appearance a probable diagnosis of actinomycosis can be made before the actinomyces granules are demonstrated. Abscesses due to a perforating empyema or tuberculosis of the ribs are more fluctuant and less brawny and uneven. Malignant disease, especially sarcoma primary in the chest wall, lung or pleura with extension or metastasis outward, is less likely to be accompanied by suppurative pulmonary lesions. The growth itself is more often rounded, harder and less fluctuant. Other metastases may be found. Tuberculous or syphilitic periostitis may be a possible cause of confusion. Local prominence of the chest wall may be noted with pulmonary or pleural echinococcus. The actinomycotic nature of the swelling in question may be established by the demonstration of the characteristic granules obtained by puncture or expressed from discharging sinuses. Aneurysm of the thoracic aorta should be considered in the presence of tumors which appear in the supracardiac or lower left paravertebral regions.

Actinomyces granules are readily recognized. Their identification has already been considered. Only typical club-bearing colonies should be regarded as actinomyces when making a diagnosis from fresh specimens. Colonies without clubs can be so regarded only after their full biologic identity has been established. This involves isolation in pure culture. Unless care is taken, grayish or yellowish granules, frequently found in the sputum and composed of leptothrix or streptothrix filaments with entangled cells may be mistaken for actinomyces. Leptothrix filaments are unbranched rods, thicker than actinomyces and stain after Gram. The streptothrix filaments appear as slender, branching, Gram-staining threads, which resist decolorization by weak acids. The absence of the characteristic "clubs" from such granules is the most trustworthy means of differentiation.

Prognosis.—This is unfavorable. The prospect for recovery is only little better with pulmonary actinomycosis than with a malignant tumor of the lung. Pulmonary tuberculosis is, by comparison, a mild disease. The cases usually prove fatal in the course of six months to a year. A duration of from two to three years is at times observed. One instance of apparent spontaneous recovery has been reported by Butler.[1] There was cough and offensive expectoration in which Hodenpyl found actinomyces granules. Recovery took place in the course of two to three months. The case deviates from the ordinary type of the disease in the absence of thoracic perforation, and it is unfortunate that the granules were not described. Surgical treatment makes the prognosis less hopeless, but thus far only six other cases[2] are known to have recovered.

Prophylaxis.—Our present knowledge does not permit the formulation of adequate preventive measures. The supposition that actino-

[1] Med. News, 1898, No. 17.

[2] See page 386. Hamm's case is excluded.

myces normally exists in the buccal cavity, the occasional association of the disease about the jaw with carious teeth, and the association of the pulmonary form with the inhalation of foreign bodies, makes reasonable the suggestion that the mouth, and especially the teeth, should be kept clean, and that when possible foreign bodies should be early removed from the bronchi. It is not improbable that the establishment of anaërobic conditions, as in a tooth cavity filled with accumulated food, or the aspiration of infected material into the deeper parts of the lungs, favors the development of the organisms. It is possible from this point of view that careless dentistry may convert a carious tooth into an anaërobic culture. Punctured wounds about the buccal cavity may likewise favor the development of the organism.

Treatment.—This is unsatisfactory. Iodid of potash is said to cure 53 per cent. of the cases in cattle. Favorable results have been reported in man from its use in actinomycosis of the jaw and abdomen. Iodid of potash is not known to have cured an undoubted case of the pulmonary form of the disease in man.

In Netter's[1] case, with a left serofibrinous pleurisy and actinomycosis of the chest wall, apparently secondary to infection of the mediastinum, recovery followed the administration of iodid of potash in doses up to 6 grams a day—61 grams in all—during a period of twenty-seven days. Pulmonary infection was not established. In one of the cases reported by Prutz[2] with pulmonary actinomycosis, disappearance of the granules from the sputum and improvement of the general condition followed numerous operations on an abscess of the thoracic wall and the administration of not less than 4000 grams of iodide of potash in the course of two years. The patient was discharged with sinuses.

Wynn[3] treated with vaccines a case of empyema, in the pus of which granules were found. It is improbable that he could have isolated true actinomyces by the cultural methods employed. The use of vaccines deserves a trial, however, in so hopeless a disease.

The results of operative procedures are more promising. The instances of reported recovery following operation are as follows:

Schlange[4] has reported two favorable cases. Actinomyces granules were found in the sputum from both. In the first, a thoracic abscess containing the granules was incised and two ribs were resected without opening the pleura. There was no evidence of actinomycosis six years after the operation. In the second case, actinomyces granules were found in a large pleural exudate. Apparent recovery followed thoracentesis, although the patient still presented a fistula in the lower abdominal region five years afterward and suffered from severe

[1] Bull. et mém. de la Soc. Méd. des Hôp. de Paris, Seance du 3 nov., 1893.
[2] Mitt. a. d. Grenzg. d. Med. u. Chir., 1899, Bd. iv, p. 63.
[3] British Med. Jour., May 11, 1907.
[4] Langenbeck's Arch. f. klin. Chir., 1892, vol. xliv.

attacks of cough every few weeks. No actinomyces could then be found in the sputum.

Jakowski[1] reports a case in which the presence of actinomyces was determined by puncture of a thoracic phlegmon. The abscess was incised by Jawdynski, the sixth to the ninth ribs were resected and an actinomycotic pulmonary cavity between the anterior and midaxillary line was thus opened. The walls of the cavity were extirpated by means of the cautery and recovery followed.

Karewski[2] has reported a fourth instance. Pulmonary symptoms had persisted for four months, and the thoracic wall was invaded. A cavity with actinomycotic granulations, pus and granules was opened by resection of the sixth rib from the axilla to the sternum. All infiltrated regions were destroyed by means of the cautery, leaving a pulmonary cavity the size of the fist, partial closure of which was effected by Thiersch's method of skin-grafting. This patient was well more than ten years after the operation.

Brentano's[3] case was operated for a tumor containing actinomyces granules in the left chest wall. The eighth, ninth, and tenth ribs were resected from the mammillary to the midaxillary line. A pulmonary lesion was not demonstrated. The tumor was incised, curetted and cauterized. The patient was still well one and one-half years later, according to Karewski[4] report.

Hamm[5] reports a case of pulmonary actinomycosis with an encapsulated empyema, as fully recovered, and Karewski[6] states that the case was still well one year and three months after the operation. The case can be accepted only with reserve, since details concerning the diagnosis and the operative procedures are lacking.

Opotkin[7] reports a case of Rasumowsky's with pulmonary abscess due to actinomycosis. The thoracic wall was perforated between the fifth and sixth ribs on the right side. Six centimeters of the sixth rib were resected and a cavity the size of an orange was found behind the thoracic wall, extruding into the lung. Actinomyces were not found in the sputum. The cavity was scraped out and cleaned. Iodid of potash was also given. After several operations, during the course of five years of observation, the process had very largely healed, only a fistulous passage remaining.

Cases in which metastases have already occurred are not amenable to surgery, and it is therefore important that the diagnosis should be made while the disease is still local and circumscribed. In the estimation of the amount of pulmonary involvement and the detection of lesions not otherwise to be found, examination by means of the

[1] Gazeta Lekarska, 1897, No. 1, Ref. Centr. f. Chir., 1897, No. 28.
[2] Berl. klin. Woch., 1898, and Langenbeck's Arch. f. klin. Chir., 1907, vol. lxxxiv.
[3] Deut. med. Woch., 1906, xxxii, 165.
[4] Langenbeck's Arch. f. klin. Chir., 1907, vol. lxxxiv.
[5] Deut. med. Woch., 1906, p. 941.
[6] Langenbeck's Arch. f. klin. Chir. 1907, vol. lxxxiv
[7] Arch. f. klin. Chir., 1908-09, lxxxviii, 469.

x-rays may be of great service. Latent metastatic distribution may take place and operation in an apparently hopeful condition prove unsuccessful.

The chances of metastasis increase with the duration of the disease, and the earlier the operation is undertaken the more likely is it to be successful. It is much to be hoped that pulmonary actinomycosis may be surgically treated before thoracic perforation takes place, but even after this has occurred the conditions may still be amenable to operation. In Jakowski's, Karewski's, and Brentano's cases, an interval of several months, of four months and of three months, respectively, had already elapsed between the beginning of pulmonary symptoms and the appearance of a thoracic tumor, and yet recovery followed radical operation. Even a long previous duration is compatible with local and circumscribed lesions, and unless metastases can be demonstrated, the case should not be regarded as hopeless. In Moosbrugger's[1] case, with pulmonary symptoms for two years and a thoracic tumor for nine months, the disease was found at autopsy to be limited to the lung, the mediastinum and pericardium. In Heinzelmann's[2] patient, likewise, the pulmonary symptoms had lasted for two and one-quarter years, and a thoracic swelling for about seven months, while at autopsy other organs than the lung, the epicardium and myocardium were unaffected.

The possibility of surgical relief is also illustrated by Karewski's success in completely curing the local disease by operation in three of his series, although the patients finally died—one from amyloid and extension into inaccessible regions, the other two from metastases.

Such conservative methods as simple incision and drainage of the superficial thoracic plegmon have usually served only temporarily, if at all, to delay the progress of the disease. Karewski believes that pulmonary actinomycosis should be treated rather as a malignant growth by extirpation than as an abscess by drainage. He recommends the free opening and destruction of all fistulous passages, the resection, if necessary, of several or many ribs to find the channels of communication with the lung and the discovery and extirpation of the primary pulmonary infection. Firm indurated tissue should be extirpated or removed, regardless of functionally important muscles. Only that which is macroscopically sound or a delimiting wall without granules should be spared. Further operations will be necessary if granules are later found in the discharge from the wounds of operation. Firm pleural adhesions usually lessen the danger of artificial pneumothorax. The danger of hemorrhage is commonly slight, and bleeding, when it occurs, can be controlled with the cautery.

[1] Beitr. z. klin. Chir., Bd. ii.

[2] Ibid., Bd. xxxix.

CHAPTER XXII.

PULMONARY STREPTOTHRICOSIS.

Under this term may be included pulmonary infection with branching filamentous organisms, the more important characters of which are described below. Much difference of opinion prevails regarding the members of this group. Most writers place actinomyces as a species, but it appears to have sufficiently distinctive characters to justify generic rank. The term *streptothrix*, in spite of technical objections, is justified by common usage, and is to be preferred to atypical actinomyces, oöspora, pseudotubercle bacillus, cladothrix, or nocardia. A considerable number of distinct species are probably responsible for infection in this group. The article by Musgrave, Clegg and Polk[1] contains an extensive bibliography.

Etiology.—The predisposing factors influencing infection are little known. Contagion has not been established. Certain species have been found widely distributed in nature, *i. e.* in the air, water, soil and on foodstuffs, and the biologic characters of the pathogenic forms suggest a habitat outside the body, so that it may be regarded as likely that pulmonary infection takes place by inhalation.

The Microörganisms.—In fresh material obtained from the lesions, the organisms are found as isolated slender filaments or a loose network of filaments which stain with the ordinary analine dyes homogeneously, or present a granular or beaded appearance. Aggregation into clusters or colonies of interlacing filaments is often observed. True branching may be seen in few or many of the filaments. They are Gram positive and show a varying degree of resistance to decolorization by acids after being stained with carbol-fuchsin. The acid-fastness is usually less than that of the tubercle bacillus, but in some instances the organisms have been as acid-fast as the tubercle bacillus. Some resistance to decolorization by alcohol has also been noted. Growth usually takes place readily but slowly on all culture media under aërobic conditions and at room as well as body temperature. Cultural peculiarities are variable. Under the microscope young colonies usually show the presence at the periphery of radially arranged and branching filaments. In smears from cultures, rods with conical extremities may be observed as well as the slender branching filaments. Bacillary and coccus-like forms may arise by the breaking up of the filaments in fresh material and in older cultures. Surface growth may be seen on bouillon or the formation of ball-like masses at the bottom of the tube without clouding of the medium. The results of animal

[1] Philippine Jour. Sci., 1908, iii, 447.

experiments are inconstant. In some instances, local abscesses are formed after subcutaneous or intraperitoneal injection or widely disseminated, yellowish, miliary tubercle-like nodules after intravenous inoculation. The nodules show on histologic examination infiltration with leukocytes and more or less extensive central necrosis. Spore formation (chain sporulation) is thought to occur.

Pathology.—The pulmonary lesions ascribed to these organisms include bronchopneumonia, abscess, gangrene, bronchiectasis and indurative processes. Fibrinous pleurisy and empyema are also observed. Perforation of the chest wall may occur. In the cases described by Flexner[1] and Löhlein[2] tubercle-like nodules were found in the lung. Changes in the bronchial wall leading to bronchiectasis were a feature of the cases described by Norris and Larkin[3] and Horst[4]. In the involved tissue, the organisms are found scattered diffusely or form loosely aggregated masses. Granules or masses of closely packed interlacing filaments with radially disposed club-shaped, eosin staining, peripheral bodies, such as are seen in actinomycosis, have not been observed in streptothricosis.

Metastatic lesions may arise in various organs of the body in consequence of perforation of the pulmonary veins. Invasion of the central nervous system with the formation of cerebral abscesses is not infrequent. Multiple subcutaneous abscesses are also observed. Invasion of the pericardium, myocardium, kidney, liver, spleen, muscles, peritoneum and lymph glands has been noted, in connection with pulmonary involvement. Streptothrix has been cultivated from the heart's blood after death by Löhlein.[5] Blood cultures were positive in eight successive trials in a case reported by Schottmüller and Fränkel[6] Infection in this instance followed the bite of a rat, and the only evidence of pulmonary involvement was transient bronchitis. The patient recovered.

Symptoms.—These are varied, and may be either acute or chronic. The clinical picture may resemble pulmonary tuberculosis, bronchopulmonary suppuration, abscess or gangrene and interstitial pneumonia. Cough, more or less abundant purulent sputum, at times streaked with blood, dyspnea and pain, with fever, night sweats, loss of weight and strength and emaciation may be observed. Hemoptysis occurred in Jamieson's[7] case. In some instances the clinical features are those of empyema, and if the chest wall is perforated, actinomycosis may be suggested. In Löhlein's case the course was that of pyemia following primary bronchopneumonia.

Diagnosis.—This may be made by the demonstration in the sputum of thread-like, branching organisms which usually resist decolorization

[1] Trans. Assoc. Amer. Phys., 1898, xiii, 31.
[2] Zeit. f. Hyg., 1909, lxiii, 1.
[3] Jour. Exp. Med., 1900–01, v, 155.
[4] Zeit. f. Heilk., 1903, xxiv, 157.
[5] Loc. cit.
[6] Münch. med. Woch., 1912, No. xxv, 1405.
[7] Australas. Med. Gaz., 1907, xxvi, 16.

by weak acids and at times also by alcohol, but are less resistant against both acids and alcohol than the tubercle bacillus. Gabbett's methylene-blue solution used as a contrast stain after staining with carbol-fuchsin is useful for the demonstration of these organisms, as it contains no alcohol and is an ineffective decolorizer. Care must be observed not to mistake streptothrices for branching tubercle bacilli from which they may be distinguished by their longer, thread-like form, tendency to appear in loose clusters of numerous interlacing filaments, less resistance to acids, the greater readiness with which they may be cultivated, cultural peculiarities and the results of animal inoculation. From actinomycetes the streptothrices may be differentiated by their loose rather than compact colony formation and the absence of radially disposed, club-shaped, eosin-staining, peripheral bodies. Actinomycetes do not resist decolorization with acids and alcohol and are cultivated with difficulty and only under special conditions. The cultural and pathogenic peculiarities of the actinomycetes and streptothrices are quite dissimilar.

Prognosis.—This appears to be very unfavorable, as all the cases of pulmonary infection in which the presence of the streptothrix was satisfactorily established have died. But as a considerable proportion of the more authentic instances of infection have been the result of careful postmortem examinations, it is possible that the outlook is more favorable than the previously reported cases seem to indicate. In Steele and Lee's[1] case, organisms resembling streptothrices in morphology and staining reaction were found in the sputum and the patient recovered. Schottmüller and Fränkel's[2] report of recovery after a general infection with these organisms has already been mentioned.

Treatment.—There is no specific treatment. Improvement of the general health and nutrition, as in pulmonary tuberculosis, is at present most likely to accomplish the best results. Pulmonary abscesses and empyema should be treated on the same principles as apply to these conditions when due to other causes.

[1] Boston Med. and Surg. Jour., October 2, 1913.
[2] Loc. cit.

CHAPTER XXIII.

PULMONARY BLASTOMYCOSIS.

Blastomycosis is a granulomatous and suppurative process involving the skin and not infrequently the internal organs also as part of a systemic infection. The infecting organism is a mold-fungus, classed by Ricketts[1] as belonging to the species oïdium. The organism is also termed monilia, endomyces or saccharomyces. In a certain number of cases the disease appears to have originated in the lungs. The first cases were described by Wernicke[2] in Buenos Ayres, Busse[3] in Germany and by Gilchrist and Stokes[4] in America. A survey and summary of 22 cases of systemic blastomycosis was reported by Montgomery and Ormsby.[5] Many of the following details are taken from their account.

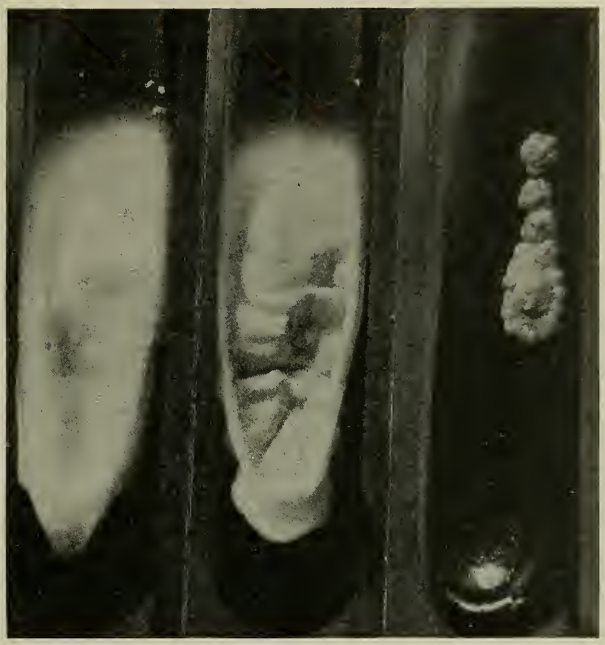
Etiology.—The *predisposing causes* of infection are unknown. Males are more frequently affected. Inheritance appears not to be a factor. Contagion has not been established. Age, occupation, and habits seem to have no bearing on the occurrence of the disease. Unfavorable hygienic surroundings have obtained in many of the reported cases. Infection may take place by inhalation of spores from decaying boards and walls in dwellings.[6] In this country most of the reported cases have been observed in Chicago and its vicinity.

Microörganism of the Disease.—The microörganism appears in the lesions as an oval or spherical body with a diameter usually of seven to twenty microns and consisting of a finely granular protoplasm, at times sporulating and often vacuolated and inclosed in a double contoured, hyaline capsule. Multiplication in the lesions takes place either by budding or, as is less often the case, by sporulation. Prickles or spines projecting from the capsule may be observed in some instances. The organism is Gram-positive. It grows well on ordinary culture media both at room temperature and in the incubator (Fig 56). Growth takes place slowly and is macroscopically visible in from two to fourteen days. According to Hamburger,[7] a slightly more abundant growth may perhaps take place on faintly acid glucose-agar. The growth is elevated, white, pasty, and yeast-like or waxy on slanted, solid media. Mycelia and aërial hyphæ are formed under certain conditions of cultivation. On examination of cultures, spherical or oval budding cells, the formation of mycelia and fruit-bearing aërial hyphæ may be observed. The biologic character of the organism

[1] Jour. Med. Research, 1901, vi, 377, and Trans. Chicago Path. Soc., 1903–04, vi, 113.
[2] Centralb. f. Bakt., 1892, xii, 859.
[3] Ibid., 1894, xv, 175.
[4] Bull. Johns Hopkins Hosp., 1896, vii, 129.
[5] Arch. Int. Med., 1908, ii, 1. For subsequent cases see ibid., 1914, xiii, 509.
[6] Arch. Int. Med., 1914, xiii, 509.
[7] Jour. Inf. Dis., 1907, iv, 201.

varies widely under different conditions. The organism is pathogenic for ordinary laboratory animals, but the results of inoculation are inconstant. Lesions when produced are similar to those in man.

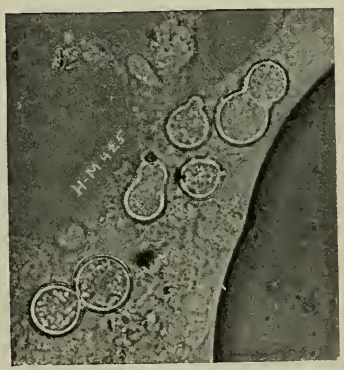
FIG. 56



a *b* *c*

Culture four weeks old: *a*, on glucose agar; *b*, on glycerin agar grown at room temperature; *c*, on glucose agar grown in incubator. (Montgomery and Ormsby.)

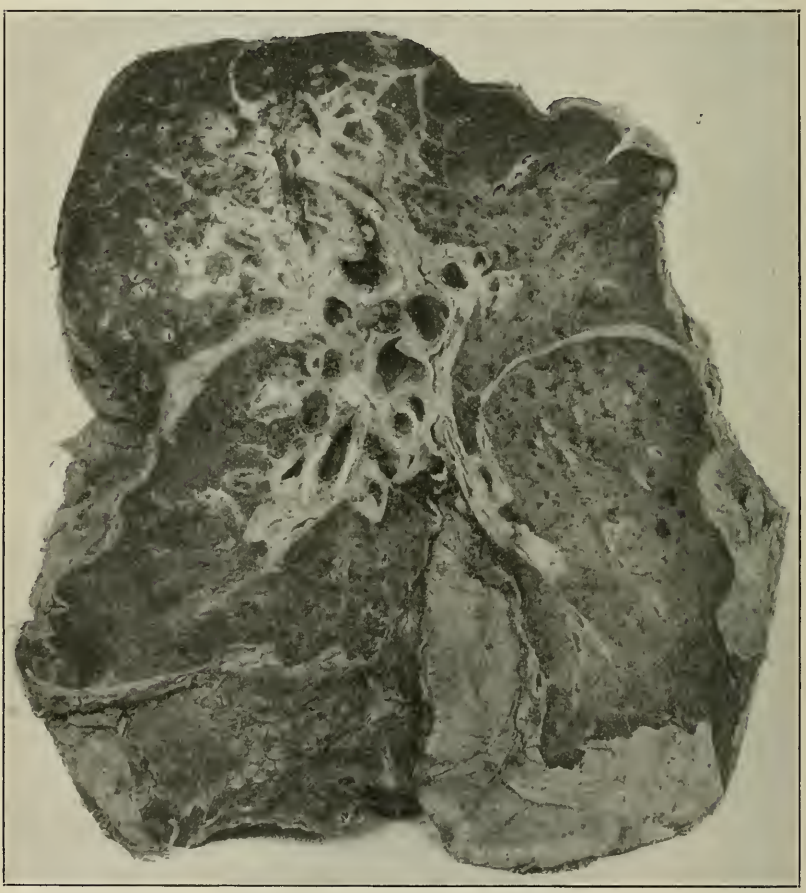
FIG. 57



Sediment from blastomycotic tissue disintegrated in 50 per cent. alcohol, showing organisms in various stages of budding. (Montgomery and Ormsby.)

The mode of infection is uncertain, but so far as the pulmonary form of the disease is concerned, an origin by inhalation is suggested by the bronchopneumonic character of the lesions. Of 11 cases with systemic blastomycosis, collected by Montgomery and Ormsby the lungs were more or less extensively involved in all. In a number of cases the earliest symptoms were pulmonary and blastomycetes were demonstrated in the sputum, suggesting the respiratory tract as the possible portal of entry. Extension probably takes place by way of the blood-stream.

FIG. 58



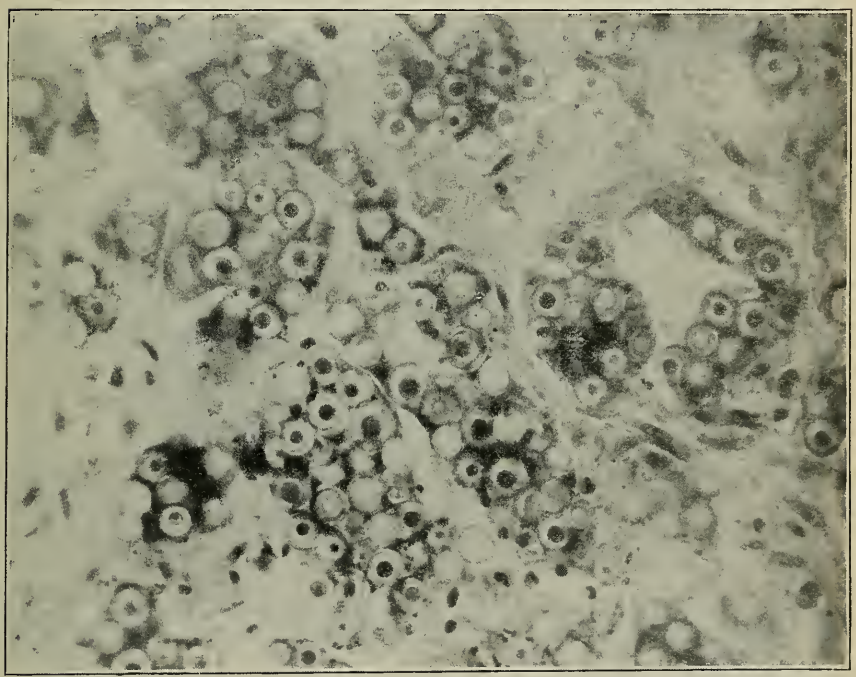
Blastomycosis of lung. Gross pathology. (Le Count and Myers.)

Immunity.—Davis[1] finds that male guinea-pigs are more susceptible to infection than females. Recovery after artificial inoculation is

[1] Jour. Inf. Dis., 1911, viii, 190.

accompanied by a low grade of immunity which manifests itself by a somewhat more speedy recovery from subsequent infections and by the development of a slight fever for a few days immediately after reinoculations. Repeated injections of an "extract" of oïdiomycetes lead to the development of an immunity in guinea-pigs. This is characterized by the more rapid walling off of organisms injected into the peritoneal cavity and a more rapid disappearance of lesions which appear in the testicles. The mode of defense of guinea-pigs against oïdiomycetes injected into the peritoneal cavity appears to consist of phagocytosis and intracellular digestion, walling off and encapsulation by connective tissue and a somewhat ill-defined and possibly questionable unfavorable influence of the serum upon the vitality of the organisms. Specific antibodies appear to be but poorly developed.

FIG. 59



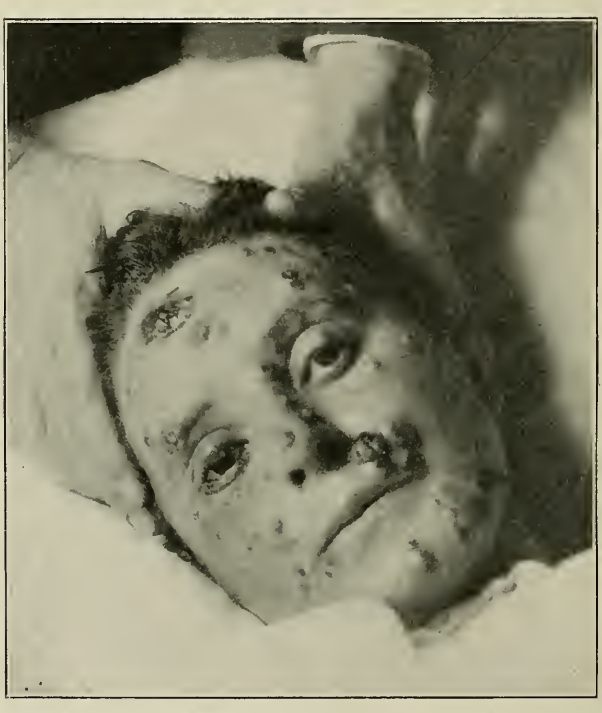
Section of lung. Large masses of blastomycetes. (Fontaine, Haase, and Mitchell.)

Pathology.—The pathologic features closely resemble tuberculosis, but the lesions are more suppurative in character and contain more numerous giant cells.

The lungs show discrete, miliary to pea-sized abscesses or confluent areas of softening. The cut surface exudes a thick, purulent fluid and a soft, cheesy, necrotic material or pus may be expressed from the involved region. Ulceration may lead to cavity formation. The

lesions are prevailingly bronchopneumonic in type. Microscopic examination shows in the central parts of the affected region an area of necrosis containing blastomycetes, pus cells, red-blood corpuscles and desquamated epithelium. This central necrotic area is bounded by a zone of granulation tissue in which are giant cells, many or all of which may contain blastomycetes. The peribronchial lymph nodes may show similar changes. The larynx, trachea and bronchi may also be involved. Fibrinous or serofibrinous pleurisy may be present.

Fig. 60



Blastomycosis. Cutaneous lesions of face. (Fontaine, Haase, and Mitchell.)

Cutaneous lesions are a characteristic feature. They comprise superficial, pea-sized or larger, moderately firm, subcutaneous nodules which gradually enlarge, soften and break down, discharging glairy mucopus and leading to the formation of open abscesses, fistulæ, crusted or open ulcers, or scars. In Le Count and Myers'[1] case about 200 cutaneous lesions were present. Deeper and larger abscesses may be observed. At times more typical cutaneous manifestations are seen in the form of elevated patches of variable size, with a rough, uneven and scaling or papillomatous surface and with a rather abrupt,

[1] Jour. Inf. Dis., 1907, vol. iv.

sloping, dark red margin. Examination, if necessary with a hand lens, may disclose large numbers of miliary abscesses at the margin of the patch.

In addition to the cutaneous and pulmonary involvement, the spleen, kidneys, liver, spinal column, cerebrum, cerebellum, spinal cord, muscles, bones, joints, meninges, myocardium, adrenals, pancreas, colon, appendix, prostate and lymph glands may be involved. Amyloid infiltration has been noted.

Symptoms.—Cutaneous manifestations have usually preceded the onset of pulmonary symptoms. In some instances the history suggests coincident pulmonary and systemic invasion. In a few cases the initial symptoms have been pulmonary. The pulmonary manifestations have usually been mild during the early part of the disease. There may be cough, discomfort in the chest and mucopurulent sputum at times streaked or stained with blood. Laryngitis with hoarseness or aphonia has been observed. On physical examination, the signs are those of consolidation over the more extensively involved regions, but it has repeatedly been noted that at autopsy the pulmonary lesions were more extensive than the symptoms and signs seemed to indicate during life.

Fever, chills, night sweats, loss of weight and strength may also be observed in connection with pulmonary and systemic involvement. Diarrhea, albumin and casts in the urine, slight adenopathy, anemia, leukocytosis, enlargement of the spleen, arthritis, caries of bone, spondylitis and corneal ulceration and infection of the vitreous have also been observed. The ends of the fingers may be clubbed.

The course of the disease is chronic, with exacerbations and remissions. The clinical course is that of pyemia, Death is usually due to systemic infection, but predominant pulmonary invasion may be largely responsible in a few instances. Following pulmonary and systemic invasion the disease usually terminates fatally within a few months.

Blastomycetes have been demonstrated in the cutaneous lesions, abscesses, sputum, cerebrospinal fluid, urine, feces, and blood.

Diagnosis.—The disease should be suspected in cases with pulmonary symptoms associated with multiple abscesses and a clinical picture resembling pyemia. In cases in which the earliest manifestations are pulmonary and before the appearance of abscesses or the more typical cutaneous eruption the condition may be mistaken for pulmonary tuberculosis. Thus far no case has been reported running its course with a pulmonary infection as the sole manifestation of the disease.

The diagnosis may be established by recognition of the nature of the cutaneous lesions and the demonstration of blastomyces in pus from the abscesses or in a fragment of the tissue. In the investigation of pus, the fresh and unstained material may be placed between slide and cover-glass and a thin layer examined under the microscope. The addition of 10 per cent. sodium hydrate to the preparation will

bring out the double contoured capsule more clearly. Sputum should be investigated in the same manner.

Prognosis.—This is unfavorable for cases with pulmonary and systemic infection. The evidence of healed and healing pulmonary lesions at autopsy in some cases suggests that the disease is not inevitably fatal.[1]

Prophylaxis.—Prevention of mold growth in dwellings by proper ventilation, lighting, and drainage may be of importance.[2]

Treatment.—This is unsatisfactory. There is no special therapy. Marked improvement or complete recovery has followed the use of iodid of potash in the cutaneous form of the disease and the drug should be tried in large doses and over a long period in the systemic infection. Every effort should be made to build up the general strength and improve nutrition by food, rest and, fresh air. The *x*-rays have been successfully applied to small superficial lesions. The use of the curette may lead to dissemination of the organisms. The injection of the filtrate of old cultures of blastomycetes may prove of value.[3]

[1] Stober. Arch. Int. Med., 1914, xiii, 509. [2] Ibid. [3] Ibid.

CHAPTER XXIV.

PULMONARY ASPERGILLOSIS.

Under this heading may be included cases of pulmonary infection with one or another species of the genus Aspergillus. The Aspergillus fumigatus is for the most part the species concerned in pulmonary infection. The fungus appears to be capable of giving rise to inflammatory, suppurative and destructive pulmonary lesions as a primary and independent infection, but secondary invasion of lungs already the seat of tuberculous or other lesions is more common in man.

Etiology.—The Organism.—Aspergillus fumigatus is a fungus belonging to the family Perisporeacea. On culture media it grows in the form of a mold, which varies in color according to the character of the media. Greenish, bluish or gray colonies may be observed. The growth is made up of a thick felt-work of colorless septate tubular hyphæ a few microns in diameter. Segmentation is observed in the broader, but is absent in the narrower filaments. Some of the filaments grow upward into the air and produce at their free extremity masses of spores. The color of the growth is due to these spore-bearing branches. The spores are very small, round or oval, smooth and about 2.5 to 3.5 microns in diameter. The spores are widely distributed in the outer world, and may be found on vegetable material of various kinds, dust from grains, on bread, etc. They are very resistant, especially against drying. Growth may be obtained on all culture media and is favored by an abundance of moisture and oxygen. Attempts to demonstrate toxin production have usually failed, but Bodin and Gautier[1] report successful experiments in certain animals by the use of filtrates of cultures. Curiously enough the pigeon proved resistant against the toxin.

Intravenous injection of birds and animals with spores causes death within a few days, and postmortem examination shows lesions microscopically resembling miliary tubercles throughout the internal organs. Microscopic examination shows areas of suppuration and necrosis enclosing the microörganisms. Inhalation experiments with spores have given somewhat variable results. Pigeons were thus infected by Dieulafoy, Chantemesse and Widal[2] and by Renon.[3] Schutz[4] produced fatal pneumonia due to aspergillosis by inhalation

[1] Ann. de l'Inst. Past., 1906, p. 209.
[2] Gaz. des Hôpitaux, 1890, p. 821.
[3] Étude sur l'aspergillose chez les animaux et chez l'homme, Paris, 1897, p. 82.
[4] Mitt. a. d. Kaiserlichen Gesundheitsamte, Berlin, 1884, Bd. ii, p. 208.

experiments in pigeons, geese, and smaller birds. Feeding experiments by Schutz were successful in a pigeon. Mycotic pneumonia resulted, probably by inhalation of spores, and ended fatally on the sixteenth day. Renon[1] produced pulmonary aspergillosis in rabbits fed on bran containing spores.

Fig. 61

Two spore-bearing heads of Aspergillus fumigatus. (Renon.)

Aspergillosis in Animals.—Infection by aspergillus has long been recognized in birds. The first instance was described in 1815 by Mayer and Emmert[2] who found the fungus in the lungs of a jay. It has since been demonstrated in many different kinds of birds, infecting not only the air sacs, bronchial tubes and lungs, but also the liver, kidneys, and other organs. De Jong[3] describes an epidemic among canaries in a part of the Netherlands. In many cases, a whitish-yellow coating was seen on the tongue and palate. In the dead animals a similar coating was found in parts of the upper air passages. Yellowish, cheesy nodules were present in the lungs. Involvement of the pleura and peritoneum in the neighborhood of the liver was also noted. Aspergillus fumigatus and diplococci were isolated from the lesions. Cattle, horses, swine, and other animals may become infected. The lungs are principally involved and the lesions resemble tuberculosis or actinomycosis. Hellens[4] has described an outbreak of the disease in sheep.

[1] Loc. cit., p. 83.
[2] Meckel's Deut. Arch., vol. i, p. 310.
[3] Centralbl. f. Bakt., 1912, 1 Abt., lxvi, 390.
[4] Arb. a. d. path. Inst. d. Universität., Helsingfors, Berlin, 1905, Bd. i, H. 1–2, p. 313.

Aspergillosis in Man.—The first report which can be regarded as a probable instance of human infection with aspergillus was published by Bennett.[1] Virchow[2] first determined the identity of the parasite in cases of pulmonary infection in man. Dieulafoy, Chantemesses and Widal[3] reported the occurrence of pulmonary aspergillosis in three pigeon feeders in Paris. The pigeon feeders hold in the mouth a mixture of water, millet and vetch seeds, which they blow into the mouth of the pigeon. Several thousand pigeons may be thus fed in a day. The pigeon feeders may become infected with aspergillosis from the grains or through the contact with infected birds. Renon[4] described the disease among the hair sorters of Paris who are exposed to an atmosphere containing rye flour which they use to remove grease from the hair. Aspergillus was cultivated from the rye flour, and of six pigeons exposed to the dust from this flour, five died of aspergillosis, the first on the seventeenth day from the beginning of the experiment.

The disease may be either primary or secondary. In Kohn's[5] case the primary character of the pulmonary lesions was first established by postmortem examination. A number of other cases have since been described, but for the most part the infection appears to be engrafted on preëxisting bronchial or pulmonary disturbances.

Pathology.—The infected parts of the lung show inflammation, suppuration, and necrosis. The typical lesion is an area of necrosis, in the centre of which is a colony of the fungus. Such an appearance may closely resemble actinomycosis. Close relation of the involved area to a bronchus may lead to more marked growth of the organism in consequence of the favoring influence of an abundant supply of oxygen. Spores may then be produced and lead to infection of nearby or remote parts of the lung. Purulent liquefaction is absent. The necrotic focus may be sequestrated and expelled with the formation of an odorless cavity. Bacterial invasion of the affected areas may or may not take place. The usual absence of fetor may be due to inhibition of the growth of putrefactive bacteria by the fungus. The lesions of tuberculosis may coexist with those due to aspergillus. Pulmonary abscess, gangrene, bronchiectasis and chronic interstitial pneumonia may result from the infection. In Kockel's[6] case there was a cavity the size of an apple in the left upper lobe. Symptoms were absent and the process was apparently arrested. In one of Virchow's[7] cases no pulmonary involvement was found, but several large colonies of fungus in the bronchi. No significant changes in the

[1] Trans. Roy. Soc., Edinburgh, 1842, Bd. xv, ii, 277.

[2] Beiträge z. Lehre von den beim Menschen vorkommenden pflanzlichen Parasiten, Virchow's Arch., 1856, p. 557.

[3] Loc. cit. [4] Loc. cit.

[5] Deut. med. Woch., 1893, No. 50.

[6] Verhandl. d. Gesellschaft d. Naturf. u. Aerzte, 69. Versamml. Braunschweig, 1897, T. ii, H. 2, p. 19.

[7] Loc. cit, p. 569.

bronchial mucous membrane were seen microscopically. Metastatic distribution of the organism has not been observed.

Symptoms.—The clinical features of primary aspergillosis are those of chronic pulmonary tuberculosis with cavity formation or chronic bronchiolitis terminating in chronic interstitial pneumonia. In the former type, there may be cough with the expectoration of purulent sputum streaked with blood. More or less abundant hemoptysis may occur. As the disease progresses, digestive disturbances, night sweats, evening elevation of temperature and emaciation may be observed. On examination, signs of bronchitis, pulmonary infiltration and finally cavity formation may be established. The disease may be fatal or cease to progress and terminate in recovery. The indurative form begins with symptoms of diffuse bronchitis. The cough is harassing and dyspnea may be a troublesome feature. Evidences of emphysema, pulmonary induration and contraction become manifest as the disease advances. As in the preceding type, the termination may be fatal with increasing marasmus or failure of the right side of the heart. Recovery may follow. Pulmonary tuberculosis may complicate the condition. In cases in which aspergillosis is secondary to already existing pulmonary lesions, the clinical picture is lacking in distinctive features.

Diagnosis.—This can be made only by the finding of fragments or spores of the fungus in the sputum. Their recognition may be facilitated by the addition of a 20 per cent. solution of sodium hydrate to the specimen to dissolve the cellular elements and thus make the fungus more clearly visible. The sputum should be fresh, as otherwise secondary infection with aspergillus spores from the air may take place. Fragments of the fungus may be found imbedded in blood-clots or masses of necrotic pulmonary tissue. The use of staining fluids is superfluous. Cultivation of the organism may be necessary to establish the identity. For this purpose Paulin's[1] fluid which has the advantage of being relatively unfavorable for the growth of bacteria may be used. The sputum is added to 50 c.c. of the sterile solution in a 100 c.c. flask. Aspergillus fumigatus colonies develop at a temperature of 38° to 40° in three to four days. Evidences of pulmonary destructive lesions without foul odor to the sputum, especially in persons engaged in occupations likely to lead to the inhalation of aspergillus spores, should suggest the possibility of the disease. Actinomyces and tubercle bacillus should also be sought in the sputum.

Prognosis.—This is uncertain, but on the whole not promising for complete recovery since even in the uncommon instances in which the aspergillus infection comes to a standstill, the damage to the lung is persistent, and may finally lead to a fatal termination. Pulmonary tuberculosis may be engrafted on the aspergillus infection. The slow

[1] See Sticker, Nothnagel's spec. Path. u. Ther., 1900, 1 Abth., Bd. ii, vol. xiv.

course and absence of generalization of the organism throughout the body make the prognosis of the primary form less grave than in pulmonary tuberculosis. The outlook in the cases with symptoms of chronic bronchiolitis and emphysema seems somewhat less favorable than in those resembling pulmonary tuberculosis.

Prophylaxis.—Means should be taken to prevent the inhalation of dust containing aspergillus spores in occupations involving this danger by cleanliness, proper ventilation, and if necessary, the use of respirators. Persons already subject to pulmonary disturbances are probably more susceptible to infection with aspergillus and should be especially careful to avoid exposure.

Treatment.—Any further chance for infection must be prevented by avoidance of contact with dry grains and vegetable material. There is no specific therapy. Chief reliance must be placed on improvement of the general strength and nutrition, by an abundance of good food and fresh air free from dust. Measures similar to those recommended for pulmonary tuberculosis may be applied with advantage to the treatment of this disease. The internal administration of iodid of potash, or arsenic in the form of Fowler's solution may be tried.

CHAPTER XXV.

ANIMAL PARASITES.

ECHINOCOCCUS DISEASE OF THE LUNG.

Etiology.—Sources of Infection.—Dogs used for herding sheep are the usual source. A small tapeworm, Tenia echinococcus, inhabits the small intestine of the dog and may occur also in other animals such as the wolf, jackal, canis dingo (Australian wild dog), and the cat. Echinococcus disease is the larval stage in the life cycle of the parasite and occurs in a large number of domesticated and some wild animals. Sheep, cattle and swine are the most frequent and important intermediate hosts. The infection of man is accidental and relatively uncommon.

Incidence of the Pulmonary Disease.—This appears to be second in importance to the disease in the liver, which embraces from 50 per cent. (Neisser) to 69 per cent. (Finsen) of all cases. Among Neisser's[1] 983 cases, only 67 (6.8 per cent.) were pulmonary. Bezou[2] found 153 (8.2 per cent.) pulmonary hydatids among 1852 cases.[3] Vegas and Cranwell[4] report 54 (5.6 per cent.) among 952 cases, collected in Buenos-Ayres and Rosario.

The sexes are about equally affected. The disease may occur at any age, but more often from twenty to forty years. It is more commonly seen among the poorer classes and those living in close contact with dogs.

Pathogenesis.—The eggs of the Tenia echinococcus are eliminated with the dog's feces in the terminal ripe segment of the worm and may be ingested with contaminated food or drinking water. They may also be carried to the mouth on hands soiled in petting dogs. The embryo, liberated from its shell in the stomach, bores its way by means of its armature of six hooks to various parts of the body.

(A) **Pulmonary Echinococcus.**—*Primary Echinococcus of the Lung.*—This is the most common form. The path taken by the embryo is not clear. Migration by way of the portal blood-stream, thence through the diaphragm and pleura, is suggested by the greater frequency of echinococcus of the liver and the right lobe of the lung. As the disease

[1] Die Echinococcuskrankheit, 1877, p. 25.
[2] Études sur les kystes hydatiques du poumon Paris, 1893.
[3] Combined Statistics of Davaine, Cobbolt, Neisser, and Finsen.
[4] Rev. de Chir., 1901, xxiii, 970.

may be found not only in other parts of the lung but in any region of the body, this is probably not the only route which the embryo can follow.

Bird[1] suggested that the eggs of the Tenia echinococcus, deposited with the feces, may be distributed as dust and gain entrance to the lungs by inhalation, thus giving rise to pulmonary invasion. There is no proof of such a path of infection and the preponderance of cases with hepatic involvement is against it.

The development of the disease in the lung does not differ from that in other regions of the body. The embryo gradually increases in size and presents an outer, thick, elastic cuticle, at first homogenous, later laminated, and an inner parenchymatous or germinal layer. This inner layer surrounds a cavity containing fluid. Brood capsules, in which heads (scolices) form, develop from the parenchymatous layer. Further growth may lead to the formation within the parent cyst of daughter and granddaughter cysts (endogenous echinococcus). This is the form usually found. I have not seen that form in which growth takes place by external budding (exogenous echinococcus) reported for the lung, although it probably occurs. In rare instances, as in the case reported by Hauser,[2] the echinococcus multilocularis has been found in the lung.

Secondary Echinococcus of the Lung.—This is less common than the primary form. (*a*) *By Extension.* It is possible that from pulmonary hydatids, by the process of external budding above mentioned, small cysts may find their way through the bronchi to remote parts of the lung and there continue to grow. A similar implantation of small cysts after spontaneous or artificial rupture into the lung of a parent cyst in the parapulmonary tissues is also possible as in the development of peritoneal cysts after rupture of an intra-abdominal echinococcus. This method of origin receives some confirmation in the experiments of Dévé.[3] Three rabbits were inoculated intratracheally with fluid obtained from the hydatid of the sheep. One animal died after fifty-one, the others were killed after fifty-seven days. Investigation of the lungs showed numerous white miliary granulations, some of which represented small cysts. Microscopic examination showed cyst formation, a stratified cuticle and an inner parenchymatous layer. Serial sections demonstrated a mass of hooklets in the wall of each vesicle. Secondary infection of the parent cyst with bacteria usually precedes or so quickly follows rupture that spread of the parasite by this means is not likely to be of frequent occurrence.

(*b*) *By Metastasis.*—It is probable that multiple and isolated cysts in various parts of the body are usually due to infection with more than one embryo of the Tenia echinococcus at the same or at different

[1] On Hydatids of the Lungs, Melbourne and Sydney, 1877.

[2] Primär, Echin. multilocularis der Pleura u. d. Lunge, Erlangen u. Leipzig, 1901.

[3] Encemencement intratracheal de sable echinococcique, Echinococose secondaire du poumon d'origine bronchique, Mem. de la Soc. de Biol., 1904, vol. lvii.

times. An exception must be noted for the echinococcus multilocularis, in which the parenchymatous, germinal layer exists both on the inner and outer side of the chitinous cuticle. From the outer germinal layer, ameboid embryos are produced and may infect not only the immediate neighborhood of the primary growth but also more remote regions by entrance into the blood or lymphatic vessels.

Pulmonary embolism following rupture and evacuation of cysts into the larger venous channels is not known to have given rise to the implantation and further development of the parasite, but has been recorded in rare instances as a cause of death. Twelve cases have been collected to 1905 by Garnier and Jornier[1] who add a thirteenth case of their own. The embolism was secondary to rupture of cysts of the liver, with evacuation of membrane or daughter cysts into the vena cava, or of cysts of the heart breaking into the right auricle or ventricle. The symptoms do not differ from those following pulmonary embolism from other causes. Occlusion of the main trunk or one of the principal branches of the pulmonary artery is usually followed by death within a few minutes or hours. After invasion of smaller branches, life may be prolonged for weeks.

(B) **Parapulmonary Echinococcus.**—(*a*) *Intact Cysts.*—In this group may be included cysts of neighboring regions which in their growth encroach upon the pulmonary space. It is not infrequent for hepatic cysts to grow upward, pushing the diaphragm before them. They may reach as high as the second rib or the clavicle. Subdiaphragmatic cysts developing in the region between the liver and diaphragm, in the spleen or kidney, may likewise elevate the diaphragm without actually invading the lung. The condition of the pleura has an important bearing on the subsequent course of cysts growing in its neighborhood. It may be free or inflamed and the site of serous, serofibrinous or purulent exudate. Partial or complete pleural adhesion is more common, however, and in this case, widespread pleural infection is avoided following the rupture of the cyst.

(*b*) *Perforated Cysts.*—According to Neisser's statistics, hepatic cysts rupture into the respiratory apparatus in about 11 per cent. of the cases. Suppuration of the cysts almost constantly precedes the rupture. Evacuation into the lung or bronchi is more common than into the pleura. In Neisser's 60 cases, the pleura was invaded in 16, the lungs or bronchi in 44. Hepatopleural or hepatobronchial fistulæ may result. Bile may be found in the pleural cavity or be expectorated.

Pathology.—The cysts may be found at any part of the lung, but the right side and especially the right lower lobe is most often affected. In Neisser's statistics, the right side was involved in 25, the left in only 12 instances. The disease was present on both sides in 6. Coincident disease of the lungs and other organs is frequent. Multiple

[1] La Presse méd., Paris, 1905, i, 369–371.

infections usually involve the liver and the lung. The pulmonary cysts vary in size from that of a pea to a child's head.

An important feature of the cysts is the presence outside the thick, elastic cuticle of the parasite itself of an adventitious membrane or connective-tissue capsule which separates the cyst from the pulmonary parenchyma. This capsule is usually thin. Its inner surface is smooth and is bounded externally by healthy lung tissue. In some instances, it is thick. Large, old cysts, which have ruptured, may be surrounded by a dense leathery capsule, about which the lung shows chronic interstitial changes of varying extent. The capsule is not invariably present and some small cysts appear to lie in direct contact with healthy pulmonary tissue. The bronchi may terminate in the wall of the capsule, by larger or smaller openings, thus presenting free communications between the cavity and the air-passages and favoring the entrance of bacteria into the sac or the exit of cystic fluid in case of rupture.

Perforation of the cyst is common. Rupture leads to evacuation of the contents into the region between the cyst membrane and the adventitious capsule from which it usually escapes into the bronchi. Perforation may also occur into the pleural cavity. Depending on the previous condition of the pleura, and the character of the cyst contents, this is followed by an accumulation within the pleura of free or encysted cystic, serous, or purulent fluid. Evacuation into the pleura is likely to be followed by the escape of cystic fluid by the bronchi and the admission of air into the pleural cavity, with the formation of pneumothorax. If the pleura is obliterated before rupture occurs, pulmonary echinococcus may perforate externally. In rare instances, perforation may take place into the spinal canal, the pericardium, the intestines, or the peritoneum.

Suppuration of the cyst may precede or follow rupture. The contents is converted into an abscess. Inflammation of the neighboring pulmonary tissue takes place. Pulmonary gangrene may be a consequence. Thrombosis of pulmonary veins may be induced. Erosion of pulmonary vessels may result in severe or even fatal hemorrhage. Pulmonary embolism following the entrance of daughter cysts into eroded vessels has been observed. Pulmonary tuberculosis occasionally complicates the process. Long continued suppuration may lead to chronic interstitial changes in the surrounding tissue. In favorable cases, the fluid contents of the cyst, daughter cysts and the cyst membrane are expectorated. The cavity gradually diminishes in size and small losses of substance may completely cicatrize.

Symptoms and Signs.—In the early stage of the development of the disease there are usually no symptoms. This latent interval is of variable duration and may last for weeks, months or years, It is more likely to be short when the pleura is involved or the cyst becomes infected early in its growth. Central and uninflamed cysts usually present the longest latent interval.

The initial disturbances are usually cough, hemoptysis, dyspnea and pain or a sense of thoracic oppression. In a small proportion of the cases, the onset is sudden with hemoptysis, the expectoration of cystic fluid, cysts or membrane, or severe dyspnea following rupture into the pleura and pneumothorax. In rare instances, such cases are immediately fatal from hemorrhage or suffocation. The different symptoms may be more fully considered.

The cough is usually dry in the early course of the disease and may be unaccompanied by expectoration until rupture takes place. It may be constant, but is more often paroxysmal. Sputum if present is usually scanty and due to an accompanying bronchitis.

Hemoptysis is an important and early symptom. It is absent only in rare instances; is usually preceded by cough, but may be the first indication of the disease. Preceding rupture, the bleeding is seldom abundant and is likely to consist of bloody streaks or small amounts of fresh blood in the expectoration. Such hemorrhages probably come from slight erosions of the connective-tissue capsule or the neighboring lung. The bleeding is usually repeated, the attacks coming at varying periods, with freedom from hemorrhage during the intervals. The patient's general condition is undisturbed and there is usually no fever. Abundant and even alarming hemorrhages occasionally occur during the early stages of the disease, as in Küss'[1] case, in which an hemoptysis of about a quart is said to have preceded by over two years a second attack followed by the expectoration of a large amount of glairy, fetid fluid. Hemoptysis accompanying or following rupture may be due to erosion of the larger branches of the pulmonary vessels and is occasionally fatal.

The dyspnea is slowly progressive and in the absence of complications its degree depends on the amount of pulmonary space occupied by the cyst. It may be intermittent. Aggravation of the dyspnea may be coincident with attacks of bronchitis. A sensation of weight, fulness and discomfort in the affected part of the lung is not infrequent. Pain is common but is not usually an urgent symptom unless the pleura is inflamed. The disease is afebrile. The general health is little if at all disturbed. Dysphagia has not been observed with pulmonary echinococcus. In rare instances, the pupils are unequal. Clubbing of the ends of the fingers and incurvation of the nails (Hippocratic fingers) have been seen. This condition may gradually disappear after the evacuation of the cysts, as in Frobeen's[2] case. The jugular veins may be dilated. Edema confined to the upper extremities was observed by Leroux.[3] Edema of the lower extremities is at times seen in the later stages of the disease. Weakness or hoarseness of the voice is sometimes present. Aphonia has not been noted.

With small cysts, centrally placed, there may be no physical signs.

[1] Société anatomique de Paris, 1907, p. 494.
[2] St. Petersburger med. Woch., 1903, N. F. xx, p. 94.
[3] See Hearn, Kystes Hydatiques du poumon et de la plèvre, p. 115.

In the presence of larger unruptured cysts, the inspiratory excursion of the affected side is likely to be diminished. The chest wall overlying the growth occasionally shows a local prominence, and the corresponding side may be larger by measurement. The diaphragm shadow, below the involved region, may be present, but of diminished amplitude. The affected area is dull or flat, but the transition from dulness or flatness to normal pulmonary resonance may be more abrupt than with pleural effusion. Shifting dulness is not observed. Hydatid fremitus is not recorded for the pulmonary form. The upper limit of a mass at the base, marked out by percussion, is not likely to show such a curve as is present with free pleural fluid, but is more often rounded, with a convex upper margin, and may then resemble encysted pleural exudate. At times, a zone of resonance may separate its lower limit from the base of the lung. Tactile fremitus is usually absent. The sound of the spoken voice and whisper is diminished or inaudible. The respiratory murmur is feeble or lost. A sudden transition to normal or exaggerated breathing may be noted at the periphery of the involved region. This is due to pulmonary compression. Rales are not heard, unless the case is complicated. Displacement of the heart to the side away from the cyst and of the liver or spleen downward may also be noted. Coincident inflammation of the lung or pleura may mask or vary the physical signs.

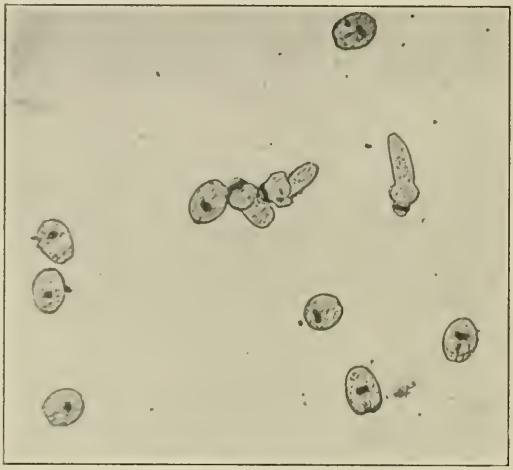
Preceding rupture, there are usually no distinctive symptoms or signs. Perforation of the cyst is commonly the first positive indication of the disease. It may occur spontaneously, or follow inflammation, trauma, exertion or puncture. Cough and dyspnea are frequent initial symptoms. Hemoptysis may precede or accompany the attack. The evacuation of the cyst contents is more often into the bronchi, but the pleura may be alone or coincidently invaded. Rupture into other regions is infrequent. Discharge by the bronchi may be accompanied by urgent symptoms of suffocation. Severe pain may follow pleural involvement. Expectorated fluid is seldom clear and watery. It is often mixed with pus or blood and may contain cysts or cyst membrane. It may be fetid from disintegration of the contents of the cyst or the neighboring lung. A salty taste may be noted by the patient. Death from hemorrhage, flooding of the respiratory tract with fluid, or impaction in the air passages of cysts or cyst membrane may follow the rupture.

When the fluid is unmixed with blood or pus, it is clear, watery and of a specific gravity of 1009 to 1012. Sodium chloride is present. Albumin may be absent or present only in small amounts. Traces of inosit, succinic acid and grape sugar may be found, but are not distinctive features. At times, especially in old cysts, cholesterin crystals are present. Cholesterin crystals have been found in pulmonary hydatid fluid, among others by v. Jaksch.[1] In suspected cases, cysts and bits

[1] Klinische Diagnostik, 1887, p. 79.

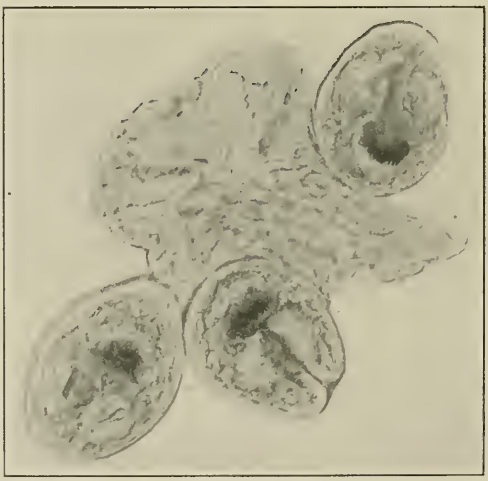
of membrane should be carefully sought. The latter has a characteristic lamellated structure. The sediment should be examined microscopically for scolices and hooklets. These may be found only after long search. Elastic tissue may be present, if pulmonary destruction is taking place.

Fig. 62



Echinococcus scolices.

Fig. 63

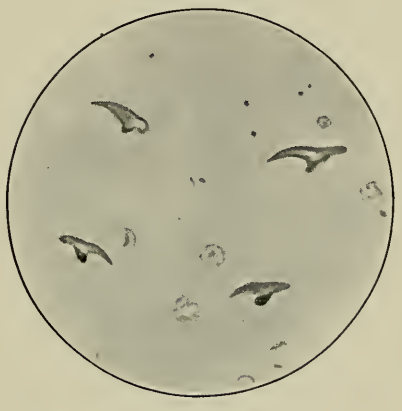


Echinococcus scolices.

Hepatic cysts which rupture through the lung usually lead to the expectoration of ochre-yellow, bile-stained sputum. Positive tests for bile pigments may be obtained. Bilirubin, cholesterin, and hema-

toidin crystals may be found. Perforation of the lung by cysts of the liver has been reported by Neisser,[1] Von Leyden,[2] Guttmann,[3] Lenhartz,[4] and Auerbach.[5] As the cyst may be walled off from the biliary passages, bile in the sputum is not a necessary feature. Cholesterin crystals occur in the sputum not only with echinococcus cysts, but also occasionally with pulmonary tuberculosis and following the perforation into the lung of old empyema or hemorrhagic pleural effusions. When they are found in the sputum, however, it is well to have echinococcus disease in mind.

FIG. 64



Echinococcus hooklets. × 375.

Urticaria is frequently observed after rupture of cysts into the serous membranes and occasionally after evacuation into the bronchi. Its occurrence in patients with pulmonary symptoms should suggest the possibility of this disease. A characteristic expectoration may be lacking, but a careful search of the expectorated material may make the diagnosis clear. Dieulafoy[6] reports the case of a man, aged forty years, with hemoptysis, frequent attacks of nocturnal oppression and dyspnea for a period of four months. This was regarded as asthmatic in origin. During an attack, the expectoration of an abundant purulent sputum was followed by severe urticaria, suggesting the possibility of hydatid disease. Careful investigation of the sputum then led to the finding of hooklets.

After rupture of the cyst, evacuation may rapidly or slowly take place. It is not uncommon for daughter cysts or cyst membrane to be evacuated at intervals over a considerable period. Fever, sweats and loss of weight and strength are common at this stage of the disease,

[1] Die Echinococcuskrankheit, Berlin, 1877.
[2] Deut. med. Woch., 1885, p. 44, u. 76.
[3] Verhandl. des Vereins f. innere Med., 1884–85, p. 184 u. 193.
[4] Berl. klin. Woch., 1899, p. 555.
[5] Deut. Aerzte Zeit., 1901, iii, 533.
[6] Quoted from Fränkel Spezielle Path. u. Therap. d. Lungenkrankheiten, 1904, p. 922.

owing to almost constant suppuration. Rales are almost invariably present over the involved region or a wider area. The signs of cavity, tympany on percussion, cracked pot resonance, a variation in the percussion sound with the mouth open and closed, and on changing the position of the patient, bronchial and amphoric breathing, metallic tinkle and metallic rales may be present. Foul, purulent sputum, containing elastic tissue or shreds of pulmonary substance may indicate the existence of pulmonary gangrene. If the pleura has been invaded, pleural friction may be heard or the presence of empyema or pyopneumothorax may be established. In unfavorable cases, the course of the disease is progressively downward. If evacuation of the suppurating cavity is not accomplished spontaneously or by operation, the patient may succumb with symptoms of sepsis. Multiple pulmonary abscesses, arising by extension or aspiration of infected material into neighboring parts of the lungs, are likely to be followed by long-continued pulmonary suppuration. Interstitial pneumonia may accompany these changes. The occasional coexistence of pulmonary tuberculosis and echinococcus disease of the lung should be remembered and the sputum frequently examined for tubercle bacilli.

Blood.—An eosinophilia in the circulating blood is frequently found. Of over 30 cases of hydatid disease collected by Cabot[1] only two were negative. The eosinophilia may amount to as high as 40 per cent.,[2] 57 per cent.,[3] or 68 per cent.,[4] but smaller percentages are more common. The absence of eosinophilia has been recorded by Bezancon and Weil.[5] Gourand,[6] Chauffard and Boidin,[7] and Boidin and Fiessinger.[8] Echinococcus disease is only one of many conditions giving rise to eosinophilia.

Duration.—This is very variable. Owing to the usual absence of symptoms in the early development of pulmonary hydatids, the date of onset is impossible to determine in most cases. To judge from the growth in accessible regions, it may take from six months to a year to reach the size of the fist. Symptoms may not be noted until the mass is considerably larger than this, and it is probable that in some cases many years may elapse during which the cyst is latent. Then follows a period of symptoms such as have been described, and this interval may occupy from a few weeks to five, six or more years. In favorable instances, rupture is followed by recovery. Convalescence may, however, be slow and repeated partial evacuation may extend over several years. In some cases, the patient is left with a chronic pulmonary infection from which he never completely recovers.

Diagnosis.—A history of opportunity for contagion is of importance. Echinococcus disease occurs only in rare instances in North America and Great Britain, and then almost always in foreigners. As

[1] Clinical Examination of the Blood, 1904, 5th ed.
[2] Achard and Clerc, Ref. in Arch. Gén. de Méd., 1902, p. 743.
[3] Seligmann and Dudgeon, Lancet, June 21, 1902.
[4] Palazzo, Giorn. Internazione de la Mediche, Bd. xxxi.
[5] Arch. Gén. de Méd., 1902, p. 743.
[6] Soc. Anatom., January 10, 1900.
[7] Soc. méd. des hôp., December 13, 1907.
[8] Ibid., January 31, 1908.

Stiles observes, the parasite is part of our American fauna. Infection of man is therefore possible from indigenous sources. Previous residence where the disease is prevalent and contact with dogs which are or have been used for herding sheep is significant.

The history of an insidious onset and latent course of a pulmonary affection which gives rise to the signs of pleural effusion elsewhere than at the base of the lung is suggestive. If at the base a rounded, convex upper border, a zone of pulmonary resonance below, persistence of the diaphragm shadow on the affected side, abrupt transition from dulness to resonance and from diminished or absent to normal or exaggerated breathing may also be of value. Physical signs of extensive pulmonary disease running an afebrile course in a well-nourished individual or an eosinophilia in the circulating blood may be factors of moment in suggesting the condition. The discovery of an hydatid cyst elsewhere, as in the liver, may also serve to explain an otherwise obscure pulmonary affection.

It is important, if possible, to make the diagnosis before rupture occurs and without resort to thoracentesis. Serum diagnosis by the method of complement-fixation now offers the hope that this may be done. A history of cough with the expectoration of clear, watery fluid, of bits of membrane or of blood followed by urticaria is important evidence. Rupture of the cyst is not always obvious and a careful search should be made for scolices, hooklets, cysts, or cyst membrane in the expectoration.

X-ray Examination.—When possible this should always be done. An earlier diagnosis may be possible by this means than by any other method of investigation. Important evidence may be obtained concerning the size and position of the growth. It may result also in the discovery of multiple cysts, only one of which has been suspected. Plates are more satisfactory than the fluoroscopic screen. The exposure is best made while the breath is held in full inspiration, during which the chest is bigger and the relation of the tumor to the diaphragm is better defined, owing to the absence of blurring from respiratory motion. Intact cysts appear on the plate as shadows of a uniform density, sharply limited from the neighboring lung and of a rounded contour. In some cases a zone of normal pulmonary tissue may intervene between the growth and the diaphragm below. Such an observation, together with the clinical features of the case, may confirm the suspicion of echinococcus disease. Perforated cysts may be indicated by a sharply limited, rounded shadow, with a relatively clear centre. In the case described by Levy, Dorn and Zadek.[1] the patient, aged forty years, expectorated echinococcus membrane one year after an initial hemoptysis. Physical examination showed no dulness, but occasional rales over the right lower lobe. X-ray examination disclosed a shadow at the base of the right lung, 5 by

[1] Verhandl. d. Berliner med. Gesellsch., 1899, xxx, 170.

4 cm., with a dark border and a clear centre. This was interpreted as a ruptured cyst. A narrow band-like shadow between the mass and the diaphragm seemed to indicate its origin by rupture from the liver. In the left lung an oval, homogeneous shadow was regarded as a second and intact cyst.

Fig. 65

Bilateral pulmonary echinococcus cyst. (Behrenroth.)

Serum Diagnosis.—Two methods have been used. Fleig and Lisbonne[1] were the first to investigate the precipitin method. Twelve drops of the patient's serum were added to 2 c.c. of hydatid fluid. Precipitation of the fluid occurred after some hours, the material being kept meanwhile at 40° to 42°. This test has also been performed by Welsh and Chapman,[2] Weinberg[3] and Bettencourt.[4] The reaction, however, is not constant.

The second method, by complement-fixation (Bordet-Gengou reaction), was first used by Guedini.[5] It has been employed by Bettencourt,[6] Weinberg,[7] Parvu and Laubry,[8] Krueter,[9] Jianu,[10] Lippman,[11] and others. Lippman collected 41 cases of echinococcus disease in man, in which the test had been tried and two of his own. Of the 43

[1] Recherches sur un séro-diagnostic du cyste hydatique par la méthode des précipitines, Comptes rend. soc. de biol., 1907, lxii, 1198.

[2] Lancet, London, May 9, 1908, and 1909, i, 1103.

[3] Comptes rend. de la soc. de biol., January 29, 1909, No. 3, vol. lxvi.

[4] Arch. de Real Instituto Bacteriologico Camara Pestana, Bd. ii, H. 3, S. 361, quoted from Jianu. Wiener. klin. Woch., 1909, No. 42.

[5] Quoted from Centralbl. f. Bakt., xl, 464; ref. and also ibid., 1908, xli, 716.

[6] Loc. cit.

[7] Loc. cit.

[8] Comptes rend. de la soc. de biol., 1909, T. lxvi, p. 467, No. 11.

[9] Münch. med. Woch., 1909, No. 36; also Beitr. z. klin. Chir., Bd. lxxvi.

[10] Wiener klin. Woch., October 21, 1909, No. 42.

[11] Berliner klin. Woch., January 3, 1910.

cases, only 2 were negative, both of whom later showed the reaction. The method, therefore, appears quite trustworthy and offers much promise. Jianu takes no more than 3 c.c. of the patient's blood, and allows it to stand for five to six hours in the thermostat, in order to obtain the maximum of complement. The antigen is obtained from the echinococcus fluid of sheep or cattle, collected fresh and under aseptic precautions in the slaughter house. An extract of the fluid may also be used. The presence or absence of hemolysis is noted on the addition of these substances to a 2 per cent. emulsion of sheep's red-blood corpuscles. No constant relation appears to obtain between eosinophilia and the reaction of fixation. The reaction may last long after operation.

Thoracentesis.—The diagnosis has often been made in this way. The procedure is attended by considerable danger, however, and cannot be recommended. Puncture of the cyst is likely to be followed by the escape of echinococcus fluid into the space between the wall of the sac and the connective-tissue capsule, thence into the bronchi or through the canal of puncture to the pleural cavity. The irritating fluid excites cough, during which the sac and the escaped fluid are subjected to increased tension. Rupture of the sac is likely to be a consequence. Symptoms of severe intoxication, as urticaria, gastro-intestinal disturbances, faintness, collapse, delirium, and even coma and death may result. Edema of the lung may ensue. Pulmonary suppuration, empyema, or pyo-pneumothorax may follow the evacuation of septic fluid. Obstruction of the bronchi by fluid, cysts, or cyst membrane or the entrance of air into the pleural sac may cause suffocation. Maydl[1] has reported 11 deaths among 16 cases in which thoracentesis was performed. Many additional fatalities have since been reported. O'Conor[2] refers to an unusual case in which the expectoration of two liters of fluid occurred while the attendant was cleaning a syringe in preparation for exploratory puncture. If the disease is suspected an exploratory incision, with full preparations for a surgical operation, should be performed. If the case is under suspicion for pleural effusion and echinococcus fluid is obtained by puncture, operation should be undertaken at once.

Examination of uninfected fluid may readily suggest the diagnosis. A clear, watery fluid, of a low specific gravity, with considerable sodium chloride and only traces of albumin, is not likely to be confused with any other condition. In some instances, however, the specific gravity is high and the amount of albumin considerable. Infection of the cyst is likely to mask the appearance of the fluid, which may then vary from a merely turbid material, with a sediment of polynuclear cells, to frank pus. Positive evidence of the character of the process will be furnished by the discovery of scolices or hooklets in the sediment. Long search may be necessary.

[1] Ueber Echinokokkus der Pleura, Wien, 1891.
[2] Lancet, London, 1903, i, 1433.

The pulmonary, pleural, or subdiaphragmatic site of an echinococcus cyst may be difficult or impossible of determination. The various forms may coexist. In Patella's[1] case the diagnosis before operation was pleural, after operation hepatic, and at autopsy pulmonary echinococcus. The physical signs of centrally placed pulmonary cysts may be slight or absent. Cysts near the periphery of the lung present the same signs as in pleural echinococcus, but the history may be helpful in the differentiation. In the pulmonary disease pain is less often present, while cough and hemoptysis are more prominent features. Dyspnea is common to both pleural and pulmonary forms, but is more often paroxysmal when the lung is affected. Perforation into the bronchi occurs more frequently with pulmonary cysts. Subdiaphragmatic cysts likely to be confused with those in the lung usually develop in the upper part of the liver or the space between the liver and the diaphragm. The clinical picture is then more like the pleural than the pulmonary form. Pain may or may not be a feature, depending on the presence or absence of infection extending through the diaphragm to the pleura. Cough and hemoptysis are not likely to occur unless rupture has taken place. Paroxysmal dyspnea is not a prominent feature and rupture into the lung is less frequently observed. When it does occur, however, the sputum is likely to be ochre-yellow in color, and to respond to the tests for bile pigments. Jaundice may be present. Downward displacement of the liver is commonly more marked in the subdiaphragmatic site. The presence of the diaphragm shadow above the growth may be an important sign. If the tumor projects below the margin of the ribs, hydatid fremitus may be felt. If a zone of resonance can be determined between the growth and the hepatic dulness it is strongly in favor of a pulmonary process.

Of the various diseases with which pulmonary hydatids are likely to be confused, tuberculosis occupies first place. In a majority of the cases a probable diagnosis of this disease has been made before rupture occurs. The two affections have much in common and mistakes are at times inevitable. A history of tuberculosis or opportunity for contagion, persistent cough with mucopurulent or purulent sputum, loss of weight and strength, night sweats and evening rise of temperature are suggestive of tuberculosis. The dyspnea is seldom marked. Fibrinous or serofibrinous pleurisy, as an apparently primary affection without symptoms or signs referable to other organs, and hemoptysis as an initial symptom or early in the course of an apparently mild pulmonary disturbance, are suggestive of tuberculosis. So also in the general examination may be phlyctenular conjunctivitis, corneal scars (if trauma, gonorrhea, or syphilis can be excluded), lupus, cicatrices from cervical adenitis, and ischiorectal abcesss. Examination of the lungs may be negative or show evidence of involve-

[1] Quoted from Maydl, Ueber Echinokokkus der Pleura, Wien, 1891, p. 71.

ment of the apices as indicated by retraction, rales, or signs of pulmonary consolidation. Bilateral apical lesions are not uncommon. With echinococcus disease of the lung, on the other hand, the cough is likely to be dry, the dyspnea more marked, the general health little if any disturbed, and the course to be afebrile. Pleurisy or hemoptysis are usually, but not always, preceded by pulmonary symptoms or signs. Although cysts may be apical, they are more commonly basal, unilateral, and right sided. The affected region is prominent rather than retracted and the signs are those of pleural effusion. Maintenance of good nutrition and signs of extensive intrathoracic disease may be striking.

Pulmonary echinococcus may also be confused with pleural effusion. A history of persistent cough, dyspnea of a paroxysmal character, and repeated hemoptysis is more frequently to be obtained in the former. Pain is more likely to be a prominent feature with pleurisy. In both the base of the lung is likely to be affected. The signs of intact cysts are those of encysted pleural effusion. As sacculated exudates are usually purulent, with an acute onset, toxic symptoms, chills, fever and leukocytosis, an insidious onset and latent course may suggest echinococcus disease. A location elsewhere than at the base may be more definitely suggestive. Free pleural fluid presents a slightly curved upper margin (Damoiseau's curve), while the contour of cysts is rounded with the convexity upward. Shifting dulness may be demonstrated with an effusion, but is absent with cysts. A zone of resonance between the dull area and the base of the lung, persistence of the diaphragm shadow on the affected side, abrupt transition from dulness to resonance, and from diminished or absent to normal or exaggerated breathing, absence of bronchophony or ægophony speak for cyst rather than pleural fluid.

Tumors of the lung, the pleura, or the mediastinum may be considered. Malignant growths are for the most part in question. The local signs are much the same, but the margin of a malignant growth is likely to present a different outline. More intense pain, stridor, paralysis of the vocal cords, dysphagia, dilatation of the cervical or thoracic veins, superficial metastases, resistance and induration of the thoracic wall, a more rapid course, and progressive cachexia are likely to be observed with such tumors. An accumulation of bloody pleural fluid is much less common with echinococcus disease. Intrathoracic aneurysm may simulate an echinococcus cyst, but the differentiation is usually easy.

A ruptured and infected echinococcus cyst may give rise to pulmonary abscess or gangrene which may then resemble similar processes from other causes. Certain features of the history, already mentioned, may suggest echinococcus disease. If the condition is known to have followed lobar pneumonia the inhalation of foreign bodies, submersion, etherization, operations about the upper respiratory tract, or on an individual known to be the subject of bronchial

or pulmonary inflammation, or trauma, or if it occurs in the course of suppuration anywhere in the body, especially in the pleura or abdomen, a different etiology may be established. The sputum may show elastic tissue or shreds of the lung, and the signs of cavity may be present on physical examination. Actinomycosis and tuberculosis should be excluded by repeated examinations of the sputum. The finding of hooklets, scolices, or cyst membrane may be the first indication that echinococcus disease is the cause.

Prognosis.—The outlook with pulmonary echinococcus allowed to run its course untreated is better than with the pleural form, but is yet very unfavorable. Recovery from death of the parasite has not been reported for pulmonary hydatids. The expectation of life without treatment cannot be definitely stated. Left to itself the cyst gradually increases in size until rupture takes place. Of Hearn's[1] 144 cases of pulmonary and pleural echinococcus collected from the literature, 82 (56.9 per cent.) died and 62 (43 per cent.) recovered. Recovery was due to the expectoration of the hydatids in 45, to simple puncture in 5, puncture or incision and evacuation by the bronchi in 7, incision of the thoracic wall in 2, and puncture with the injection of iodin or evacuation by the intestine in one each.[2] Death when it occurs is usually due to suffocation, hemorrhage, pneumothorax, or sepsis. It may be sudden or life may be prolonged, the patient gradually dying of asthenia. It is relatively uncommon even in the recovered cases, for complete relief from pulmonary symptoms to follow spontaneous evacuation by the bronchi. Infection of the cyst cavity and the neighboring or remote parts of the lung is likely to leave a permanently damaged pulmonary tissue. Reimplantation of the growth is a possible sequel to evacuation into the bronchi, as already mentioned. The chance of recovery is far better from surgical intervention.

Treatment.—There is no medical treatment. Simple puncture with or without the injection of iodin, carbolic acid, corrosive sublimate, or other substances has been frequently and at times successfully performed. It is, however, a dangerous method and should be strongly condemned. The objections to puncture have already been sufficiently emphasized (see p. 415). If, as occasionally happens, exploratory puncture, undertaken for a suspected pleural effusion, discloses echinococcus fluid, the danger of its escape into the bronchi should be avoided by an immediate resort to surgical intervention

Intact Cysts.—The condition of the pleura has an important bearing on the operative procedure. If the pleural sac is already obliterated, the operation is relatively simple and the danger of artificial pneumothorax is eliminated. As it is never possible with certainty to know in advance whether the pleura is partially or wholly free or adherent it is safer to proceed in all cases as cautiously as if it were free. The

[1] Kystes hydatiques du poumon et de la plèvre, Paris, 1875.

[2] The total here as in Hearn's table amounts to only 61.

incision is made over the site of the tumor. Subperiosteal costatectomy is done over a sufficient area, and if the pleura is found to be obliterated, the lung may be incised with care not to open the cyst membrane. Having opened the connective-tissue capsule an attempt may be made to remove the cyst entire. If this cannot be accomplished without rupture the cyst membrane may be drawn into the wound of operation and aspirated in such a manner that its contents will not escape into the connective-tissue capsule. The collapsed cyst may then be shelled out from its capsule and the cavity then be lightly packed with gauze. Irrigation with antiseptic fluids is not to be advised. In cases uncomplicated by pulmonary inflammation or induration the defect in the lung is rapidly closed. In cases in which the pleural sac is free, and without urgent symptoms, the operation may be done in two stages, at the first of which the two layers of the pleura are united by suture about the margin of the field of operation. An interval is then allowed to elapse before pneumotomy is done. An anchor stitch through the pulmonary pleura and including also some of the pulmonary tissue may prove a safeguard against pulmonary retraction and sudden pneumothorax during the manipulations.

Careful localization of the cyst should precede operation. For this purpose, examination with the *x*-rays is almost indispensable. If the location of the cyst is doubtful or if it appears to occupy a central position, Garrè[1] suggests fixation of the lung at one or two places by a strong, deep suture, free opening of the pleura and exploration of the affected lobe by the index finger, or if necessary by the whole hand introduced into the pleural space.

Ruptured Cysts.—After evacuation has been partly or wholly effected by way of the bronchi the indications for operation are less clear, and opinion is divided between an expectant policy and operation. During the period immediately following rupture the patient is in danger of suffocation from the flooding of the air passages with fluid, cysts, or cyst membrane. In some instances cysts and cyst membrane are expectorated at intervals over a considerable period, and the danger period is correspondingly prolonged. Suppuration of the cyst commonly precedes or soon follows rupture, and if not immediately fatal, greatly endangers the ultimate restoration of the pulmonary tissue to normal. Fatal hemorrhage may also occur. There is also the possibility of dissemination of the parasite into other parts of the lung. The danger of this, however, is as yet little known. One must weigh on the one hand the dangers incident to rupture and on the other those of the operation itself. In general it may be said that with the progress already made in thoracic surgery the patient's chances are better in the hands of an experienced operator, when the cyst is incompletely evacuated or with evidence of persistent suppuration. Following rupture into the pleura operation is also indicated.

[1] Garrè and Quincke, Grundriss der Lungenchirurgie, Fischer, Jena, 1903, p. 81.

PULMONARY DISTOMATOSIS (LUNG-FLUKE DISEASE.)

Parasitic Hemoptysis.—Etiology.—This interesting disease is endemic in Japan and China. It has been reported also from Korea and the Philippine Islands. It is said that in certain parts of Formosa 15 per cent. of the population are affected. Inouye[1] found that in Tama (in the Distoma region) among 38 patients, there were 28 (73.6 per cent.) with the disease in other members of their families, and states that it is not uncommon for whole families to be swept out of existence by it. Paul[2] reports that 39 per cent. of the school boys in Kumamoto were affected. The prevalence varies considerably in different localities. Among 20,793 patients in the hospital at Okayama (1891–1897) 87 (0.4 per cent.) had the disease. In Matuyama 2.16 per cent., in Kumamoto 5.9 per cent., and in Tokushima 14.3 per cent. of patients with respiratory disease were sufferers from it.[3] Imported cases are in rare instances found in various countries. Stiles[4] and Fehleisen and Cooper[5] have reported instances of human infection in America, imported from Japan. Null[6] observed a case in a Korean. Abend's[7] case may have originated in America. The disease occurs also in dogs, cats, swine, cattle, and tigers. In Okayama 7 of 130 dogs killed in 1897 were infected.

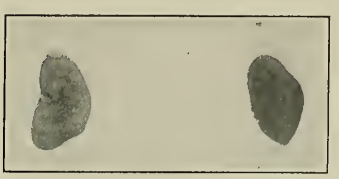
Mountainous regions appear to be most affected. A large proportion of the cases occur in males. Of 481 patients reported by Inouye, 426 (88.5 per cent.) were men and 55 (11.4 per cent.) women. The disease is more common among peasants, and from sixteen to thirty years of age.

The Parasite.—This was first described in 1878 by Kerbert,[8] under the name of Distoma Westermanni,[9] the specimen being obtained from the lungs of a tiger. Its relation with parasitic hemoptysis was established in the course of several years by the combined efforts of several workers. The eggs of the parasite were discovered in the sputum of a Japanese in 1878 by Baelz,[10] but were at first wrongly regarded as protozoa. Manson[11] also discovered the eggs in Amoy and obtained a specimen of the worm found by Ringer (1879) in the bronchi of a man from Formosa. This specimen was named Distoma Ringeri by Cobbold.[12] Its identity with the worm found in the lungs of a tiger by Kerbert[13] was discovered by Leuckart.

[1] Zeit. f. klin. Med., 1903, vol. l. [2] Lancet, December 19, 1896.
[3] Inouye, loc. cit.
[4] Johns Hopkins Hosp. Bull., July and August, 1904.
[5] Jour. Amer. Med. Assoc., February 26, 1910.
[6] Northwest Med., December, 1911. [7] Deut. Arch. f. klin. Med., 1910, c, 501.
[8] Zool. Anzeiger, No. 12, p. 271.
[9] *Synonyms.*—Gregarina pulmonalis s. fusca., Baelz, 1880; Distoma Ringeri, Cobbold, 1880; Distoma pulmonalis Kinono, Suga and Yamagata, 1881; Distoma pulmonale, Baelz, 1883; Mesagonimus Westermanni Rail, 1890.
[10] Ueber parasitäre Hamoptoë. Gregarinosis pulmonum, Centralbl. f. d. ges. med. Wissenschaften, 1880, No. 39.
[11] China Imperial Maritime Customs, Med. Rep., 1880, vol. xx.
[12] Jour. Quekett Micr. Club., vol. vi, pp. 139–140. [13] Loc. cit.

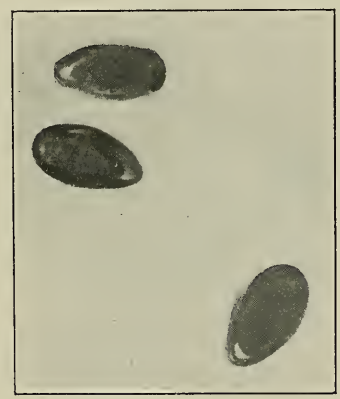
The worm is a plump, oval, or pyriform spinose fluke, 7.5 to 16 mm. long, 4 to 8 mm. broad, and 2 to 5 mm. thick. Fresh specimens are of a pinkish or reddish-brown color. The testicles and ovary are branched, the intestinal ceca unbranched.[1] The eggs are oval, golden

FIG. 66



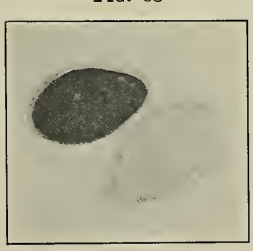
Pulmonary distoma. Adult worm. × 2.

FIG. 67



Eggs expressed from worm. × 200.

FIG. 68



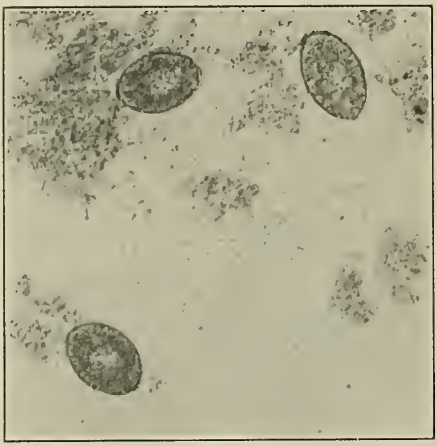
Egg and empty shell. × 200.

yellow, thin shelled, 80 to 100 by 50 to 60μ, with an operculum at one end, and contain finely granular masses. They are larger than the eggs of other parasites commonly found in man, and can even be

[1] For more detailed descriptions, see Stiles and Hassall, 1900, pp. 560–611.

seen with the naked eye as brownish specks, when material containing them is pressed into a thin layer between cover-glass and slide and examined by transmitted light. They most resemble the eggs of Bothriocephalus latus, from which they can be differentiated by their larger size. The eggs contain no embryo when discharged. As many as 12,000 eggs may be expectorated in a day.

Fig. 69



Eggs of bothriocephalus latus in stool. × 200.

The source of infection of man is unknown. Nakahama[1] succeeded in developing embryos from eggs kept in water at 30° to 35° C., and changed every day or every other day for four weeks. It is probable that the embryos enter a snail or fish as intermediate hosts and that human infection follows the ingestion of infected food. Of this there is no direct evidence, but it is suggested by analogy with other flukes (Fasciola hepatica and Opisthorchis felineus) the life history of which is better known. Contaminated water is also a possible source. The portal of entry and the course taken to the lungs is uncertain, but it is assumed by many Japanese investigators that the worm enters the intestinal canal with food or drink, perforates the intestinal wall, and finally makes its way into the lung.

Pathology.—The worm is found in cystic cavities about the size of a hazel-nut, deep within the lung or more commonly superficially placed just beneath the pleura. Within the lung they may be felt as small nodules. At the surface they may project as hemispherical prominences of a bluish-gray color. As many as twenty-eight may be found. The walls of the cysts are formed of connective tissue,

[1] Quoted from Inouye, loc. cit., p. 132.

the inner surface of which is usually smooth. In each cavity from one to three worms are present. A reddish, dirty brown, or chocolate-colored slimy fluid, containing blood cells, débris, large numbers of eggs, and Charcot-Leyden crystals may also be found. Empty cavities may be present. Neighboring cysts at times communicate with each other by sinuous channels, and rupture of the intervening walls may result in irregular cavities of considerable size. The cavities communicate with the bronchi by one or more openings. Yamagiwa[1] regarded the pulmonary tissue as the site of the cavity. Inouye[2] found in cats that the inner surface of the cavity was covered with pavement epithelium and in the outer wall were non-striated muscle fibers, and believes the bronchi the site of formation. Tanaka[3] found the cavities to be due to dilatation of the smaller bronchi in a dog. The lung tissue appeared to be the site of the cavities in a man on whom a postmortem examination was made. The demonstration of the parasite in other parts of the body than the lungs makes it probable that pulmonary infection is not confined to the bronchi. Pleural adhesions are common.

Otani,[4] Yamagiwa,[5] and Inouye and Katsurada[6] have reported autopsies on cases with cerebral infection. Cysts and eggs were found in the right frontal, and cysts, two worms, and eggs in the occipital lobes (Otani). Cysts and eggs were present in the temporal lobe and in the optic thalamus (Inouye). Disseminated dark gray, resistant areas containing eggs were found in the cortex of the occipital, parietal, and central lobes. These foci showed round-celled infiltration at their periphery (Yamagiwa). The lungs were infected in two of the cases (Otani and Yamagiwa). Infection of the liver, intestinal wall, peritoneum, diaphragm, cervical glands, upper part of Poupart's ligament, orbital cavity, scrotum, and lower eyelid has also been observed (Inouye). Miura[7] found numerous areas resembling miliary tubercles and containing eggs in the great omentum, and Tanaka[8] found several similar nodules in the peritoneum. In neither case could the mother worm be found.

Symptoms.—Pulmonary infection is the usual type of the disease. The onset is commonly insidious. The patient first notices a gradually increasing cough and expectoration, which are likely to be more severe in the morning on rising. The cough is seldom severe enough to disturb sleep. In rare instances it is paroxysmal, and asthmatic attacks may be simulated. Thoracic pain is not uncommon. It was noted among 92 patients in 34 (36.9 per cent.) of whom 28 had thoracic retraction (Inouye), and is doubtless caused by pleuritis. Dyspnea,

[1] Virchow's Arch., 1892, cxxvii, 452.
[2] Loc. cit.
[3] Wiener klin. Woch., 1911, No. 2, p. 49.
[4] Zeit. d. med. Gesellsch. in Tokio, 1887, Bd. i. See Yamagiwa, Virchow's Arch., 1890, cxix, 447.
[5] Ibid.
[6] Inouye, loc. cit.
[7] Virchow's Arch., 1889, Bd. cxvi.
[8] Loc. cit.

palpitation, and cardiac apical murmurs, due to anemia following hemoptysis, are sometimes observed. Hoarseness is occasionally present.

The sputum varies in color from yellow to rusty brown or dark red, from admixture of eggs and blood. It also contains mucus and pus, and may have a peculiar odor from the presence of blood. It may be absent for a time, is usually small in amount, but may reach 100 c.c. a day. The only distinctive feature of the sputum is the presence of the eggs, which can be identified with certainty only on microscopic examination. Blood, pus, mucous threads, alveolar and bronchial cells may also be found. Charcot-Leyden crystals are almost invariably present. Structures resembling Curschmann's spirals were found in 17 (18.4 per cent.) of 92 cases examined by Inouye. They are 3 to 4 cm. long and about 1 mm. thick, of a pale red or brown color. Taylor and Mimachi each found an expelled worm in the sputum. Mimachi's case was complicated with pulmonary tuberculosis.

Hemoptysis is the most striking feature of the disease. It is common but not invariably present, and occurs as bloody points, streaks, or frank hemoptysis. Baelz has reported a case in which there was the loss of a pound of blood within a few hours. Bloody sputum is more often seen during the colder months of the year, after excessive physical or mental exertion, the use of alcohol and tobacco. The bleeding has been ascribed to disintegration of the cyst wall and erosion of blood-vessels. Inouye suggests that the parasite sucks blood from the cyst wall, which continues to bleed after the suction is stopped. A severe grade of anemia, ending fatally, may follow repeated attacks of hemoptysis.

On physical examination the patient is usually found to be well nourished. Signs of pulmonary disease are usually lacking, except in severe cases. There may be diminished expansion of one side. Inouye finds retraction of the chest, especially in the infrascapular region, among the most common signs. This is due to pleuritis. Slight dulness, an increased sense of resistance, diminished vesicular or broncho-vesicular breathing, and dry or moist rales may be found. The signs of cavity formation are seldom present. A patchy distribution of the pulmonary signs is suggestive of the disease. The temperature is usually unelevated. Night sweats are uncommon.

Complications.—Infection of the brain by the worms or their eggs appears to be one of the most common and serious complications. Among Inouye's 92 cases, 3 showed cerebral symptoms (headache, vertigo, weak memory), 2 epilepsy, and 1 epilepsy and left hemiplegia. Inouye has collected 19 cases with cerebral symptoms. Among them, 8 had general and 6 unilateral (2 right- and 4 left-sided) spasms. Five had hemiplegia. Paresis of the right arm, color ring, vertigo, psychic blindness, etc., were also observed. It seems probable that the eggs reach the brain as emboli, gaining entrance to the circulation through a pulmonary vein. The presence of worms in the brain, as

in Otani's case, is unexplained. In rare instances the worm has been found in the eyelid, where the resulting tumor may obstruct vision Cases of hepatic cirrhosis with ascites have been described in which eggs of the pulmonary distoma were found in the interstitial tissue of the liver, but the eggs may have been coexistent with cirrhosis from another cause.

Diagnosis.—This is usually easily made from the presence of the eggs in the sputum. A mass of the fresh material should be pressed in a thin layer between slide and cover-glass and examined with the low power of the microscope. The presence of Charcot-Leyden crystals alone is strongly suggestive of the disease in patients who live in infected regions and careful and repeated search for the eggs should be made. In cases in which no sputum can be obtained, as in young children or the aged, search for the eggs in the stools may be successful. The eggs of Bothriocephalus latus should then be carefully differentiated from those of the lung-fluke.

Pulmonary distomatosis may closely simulate tuberculosis and the two diseases may be combined. In the former, pulmonary changes are less often found at the apices, the sputum is more likely to be brown in color, frank hemoptysis is less frequent, the disease is more often afebrile, and the nutrition is less disturbed. The presence of eggs or tubercle bacilli in the sputum may establish the diagnosis of one but does not exclude the other.

Prognosis.—This is usually good for the uncomplicated pulmonary form, which may last from a few to twenty or thirty years. The viability of the worms is unknown but it is probable that such protracted cases are due to repeated infections. It is said that the disease gradually subsides, if the patient leaves an infected region. The prognosis of the cerebral form is serious.

Prophylaxis.—Reliable preventive measures cannot be formulated until the life-history of the parasite is established. Until then the following precautions may be observed: An infected region may be avoided. The sputum of infected individuals should be expectorated into a special receptacle, which should then be burned. Infected animals (dogs, cats, swine) should be killed. Bathing should not be practiced in infected streams, drinking water should be filtered or boiled, green vegetables should be thoroughly washed, and snails and fish should be thoroughly cooked, when used for food.

Treatment.—There is no specific treatment. When possible, patients should leave an infected region. If the site of the disease can be located, surgical interference may be considered. The usual superficial site of the pulmonary infection is of favorable moment but great care should be taken not to infect an intact pleura. The operative technique may well be that for pulmonary abscess or gangrene. Pleural pain and hemoptysis should be treated by rest and such other measures as are elsewhere described for these symptoms.

Hepatic Distoma.—An instance of pulmonary invasion by a species of liver fluke is reported by De Gouvêa.[1]

OTHER PARASITES.

Strongyloides.—Gage[2] found a few filariform larvæ in the sputum and enormous numbers of rhabditiform larvæ of Strongyloides intestinalis in the stools of a patient who later came to postmortem examination. The lungs showed numerous areas of bronchopneumonia. The intestinal mucosa was everywhere deeply injected and showed extensive, superficial ulceration. The mucus from the duodenum contained large numbers of adult worms, active rhabditiform larvæ, and numerous eggs. Adult worms, larvæ, and eggs were found in the intestinal wall. Larvæ were present in lymph spaces and lymph vessels of the intestine, and two larvæ were found in the lung by means of serial sections. Gage suggests that invasion of the lung may occur by entrance into the lymph channels of the intestine, thence into the thoracic duct, the subclavian vein and the blood stream, and that swallowed larvæ may develop into adult worms.

Strongylus Longevaginatus.[3]—This is reported once in the lungs of a girl, aged six years.

Uncinaria.—Richard[4] found larvæ of the hook-worm in the sputum from a patient with bronchitis.

Ascaris.—Lucksch[5] reports the case of a man shot in the upper abdominal region. Death followed fifteen days later. At autopsy one ascaris was found on the left side and another on the right in branches of the pulmonary artery. It seemed probable that the worms had emerged from a hole in the common bile duct and entered an opening in the inferior vena cava, thus gaining entrance to the venous circulation.

Cysticercus Cellulosæ.—Infection of the lungs with larvæ of the tenia solium is rare. Kühn[6] collected seven cases and added one of his own. From three to sixteen of the parasites have been demonstrated in the lungs. Other organs also are usually infected. The lungs may be free and yet large numbers may be present in other parts of the body. Infection may take place by the entrance of a segment or ova of the tape-worm into the stomach through the pylorus or cardia.

Cercomonas.—Litten[7] found cercomonas (monas lens) in the sputum and the pleural exudate from a patient with pleurisy with effusion and pneumothorax. Tubercle bacilli were also present in the sputum. Litten refers to an observation by Kannenberg in which cercomonas was found in lung gangrene.

[1] Hilario de Gouvêa, La Distomatose pulmonaire par la Douve du Foie, Paris, 1895.
[2] Jour. Med. Research, 1910, xviii, 177.
[3] Diesing, Systema Helminthum, 1851, ii, 317.
[4] Postgrad., New York, 1909, xxiv, 475.
[5] Askariden als Emboli in der Lungenarterie, Wiener klin. Woch., 1905, No. 15, p. 377.
[6] Cysticerkus cellulosæ in den Lungen, Inaug. Diss., Leipzig, 1905.
[7] Berl. klin. Woch., May 3, 1886.

CHAPTER XXVI.

TUMORS OF THE BRONCHI AND LUNG.

BENIGN TUMORS OF THE LUNG.

These are of little clinical interest, and occur only in very rare instances, being usually first discovered at the postmortem examination. *Fibromata* have been described as small, discrete masses, varying in size from a millet seed to a hazel nut. They are usually peribronchial and are probably the result of inflammatory processes. Ferkel[1] reports a case of fibromyoma in the apex of the left lung the size of a lemon. *Osteomata* are also occasionally seen as rounded nodules, seldom exceeding the size of a pea or more commonly as masses of irregular shape with jagged projections. An unusual instance is reported by Port and referred to by Virchow.[2] In this case, a more or less circumscribed tumor-like mass the size of the fist occupied the right upper lobe. A large elongated bony projection extended from it toward the root of the lung, and several isolated smaller nodules were found in the upper and lower lobes. In Cohen's[3] case, there was a diffuse formation of bone in the greater part of the right upper lobe. A distinction should be made between calcareous deposits in pathologic tissue and true osteoma. *Lipomata* are very uncommon, but may be seen as globular masses of fatty tissue in the interlobar or subpleural region. Primary cartilaginous tumors, with or without an apparent relation with the bronchi, have been reported by Wagner,[4] Virchow,[5] Lesser,[6] Hart,[7] Lakin,[8] and others. In Hart's two cases the complicated mixed structure of the growth justified the term "Adeno-fibro-lipo-chondroma myxomatosum."

Dermoid cysts, primary in the lung, occur only in very rare instances. They are more common, but still rare, as mediastinal growths which in their development may encroach upon or develop at the expense of the pulmonary space. Atelectasis, venous thrombosis, and dislocation of the heart have been observed. Degenerative changes in the cyst may lead to inflammation in its neighborhood. Perforation into the

[1] Zeit. f. Krebs-Forschung, 1909–10, vol. viii.
[2] Die krankhaften Geschwülste, Bd. ii, p. 102.
[3] Ein Fall von diffuser Knochenbildungen in der Lunge, Virchow's Arch., 1885, ci, 156.
[4] Arch. f. Heilkunde, 1861, Bd. ii.
[5] Die krankhaften Geschwülste, Berlin, 1863, Bd. i.
[6] Virchow's Arch., 1877, Bd. lxix.
[7] Die primären Enchondrome der Lunge, Zeit. f. Krebs-Forschung, 1906, vol. iv.
[8] Arch. Middlesex Hosp., 1912, xxv, 37.

lung and communication with branches of the bronchial system was noted in 14 of the 44 cases collected by Dangschat.[1] Coincident cavity formation in the lung may or may not exist. The disease may occur at any age, but is more common before thirty. It is slowly progressive, lasting usually over two years. A duration of five, ten, twenty and even more than forty years has been observed. The finding of hairs in the sputum is the most important diagnostic feature. These may persist for many years. The symptoms and physical signs do not differ essentially from those with mediastinal or pulmonary tumors from other causes. Local prominence of the chest, in which at times fluctuation may be determined, is important. Extirpation or drainage is the only successful treatment. Katase[2] reports an instance of teratoma of the lung, and finds six other cases in the literature.

MALIGNANT TUMORS OF THE BRONCHI AND LUNG.

Malignant tumors of the lung are usually secondary, rarely primary. The primary tumors may be cancer or sarcoma. Adler[3] has written at length on this subject and reviews the literature.

Primary Cancer of the Lung.—Incidence.—In the combined statistics of Reinhard,[4] Fuchs,[5] Wolf,[6] Pässler,[7] and Fröhlich[8] among 46,169 autopsies primary cancer was found in only 105 (0.22 per cent.) or once in about every 500 sections. Among 1000 malignant tumors (870 cancer, 130 sarcoma), analyzed by Pässler, were 16 cases of cancer and 4 of sarcoma primary in the lung, thus indicating an incidence of 1.6 per cent. of all malignant tumors and 1.83 per cent. of all cancers for primary cancer of the lung.

Etiology.—The cause of cancer of the lung is as little known as that of similar growths elsewhere. Trauma has been thought to induce the disease, and a history of injury to the chest can be obtained in a certain number of cases, but their proportion is too small to suggest that this is a significant factor. It is possible that more importance may be ascribed to local irritation. The coincidence of pulmonary cancer and tuberculosis has not infrequently been observed. Thus Wolf[9] found 13 of 31 cases of primary pulmonary cancer complicated with tuberculosis, which he was disposed to regard as a probable

[1] Beiträge zur klinischen Chirurgie, Tübingen, 1903, vol. xxxviii.
[2] Cent. f. allg. Path. u. path. Anat., 1912, xxiii, 146.
[3] Primary Malignant Growths of the Lungs and Bronchi, Longmans, Green & Co., 1912.
[4] Der primäre Lungenkrebs, Arch. f. Heilk., 1878, xix, 369. Cancer and sarcoma are not differentiated by Reinhard.
[5] Beiträge z. Kenntniss der Geschwulstbildungen in der Lunge, Diss. München, 1886.
[6] Die primäre Lungenkrebs, Fortsch der Medicin, 1895, No. 18, Bd. xiii, p. 725.
[7] Ueber das primäre Carcinom der Lunge, Virchow's Arch., 1896, cxlv, 191.
[8] Ueber das primäre Lungenkarzinoms, Inaug. Diss., Berlin, 1899.
[9] Fortschritte der Med., 1895, xiii, 725 and 765.

cause in 8 cases. Lenhartz[1] found tuberculosis in 3 of 14, Dömeny[2] in 4 of 10 cases and Watsuju[3] in 3 of 6 cases. Watsuju found metaplasia of the ciliated epithelium in the region of the larynx (twice), the trachea (once), and the bronchus (twice) into flat epithelium in 3 of 30 tuberculous bodies which he examined. In one of the cases, he noted slight proliferation of the lowest layers of cells and extension through the basement membrane of isolated cell clusters. In rare instances, carcinoma has been found developing in a tuberculous cavity, among others by Friedländer,[4] Schwalbe,[5] Wolf,[6] and Perrone.[7] Previous local lesions, such as simple, tuberculous or syphilitic ulcers in the region of the primary bronchi or their branches, extension to the bronchi of glandular mediastinal suppuration, or pigment perforation may serve as predisposing factors in the development of bronchial cancer, just as gastric ulcer or gall-stones is occasionally followed by cancer of the stomach or bile passages.

Males are more frequently affected. Of 68 cases in Pässler's series, in which the sex was known, 50 (73 per cent.) were males. It is unusual for the disease to develop before the fortieth year. Only 6 of 66 cases were under forty, while 27 were sixty or over.

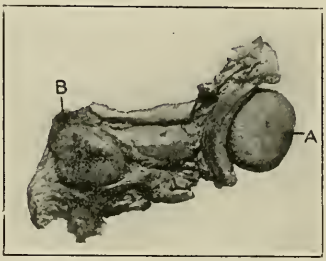
Pathology.—In general, the right lung appears to be more often involved. In Pässler's series, the region of the tracheal bifurcation was affected in 5 cases, the disease extending thence into the left primary bronchus in one, into the right in two instances. The right lung was the site of the growth in 35, the left in 24 and both in 9 cases. None of the lobes can be regarded as specially disposed to cancer. The upper and lower lobes are subject to the development of primary growths with about equal frequency. Involvement of the apex may be observed, as in Kasem-Beck's[8] and Schröder's[9] cases.

The gross appearance is very variable, but a relation with the bronchial system is a striking feature in a large proportion of cases. A single, small, rounded tumor mass may in rare instances be found projecting into one of the larger or smaller bronchi, and partially or wholly occluding its lumen. In one of the Massachusetts General Hospital cases (Autopsy 984), a circumscribed, spherical carcinoma about 1 cm. in diameter, was discovered in the lower part of the upper lobe of the right lung. This was found on microscopic examination to occupy the lumen of a small bronchus and to be made up principally of cuboidal and columnar cells, in places forming imperfect tubules and apparently taking its origin from the bronchial mucous

[1] Ebstein and Schwalbe, Handbuch der prakt. Med., 1899.
[2] Zeit. f. Heilkunde, 1902, Bd. xxiii, Abt. f. path. Anat., H. 4.
[3] Zeit. f. Krebs-Forschung, 1904, i, 445.
[4] Cancroid in einer Lungenkaverne Fort. d. Med., 1885, Bd. iii, No. 10, Ref.
[5] Entwickelung eines primären Karzinoms in einer tub. Kaverne, Virchow's Arch., cxlix, 329.
[6] Loc. cit.
[7] Cancroid in einer tub. Lungenkav. in Orth Festschrift, Berlin, 1906.
[8] Zentralbl. f. innere Med., No. 12, 1908.
[9] Deut. Aerzte-Zeit., Berlin, 1906, p. 313.

glands. Some tumor cells could be seen infiltrating the neighboring alveoli, but no metastases were found. The new growth is seldom discovered at such an early stage. In a second case (Autopsy 2503, see Fig. 70), a small tumor projecting into the bronchial lumen had already metastasized with a neighboring gland. It is more common in this predominant bronchial group to find that the primary growth infiltrates the bronchial wall and encroaches on its lumen for a considerable distance. The projection into the bronchial lumen may be intact or ulcerated. Extension of the tumor is likely to take place by way of the bronchial wall and to outline the bronchial divisions as it spreads from its point of origin. In places, the radial arrangement is less striking, and the pulmonary parenchyma is also invaded to a greater or less extent. Small or large, discrete or confluent tumor nodules or masses may thus arise, many or few of which may be seen to surround the bronchi. In a small proportion of the cases, the bronchi appear to take only an insignificant part in the process, and

FIG. 70



Carcinoma (*a*) of bronchus with metastasis into neighboring lymph gland (*b*) (actual size). (Dr. Oscar Richardson.)

the pulmonary parenchyma is predominantly affected. The new growth is usually white, grayish or grayish-yellow in color, and hard or firm in consistency. Dense, resistant masses are more especially to be found at the root of the lung. Primary or secondary tumors developing within the lung substance may be softer and even marrow-like in character. Secondary degenerative changes are not uncommon. Fatty degeneration, softening and ulceration of the centre of a growth communicating with the bronchi may result in the formation of cavities, with irregular, shreddy walls. Infection through the bronchi is in part responsible for regressive changes. Hemorrhage from the eroded surface is common.

The condition of those parts of the lungs unaffected by the new growth is variable. In some instances there are no noteworthy changes. There may be emphysema. Atelectasis may occur in compressed regions. Acute inflammatory processes, bronchopneumonia, less often lobar pneumonia, abscess, and gangrene may complicate the disease. Chronic pulmonary lesions of a tuberculous or non-tuber-

culous character, may be found. They may precede or follow the new growth. Partial occlusion of a bronchus may give rise to stagnation of secretion beyond the site of the obstruction. Infection of the bronchial wall and the lung may then lead to bronchiectasis, single or multiple pulmonary abscesses and interstitial pneumonia. Bacterial or cancerous invasion of the pleura may cause adhesive, fibrinous, serofibrinous, hemorrhagic or purulent pleurisy. Pneumothorax is observed only in rare instances.

Metastases were absent in only 11 of 74 cases analyzed by Pässler. In the remaining 63 cases, the regional lymph glands were the most common site of secondary deposits and were affected in 40. The lung was secondarily involved in 31, the liver in 23, the pleura in 19, the bones in 12 and distant lymph glands and the kidney in 8 each, while the larger vessels of the thoracic cavity (the venæ cavæ, pulmonary arteries and veins) in an equal number. The spleen and adrenal were each involved in 6 instances. Metastases may occur in almost any region of the body. Among the remaining regions, metastases in the brain in 5 and the skin in 2 cases may be mentioned. Metastases in the mediastinal lymph glands may give rise to compression or thrombosis of the mediastinal veins, with resulting stasis, and to compression and invasion of the esophagus, trachea, and recurrent laryngeal nerves. The new growth may invade the heart muscle or the pericardium. An exudative pericarditis may result. Extension through the intervertebral foramina into the spinal canal has caused transverse myelitis.

On microscopic examination, cylindrical-celled cancer is the prevailing type, but polyhedral cells are usually also found to compose a variable proportion of the cells, and may predominate in the sections. Flat-celled epithelial cancer is less commonly observed. In this group, cornification is occasionally seen.

Concerning the histogenesis of pulmonary cancer, much difference of opinion has prevailed, and the question cannot yet be regarded as settled. The appearance and arrangement of the cells in the cylindrical-celled cancer suggest its origin from the epithelium of the bronchial mucous membrane or the bronchial mucous glands. An origin from the bronchi appears to be sufficiently established by the occcasional finding of small tumors within and not exceeding the limits of the bronchial structures, and the special disposition of a large majority of all primary lung cancers to develop in or along the bronchi or their divisions. The predominance of the cylindrical-celled type of cancer is still further confirmation of such an origin. Among Pässler's series of 54 cases, the primary source appeared to be the bronchi in at least 47 (87 per cent.). The histogenesis of the flat-celled epithelial cancer is less clear. This form may be regarded as taking its origin from the alveolar or the bronchial epithelium by a process of metaplasia. The morphologic similarity between flat epithelial cancer cells and alveolar epithelium may be urged in support

of an origin from the alveoli, while the finding of apparent transitions from normal cylindrical bronchial epithelium to flat cancer cells, the occasional presence of cornification and epithelial perles may be urged in favor of a bronchial origin.

The spread of cancer of the lung, as was first shown by Stilling,[1] takes place principally by way of the lymph vessels in the walls of the bronchi and the bloodvessels, and by way of the bronchi themselves. A cancer primary in the wall of a bronchus invades and further develops within its lumen, through which it finds its way into the pulmonary alveoli. Extension by continuity is probably unnecessary and, as Pässler has suggested, tumor particles may be carried by aspiration from the region of the hilus of the lung to the finer branches of the bronchi, where they lead to secondary nodules apparently developing in the pulmonary parenchyma. Pulmonary cancer appears to enlarge by proliferation of cells composing the tumor itself (central growth) rather than by the transformation of peripheral and non-cancerous into cancer cells (peripheral growth).

Lymphatic invasion, with extension to the bronchial and mediastinal lymph glands, takes place after a certain period in the development of all pulmonary cancers. In rare instances, however, cancerous lymphangitis, involving a part or the whole of one lobe or of one or both lungs, becomes so striking a feature as to justify the term *miliary carcinosis*. When the subpleural lymphatics are affected, they may appear as a coarse grayish-white network, on the surface of the lung, outlining the perilobular, periacinous, and perialveolar lymphatics. On cross section, the injected pulmonary lymph vessels appear as fine, miliary, grayish granulations which may be readily overlooked or confused with miliary tubercles, their true nature at times first becoming apparent on microscopic examination. Larger or smaller nodules or masses of cancer may be associated. Pulmonary carcinosis is more commonly observed in secondary than in primary lung cancer. When generalized, it may arise by retrograde infection of the lung from the mediastinal glands, as suggested by Girode.[2]

Primary Sarcoma of the Lung.—This is much less common. The following report is based on 42 cases[3] of certain or probable primary sarcoma.

[1] Ueber primären Krebs der Bronchien und des Lungenparenchyms, Virchow's Arch., Bd. lxxxiii, p. 77.

[2] Lymphangite cancéreuse pleuropulmonaire sans cancer du poumon., Arch. gén. de méd., Janv., 1889.

[3] Poisson et Robin. (Gaz. méd. de Paris, 1856, No. 9.) Demange. (Rev. Méd. de l'Est., Août, 1875.) Chiari. (Anz. d. Gesellschaft der Aerzte in Wien, 1878, No. 6.) Reinhard. (Arch. d. Heilkunde, 1878, vol. xix, second case.) Weichselbaum. (Virchow's Arch., Bd. lxxxv, p. 559.) Blumenthal. (Primäre maligne Lungentumoren, Inaug. Diss., Berlin, 1881.) Rütimeier. (Korrespondenzbl. f. Schw. Aerzte, 1885, p. 576.) Fuchs. (Inaug. Diss., München, 1886); two cases (I and II). Hildebrand. (Zwei Fälle von primären malignen Lungentumoren im Anschluss an Tuberkulose, Inaug. Diss., Marburg, 1887.) Origin from lung or bronchial lymph glands somewhat doubtful. Schech. (Deut. Arch. f. klin. Med., 1890–91, xlvii, 411.) Spillmann and Haushalter. (Gaz. hebd. de méd. et chir., December 5, 1891.) Thought to originate in

Etiology. — Etiologic factors are uncertain. The ages of the reported cases vary from three to seventy-eight years. Sarcoma is much more common at an early age than cancer. In the first decade, only two cases are recorded. Two cases were from ten to twenty, 9 from twenty to thirty, 5 from thirty to forty, 5 from forty to fifty, six from fifty to sixty, 4 from sixty to seventy, and 5 from seventy to eighty. Thus in this series, nearly two-thirds were under forty. Males are more commonly affected, numbering 25 of the 38 cases in which the sex is given.

A remarkable endemic malignant disease of the lungs is described by Härting and Hesse[1] among the workers in the Schneeberger mines. Of about an average number of 650 men employed, 63 were affected between 1869 and 1871, 47 from 1872 to 1874, and 40 from 1875 to 1877. About 75 per cent. of the deaths from all causes were due to this. The disease should be classed not as carcinoma, but as lymphosarcoma, and appeared to take its origin from the bronchial lymph glands. Its earliest appearance was after twenty years, rarely after fifty years of service in the mines. The cutters were earliest affected. The disease is ascribed to the irritating effect of inhaled arsenic in combination with cobalt. Arnstein[2] reports as the result of the examination of postmortem material from two cases that the condition in one proved to be chronic tuberculosis and in the other pulmonary carcinoma, in many places showing a sarcoma-like structure. Of three other cases reported to him by Schmorl, one proved to be pavement-celled carcinoma, and the two remaining cases round-celled sarcoma.

Pathology.—Pulmonary sarcoma usually occurs as small or large multiple and isolated or solitary tumors, varying in size from a hen's

the lung but may have come from the pleura. Braureuter. (Inaug. Diss., München, 1891.) Origin from bronchial lymph gland at the root of the lung. Vandervelde. (Jour. de méd. chir. et pharmacol., Brux., 1892, xciv, 193.) Ranglaret. (Bull. soc. anat., 1893, p. 591.) Origin undertain. Raymond. (Ibid.) Ferrand. (Bull. et mém. soc. méd. d'hôp. de Paris, 1893, s. S, x, 796.) Habershon. (Trans. Path. Soc., London, 1897, 8, xlix, 17.) Pollak. (Ein Fall von prim. Lungensarkom., Inaug. Diss., Würzburg, 1897.) Milian et Bernard. (Bull. soc. anat., 1898.) Hellendahl. (Zeit. f. klin. Med., 1899, Bd. xxxvii.) Schnick. (Inaug. Diss., Greifswald, 1899.) Meyer. (Beitrag zur Casuistik der prim. Lungensarugcome, Ina. Diss., München, 1900.) Milian et Mauté. (Bull. soc. anat., Janvier, 1901.) Lewit. (Inaug. Diss., Erlangen, 1901.) Baumann and Bainbridge. (Trans. Path. Soc., London, 1902–03, liv, 150.) Rolleston and Trevor. (British Med. Jour., 1903, i, 361.) Clement. (Lyon méd., 1904, cii, 630.) Kobylinski. (Ueber prim. Sarkome in der Lunge, Inaug. Diss., Greifswald, 1904.) Two cases. Roth. (Ueber primäres Lungensarkom. mit einem kasuistischen Beitrag, Inaug. Diss., München, 1904.) Broc. (Bull. et mém. Soc. anat. de Paris, 1905, lxxx, 90.) Schmidt. (Cor.-Bl. f. Schw. Aerzte, Basel, 1905, xxxv, 53–55.) Pater et Rivet. (Arch. de méd. exp. et d'anat. path., Paris, 1906, xviii, 85–101.) Eckersdorff. (Centralbl. f. allg. Path. u. path. Anat., 1906, xvii, 355.) Two cases. Delporte et Guibal. (Arch. de méd. et pharm. mil., Paris, 1907, i, 286.) Curl. (British Med. Jour., 1908, i, 1408.) Lehndorff. (Wien. med. Woch., 1909, xxii, 1053.) Boschowsky. (Frankfurter Zeit. f. Path., 1911–12, ix, 239.) Steven. (Amer. Jour. Med. Sci., 1912, cxliv, 193.) Bergé et R. J. Weissenbach. (Bull. et Mém. d. la soc. Anat. d. Paris, 1912, lxxxvii, 210.)

[1] Der Lungenkrebs, die Bergkrankheit in den Schneeberger Gruben, Vierteljahrschrift für Gerichtliche Medicin und öffentliches Sanitätswesen, 1879, xxx u. xxxi, 296.

[2] Verhandl. d. deut. path. Gesellsch., 1913, xvi, 332.

egg to an infant's head. The large, single tumors are somewhat more common. In some instances, a diffuse growth uniformly infiltrates the tissue. The disease is more common on the left side as in 24 of this series. The right side was involved in 14, both lungs in 4 cases. The disease shows no striking disposition to invade one lobe more than another. A location in the left lower or right upper lobe, singly or combined with other regions, was somewhat more common than elsewhere. The tumors are rather soft than hard, and of a whitish, grayish, or reddish color. Metastases are found in the lung, the bronchial, mediastinal, or other glands. The bronchial and mediastinal glands are most often affected, but secondary deposits may be found in any organ of the body. In general it may be said that metastases appear to be less common with pulmonary sarcoma than with cancer, while growth by extension is more frequent. In rare instances, the sternum, ribs or vertebræ are eroded. Fatty degeneration, suppuration, and cavity formation are not infrequently observed. Calcification and ossification of a part of the tumor is occasionally seen. Complicating lesions in the lung, the pleura and other nearby or remote organs do not differ essentially from those with pulmonary cancer.

Various histologic types of sarcoma are represented in the pulmonary form of the disease. Round-celled sarcoma is more common than other forms. The cells may be small or large. Spindle-celled sarcoma stands next in frequency. Giant-celled, lympho-, myxo- and fibrosarcoma are occasionally observed. A papillary adenosarcoma was found in one instance. The growth probably takes its origin from the peribronchial lymphatic or connective tissue.

Symptoms.—The clinical features of pulmonary cancer and sarcoma are practically the same. The two diseases are therefore considered together in the following description.

The manifestations, their grouping and progress are so variable in different cases that it is difficult to construct a typical clinical picture. In a number of the cases, however, a patient in previous good health begins to cough, at first without expectoration. The cough is constant and harassing, and later accompanied by a scanty mucoid or mucopurulent sputum in which at times bloody streaks or masses are noted. The general health may be little if at all disturbed. Sooner or later, there is dyspnea, at first only after unusual exertion, but gradually increasing in duration and intensity until it becomes constant and distressing. Pain of slight degree is common, and is usually referred to the axillary region, but may be felt in the sternum, shoulder or abdomen. It is seldom a prominent feature. A troublesome sense of intrathoracic discomfort or pressure is frequent. With the progress of the disease the general condition suffers. Loss of weight and strength may be progressive. The appetite fails. Cough and dyspnea may become paroxysmal. Orthopnea is not infrequent. Night sweats are uncommon. Death may take place from asthenia, in an attack of suffocation, from hemorrhage, a complicating infection, or metastases.

Cough is usually an early symptom, but may be absent throughout in rare instances. Dyspnea may be the first symptom and is usually a prominent and progressive feature. It is more troublesome with rapidly growing tumors, those complicated by pleural effusion, or when the new growth compresses or invades the trachea or larger bronchi. Involvement of the larger tubes may cause stridor.

Pain is common, but not usually severe unless the pleura is involved. It may then be intense. Fever of an irregular or intermittent type may be present, and was noted in 19 of Fränkel's[1] 35 cases of malignant lung tumor. It may be due to secondary infection or absorption of toxic material. In a small proportion of the cases there are important localizing symptoms referable to extension or metastasis into the mediastinum. Compression of the esophagus or recurrent laryngeal nerve may cause dysphagia or hoarseness. Involvement of the vagus, the phrenic or sympathetic nerves is also probable, but is thus far not indicated in the clinical histories of the reported cases. Extension to the spinal cord through the intervertebral foramina may cause transverse myelitis. Symptoms referable to metastases in other organs, as in the brain, may in rare instances complicate the clinical picture. If cerebral symptoms are an early feature they may mask the pulmonary disease, as in Pässler's[2] patient, a man aged sixty-three years, who had right-sided hemiplegia. His pulmonary symptoms were regarded during life as postapoplectic, but proved at postmortem examination to be due to primary lung cancer. The cerebral lesions were metastatic.

Physical Signs.—In general, the cases may be divided roughly into two groups. In the first and larger group, the physical signs are for the most part referable to the lung within which the disease develops, extending peripherally toward the pulmonary surface, at times into the pleura. In the second and smaller group, the root of the lung is primarily affected, the disease extending thence into the lung, the mediastinal glands or both. In this class, the physical signs are principally due to the enlarged mediastinal glands.

In the *pulmonary form* of the disease, examination of the lungs may be negative, if the tumor is centrally placed. Unequal respiratory motion of the two sides of the chest may be observed. Over the site of a process which reaches the periphery or secondarily involves the pleura, the intercostal spaces may be narrowed or fuller and wider than normal. There is dulness or flatness, a sense of resistance, diminished or absent tactile fremitus, voice and whispered sounds, and respiratory murmur. Rales are absent in uncomplicated cases.

New growths at the *root of the lung*, with extension or metastasis to the mediastinum may be indicated by dulness over and for a variable but usually only short distance to either side of the upper sternal region in front and the upper dorsal spines behind. Atypical

[1] Spec. Path. u. Ther. der Lungenkrankheiten, 1904. [2] Loc. cit., Case III.

murmurs due to compression of the great mediastinal vessels may occasionally be heard. Partial occlusion of a main bronchus may be suggested by the presence of a peculiar bronchial murmur, heard to one or the other side of the spinal column at the level of the hilus of the lung, and due to narrowing of the air current as it passes the obstruction. It is spoken of by the French as "Cornage." An interesting variation in the physical signs on the part of the lung may be suggestive. Dulness or dull tympany, with faint bronchial or absent breathing, discovered over a certain pulmonary territory, may change its degree and extent from time to time, as in the cases described by Grünwald,[1] Fränkel and others. The dulness and diminished breathing are due to occlusion of a bronchus supplying the affected region, with consequent atelectesis of the lung. Relief of the obstruction through ulceration of the tumor mass or eccentric pull of contracting connective tissue may be followed by the reëntry of air and inflation of the lung. The repeated closing and opening of the bronchus are followed by the appearance, modification or disappearance of the signs.

Inequalities of the radial pulses may be determined. Tracheal tug may be demonstrated, but less often than with aortic aneurism. It may be due to transmission of pulsations from the aorta to a primary bronchus through an intervening and enlarged gland, as in Auerbach's[2] case, with metastases into the mediastinum from a carcinoma of the stomach. Adhesions between the aorta and the trachea or bronchi in consequence of glandular involvement may likewise be a cause. Thoracic pulsation may occasionally be observed, especially in the upper sternal region. It is usually due to transmission of impulses from the aorta to a tumor mass in apposition with it and the chest wall.

Dilatation of the superficial veins is not uncommon. It may be due to compression or thrombosis of the mediastinal vessels. The venous dilatation is usually limited to the upper sternal and cervical region and may occur on one or both sides. The veins of the shoulder or upper abdomen may also be involved. Edema of the chest wall over the site of the new growth is occasionally seen. In Reinhard's case, the temporal veins were tortuous; the face, neck, arms and thorax as far as the attachment of the diaphragm were edematous. Cyanosis may also be noted. The heart may be displaced by a pulmonary or pleural tumor, with or without the presence of pleural fluid.

Metastases and cachexia are common to a certain proportion of both types of the disease. Metastases may occur in any part of the body, but in accessible regions in only a small number of the cases. Palpably enlarged lymph glands were noted in 8 (18.6 per cent.) of 43 cases collected by Angeloff.[3] Glandular invasion may affect the supraclavicular, the cervical or axillary glands. The left supraclavi-

[1] Münch. med. Woch., 1889, p. 548. [2] Deut. med. Woch., 1900, No. 8.
[3] Ueber das primäre Lungencarcinom Inaug. Diss., München, 1905, p. 46.

cular group are somewhat more often involved. General adenopathy may be seen in rare instances, as in Pater and Rivet's case of primary lung sarcoma. Cachexia may develop early or late, at times not at all in the course of the disease.

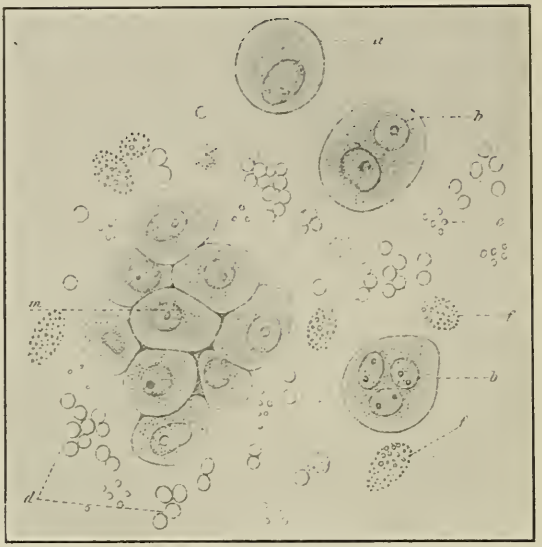
Sputum may be absent. When present, it is very variable in character and without distinctive features on macroscopic examination. It is usually scanty, mucoid or mucopurulent. An abundant purulent expectoration is occasionally seen in the later stages of new growths which have undergone necrosis and cavity formation. In such cases it may be foul. Blood is present in the sputum in from a third to a half of the cases. Repeated small amounts in streaks or masses are more common. Intimate admixture with blood may give the sputum a rusty color. Gelatinous, reddish sputum resembling currant jelly has been thought distinctive of malignant tumor, but is found in other conditions. It is present in only a small proportion with tumor. V. Criegern[1] found it in only 14 of 150 cases of malignant pulmonary disease. Frank and even fatal hemorrhage may occur. In one of Pässler's[2] cases, hemoptysis was an initial symptom and proved fatal in the last of three attacks on successive days. At the postmortem examination, it was found that a carcinoma of the right bronchus had eroded a branch of the pulmonary artery.

Tumor fragments have been found in the sputum from cases of primary pulmonary cancer by Claisse,[3] Menetrier,[4] and Weininger;[5] primary sarcoma by Feldt;[6] secondary cancer by Claisse,[7] Troisier[8] and Menetrier;[9] and secondary sarcoma by Hampelm,[10] Huber[11] and Feldt.[12] They are more likely to be found when the sputum is bloody and are probably commoner than the small number of reported cases indicate. Secondary infection and necrosis of the tumor, however, may convert them into a conglomerate mass of degenerated cells and debris without characteristic structure. The search is more likely to be successful if the fresh sputum, mixed with normal saline solution, is examined in a flat glass dish with a black background and coherent balls or masses carefully teased apart. Bits of new growth, washed free of adherent blood and mucus, may then appear as reddish, grayish or whitish particles or shreds. In Hampeln's case with a giant-celled sarcoma of the lung secondary to an osteosarcoma of the leg, the pulmonary growth had invaded a primary bronchus, and masses as large as 5.5 cm. long and 2.5 cm. thick were expectorated. In Feldt's case, of round-celled sarcoma, particles scarcely 1 mm. in diameter satisfactorily demonstrated the histologic structure. Suspected

[1] Akute Bronchiektasie, Leipzig, 1903, p. 108.
[2] Loc. cit., Case III.
[3] Soc. méd. des hôp., January 6, 1899.
[4] Ibid.
[5] Zeit. f. Heilkunde, 1901, p. 78, Case II.
[6] Deut. med. Woch., July 9, 1903.
[7] Loc. cit.
[8] Ibid.
[9] Ibid.
[10] St. Petersburger med. Woch., 1876, No. 40.
[11] Zeit. f. klin. Med., 1890, xvii, 341.
[12] Loc. cit.

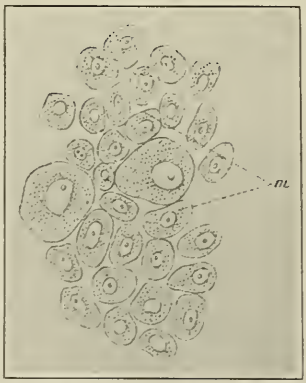
material should be hardened, cut and stained according to the usual method.

Fig. 71



Fresh sputum from a case of malignant disease of the lung: *a*, large mononuclear cell; *b* and *b*, polynuclear cells; *d*, red-blood corpuscles; *e*, fine fat drops; *f*, granular cell; *m*, large cell group. × 275. (Betschert.)

Fig. 72



Fresh sputum. Malignant disease of lung: *m*, cell group. × 275. (Betschert.)

Numerous isolated *cells or cell clusters* (Figs. 71 and 72) may also be found in the sputum from cases with pulmonary carcinoma, as in the cases described by Hampeln;[1] Japha,[2] Betschert[3] and others.

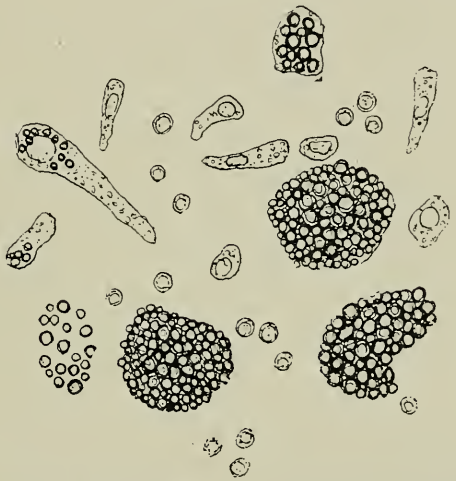
[1] Petersburger med. Woch., 1887, No. 17, and Zeit. f. klin. Med., 32, 1897, p. 247, q. v. for a discussion of the subject.

[2] Ueber prim. Lungenkrebs, Inaug. Diss., Berlin, 1892.

[3] Virchow's Arch., 1895, cxlii, 86.

Hampeln regards a sputum composed exclusively or for the most part of unpigmented, polymorphous, polygonal cells of variable size and with well-defined nucleus and nucleolus, isolated and in clusters, as distinctive of new growth. As he suggests, the normal squamous cells from the surface of the mucous membrane of the mouth, pharynx and larynx, the small polyhedral or cubical cells of the deeper layers of the air passages and the polygonal alveolar epithelium are found only in rare instances in the sputum, and then only in isolated examples. Lenhartz[1] ascribes a greater diagnostic importance to large, strongly refractive spherical bodies with coarse or fine, fatty granules ("Fettkörnchenkugeln." See Fig. 73).

FIG. 73



Refractive spherical bodies with coarse or fine, fatty granules "Fettkörnchenkugeln" (Lenhartz.)

Complications.—These are numerous and responsible for much of the complexity in the clinical picture. Bronchitis is frequent in the neighborhood of the new growth or over a wider area. Ulceration with consequent cavity formation may give rise to an abundant, purulent, foul sputum mixed with blood. Secondary infection of the lung may cause bronchopneumonia, abscess, gangrene, and pulmonary induration, and the clinical aspect may then be that of a suppurative process without evidence of malignant disease. Partial or complete closure of a bronchus may cause bronchiectasis beyond the point of the obstruction. Atelectasis may likewise be a consequence and result in retraction of the side, dulness, diminished or absent respiratory murmur, voice and tactile fremitus over the affected region. Such

[1] Ebstein-Schwalbe, Handbuch der praktischen Medizin, 2 Aufl., Bd. iv, p. 360.

signs were present in Körner's[1] case over the greater part of the right lung. At autopsy the right primary bronchus was found obstructed. The right lung was completely retracted and for the most part airless, but without inflammatory changes. Lobar pneumonia may complicate the disease and prove fatal.

Involvement of the pleura or pericardium is not uncommon. Pleurisy pain may be a distressing feature. An accumulation of fluid may aggravate the dyspnea and obscure the signs of underlying pulmonary disease. Evident pleural exudate which gave rise to more or less troublesome symptoms during life was noted in 8 of the 62 cases of primary lung cancer collected by Angeloff.[2] The exudate was serohemorrhagic in 6, serous in one, and purulent in the last case. Pneumothorax has not been observed.

Metastatic growths in regions remote from the lungs may lead to disturbances which dominate the clinical picture. Intracranial invasion may cause symptoms of meningitis, cerebral tumor or hemorrhage, the secondary nature of which may be first ascertained at autopsy.

Diagnosis.—This has been correctly made during life in only a few instances. The rarity of the disease, the consequent failure to consider it in obscure cases and the readiness with which it may be confused with more common conditions are largely responsible. The finding of tumor fragments in the sputum is the only distinctive sign. Of especially suggestive features may be mentioned the occurrence of such pulmonary symptoms as have been described in a patient past forty, without a family history of tuberculosis or known opportunity for contagion, with progressive failure of health and strength, bloody sputum, absence of fever, physical signs like those with encysted pleural effusion, and evidence of mediastinal pressure. In addition, a bronchial murmur heard to one or the other side of the spinal column over the lung hilus and a variation in the physical signs suggestive of successive closure and opening of a bronchus may be of importance. The discovery of enlarged glands in an accessible region and a negative tuberculin test will also be of assistance. The age of the patient has a certain bearing on the diagnosis, inasmuch as cancer develops before the fortieth year only in rare instances, while sarcoma occurs practically at any age. The much greater frequency of primary cancer may be taken into consideration, unless definite evidence of either cancer or sarcoma can be obtained.

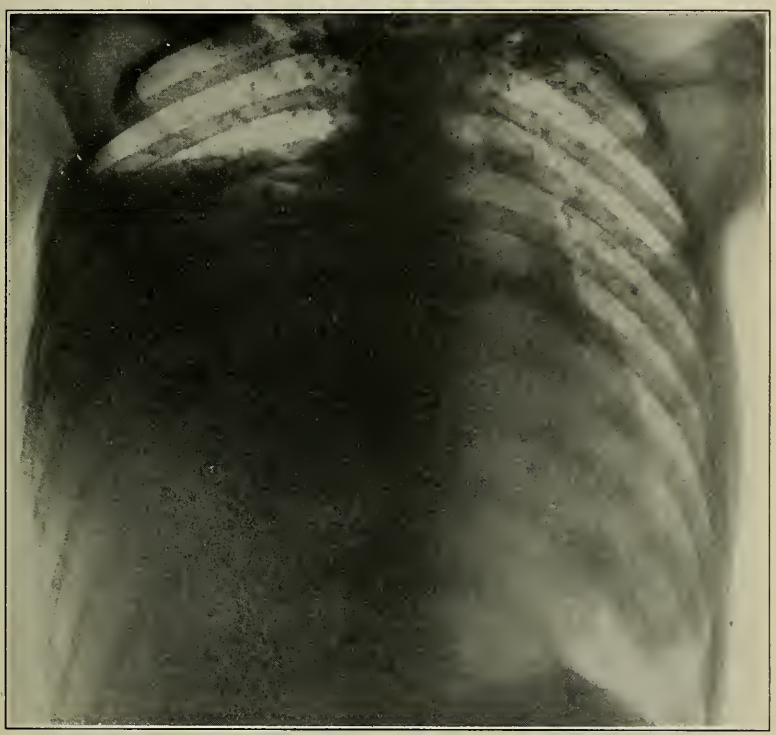
X-ray Examination.—This may be helpful when interpreted in the light of a careful clinical investigation. The location and extent of the new growth in the lung and the presence of metastases in the mediastinum may be determined. An unexpected central lesion may be found. The absence of a shadow at the apex when an upper lobe

[1] Ein Fall von primärem Krebs der grossen Luftwege mit sieben Wochen lang bestehender Obstruktionsatelektase d. ganz. rechten Lunge, Münch. med. Woch., 1888, No. 11.

[2] Ueber das primäre Lungencareinome, Inaug. Diss., München, 1905.

is involved may help in the differentiation between tumor and tuberculosis. It is especially in the new growths taking their origin from the hilus that the *x*-rays may be expected to be of most value. A dense shadow at the root of the lung with radial projections along the course of the larger bronchi toward the periphery is suggestive of primary cancer. Plates taken with the breath held in full inspiration will be found most satisfactory. The exposure may well be dorsoventral, ventrodorsal, and in various oblique positions. The fluoroscopic screen may also be used.

FIG. 74



Metastatic sarcoma. Spindle-celled sarcoma removed from lumbar region six years ago. Operation for local recurrence two years ago. Dense shadow occupying greater part of left side of chest. At right base two small nodules. Upper part of both sides studded with small nodules. Displacement of the heart to the right. (No. 186,393.)

Exploratory Puncture.—Positive results by this means have been obtained by Krönig[1] in a case of primary sarcoma, and Hellendahl[2] in two cases, one of primary and the other of secondary sarcoma. When in doubt as to the presence within the syringe of aspirated

[1] Diagnostischer Beitrag zur Herz- und Lungenpathologie, Berl. klin. Woch., 1897, vol. li.

[2] Ein Beitrag zur Diagnostik der Lungengeschwülste, Zeit. f. klin. Med., 1899, xxxvii, 435.

particles, Hellendahl recommends filling the instrument with normal salt solution which may then be shaken to dislodge the smallest fragments. The contents are then expelled and carefully examined. Or the syringe may be partially filled with normal salt solution before the puncture, and small particles prevented from clinging to the walls of the instrument. The material thus obtained may be hardened, cut, and stained. The method, undertaken solely for the purpose of diagnosis, cannot be recommended. Puncture of a lung, the site of new growth which has undergone ulceration, is not without danger. Instrumental injury of vascular tissue composing the new growth, or of vessels lining the walls or traversing the lumen of cavities may be the source of fatal hemorrhage. Fränkel[1] refers to an unfortunate experience of this sort. When an exploratory puncture has been made, however, for the purpose of evacuating pleural fluid, the opportunity of examining any particles obtained during the procedure should not be lost. Although the presence of malignant disease may be established in this way, it may always be a question whether the disease is primarily pulmonary or pleural. Both cancer and sarcoma may take their origin from the pleura as well as the lung.

Examination of pleural fluid obtained by puncture may suggest the diagnosis. Involvement of the pleura in the new growth is likely to give rise to hemorrhagic fluid of a type corresponding to the transudates. The specific gravity is likely to be 1018 or under. Desquamated endothelial cells from the free surface of the pleura may predominate in the sediment. Atypical cells, in few or many of which mitoses are observed, may afford important evidence. An abundance of spindle cells may establish the diagnosis.

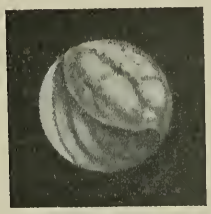
Some evidence of the intrathoracic conditions may be obtained during the puncture. The operator may note a sense of resistance as if the instrument were penetrating dense pleural or pulmonary tissue. It may be difficult or impossible to decide between pleural or pulmonary resistance, but the appearance of fluid only after deeper insertion through dense tissue suggests pleural, while a successful result only after partial withdrawal suggests pulmonary involvement. Unexpected, persistent dyspnea and oppression, dulness, and diminished or absent breathing after evacuation of pleural fluid may also be suggestive.

Bronchoscopy.—The successful bronchoscopic demonstration of a carcinoma is reported by V. Schrötter.[2] Several examinations were made. A flat, yellowish prominence was seen on the anterior wall of the right primary bronchus (see Fig. 75) at the first examination. During the course of about four months the tumor increased in size until it almost filled the bronchial lumen, leaving only a small slit posteriorly. Ulceration was not observed. Microscopic examination of fragments of the tumor obtained during the procedure showed

[1] Spez. Path. u. Ther. d. Lungenkrankheiten, 1904, p. 953.
[2] Zeit. f. klin. Med., 1907, vol. lxii.

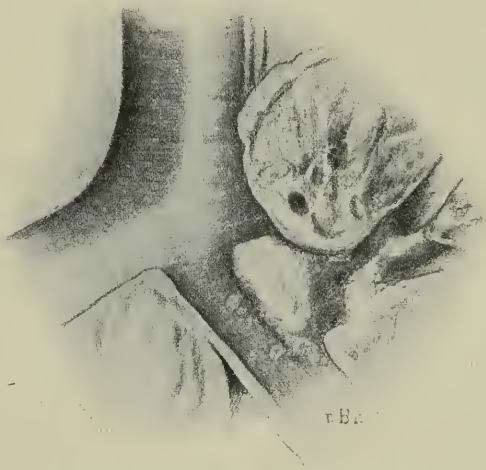
flat-celled carcinoma. At autopsy a cancer of the right primary bronchus with carcinomatous invasion of the right upper lobe was found. Bronchoscopy should not be performed by other than experienced hands and is even then not without danger. The possibility of aortic aneurysm must first be excluded.

FIG. 75



Bronchoscopic demonstration of carcinoma of right primary bronchus. (Schrötter.)

FIG. 76



Appearance at autopsy of carcinoma, seen by bronchoscopy, as shown in Fig. 75. Partial occlusion of right primary bronchus by tumor arising from point of origin of bronchus to the right upper lobe. (Schrötter.)

Of pulmonary conditions, primary malignant disease is most likely to be confused with tuberculosis. Cough, pain, dyspnea, bloody sputum, and a rapidly downward course may be present in both affections. In typical and uncomplicated cases, however, certain differences may be noted. A family history of tuberculosis or opportunity for contagion, hemoptysis or pleurisy as an initial symptom, cough with abundant purulent sputum, relatively slight dyspnea, without thoracic oppression, early and persistent fever of an intermittent type, night sweats, involvement of one or both apices, with

rales, dulness, bronchial breathing, increase of voice, whisper and tactile fremitus, certain or probable evidence of previous tuberculosis lesions elsewhere than in the lung, and a reaction to tuberculin are in favor of tuberculosis. With tumor, on the contrary, bloody sputum is more likely to appear late than early, and to be preceded by more severe and more rapidly progressive dyspnea. Intrathoracic oppression, cough, scanty, mucopurulent rather than abundant and purulent sputum, stridor, absence or late appearance of fever, night sweats only in rare instances, and a tendency to spare the apices are found with tumor. Over the involved region dulness only is common to both tumor and tuberculosis. With tumor the affected region may be flat and resistant, with diminished or absent breathing, voice, whisper and tactile fremitus, without rales. Enlargement of accessible lymph glands and the signs of mediastinal pressure are in favor of tumor. Repeated negative search for tubercle bacilli in the expectoration is of some moment in excluding tuberculosis. The finding of tubercle bacilli or tumor fragments will definitely settle the diagnosis. Tumor and tuberculosis at times coexist, and to prove the presence of the one does not necessarily exclude the other.

Degenerative changes in the tumor with cavity formation, stagnation of secretion in parts beyond an obstructed bronchus, bacterial infection resulting in abscess, gangrene, bronchiectasis and interstitial pneumonia may so obscure the presence of malignant disease as to make its detection difficult or impossible. Echinococcus cyst may also simulate malignant tumor.

In the presence of a mediastinal growth it may be difficult to decide whether this has arisen by metastasis into the glands from a primary tumor of the lung or is itself primary with or without secondary pulmonary involvement. Primary and independent mediastinal tumors are usually sarcomata, originating in the mediastinal connective tissue or lymph glands, the peribronchial lymph glands or the thymus. They tend to form more rapidly developing and extensive growths than the secondary cancerous or sarcomatous deposits in this region. A wider area of dulness of an irregular contour may therefore be expected. The progress of the affection is likely to be different, the first signs of disturbance being referable rather to the mediastinum than the lung. With pulmonary tumors, on the contrary, the onset is likely to be with dyspnea, cough, bloody sputum, pain from pleural involvement, and with signs of pulmonary or pleural invasion earlier in the course of the disease. Radiographs may show more extensive pulmonary involvement than can be determined by physical examination alone.

The same difficulty of deciding the point of origin obtains between pulmonary and pleural new growths. Early metastasis to the pleura from the lung may present the clinical picture of a primary pleural disease. It may in general be said of primary pleural tumors, however, that dyspnea and cough are not usually striking features at

first; bloody sputum is less often present, and then later in the disease, while the features of onset are like those with pleuritis. Pain is usually a prominent symptom. An accumulation of pleural fluid is almost constant.

Aortic aneurysm may simulate secondary as well as primary mediastinal malignant disease. Venous dilatation is more common and more marked with tumor. Metastases in accessible regions may be found. The site of the process, more uniform outline to the dulness, stronger systolic pulsation, thrill, murmurs, fluoroscopic and radiographic examination may make the diagnosis of aneurysm possible.

Prognosis.—This is unfavorable. The duration from onset to fatal termination is variable, but is usually under one year, over two years only in rare instances. In Hellendahl's case the duration was six years.

Treatment.—This is unsatisfactory. For the present, palliative measures alone can be considered. Heat or cold may be applied locally for the pain. Fixation may also be tried. Bromides may be of service. Resort must usually be made sooner or later to opium or its derivatives for the relief of a distressing and ineffective cough, pain or dyspnea. The removal of pleural fluid may temporarily relieve the symptoms. Repeated withdrawal may be necessary.

Surgical measures for malignant disease of the lung have been undertaken only in rare instances. In the present state of our knowledge, primary tumors are not detected at a sufficiently early stage to offer the hope of cure. The uncommon finding at autopsy of an isolated small primary tumor, without metastases, as in the Massachusetts General Hospital case previously mentioned, indicates that complete and successful operative removal is possible. In Haidenhein's[1] case a carcinomatous nodule the size of a hazel-nut was unexpectedly found in the wall of a bronchiectatic cavity, an extensive pulmonary resection having been performed for bronchiectasis. Surgical interference has been occasionally attempted for secondary malignant disease of the lung. The cases comprise for the most part sarcomata or chondromata secondary to growths in the thoracic wall. Tschekan[2] has collected 12 cases, including one of his own; 6 patients died within the first 24 hours of pneumothorax or collapse; 6 recovered from the operation. In the latter group, Krönlein's case is noteworthy. A secondary sarcoma of the lung, the size of a nut, was excised from the lung of a girl, aged eighteen years. The tumor twice reappeared in the scar and was operated, the patient dying, however, of generalization of the tumor seven years after the first operation. Excision of the middle and lower lobes for sarcoma has been unsuccessfully performed by Helferich.[3]

Little can be expected of *x*-ray treatment of deep-seated malig-

[1] Centralbl. f. Chir., 1901, Kongressberichte, p. 65.
[2] Allg. med. Central-Zeit., 21 Mai, 1904, p. 374.
[3] Deut. Congress f. Chir., 1898.

nant disease. Krukenberg[1] noted temporary improvement of the pulmonary metastases in a patient with fibrosarcoma under *x*-ray treatment.

Secondary Malignant Disease of the Lung.—This is much more common. Its greater frequency may be judged by Reinhard's[2] figures. Among 545 cancers[3] in various regions the lungs were secondarily involved in 74, while in only 5 cases was the disease primary in the lung.

Of 178 cases of cancer coming to autopsy at the Massachusetts General Hospital the lungs were secondarily invaded in 22 (12 per cent.) Pulmonary invasion may take place by infiltration from contiguity, by metastasis through lymph or bloodvessels, and probably also by inhalation when a primary growth communicates with the respiratory tract above. Secondary deposits in the lung may thus occur from primary malignant disease in nearby or remote parts of the body, but are more likely to arise in connection with a primary growth in neighboring organs, as from the stomach in 7 and the breast in 4 instances in this series. They may, however, complicate a malignant growth anywhere. The extent of the pulmonary involvement is very variable. There may be single or multiple nodular growths of small or large size. Diffuse invasion is less common. In rare instances, local or general cancerous lymphangitis (miliary carcinosis) occurs. Extension by continuity, as from a cancer of the breast is likely to give rise to most marked pulmonary involvement. The disease may then remain unilateral and localized. The pleura is usually extensively involved when the disease spreads through it to the lung from abdominal, mammary or mediastinal growths. A diffuse cancerous pleuritis, with or without the accumulation of serofibrinous or hemorrhagic fluid, is likely to follow. In rare instances, however, the pleura itself may be spared, although the infection has apparently passed through it on its way to the lung. It is uncommon for the lungs to be the only site of secondary deposits. The histologic type of the secondary growth is usually the same as that of the primary tumor.

In their clinical aspect secondary cancers of the lung present a variable picture. The pulmonary process is not infrequently latent, and is first discovered at the postmortem examination. In other instances it may dominate the scene and obscure symptoms referable to a primary growth in a nearby organ. The symptoms and physical signs do not differ from those in primary cancer of the lung.

Sarcoma is in general less common than carcinoma, and thus secondary pulmonary sarcoma is less frequently observed than secondary cancer. Secondary invasion of the lung, however, is relatively more common with sarcoma than with cancer. Of 42 cases coming to

[1] Fortschr. a. d. Gebiete d. Röntgenstr., 1912–13, cxci, 383.
[2] Arch. f. Heilkunde, 1878, vol. xix.
[3] Carcinoma and sarcoma were not differentiated.

autopsy at the Massachusetts General Hospital with sarcoma in various regions, the lungs were secondarily invaded in 15 (35 per cent.) The lungs are a common, and may be the only, site of secondary deposits from sarcoma in various parts of the body. In general the pathologic and clinical features do not differ from those in secondary cancer. At times the histologic type of the original growth is not reproduced, and thus a pulmonary metastasis from an osteosarcoma or chondrosarcoma developing elsewhere may contain neither bone nor cartilage. Pulmonary deposits from a melanotic sarcoma may likewise fail to show pigmentation.

CHAPTER XXVII.

LUNG HERNIA (PNEUMONOCELE)

By this is understood the protrusion of a part of the lung through a defect in the chest wall, the thoracic defect being covered by skin. Diaphragmatic hernia is not considered here but is discussed in the section on Pneumothorax.

The first observation on lung hernia is ascribed to Roland (1499). Contributions to the subject have been made, among others, by Morelle-Lavellé,[1] Auer,[2] who collected 51 cases, and by Urbach,[3] who added 33 cases. A few additional instances have since been reported.

Two groups may be recognized: *Congenital hernia* develops usually within a short interval after birth in infants born with defects in the chest wall. Owing to the collapsed and airless condition of the lung before birth, hernia does not occur *in utero*, but first appears after the lung becomes air-holding, and probably in consequence of crying or coughing. In Polya's[4] case, development of a hernia due to congenital defect of the thorax was delayed until adult life. *Acquired hernia* may follow trauma, when the thoracic wall is torn, crushed, or perforated without a break in the continuity of the overlying skin in consequence of the injury. The defect in the wall may involve the intercostal muscles alone or the bony structures as well. The hernia may occur at once or develop after a time through less resistant scar tissue (consecutive lung hernia). In Trevisano's[5] case a hernia occurred at the site of repeated punctures of the chest on account of pleurisy with effusion. The hernia may be due to a defect from extension of suppuration from the lung or pleura to the chest wall or abscess of the wall itself (such as caries of the rib). The location of hernia due to trauma or pathologic intrathoracic or thoracic processes is variable and depends on the site of the resulting defect in the wall. In a few instances, hernia occurs as a consequence of increased intrathoracic pressure in connection with emphysema and chronic cough or severe physical exertion, especially heavy lifting, the so-called spontaneous hernia. The intercostal spaces near the sternum and the supraclavicular fossæ (between the scaleni and the sternocleidomastoids) are likely to be the site of the rupture in this form.

[1] Hernies du poumon., Mém. de la soc. de Chir., 1847.
[2] Beitrag z. Kenntniss d. Lengenbrüche, Inaug. Diss., 1892.
[3] Ueber Lungenhernien, Deut. Zeit. f. Chir., 1909, cii, 89.
[4] Pester med.-chir. Presse, 1909, No. 13; quoted from Centralbl. f. Chir., 1909, p. 923.
[5] Gaz. degli osped. e stelle cliniche, 1904, No. 16.

One instance (No. 188,499) of lung hernia in the right supraclavicular region is recorded among the Massachusetts General Hospital cases.

Pain may be felt at the site of the hernia and is likely to be increased with long breath or cough. It may be troublesome enough to prevent severe exertion or incapacitate the patient from work. The pain is more pronounced in the early period after the development of the hernia and may diminish or disappear later. Hemoptysis has been observed.

FIG. 77

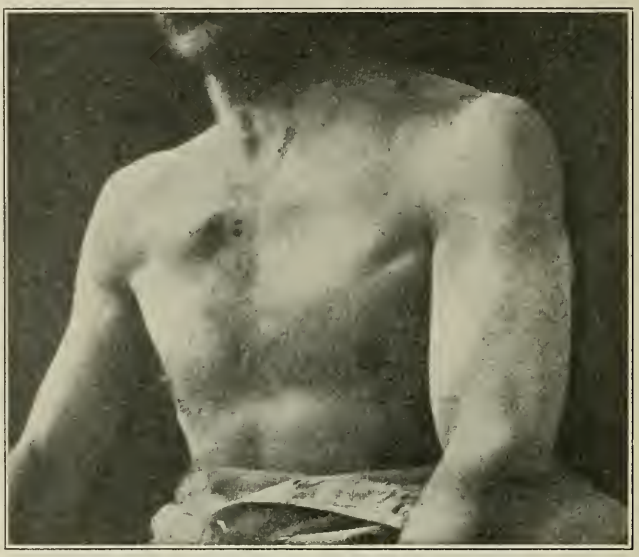
Lung hernia. (Goldflam.)

The hernia forms a rounded tumor covered by skin or scar tissue and varies in size from that of a hazel-nut to two fists. Increase in size may be observed during forced expiration, cough, or bending forward, diminution or disappearance in size during quiet respiration, during inspiration or on standing erect. It is soft, elastic and reducible, unless held by adhesions. Crepitation may be felt on compression and during reduction. A more or less circular, oval, slit-like or irregular orifice may be felt in the chest wall after reduction. The tumor is usually resonant or tympanitic on percussion. Vesicular breathing and expiratory crepitation may be noted on auscultation. The voice sounds and the tactile fremitus are increased. The hernia may be constant or intermittent and present only during forced expiration, cough, or exertion. Bilateral hernias have been observed in rare instances. Strangulation of the hernia took place in Wightman's[1] case.

[1] British Med. Jour., February, 1898, p. 365.

Lung hernia must be differentiated from tumors of the thoracic wall, perforating lung abscess, empyema necessitatis, and aneurysm. In one instance which came under my observation a pyopneumothorax which perforated the chest wall in the third left interspace was at first mistaken for lung hernia.

Fig. 78



Lung hernia. (Volpius.)

The hernia may remain stationary, increase in size from gradual enlargement of the orifice, or diminish and finally disappear. The condition is rather troublesome than dangerous.

Any underlying condition giving rise to cough should be appropriately treated. Severe physical exertion and straining at stool are to be avoided. The hernia should, if possible, be reduced, and recurrence prevented by the application of a suitable truss. Osteoplastic closure of a large thoracic hernial orifice was attempted by Vulpius[1] with partial success.

[1] Berl. klin. Woch., 1900, No. 50.

CHAPTER XXVIII.

PULMONARY ARTERIOSCLEROSIS.

The pulmonary artery and its branches may show arteriosclerotic changes similar to those observed in the systemic arteries. A widely distributed and severe grade of sclerosis is occasionally found. Crudeli[1] and Wolfram[2] have each described an instance of aneurysmal dilatation of the pulmonary artery in connection with arteriosclerotic changes in the vessel. Sclerotic changes without the formation of aneurysm have been observed by Klob,[3] Romberg,[4] Aust,[5] Brüning,[6] Torhorst,[7] Fischer[8] and others. Fischer systematically investigated a large amount of pathologic material and found sclerotic changes in the pulmonary arteries in 100 out of 700 autopsies. Coincident arteriosclerosis is usually present in the aorta and other systemic arteries, but in some instances the pulmonary artery and its branches are predominantly or apparently exclusively involved.

A secondary and a primary form have been described. In most instances such other lesions as emphysema, mitral disease, especially stenosis, extensive pleural adhesions or chronic interstitial pneumonia have suggested that increase of pressure in the pulmonary circuit and consequent embarrassment of the circulation may be responsible. Syphilis may also be a factor. In two instances (Autopsies 2572 and 2788) among the Massachusetts General Hospital cases a marked degree of arteriosclerosis was found in the pulmonary artery and its branches. In rare instances, as in the cases reported by Mönckeberg[9] and Sanders,[10] the pulmonary arterial changes are unassociated with significant lesions in the lungs or other parts of the circulatory apparatus, to which they could be regarded as secondary. Hypertrophy and dilatation of the right side of the heart are usually present in both groups. The cause is uncertain in the primary cases. The development of the arterial lesions at thirty-three years of age in Sander's and one of Mönckeberg's cases, suggests the possibility of a congenital alteration in the vessel wall.

The appearances in pulmonary arteriosclerosis are in general similar to those in arteriosclerosis of the aorta and its branches. There

[1] Riv. clin., vii, 2, p. 37.
[2] Gaz. lekarska, 1883, Nos. 24 and 25. See Virchow-Hirsch's Jahresber., 1883, ii, 162.
[3] Wien. Wochenbl., 1865, xxi, 45.
[4] Deut. Arch. f. klin. Med., 1891, xlviii, 197.
[5] Münch. med. Woch., 1892, p. 689.
[6] Ziegler's Beiträge, Bd. xxx, p. 457.
[7] Ibid., Bd. xxxvi.
[8] Deut. Arch. f. klin. Med., 1909, lcvii, 230.
[9] Deut. med. Woch., August 1, 1907.
[10] Arch. Int. Med., 1909, iii, 257.

may be yellowish or yellowish-white flat projections of variable size in the pulmonary artery and usually most often just above the pulmonary valves. Similar areas may be found in the primary branches and their medium and smaller divisions, at times in greater abundance about the orifices of the branches. This represents the nodular form. Diffuse sclerotic changes may also be observed. The arteries may be dilated as far as their finest divisions. Stiffness of the vessels may be noted. Softening with the formation of atheromatous ulcers was not observed in any of Fischer's cases. Microscopic examination shows thickening of the intima from increase of connective tissue. Fatty degeneration and at times calcification may be noted. Less marked degeneration of the media in the form of isolated fatty and hyaline changes may also be present.

The clinical features are those of cardiac failure, with dyspnea and other evidence of stasis in the venous system. In Romberg's case a congenital cardiac lesion was suspected on account of the extreme cyanosis. Examination of the heart may show enlargement to the left in consequence of hypertrophy and dilatation of the right ventricle. An increase in size to the right of the sternum may be demonstrable if the right auricle is hypertrophied or dilated. In some cases, dulness has been noted in the left second interchondral space and may be ascribed to dilatation of the pulmonary artery. Various murmurs may be heard. A systolic, rough murmur confined to the second left interchondral space may be due to roughening of the pulmonary artery. A diastolic, blowing murmur in the same region and transmitted downward along the left edge of the sternum, without other signs suggestive of aortic regurgitation, may be due to insufficiency of the pulmonary valves. Accentuation of the second sound in the second left interchondral space may also be present. It is possible that examination with the *x*-rays may afford evidence of dilatation and calcification of the pulmonary artery. The signs are difficult to interpret and the diagnosis has as yet not been made during life and confirmed at postmortem examination.

SECTION III.

DISEASES OF THE PLEURA.

CHAPTER XXIX.

PLEURITIS.[1]

Historical.—The term "pleuritis" was in use previous to the time of Hippocrates, but designated any febrile disease accompanied by pain in the side, and thus included disease of neighboring organs as well as the pleura. Hippocrates and Galen separated peripneumonia from pleuritis, which was regarded as an affection of the costal pleura alone. Boerhaave was the first to establish the site of pleurisy exclusively in the pleura, a view which Van Swieten shared, while Sydenham, Haller, and Morgagni believed that both lung and pleura were often, if not always, involved together. Pinel was the first to class pleuritis definitely as an inflammation of the serous membranes and to regard it as an independent disease, from the anatomic lesions. Laënnec's masterly account of pleuritis and its recognition laid the foundation for our present knowledge, and since his time little advance has been made in diagnosis by physical signs. More accurate anatomic and pathologic knowledge has led to a better understanding of the relation between diseases of the lung and the pleura, of the value of thoracentesis, of the importance of tuberculosis in pleurisy, and of the diagnostic value of various forms of cells in pleural fluids.

Thoracentesis.—The evacuation of pleural fluid by operation dates back to a remote and uncertain period. The legend runs, as Cicero and Pliny relate, that the suggestion of operation had its origin in the wounding of Pheraeus who, told by his physicians that he had an incurable ulcer on the lungs, exposed himself in battle that he might be slain, but the enemy's weapon pierced his side, allowing the pus to escape, and he recovered.

[1] The statistical data on pleuritis are from three sources: (1) The Massachusetts General Hospital (M. G. H.), Boston; (2) the Presbyterian, and (3) Roosevelt Hospitals, New York. I am greatly indebted to W. B. James, of New York, for his kindness in placing many valuable data on diseases of the pleura at my disposal. The M. G. H. data were in great part gathered by C. L. Overlander. The hospital records are rich in data on the cytology of pleural fluids, much of the work on which was done by P. Musgrave.

Galen states that the life of Cinesias was saved by Euryphon, of Cnidus, who opened the chest with the actual cautery. The operation was frequently performed in the time of Hippocrates. The diagnosis was made from observation of the breathing, fever, pain and cough, succussion sounds, the position of the patient, and swelling of the side. Evacuation was accomplished by the actual cautery, the knife, and perforation of a rib. The operator is cautioned to prepare for operation by washing the patient with warm water. Celsus and Galen employed the operation, but it was regarded as dangerous and was largely given up among the Greeks and Romans. In the sixteenth century the operation was again recommended, among others, by Ambroise Paré, but was seldom done except in extreme cases. It was often practised in the seventeenth and eighteenth centuries, but had many opponents, and was usually unsuccessful. Dupuytren had only 4 recoveries in 50 cases, and himself died of empyema, saying of himself that he would rather die by the hand of God than of man. Druin, about the year 1665, proposed the use of the trocar as a substitute for the actual cautery in opening the chest. Aspiration was employed by Scultetus in 1669. An incision was made with the knife, and by puncture with the sharp cannula. Suction was applied by the mouth, by cups, and by syringes.

The great improvement in the diagnosis of thoracic disease following Laënnec's publications did not exert an immediate influence on the question of thoracentesis, but finally overcame previously existing indecision. Laënnec, himself, was not an earnest advocate of operation, and states that he never obtained any lasting success by its use. He recommended operation in acute pleurisy with fluid accumulation, when at the end of some days there is danger of suffocation, and in chronic cases, where other means have failed. He advised puncture with the trocar when, owing to weakness, the total evacuation of the fluid may cause dangerous syncope or as a means of alleviation in hopeless cases.

Among others in Germany, Becker (1834), Schuh and Skoda (1841), and Wintrich (1854); in France, Trousseau (1843), Marotte (1854), and Sédillot (1855); and in England (1844), Hughes and Cock, Roe and Thompson, advocated thoracentesis. In America at this time the general opinion was against the procedure. As Bowditch wrote in 1851, the operation "is strongly advocated by a few and as strongly opposed by others, and looked upon with indifference by the great mass of European physicians."

In 1849 or 1850 H. I. Bowditch,[1] who had long been impressed with the necessity of operation for pleural fluids, was confirmed in this opinion by the paper of Hughes and Cock. In 1850, he saw a case which, in his opinion, demanded tapping, and called Morrill Wyman in consultation. The operation was done by Wyman, who used an

[1] Amer. Jour. Med. Sci., 1852.

instrument devised by him, consisting of an exploring trocar to which was attached a strong suction pump. From this time Bowditch became an earnest advocate of aspiration, and by his publications did more than any other to introduce the method into practice in America and Germany. His conclusions as to the indications for operation are of historic interest, and very nearly represent the opinion of the present day, viz., to operate in acute or chronic cases where the chest is full and distended with fluid, even without dyspnea; where there is alarming or paroxysmal dyspnea, even if the chest be only partially filled with fluid; in all *acute* cases where the remedies employed do not produce ready absorption, and, "furthermore, as it may be of service in relieving dyspnea and helping on the more rapld cure, it may, therefore, become a question whether even a small quantity of fluid should not be removed within a week after the first attack of acute pleurisy."

The apparatus for aspiration has undergone certain important modifications. In 1858, Thompson[1] described a lateral outlet from the body of the cannula. This was modified by Fraenzel[2] in 1874 by adding a stopcock in the lateral outlet and a device for preventing the entrance of air into the body of the cannula when the stylet is withdrawn. In 1869, Dieulafoy devised an aspirator consisting of a fine needle connected by a rubber tube to an apparatus in which the air can be exhausted. In 1872, Potain and Castiaux, in Paris, and von Rasmussen, in Copenhagen, suggested the bottle aspirator in which negative pressure is maintained by an air pump. Dieulafoy's rack aspirator and Potain's bottle method are still much in use. By the use of these instruments the entrance of air into the pleural sac during aspiration is prevented, thus obviating the danger of artificial pneumothorax and possible infection of the pleura.

Aspiration in both serous and purulent effusions was at first a common practice, but aspiration is now generally restricted to other than purulent fluids and free incision is used for empyema.

Occurrence.—From the point of view of the pathologist, the occurrence of pleuritis is very frequent. Including simple adhesions with other more marked changes in the pleura, pleuritis was found in 160 (74.4 per cent.) of 215 cases at autopsy (M. G. H.). Such processes pass unheeded or undiagnosed in the great majority of patients, as is shown by the striking disparity between autopsy and clinical reports. Thus, of 35,207 patients admitted to the medical wards of the Massachusetts General Hospital from 1897 to 1913 inclusive, only 975 (2.7 per cent.) are recorded as suffering from pleuritis. Fraley's[3] figures for the Pennsylvania Hospital are nearly the same, 505 (2.5 per cent.) in 19,396 cases. Gerhardt reports 3.47 per cent. of cases with pleuritis in Würzburg among medical patients during thirteen years, and 0.9 per cent. in eight years at the Charité in Berlin. Uncom-

[1] Med. Times and Gaz., 1858, p. 329.
[2] Berl. klin. Woch., 1874, vol. xii.
[3] Amer. Jour. Med. Sci., May, 1907.

plicated inflammation of the pleura is not a frequent cause of death. Thus, of 2,642,555 deaths recorded in the *United States Census Report* for five years (1900 to 1904), only 7420 (0.2 per cent.) are assigned to pleurisy.

General Etiology.—Age.—Pleuritis has been described in the newborn, but is relatively uncommon in infants. Wrany (quoted from Gerhardt) noted pleuritic adhesions in infants of fifteen days and three weeks. Holt states that the youngest case in which he has found extensive pleuritic adhesions is in an infant of three months. Baron[1] found evidence of pleuritis in 159 of 403 autopsies on children. Pleuritic effusions in children are more often purulent and metapneumonic in origin, while in adults serous and tuberculous pleuritis is more common.

The relation of age differs somewhat between clinical and mortality statistics. Of 760 clinical cases (M. G. H.)[2] of different forms of pleuritis, 63 were ten and under, 114 eleven to twenty, 255 twenty-one to thirty, 178 thirty-one to forty, 83 forty-one to fifty, 51 fifty-one to sixty, 12 sixty-one to seventy, while 4 were seventy-one to eighty. Thus, about one-third of the cases occurred from twenty-one to thirty and more than one-half from twenty-one to forty. In mortality returns, the cases are much more evenly distributed through the different ages, with a larger proportion at the extremes of life. Of 7420[3] cases in the *United States Census Report* for five years (1900 to 1904) certified as dying from pleuritis, there are 997 under five (302 under one), 425 from five to fourteen, 755 from fifteen to twenty-four, 938 from twenty-five to thirty-four, 974 from thirty-five to forty-four, 1897 from forty-five to sixty-four, and 1415 sixty-four or over. These figures suggest that pleuritis is less common but more fatal at the extremes of age.

Sex.—In general, males are much more frequently affected. In my series of 1681 patients with fibrinous, serofibrinous, or purulent pleuritis, 1213 were males, 468 females. In the *United States Census Report* (1900 to 1904) there were 4251 males, 3169 females. There appears to be no striking difference in the relation of sex at the different ages or in the different forms of pleuritis, males in general exceeding females.

Occupation.—The relation between pleuritis and occupation may be considered to be that of the diseases to which pleuritis is most often secondary. Thus, occupations predisposing to pulmonary tuberculosis or other respiratory infections may indirectly lead to pleuritis. As in tuberculosis, its influence is largely referable to poverty, poor ventilation, overcrowding, an inadequate wage, and, perhaps most important of all, ignorance in the disposal of infected material. Those occupations in which there is the greatest amount of dust, aiding

[1] Journ. f. Kinderkrankheiten, vol. i, p. 20.
[2] Children comprise only a small number of the total admissions.
[3] Age unknown in 19 cases.

in the distribution of expectorated bacilli, may most often be expected to lead to tuberculous pleuritis. The tabulation of occupation and pleurisy with effusion in 279 cases (M. G. H.) shows that dusty employment obtained in 60 (21.5 per cent.).

Season.—Since respiratory infection occurs more often during the colder months of the year, and because of the frequent association of pulmonary and pleural infection, a similar relation with the seasons may be expected to obtain in pulmonary and pleural infection. This has been shown to be the case. It is confirmed by 762 patients, of whom 248 (32.5 per cent.) sought the hospital clinic during March, April, or May, the greatest number of cases for any month being 94 in March; while 189 (24.8 per cent.) presented themselves in June, July, or August, 178 (23.3 per cent.) in December, January, or February, and 147 (19.2 per cent.) in September, October, or November.

Exposure.—With the growth of knowledge concerning the role of bacteria in the disease, exposure has come to be regarded as of little moment as a principal cause. It cannot, however, be totally disregarded, but must be looked upon rather as a contributing factor in certain cases. It is probable that in some unexplained way it favors the development of organisms already present in the respiratory tract. Of 467 cases of fibrinous and serofibrinous effusion it was a possible contributing cause in 34 (7.2 per cent.).

Bacterial Etiology.—As yet it is impossible to separate the inflammations of the pleura into sharply defined groups according to their bacterial etiology, with a characteristic clinical picture, pathology, course, and termination. Fibrinous, serofibrinous, or purulent pleuritis may be due to one or more different organisms in the same or in different cases. The number of organisms concerned is comparatively small, and in the great majority of cases comprises the tubercle bacillus, the pneumococcus, or the streptococcus. Pleural fluids, from the readiness with which they can be obtained for examination, are the most promising field for investigation, but fluids, in other respects similar so far as our present methods go, may show different bacteria.

The limited number of different organisms concerned is probably due to the relation of the pleura to the deeper parts of the respiratory tract, where mixed infections are less common. The tendency of the tubercle bacillus to invade the subpleural tissue or the thoracic glands in close relation with the pleura is well known, and explains its frequent invasion of the pleura.

Tubercle Bacillus.—This is a frequent cause of pleuritis, either alone or in combination with other organisms, but it is not yet possible with any degree of accuracy to state in what proportion of cases it is a factor in the different forms. It is undoubtedly one of the most common but not the only cause of fibrous adhesions and scars so commonly found in the pleura and most often at the apices. In many instances these are the result of extension of inflammation about tuberculous foci, evidence for which is afforded by the presence in the underlying

pulmonary tissue of caseous, fibrocaseous, or calcified areas. When not so associated, they cannot be regarded as necessarily tuberculous in origin, and may arise from preceding inflammation due to other organisms. The tubercle bacillus with other organisms is at times undoubtedly a cause of fibrinous pleuritis, and tubercles may be found in such tissue. The failure to find other organisms than the tubercle bacillus in purulent pleural exudates does not establish their independent relation with the latter, for other organisms may have been present and died out.

The tubercle bacillus plays a most important part in serous effusions, in which it has been demonstrated in from 22 to 85 per cent. by different observers as a contributing or principal cause. At present we have no certain means of excluding it, and it may still exist even with negative inoculation experiments.

Pneumococcus.—The pneumococcus may be a cause of fibrinous, serofibrinous, or purulent pleuritis. It is a common factor in the fibrinous form. It is only rarely a cause of clear serous effusions, but is more common in turbid exudates and is frequent in purulent effusions. It is common in the primary empyemas of children and in all effusions complicating lobar pneumonia.

Streptococcus.—This is less common in serofibrinous exudates than the pneumococcus, but is not infrequently present in empyema. It is common in suppurative pleuritis secondary to such diseases of the lung, as lobar pneumonia and bronchopneumonia, abscess, gangrene, bronchiectasis, following trauma to the chest wall or septic processes in more remote parts of the body.

Other Organisms.—Staphylococcus pyogenes aureus is, perhaps, the next most common organism found in pleural exudates. Streptococcus mucosus capsulatus, influenza bacillus, Friedländer's bacillus, diphtheria bacillus, micrococcus tetragenus, bacillus ramosus, bacillus pyocyaneus, and bacillus subtilis have been occasionally found, either alone or in combination, and at times associated with the tubercle bacillus, the pneumococcus, or the streptococcus in purulent exudates. The typhoid bacillus has rarely been cultivated from pleural fluids of a serofibrinous, hemorrhagic, or purulent character. The demonstration of an organism with the morphology, staining reaction, and cultural peculiarities of the gonococcus is reported by Bordoni-Uffreduzzi.[1] The cultures are not described.

Classification.—It is impossible at present to classify the inflammations of the pleura satisfactorily according to their etiology. The most convenient and practical division is into acute and chronic pleuritis, each of which may be primary or secondary, and according to the clinical or pathologic findings, fibrinous, serofibrinous, or purulent. The terms "primary" and "secondary" are convenient for the description of clinical cases, but are somewhat misleading and

[1] Deutsch. med. Woch., 1894, No. 22.

need a word of explanation. Pleuritis is in reality only very rarely primary, almost always secondary to disease of neighboring organs, especially the lung. When cases are referred to as primary, therefore, it should be understood that the starting point of the disease in other organs has not been detected. Throughout the sections on effusions, mention is made of small, medium, and large amounts of pleural fluid. In general, by "small" may be understood an effusion which does not rise above the angle of the scapula; by "medium," an upper level between the angle and spine of the scapula, and by "large," a higher level.

ACUTE FIBRINOUS PLEURITIS.

Fibrinous or Plastic Pleuritis.—The examination of cases with fibrinous pleuritis at the postmortem table shows that small amounts of fluid are usually present. From its clinical importance, however, the group deserves separate consideration.

Etiology.—The absence of fluid for examination makes the etiology of fibrinous pleuritis somewhat less certain than the other forms, but the cases fall into two principal groups, those in which the disease is apparently (1) primary and those (2) secondary to disease of the lung or other part of the body.

1. *Primary.*—This forms the largest group in clinical cases. The disease seldom occurs in perfectly healthy individuals, and some disturbance of the respiratory tract may precede, but more often accompanies, the stitch in the side. In this series, 223 (64.6 per cent.) of 345 cases may be regarded as belonging to this class. Exposure was a possible contributing factor in 30 and alcoholism may have played a part in 19 cases. The clinical history and subsequent course of primary dry pleurisy indicate that it is due to tuberculosis in the vast majority of the cases.

2. *Secondary.*—The disease may be secondary to infective processes in any part of the body. Disease of the lung occupies first place and bronchitis is an important factor. It is probable that small areas of pulmonary invasion, too small to be detected on physical examination, frequently accompany bronchitis, and that bacteria find their way from the peripheral parts of the lung to the pleura. Infection with the tubercle bacillus, especially in the lung or bronchial lymph glands, may be regarded as the starting point of pleural infection in a large proportion of cases. In this series there was probable or certain pulmonary tuberculosis in 18 cases (5.2 per cent.), of which 6 showed tubercle bacilli in the sputum. The lung was involved in 16, tuberculous peritonitis was present in 1, and an anal fistula in the remaining patient. Lobar pneumonia is a frequent cause and is represented by 15 cases. Bronchopneumonia, abscess, gangrene, and bronchiectasis are less frequent causes. Of infections in more remote parts of the

body may be mentioned acute or chronic endocarditis, tonsillitis, pyorrhea alveolaris, arthritis, pericarditis, typhoid fever, and uterine sepsis. Dry pleurisy is not infrequent in the later stages of all chronic diseases accompanied by asthenia and increased susceptibility to infection. Trauma with or without gross injury of the tissues may lead to fibrinous pleuritis and usually by infection from the lungs. Pulmonary infarction is an occasional cause. If the venous thrombosis is latent and hemoptysis does not occur the pleurisy may be regarded as primary.

Relation to Tuberculosis.—The frequency with which pulmonary tuberculosis begins with and is accompanied by symptoms referable to the pleura gives ample testimony of its important relationship. Of 1000 cases in the Winyah Sanatorium, 201 had pleurisy prior to the onset of pulmonary tuberculosis (von Ruch). Although the apical localization of these changes is most frequent, pulmonary tuberculosis is often accompanied by similar processes in other parts of the pleura. Acute fibrinous pleuritis may occur and tubercles may be found in the tissue.

The proportion of cases in which the tubercle bacillus is responsible for fibrinous pleuritis cannot be definitely stated. A study of my cases suggests that this form of pleuritis as an apparently primary affection is tuberculous in about the same proportion of cases as in primary serofibrinous pleuritis. This seems to be indicated by the subsequent course. (See Prognosis, p. 465.) It should be noted, however, that coincident tuberculosis was demonstrated in a smaller proportion of cases of fibrinous (5 per cent.) than of serofibrinous pleuritis (13 per cent.), but this may have been due to the fact that the pulmonary process was in a less advanced stage.

Although the tubercle bacillus may be equally responsible for fibrinous and serofibrinous pleuritis, there is some indication that a mixed infection with other organisms is more frequent in the former. An abundant fibrinous exudate is not typical of infection with the tubercle bacillus alone. The behavior of the white count is also suggestive of mixed infection, being above 12,000 in 19 (39.5 per cent.) of 48 cases of primary fibrinous pleuritis, while only 3 (9.09 per cent.) of 33 cases of primary serofibrinous effusion, known to be tuberculous, exceeding this figure.

Pathology.—The inflamed pleura lacks its normal lustre, is dull, opaque, and coarsely or finely granular, an appearance which can best be seen by scraping the tissue with the knife. It is grayish-white, or reddish, and deeper red in places where ecchymoses are present. The membrane is thickened and may reach a centimeter or more in width. The surface of an abundant exudate may be thrown into folds or projecting masses of various shapes. The amount of exuded liquid varies. There is practically always more than the normal amount of pleural fluid and this is usually cloudy. The extent of pleural involvement varies from a part to the whole of the pleura. It is not uncom-

mon to find some extension of the inflammation along the interlobular septa in cases with severe fibrinous pleuritis.

On microscopic examination, desquamation and degeneration or absence of epithelial cells are found. The subserous tissue is swollen and contains an increased number of polynuclear cells. Lymph and bloodvessels are widened. The surface of the pleura is the site of a fibrinous layer containing numerous pus cells and serum. With the beginning of resolution the fibrin undergoes fatty metamorphosis and in mild cases may entirely disappear. In more severe inflammations the two layers of pleura become adherent. Organization, round-celled infiltration, and connective-tissue formation take place, giving rise to adhesive pleuritis.

Site.—This is variable, but the process is most often discovered clinically in the lower lateral and anterior aspects of the chest. This is due to the more frequent occurrence of fibrinous pleuritis at the bases, the greater respiratory excursion of the lower part of the lung, increasing the loudness of friction sound, and the relative thinness of the thoracic wall, facilitating the detection of pleural processes here. The more frequent discovery of pleural friction in the lateral and anterior rather than in the posterior part of the chest may be due also to the tendency of small amounts of fluid to collect at the base posteriorly, with mechanical limitation of pulmonary motion and slight intervention of fluid between lung and chest wall in this region. Of 323 cases in which the site of the process was noted in this series, it was on the right in 134 patients, in 131 on the left, while the process was limited to the right upper chest in 20, to the left upper chest in 9. Of the remaining 29 cases, a situation at both bases in 7, in the diaphragmatic pleura in 3, and throughout the left side in 1 may be mentioned.

Symptoms.—Prodromata are relatively uncommon. Cough and expectoration, due to respiratory infection, may precede the stitch in the side. In a majority of the cases the onset is sudden, with pain, which varies much in intensity. An initial chill is rare. The temperature is often not elevated and was not above normal in 82 (23.7 per cent.) of 345 cases. A temperature of 99° to 100° or 101° is not uncommon. It may rise to 103° or higher, but high temperature is more often seen in complicated cases. Fever, usually gradually subsides within a few days.

Pain.—Pain is an almost constant feature. It may be absent after the acute symptoms have subsided or at the extremes of age. It is often described as sharp, stabbing, or cutting, sometimes dull and dragging in character. It is usually circumscribed, rarely diffuse, and is felt in the axillary or mammary region, less commonly in the anterior or posterior lateral and lower parts of the affected chest. It may radiate to the shoulder or lumbar region, less commonly into the upper extremity, the neck or abdomen. The rare cases in which the pain is at first referred to the *abdomen* are troublesome for diagnosis. Of 145 cases in this series this occurred in 8 (5.5 per cent.),

and may have been due to diaphragmatic pleurisy. Pleuritic friction may be absent and the case may then present the picture of an acute abdominal affection. The pain is usually in the upper abdominal region. It may be accompanied by tenderness and muscular spasm and suggest an inflammatory abdominal condition. Indeed, laparotomy has occasionally been performed in cases in which a few days later the pleuritic origin of the symptoms became obvious from the presence of friction or effusion. Capps[1] explored the pleural cavity by means of a wire passed through the cannula of an instrument for thoracentesis. The visceral pleura seemed devoid of pain sense. Irritation of the parietal pleura gave rise to pain over the site of irritation. Irritation of the central portion of the diaphragmatic pleura caused pain in the neck, of maximum intensity along the ridge of the trapezius muscle (fourth spinal segment). Irritation of the peripheral rim of the diaphragmatic pleura elicited pain in the lower thorax, the lumbar region or the abdomen.

The pain of fibrinous pleuritis is usually of moderate intensity, at times almost unbearable, at others slight, and present only with long breath or cough. It may be continuous or intermittent, but is usually most marked at the beginning of the illness, disappearing suddenly or gradually within a week to ten days. In some cases it may last for weeks or months. Movement, laughter, pressure on or percussion of the affected side, quick change of position, even elevation of the arm, may start or aggravate it. With the advent of pleural effusion, pain diminishes or disappears. The cause of pain in pleural disease is uncertain. It is probably due to irritation of terminal nerve filaments in the inflamed tissue.

Cough.—This is present in a large proportion of cases. Of 145 patients it was noted in 103 (71 per cent.). It was stated to be absent in 18, and the records are silent on this point in 24. It is usually ascribed to pleural irritation, and a relation with this is suggested by the frequency with which forced respiration excites cough, and by its relief when the side is immobilized. Experimentation in animals has failed to confirm this supposition, but it may be that animals are less susceptible to pleural irritation. It is probable that pulmonary infection plays a part in its production, for in 44 cases (30.3 per cent.) expectoration accompanied the cough and rales were noted in 45 (31 per cent.). The sputum lacks characteristic features. It was mucopurulent or purulent in many. In 6 cases it was bloody.

Dyspnea.—Quick respiration may exist without dyspnea. When it occurs, dyspnea is usually slight. It may be due to fever, an effort on the part of the patient to limit the excursion of the lung, because of pain, or to encroachment on pulmonary space by an effusion.

Physical Signs.—The position, if confined to the bed, is inconstant; at times some relief is afforded by lying on the affected and at other

[1] Trans. Assoc. Amer. Phys., 1910, xxvi, 486.

times on the unaffected side. The patient is often more comfortable with the upper part of the spine deflected toward the diseased pleura and the shoulder of that side depressed, from the fixation and compression which this position affords. A diminished expansion and elevation of the involved side can be seen as well as felt, most often in the lower lateral thoracic region. The pulmonary excursion, as shown by percussion of the lower pulmonary margin at the end of inspiration and expiration, and by the amplitude of the diaphragm phenomenon, is usually diminished for both lungs, much diminished or absent on the affected side, and the interspaces are slightly narrower. Percussion may be painful. A change in the percussion note may be determined. The respiratory murmur is diminished but vesicular in character; the vocal fremitus may be diminished, but is usually unchanged.

Pleuritic Friction.—A friction rub can be heard and not infrequently felt as early as twelve to twenty-four hours after the onset. Its occurrence and resemblance to the creaking of leather did not escape Hippocrates. It is often jerky and may be inconstant, present during one, absent at the next respiration, such irregularity being due to alternate fixation and motion of the visceral against the parietal pleura. It may disappear during the course of the examination. The rub is more distinct during inspiration than expiration. Fibrinous pleuritis may exist without friction sound, and friction does not exclude fluid in a neighboring part of the pleura. The sound is not pathognomonic of pleuritis.

Pseudopleuritic Friction.—Students frequently confuse with pleural friction a sound often heard over the back in normal individuals. This sound is commonly heard during the examination of the posterior thoracic region while the patient's arms are folded across the chest, each hand resting on the opposite shoulder. It does not usually appear at once and may be present only after two or more minutes of forced respiration. It begins as an inconstant, rumbling, grating sound, at first confined to inspiration, becoming more and more intense and finally occupying both phases of respiration. It may be harsh and hardly to be distinguished by quality alone from pleuritic friction. A variation in intensity may be noted in different patients and in the course of the examination of the same patient, ordinarily increasing for a time and then gradually fading away. It may be reproduced after an interval of quiet and heard in subsequent examinations. It is usually bilateral. At times it can be felt with the hand and may be audible several inches from the side. The patient may appreciate it as a grating sensation but it causes no pain. In the back it is confined to the scapular region and may be followed upward to a point of maximum intensity over the shoulder-joint. At times it can be heard along the clavicle and down the arms as far as the hand. Removal of the hands from the shoulders may abolish it. The sound is due to crepitus at the shoulder-joint. It is rougher than the sound heard

over any contracting muscle of the extremities and is not to be regarded as a muscle sound. Its less jerky character, bilateral position over the scapulæ, maximum intensity over the shoulder-joint, disappearance on shifting the arms and the absence of pain serve to distinguish it from pleuritic friction.

Pleuropericardial Friction.—This is not infrequent and is often difficult of interpretation. It may be due to inflammation of the pulmonary, costal, or that part of the mediastinal pleura overlying the heart. It is likely to be influenced by the movement of the heart as well as by respiration. Owing to the variable line of reflection of the left costal pleura over the cardiac region, a distinction between pericardial and extrapericardial friction cannot always be safely made from its situation alone, but in general it may be said that pleuropericardial friction is uncommon over the superficial cardiac dulness, and is usually heard outside this region. It is influenced more than pericardial friction by the respiratory movements. If the patient stops breathing, the friction sound may diminish or disappear.

Pseudopleural Intrapulmonary Sounds.—Loud sonorous rales may occasionally simulate pleural friction. Their less jerky character and disappearance after cough may suggest their pulmonary origin.

Pleural Crepitation.—At times with symptoms of pleuritis, fine, inspiratory crepitations are heard over the site of the suspected process. These may be pleural in origin, but can hardly be differentiated from intrapulmonary rales.

Blood.—*White Cells.*—Fibrinous pleuritis is more often accompanied by leukocytosis than serofibrinous pleuritis. Thus, of 48 cases of primary fibrinous pleuritis, the white count was 12,000 or over in 19 (39.5 per cent.). Of these 19 cases, the white cells numbered 12,000 to 13,000 in 3; from 13,000 to 14,000 in 4; 14,000 to 15,000 in 4; 15,000 to 16,000 in 2; 16,000 to 20,000 in 3, and 20,000 to 24,000 in 3. The difference between the white count in primary fibrinous and that in primary tuberculous serofibrinous pleuritis is quite striking in my small series of cases, only 3 of 33 cases in the latter group showing 12,000 or more white cells.

Sequelæ.—Of 345 cases, pleural fluid was discovered as a sequence of the process in 5.

Diagnosis.—This is usually easily made from the presence of a friction rub. Cases with an acute onset, with cough and stitch in the side, aggravated by respiration, are due to pleuritis in a large proportion of the cases, even if no friction rub can be heard. The diagnosis of diaphragmatic pleurisy is often troublesome and may remain in doubt for several days. Cases in which pain along the lower thoracic margin is the only symptom are most difficult of diagnosis. To judge from the remarkable frequency with which there is postmortem indication of previous disease of the pleura, it is probable that an undetected pleurisy is the cause in a large proportion of the cases. Rarely the pain is the precursor of herpes zoster. Pulmonary embolism from

venous thrombosis should always be considered as a possible cause of an apparently primary dry pleurisy. Phlebitis of the veins of the extremities is not always manifest and the embolus may come from a pelvic, abdominal or thoracic vein. The possibility of spinal disease must be borne in mind. Tertiary syphilis and tumor are to be considered. Lead poisoning, caries of the ribs, periostitis, and thoracic aneurysm should be excluded. The *x*-rays may help in the diagnosis. A diagnosis of pleurodynia or intercostal neuralgia amounts to a confession of ignorance concerning the cause of the process.

In typical cases there is little danger of confusion, but the signs may be those of thickened pleura, dulness, diminished vesicular breathing, with preservation of the fremitus, even a friction rub, and yet fluid may be present. The fluid may exist between lung and diaphragm, where small amounts are likely to collect first, and rise little above the pulmonary margin between lung and chest wall. In other cases there may be evidence of thickened pleura and oftenest in the lower anterior aspect of the chest, with fluid in the posterior, inferior thoracic region. Again, fluid may be encapsulated and fibrinous pleuritis with friction coexist. In doubtful cases an exploratory puncture must be made. Cases with complicating pulmonary disease are likely to cause most difficulty in diagnosis.

Primary dry pleurisy should be regarded as probably tuberculous in origin. Preceding good health, satisfactory general condition and mild symptoms during the attack are not to be regarded as sufficient evidence against this diagnosis. Primary dry pleurisy, as an indication of tuberculosis, is equal in significance to primary pleurisy with serofibrinous effusion or hemoptysis out of a clear sky.

Prognosis.—The immediate outlook in fibrinous pleuritis is good. The more remote prospects are less favorable. Of 82 cases of primary dry pleurisy in my series[1] 60 have been followed since their discharge from the hospital. Of these, 18 (30 per cent.) certainly or probably developed tuberculosis. Their subsequent course has been followed from one to twelve years, the average interval being four or five years. The outcome of primary dry pleuritis is thus nearly or quite as bad as that of primary serofibrinous effusion. The prognosis of the secondary form is that of the underlying cause. Pain may persist after the attack; 15 patients (25 per cent.) complain of occasional or persistent pain.

Treatment.—The immediate indication is the relief of pain, on which the cough and dyspnea largely depend. *Rest* is the first consideration. In all cases in which there is fever or severe pain, the patient should be in bed. Even in mild attacks, rest shortens the duration and may prevent extension or the occurrence of an effusion.

Fixation of the side limits the play of the pulmonary against the parietal pleura and may produce immediate relief. It may be accom-

[1] Lord, Boston Med. and Surg. Jour., April 15, 1909.

plished with adhesive plaster, of which zinc oxide plaster is best. One end of a strip of well-warmed adhesive plaster, the width of the hand and long enough to reach from the spine to the sternum, is applied against the paravertebral region. The operator then forcibly wraps the strip about the lower thoracic region so that it lies stretched over the lower ribs, and thus limits their excursion. In women with pendulous breasts, several narrow strips of plaster, extending from the paravertebral region downward and forward, from the sternum downward and backward and intersecting in the axillary region, may be more comfortable. The plaster should not be allowed to remain longer than a week to ten days, and care taken in its removal not to cause abrasion of the skin. A tight thoracic swathe, with shoulder and peroneal straps, has the advantage of ready removal for physical examination, and does not lead to irritation or infection of the skin. It is to be preferred for patients in bed. In some cases, perhaps from diaphragmatic involvement, fixation of the thorax fails to give relief. In such cases an ice-bag or hot-water bottle may be efficient. If these means fail, a hypodermic injection of morphin may be given.

A possible source of infection should be sought, and if found in any part of the body, should receive appropriate treatment. The occurrence of dry pleuritis should always suggest the possibility of tuberculosis. The chance of this is much increased by a family history of the disease or opportunity for contagion. Careful examination of the lungs, the sputum, and the use of tuberculin may furnish positive or suggestive evidence.

All cases of *primary* fibrinous pleurisy, even the mildest forms, in patients otherwise in apparent health, should be treated as if tuberculous until the pleuritis can be proved to be due to another cause. The best results in most instances can be obtained only when the patient is frankly told the probable seriousness of his trouble and the danger if untreated of developing more extensive tuberculosis. He can otherwise hardly be expected to undergo the necessary restrictions on his mode of life. The inability to make more than a probable diagnosis of tuberculosis in the primary dry pleurisies without fluid for examination should not be allowed to act to his detriment. The later histories clearly show how imminent the danger is and that hesitation and delay may bring him a second time under observation with the disease too advanced for successful treatment.

The general management of suspected or proved pleural tuberculosis may, in brief, be considered to be the same as that for incipient or manifest pulmonary tuberculosis. Rest, fresh air, and extra feeding are of chief importance. Mild cases of simple dry pleurisy can often sufficiently modify their surroundings to make "home" treatment a success, but the necessity for discontinuance or change of occupation, removal to more favorable quarters, choice between treatment at home, in a tuberculosis class, or in a sanitarium can be decided only after careful consideration of the circumstances in each case.

The physician's responsibilities do not end with the apparently favorable outcome of the acute attack. No matter how mild this has been or how reassuring the general condition appears to be, permanent results can be attained only by supervision at regular intervals and instruction to report at once on the occurrence of another attack, failing health, rise of temperature or other suspicious symptoms.

ACUTE SEROFIBRINOUS PLEURITIS.

Etiology.—Serofibrinous effusions arising from inflammation of the pleural sac may be divided into three principal groups: (1) *Tuberculous pleuritis* comprises the largest and most important division. (2) *Infectious (non-tuberculous) pleuritis* stands next in frequency and is a well-defined class. (3) *Other causes* are relatively infrequent and often difficult to group. They are the product of more than one factor, such as general hydremia or venous stasis, on which an inflammatory process is superimposed.

1. **Tuberculous Pleuritis.**—It is remarkable in how many cases serofibrinous pleuritis is apparently primary without evidence of disease in other organs. Thus of 1185 cases the disease of the pleura was unassociated with positive findings elsewhere in 750 (63.4 per cent.). The pleural disease was combined with suggestive or positive evidence of pulmonary or other tuberculosis in 160 (13.5 per cent.). The lung was the most frequent site of tuberculosis in this group with 149 cases, of which 47 showed tubercle bacilli in the sputum. Tuberculous peritonitis was present in 9 and tuberculosis in other regions in 2 patients.

There is good reason to believe that a large proportion of cases of serofibrinous effusion, more especially the primary cases and those secondary to pulmonary tuberculous lesions, are due to tuberculosis. This point of view is largely the result of recent investigations and is based on the following:

(*a*) *Tuberculosis of Other Organs.*—In Osler's 195 cases, 30 showed tubercle bacilli in the sputum. Pleural effusion as a symptom of pulmonary tuberculosis usually comes early if at all. Dense pleural adhesions commonly obliterate part or the whole of the pleural sac in an advanced stage of the disease.

(*b*) *The Subsequent History.*—The after histories of 130 cases of primary pleurisy with effusion by Hedges[1] showed that at least 40 per cent. died of or had tuberculosis within six years. Osler[2] refers to 86 cases of which 34.8 per cent. became tuberculous and died, while Sokolowski[3] followed 26 cases for six years. Of Sokolowski's cases, 10 (38 per cent.) developed tuberculosis. The subsequent course of 90 cases of primary pleurisy, irrespective of its type, was

[1] St. Bartholomew's Hosp. Rep., 1900, xxxvi, 83.
[2] British Med. Jour., October 15, 1904.
[3] Klinik der Brustkrankheiten, 1906.

investigated by V. Y. Bowditch.[1] Of this series, 32 (35 per cent.) died of or had phthisis. Sears[2] followed a similar series from the records of the Boston City Hospital to the state archives and found that of 86 known to have died the cause was some form of tuberculosis in over 55 per cent.

(*c*) *Postmortem Evidence.*—Of 131 cases of different types of pleuritis examined postmortem by Osler, 32 were found to be definitely tuberculous.

(*d*) *The Tuberculin Reaction.*—This is positive in a large proportion of the cases—in 73.7 per cent. of Beck's series and in 7 of 8 cases by F. W. White. In my series (M. G. H.) tuberculin was given in 47; 36 (76.5 per cent.) gave a positive reaction. A positive result merely means tuberculosis somewhere, not necessarily in the pleura.

(*e*) *The Character of the Exudate.*—The evidence is based on the character of the cells, the demonstration of tubercle bacilli in the fluid, and the results of animal inoculation.

Character of the Cells.—Lymphocytes predominate in a large proportion of serofibrinous fluids from patients known to have tuberculosis of the pleura; they are likewise in excess in cases in which pulmonary tuberculosis is certainly or probably present, and the same cellular formula is present in idiopathic pleurisy with effusion. Excess of lymphocytes is not invariably proof of a tuberculous pleurisy.

Tubercle Bacillus in the Fluid.—The effort to cultivate tubercle bacilli from serous effusions practically always fails. Simple microscopic examination likewise is usually unsuccessful. Of 415 cases collected by Netter from various sources, bacilli were found in only 9 (about 2 per cent.). Inoscopy or sedimentation has given more positive results. In primary cases, Jousset claimed by means of inoscopy to have found tubercle bacilli in 23 cases (100 per cent.), but other observers have failed to confirm his results. In 115 cases at the Massachusetts General Hospital in which tubercle bacilli were sought in the fluid, they were found in 24 (20.8 per cent.). Körmöczi and Jassniger[3] found bacilli in 3 of 8 cases. Zebrowski,[4] by simple sedimentation of a large quantity of fluid, prevented from coagulation by the addition of sodium fluoride, found bacilli in 12 (55 per cent.) of 22 primary cases and in 10 (83 per cent.) of 12 secondary effusions.

Animal Inoculation.—The most convincing evidence is obtained by animal inoculation. Of 66 cases in my series the results were positive in 15 (22.7 per cent.). Aschoff,[5] using 3 c.c. of fresh exudate, obtained positive results in 9 (75 per cent.) of 12 cases; Eichorst[6] with 15 c.c. in 65.2 per cent. of 23; and Le Damany,[7] by the inoculation of 10 to 50 and at times as much as 300 c.c., in all but 8 (85 per

[1] Trans. Amer. Climat. Assoc., 1889, vi, 1–13.
[2] Boston Med. and Surg. Jour., 1904, cl, 209.
[3] Deut. med. Woch., 1904, p. 342.
[4] Ibid., 1905, No. 36.
[5] Zeit. f. klin. Med., 1896, xxix, 440.
[6] Cor.-Bl. f. Schw. Aerzte, 1895, xxv, 385.
[7] Presse méd., November 24, 1897.

cent.) of 55 primary cases, while in 4 of the 8 negative cases coincident lesions indicated their tuberculous origin. Repeated intraperitoneal injections of from 10 to 50 c.c. were made each week. It should be remembered that human as well as horse serum is capable of sensitizing guinea-pigs and that repetitions after a longer interval may result in severe symptoms of anaphylaxis and in death of the animal. It is fair to assume that the percentage is higher than these figures show. Tubercle bacilli may be absent from the particular sample of fluid investigated, or postmortem examination of animals at too short an interval may introduce a small error. In rare instances glandular lesions which can be conclusively demonstrated as tuberculous only after microscopic examination of stained sections may be observed in animals six weeks after inoculation. It is safer therefore to inoculate more than one animal and to sacrifice only the manifestly tuberculous animals after the customary interval of six weeks and to allow others to live for three months.

By the presence of tubercle bacilli in the sputum, in the fluid by animal inoculation or inoscopy, or by operation, Musgrave proved the tuberculous character of 28 (54.9 per cent.) of 51 primary or secondary effusions.

There can be no doubt from these considerations that tuberculosis occupies first place in the etiology of pleural effusions in any large series of cases. When such cases are demonstrated as tuberculous, it is probable that they have been so from their inception, and not through secondary infection with the tubercle bacillus, although such an event cannot be excluded as a rare occurrence. All serofibrinous effusions cannot be classed as tuberculous.

2. **Infectious (Non-tuberculous) Pleuritis.**—Infection of the pleura with other organisms than the tubercle bacillus is capable of causing serofibrinous effusion. The pneumococcus is the most frequent cause in this group. The streptococcus and other organisms may likewise be a cause. A difficulty lies in the exclusion of the tubercle bacillus as a mixed infection.

(*a*) *Metapneumonic Pleuritis.*—This is a well-defined group and is represented by 62 (5.2 per cent.) of 1185 cases with serofibrinous effusion.

Small effusions of a serofibrinous or purulent character are common in lobar pneumonia. Maragliano demonstrated serofibrinous or purulent effusion in 38 of 58 cases, by means of exploratory puncture. If small amounts are included, a serofibrinous is more common than a purulent exudate. Norris[1] in 127 autopsies in pneumonia, found serous in 5 and purulent fluid in 20 cases, while Kerr in 173 autopsies found 38 with serofibrinous and 6 with purulent effusion. Of 154 autopsies on cases with lobar pneumonia (M. G. H.), a pleural effusion was present in 57, and in these the fluid was cloudy in 30, clear

[1] Osler's Modern Medicine, 1907, ii, 598.

in 10, purulent in 9, and hemorrhagic in 6. The largest amount at autopsy was 500 c.c., and was unrecognized during life. The cloudiness so commonly seen in such effusions is usually due to fine fibrinous flocculi. Tuberculosis was present in the lungs or bronchial glands in 9 of the cases, in 6 of which it appeared to be obsolete, while in 1 it was a probable cause of the effusion. In Sello's cases the effusion was demonstrated at the beginning of the pneumonia in 2, during the course of the disease in 31, and afterward in 24. The independent existence of serofibrinous effusion accompanying pneumonia and due to infection with other organisms than the tubercle bacillus cannot be doubted. In support of this is its association with an inflammatory disease of the lung, usually due to the pneumococcus, the presence in the fluid of pneumococci or other organisms which alone are capable of causing pleuritis with effusion, and the absence in cases with serofibrinous effusion and pneumonia of tuberculous lesions at autopsy.

(*b*) *Rheumatism.*—This was coincident with pleuritis with effusion in 13 cases (0.9 per cent.). There is no proof that the rheumatic poison can alone infect the pleura, and it seems misleading to speak of a rheumatic pleuritis in the sense in which this term is sometimes used to designate a pleuritis with or without arthritic symptoms, in which a favorable result is obtained following the administration of salicylic acid preparations. Until proof can be offered that rheumatic fever is due to a specific organism, and this can be demonstrated in pleural effusions as a cause, it is better for clinical purposes to regard such effusions as complicate arthritis as only possibly rheumatic in origin. Infection of the joints and the pleura, with discovery of streptococci in both, was associated with panophthalmitis in one case; in another the joints, the pleura, the endo- and pericardium were simultaneously involved. In both cases the pleural fluid showed an excess of polynuclear cells, viz., 95 per cent. and 65 per cent., respectively. As in other forms of pleuritis, tuberculosis must be excluded.

(*c*) *Trauma.*—Serofibrinous effusion followed trauma in 10 cases (0.8 per cent.) in this series. The effusion may be due to simple infection or to tuberculosis. Traumatic serous pleuritis has been followed by the development of pulmonary tuberculosis (Lebert), and tubercle bacilli have been found in the fluid by Chauffard, Herbert, Barjon and Lesier, and Chevastelon (quoted from Chevastelon).

(*d*) *Typhoid Fever.*—The association of serofibrinous effusion and typhoid is rare, occurring in only 7 cases (0.5 per cent.) in this series. Among 1500 cases of typhoid, McCrae[1] noted only 3 with serous effusion. The bacilli have been obtained in pure culture from the fluid by Fernet, Achard and Gordinier, and Lartigau. In Achard's case the fluid was turbid and its agglutinative power was ten times

[1] Osler and McCrae's *Mod. Med.*, 1913, I, 123.

that of the patient's blood serum. In Gordinier and Lartigau's case the fluid was greenish-yellow and opalescent. Pleural effusions in the course of typhoid fever may also be hemorrhagic, but are most commonly purulent. The complication may occur early, as in Fernet's case, but is more often found during the course of the disease. It is not certain that the typhoid bacillus alone is capable of causing serofibrinous effusion. General infection with typhoid bacilli is so common in typhoid fever that the mere presence of typhoid bacilli in the exudate does not suffice to establish the independence of typhoid pleuritis. The agency of other organisms, and especially the tubercle bacillus, must be rigorously excluded. In Achard's case 20 c.c. failed to produce tuberculosis in an inoculated animal.

(*e*) *Infection in any part of the body* may be a cause of serofibrinous pleuritis, although the effusion accompanying septic processes is more often purulent in character or becomes so after passing through a serofibrinous stage. Pulmonary infection resulting in bronchopneumonia, pulmonary infarction, pericarditis, malignant endocarditis, uterine sepsis, etc., may lead to serofibrinous pleuritis. In such cases the serous rather than the purulent character of the effusion may be due to the small number or diminished virulence of the infecting organisms or to increased resistance on the part of the patient.

3. **Other Causes.**—A sharp, dividing line cannot always be drawn between transudates and exudates. The presence of fibrinous flocculi or clot justifies an inclusion in the class of serofibrinous fluids. Fibrinogen is present in all fluids and an admixture with blood may cause clotting. An inflammatory process may readily be superadded to a transudate and thus complicate the differentiation.

Pathology.—1. **Pleura.**—The appearance of the pleura does not usually differ from that in simple fibrinous pleuritis. The fluid commonly occupies the most inferior parts of the cavity, and in acute cases the fibrinous layers on the two pleuræ are usually easily separated where they lie together above the fluid. Bands of adhesions may traverse the fluid and connect the visceral and parietal layers. In the more chronic cases the two pleuræ may be more or less firmly united above the fluid. It is less common to observe encapsulation of serofibrinous than of purulent fluid. Sacculated exudates are most common at the posterior and inferior aspect of the pleural sac. Rarely more than one encapsulation occurs, and the contents of the two may vary, in one serous, in the other purulent fluid. Miliary tubercles may occur in the pleura without fluid or fibrinous exudate. Both fluid and fibrinous exudate, however, are more common. In the gross appearance the pleura may not differ from that seen in the simple form, and tubercles may be discovered only on miscroscopic examination.

2. **Side Affected.**—The left side is the more frequent site of the process. Of 1085 clinical cases the effusion was confined to the left side in 570, to the right in 487, while both were involved in 28. In

one the effusion was sacculated on the left, posteriorly, near the spinal column, over an area eight inches in diameter.

3. **The Effusion.**—This is quite variable in its character. It may be largely serous, with only a small amount of scattered fibrinous flocculi. The fibrin may exist as wavy, skein-like masses in suspension, or as more compact, whitish, coarse, membranous shreds or curd-like deposits. A clot usually forms in a variable but short period after evacuation, and may be found as a small, jelly-like mass at the bottom, or may comprise almost the whole volume of the fluid, with only a thin layer of clear serum about it. The fluid is usually amber colored, with an admixture of greenish or reddish from the presence of blood. It may be brownish on removal or turn so after standing. When mixed with considerable amounts of blood it may be blood red, and, if removed after having long remained in the chest, may be darker, even chocolate colored. With jaundice the fluid is more deeply colored and responds to the tests for biliary substances. Most fluids are clear or only slightly opalescent from the presence of albumin in fine subdivision, fibrin in the form of flocculi, clot, fat, or cellular elements. No sharp dividing line can be drawn between serofibrinous fluids cloudy from the presence of numerous cells and those with more or less frank admixture of pus. It must be remembered that cellular elements tend to sediment within as well as outside the chest, and that an abundance of polynuclear cells obtained on tapping the upper layers of a pleural fluid may be associated with a sediment of pus at the bottom.

(*a*) The *amount* of fluid is very variable. In acute fibrinous pleuritis there is practically always more than the normal amount of fluid in the pleural sac. Even when the process is confined to the upper parts of the pleura, small amounts are often found at the bases. In 500 cases the amount varied from a few to 4620 c.c., the largest measured amount at any one tapping. The right chest is more capacious than the left and larger amounts are likely to be present in men than in women.

(*b*) *The Reaction.*—This varies with phenolphthalein and litmus. Both exudates and transudates are acid to phenolphthalein, with inconstant differences in the degree of acidity. "Litmus usually reacts acid to exudates; acid, neutral or even alkaline to transudates, this apparent discrepancy being due to the disodium phosphate, which reacts neutral to litmus and acid to phenolphthalein" (Miller).

(*c*) *Specific Gravity.*—The determination of this is of great value in differentiating exudates from transudates. The fluid should, if necessary, stand several hours to allow the escape of air (Miller). It is surprising with what constancy inflammatory fluids have a specific gravity of 1018 or over. Exceptions are not common even in a large number of cases. Of 224 cases only 19 had a specific gravity below 1018. There appears to be no noteworthy difference in the specific gravity of serofibrinous fluids accompanying primary disease of the

pleura, those associated with pulmonary tuberculosis, pneumonia, rheumatism, typhoid fever, or other inflammatory processes. In transudates, uncomplicated by inflammation of the pleura, the specific gravity is usually below 1018. It has been shown that the amount of salts and extractives is very nearly the same (Runeberg, Méhu, Reuss, Hoffman) in fluids of different origin and after the removal of albumin, amount to about 1.08 per cent. in non-inflammatory fluids and to about 1.18 per cent. in inflammatory fluids. A variation in the specific gravity of pleural fluids is dependent for the most part on differences in the amount of albumin.

(*d*) *Albumin.*—This exists in the form of serum albumin, serum globulin, and fibrinogen, to which, if present in sufficient amount, is due the property of spontaneous coagulation. Inflammatory fluids contain a relatively large amount of albumin and fibrinogen. In general, exudates have a specific gravity of 1018 or higher, with 4 per cent. or more of albumin.

Nucleo-albumin (*Primavera and Rivalta*) may be demonstrated by the addition of a drop of the fluid to be tested to a dilute solution of acetic acid (2 drops glacial acetic to 200 c.c. water). If nucleo-albumin is present, a slight turbidity is produced in the fluid. Runeberg performs the test by adding a few drops of acetic acid to the fluid to be tested. The substance, the identity of which is uncertain, is demonstrated by marked turbidity of the fluid in exudates and very slight or no change in transudates. It is somewhat soluble in an excess of acetic acid and completely soluble in alkalies.

The determination of the amount of albumin in these fluids is of some importance in judging their origin. Estimation by weight of the precipitated proteid or the total nitrogen (Kjeldahl) is too complicated for general use. Esbach's and Purdy's methods of estimating albumin in urine are only approximately accurate for pleural fluids, as is shown by comparison with the results obtained by more exact methods. Reuss has devised a formula for estimating the amount of albumin, based on the practical lack of variation in salts and extractives and the almost constant relation between the specific gravity and albumin. By his formula $A=\frac{3}{8}(S-1000)-2.8$, in which A = albumin and S = specific gravity, the amount of albumin may be calculated and the error amounted to as high as 0.5 per cent. in only 1 of 24 cases in which the albumin was carefully determined by weight.

(*e*) *Fat, uric acid, cholesterin, glucose, biliary acids,* and *pigments* are occasionally found.

(*f*) *Cellular Elements.*—The sediment obtained after standing or sedimentation shows red-blood corpuscles, polynuclear leukocytes, small mononuclear (lymphocytes) and endothelial cells. Eosinophiles and mononuclear cells intermediate between the small lymphocyte and endothelial cell are common, but usually comprise only a small proportion of the total number. An occasional mast-cell is not an infrequent finding.

Tuberculous Fluids.—During the first few days following tuberculous infection of the pleura there may be an excess of polynuclear cells, as has been shown by Widal, Tulland, Wolff, and others, but it is generally agreed that fluids due to tuberculous pleuritis show an excess of lymphocytes. In 28 cases (M. G. H.), proved to be tuberculous by the finding of tubercle bacilli in the exudate or positive inoculation, the lymphocytes numbered 90 to 100 per cent. in 24; 88 per cent. in 1; and from 70 to 75 per cent. in the remaining 3, of which 2 showed 15 per cent. endothelial cells, the third 16 per cent. eosinophiles. The lymphocytes thus predominated in all.

In effusions arising in the course of pulmonary tuberculosis, the lymphocytes have likewise been shown to predominate, but, owing to the chance of mixed infection from the lung, a variable and at times considerable proportion of polynuclear cells may be present. Of 19 cases examined by Miller, the lymphocytes comprised 95 per cent., or more, in 16. Neutrophiles predominated in 1. In 28 cases with probable or certain pulmonary tuberculosis (M. G. H.) the lymphocytes numbered 80 to 100 per cent. in 20. In 6 the leukocytes were degenerated, in 1 there were about equal proportions of polynuclear cells, while in the last case the endothelial cells numbered 85 per cent.

Idiopathic effusions likewise show a predominance of lymphocytes, and for this as well as other reasons should be mentioned in this group. In 100 cases (M. G. H.) the lymphocytes ranged from 70 to 100 per cent. in 85. In 14 of the remaining cases polynuclear cells were in excess, in explanation of which a mixed infection may be suspected. Small endothelial cells reached 15 per cent. in 2, in 1 case numbering 65 per cent.

Unfortunately, not all fluids showing a predominance of lymphocytes can be regarded as tuberculous from the cellular formula alone. Miller had one case of unknown origin with 97 per cent. lymphocytes and no reaction to tuberculin. In 2 cases (M. G. H.) of idiopathic effusion, with counts of over 95 per cent. of lymphocytes, there was no reaction to tuberculin. Naunyn has observed that long-standing transudates may show an excess of lymphocytes, and this is confirmed by one of the present series with 95 per cent. lymphocytes in a fluid later shown by autopsy (M. G. H.) to be due to chronic passive congestion and not to tuberculosis. Despite the exceptions, however, a predominance of lymphocytes must be regarded as strongly suggestive of tuberculous pleuritis, especially when passive congestion can be excluded.

Infectious (non-tuberculous) Fluids.—Infection of the pleura with other organisms than the tubercle bacillus usually gives rise to an excess of polynuclear cells in the exudate. Musgrave studied 12 cases; the polynuclear cells predominated in all. Miller reported 7 cases. The neutrophiles were in excess in most, but in 2, one of whom failed to react to tuberculin, there were 97 per cent. of lymphocytes. In my series there are counts on 16 cases. In general, the fluids differed

from those obtained in tuberculous cases in their more turbid character, the lower percentage of lymphocytes and higher proportion of polynuclear and endothelial cells. In 1 of 11 metapneumonic effusions the lymphocytes numbered 82 per cent. In 2 cases associated with an arthritis, there were 65 and 95 per cent. polynuclears. The lymphocytes predominated in 2 of 3 cases in which the effusion followed trauma. Tuberculosis could not be excluded. Naunyn states that lymphocytes may predominate in acute cases which are subsiding, or in mild infections.

For transudates, endothelial cells in large numbers occurring especially in sheets or plaques, are characteristic, but lymphocytes may predominate in mechanical effusions of long standing. A secondary infection may modify the cellular formula, with relative increase in polynuclear cells.

The value of cytology in the diagnosis of the cause of pleural effusions has proved somewhat less valuable than was at first anticipated. The exceptions are too numerous to admit of definite conclusions from the cells alone, but the method is of assistance with other factors in any given case.

4. **Intrapleural Tension.**—With small effusions this may still be negative. As the fluid increases in amount the tension rises and becomes positive after the pulmonary elasticity is spent. Various factors influence the pressure. It may be relatively high with a small amount of fluid if pulmonary retraction is prevented by pleural adhesions, by pulmonary or mediastinal disease. Pitres[1] finds that the pressure may vary from 0 to +2 or +3 with less than 1000 c.c., from +8 to +22 with 1000 to 2000 c.c., and from +20 to +48 mm. Hg. with more than 2000 c.c. The pressure fluctuates with the phases of respiration. An initial positive pressure may fall during deep inspiration to −40, as noted by Schreiber.[2] After aspiration the fall may be greater and with deep inspiration even to −90 mm. Hg. The fluid is also under a pressure of its own fluid column and the tension thus varies at different levels.

5. **Mechanical Effects of the Exudate.**—With small effusions the lung contracts and becomes atelectatic. With large effusions it is compressed, completely emptied of air, and for the most part of blood, and may be found as a brown mass, not larger than the closed fist, lying against the spinal column in the upper and posterior part of the affected side. In the absence of long-standing and extensive inflammatory changes it is still capable of reëxpansion after removal of the fluid. Under less favorable circumstances, extensive adhesions, the formation of dense connective tissue on its surface and within its substance may prevent this. Such a result is much less common with serofibrinous than with purulent exudates, and since it has become the custom to tap early. The belief is held by some that

[1] Arch. clin. de Bordeaux, 1896, v, 70. [2] Deut. Arch. f. klin. Med., vol. xxxiii.

persistent effusions exert a favorable effect on tuberculous processes in the neighboring lungs in consequence of mechanical compression and immobilization, but this is doubtful, and the danger of secondary changes in the pleura and lung offset any fancied advantage in allowing the fluid to remain.

In consequence of diminished negative pressure within the thorax, the intercostal spaces show less than their normal depression. Early in the disease they may be narrowed from spasm of the intercostal muscles. With large effusion and increase in size of the affected side the spaces may actually be widened from pressure, and perhaps, also, from paralysis of the intercostals. Later, following the absorption or removal of fluid, the thoracic wall may be depressed, and the intercostal spaces narrowed from contraction of scar tissue. The diaphragm, and with it the liver or spleen, is at first depressed from the loss of the normal negative intrathoracic pressure. With large effusions, the diaphragm is forced downward by positive pressure from above and the weight of the superimposed fluid. The dislocation of the mediastinum and the heart from small effusions is a result of a disturbance of equilibrium between the two pleural sacs. It is dislocated by positive pressure with large effusions. Pressure on the esophagus may lead to dysphagia, and pressure on or invasion of the region about the vagus, to recurrent laryngeal paralysis.

The ultimate causes of circulatory symptoms have been the subject of much experimentation. They do not appear to be due to changes in the blood-pressure from narrowing of the pulmonary circulation, which may be obstructed even to four-fifths of its extent without a permanent fall of blood pressure (Lichtheim *et al.*). Even a slight increase of intrathoracic pressure, however, leads to considerable circulatory disturbance, as is seen in the swelling of the cervical veins in coughing and straining. D. Gerhardt[1] believes this to be due to diminished outflow of blood from the intrathoracic veins, obstruction to the pulmonary capillaries and veins, and reflex depressor action. Compensation may be effected by increased depth of respiration. Toxins, fever, carbon dioxide poisoning, or existing cardiac disease may likewise be factors.

6. **Protective Action (?) of the Effusion.**—Aside from the favorable action which an effusion may be thought to possess in the limitation of motion of the affected lung, a conservative function has been assumed on the ground that it may contain protective substances. At present this can neither be denied nor affirmed. Opie's studies[2] on pleurisy induced in dogs by intrapleural injection of turpentine may have a bearing on this question. He finds that the fibrinous exudate contains a proteolytic enzyme (or enzymes) the exuded serum an anti-enzyme, which prevents autolysis and promotes resolution. In his experiments removal of fluid appeared to hasten autolysis,

[1] Zeit. f. klin. Med., 1904, vol. lv. [2] Trans. Assoc. Amer. Phys., 1907, vol. xxii.

and promote incomplete resolution and greater abundance of fibrin. It may even induce empyema in dogs. The danger of transforming a serofibrinous effusion into empyema by the withdrawal of fluid, as suggested by Opie's experiments, appears to be insignificant in clinical cases.

7. **Absorption.**—Various factors probably play a part in absorption. Hydremic and congestive transudates are rapidly absorbed under favorable conditions. Inflammatory fluids containing relatively few formed elements and fibrin may likewise spontaneously disappear. Purulent fluids, however, may remain indefinitely unless evacuated by perforation or operation. Large effusions are less often absorbed. The mechanism is probably largely mechanical. Small, serous, effusions, unassociated with fibrinous obstruction of pleural lymphatics, and interfering relatively little with respiratory changes of intrapleural pressure, are most favorable for absorption, while the opposite obtains in large and inflammatory fluids. West[1] refers to the "lymphatic pump," the action of which is suspended by fibrin plugging the pleural stomata and large effusions which prevent aspiration on the affected side. It is probable that osmosis, also, is a factor. Rothschild[2] finds that fluids showing less molecular concentration than the blood, as indicated by a higher freezing point, are more likely to be absorbed than those in which the opposite relation obtains. In the latter instance abstraction of fluid from the blood may increase the amount of pleural fluid until isotonicity is established. Absorption is delayed by the production of artificial pneumothorax as shown by Fleiner[3] and Naegeli.[4]

Symptoms —1. **Primary Form.**—Prodromata are uncommon. Slight cough and failing health may precede the onset. An initial chill is rare; chilliness is common. The disease began gradually in more than one-half (60 per cent.) of my series. There is malaise, pain of variable intensity, fever, and cough. Sudden onset, in which the patient's activity is abruptly interrupted, is less common. In exceptional cases the initial features may suggest pneumonia. There is chill, fever, and severe pain in the side, but no rusty sputum. An insidious onset, especially at the extremes of age, is not infrequent. In a small proportion the symptoms are sufficiently characteristic to suggest the diagnosis from the history of initial pain, which gradually diminishes or stops as the fluid accumulates and the dyspnea increases. The temperature may gradually rise as long as the fluid increases, is continuous during this period, intermittent with the effusion at a standstill, and often absent during absorption. It may reach normal at the end of a week or ten days, although continuous or irregular fever may last for a much longer period. The exudate may be discovered by the third or fourth day; if untapped, may gradually

[1] Lancet, March 25, 1905. [2] Deutsch. Aerzteztg., 1901, H. 40, p. 241.
[3] Virchow's Arch., vol. cxii, pp. 97 and 282.
[4] Zeit. f. d. gesamte exp. Med., 12 März, 1913.

increase during the next ten days, then gradually diminish, to disappear in favorable cases during the third, fourth, or fifth week of the illness.

The disease is often atypical. General symptoms and fever may predominate, and, aside from the pulmonary findings, typhoid fever may be suggested. Pain in the abdomen, with muscular spasm and tenderness, may mislead the observer into the diagnosis of an acute abdominal affection. Both onset and course may be latent or sudden, severe, even rapidly fatal (pleuritis acutissima). There may be an initial chill, rapid rise of temperature, intense dyspnea, cyanosis, rapid pulse and respiration, delirium, and death in a few days with symptoms of suffocation. An immediate resort to evacuation may be life saving in such cases.

2. **Secondary Form.**—The onset and course are often so masked by the existing disease that symptoms referable to the pleura are unnoticed or absent. The presence of pleural effusion may then be discovered only during a routine physical examination, or, if this is neglected and the disease is fatal, at autopsy. The presence or absence of symptoms largely depends on the mildness or severity of the primary disease. In pulmonary tuberculosis, however, the symptoms may be typical, since effusion usually occurs early, if at all, in its course, from the frequent obliteration of the pleural sac by adhesions in the more advanced stages. In lobar pneumonia, typical symptoms of effusion are usually lacking or only with difficulty differentiated from those due to the pneumonia itself. There may be an accession of pain, dyspnea, or cough. The respirations, pulse, and temperature may rise above their previous level. A failure of the temperature to drop at the expected time may be the first indication.

3. **Special Symptoms.**—*Pain.*—This is usually one of the first and most typical symptoms. It was present in 89 of 100 cases of primary serofibrinous effusion in this series. It may be absent, as in 5 cases. Associated tenderness over the inflamed pleura is frequent.

Cough.—This is probably next in frequency, occurring in 83 per cent., absent in 12 per cent., and not given in 5 per cent. It is usually short and dry, but may be accompanied by expectoration (48 per cent.). The sputum is mucoid or muco-purulent; rarely it may contain blood (2 per cent.) Cough alone may be due to pleural irritation. Expectoration should suggest a pulmonary complication, usually an infection, more rarely edema, evidence of which may be furnished by the character of the sputum.

Respiration.—Short, quick respiration is frequent in the early stages from pain and spasm of the respiratory muscles. The rate may be elevated from fever, encroachment on the thoracic space by fluid, associated pulmonary disease, or embarrassment of the circulation from pressure. The normal relation between the rate of respiration and pulse is much more often maintained with pleural effusion than with pneumonia. Quick respiration is more often observed at the

onset and after exertion. When the patient is at rest and the exudate has gradually accumulated, one side of the chest may contain its full capacity of fluid without disturbance of the normal respiration-pulse ratio.

Dyspnea.—The embarrassment of respiration may amount to dyspnea. This is more frequent in rapidly formed and large accumulations, and may become orthopnea. At times, however, with small effusions and much limitation of respiratory motion, there may be marked dyspnea. Cyanosis, with or without turgescence of the cervical veins, is likely to accompany marked interference with respiration.

Temperature.—There is no typical fever curve. The temperature is more often elevated and in general reaches a higher level than with dry pleurisy. Of 100 primary cases in my series, only 10 were without fever. From 100° to 102° is an average pyrexia. In rare instances the temperature may reach 104° to 105° or higher. It is likely to be high in children and robust patients. Absence of fever is occasionally observed in old or debilitated patients and in terminal infections, when it may be subnormal.

Pulse.—This presents no special features. The rate usually corresponds to the fever curve. The rapid accumulation of a large amount of fluid may embarrass the circulation and cause a rapid and feeble pulse.

Febrile or Toxic Symptoms.—These are not especially characteristic and are such as may be seen in other infectious processes. At the onset there may be headache, insomnia, malaise, and general pains. The skin is hot and dry. As the fever drops, there may be sweating, which may become a prominent symptom if the process is long continued. There may be thirst, anorexia, even nausea and vomiting, but gastric disturbances are uncommon. In protracted cases the loss of strength and weight may be marked.

Hoarseness may be due to pressure on or paralysis of the recurrent laryngeal nerve. *Dysphagia* from pressure on the esophagus may be present. Ferber has observed that the passage of food through the esophageal foramen may be accompanied by pain, when there is diaphragmatic pleurisy. *Singultus* is a rare and interesting symptom. It may be most distressing when the diaphragm is involved.

Urine.—During the acute stage, the urine presents the usual features common to febrile disturbances. It is small in amount, of high color and specific gravity, with an increase of urea and uric acid and a diminution in the chlorides. During absorption, the amount may rise rapidly with an increase in the output of chlorides, the so-called "chlorine crisis," while urea and uric acid are diminished. Traces of albumin and a few hyaline casts may be present and can be ascribed to fever, toxemia, or rarely to statis.

Physical Signs.—Small amounts of fluid collect in the most dependent part of the thoracic cavity, in the costophrenic sinus posteriorly,

and in the region between lung and diaphragm. Until the amount of fluid becomes considerable, it intervenes very little between lung and chest wall. In Garland's experiments there was scarcely a trace of a rim of fluid between the lower border of the lung and the chest wall, with injections which occupied less than one-third of the thoracic cavity. In explanation of this it is assumed that there is a greater elastic traction in the lower than in the upper parts of the lung. Larger amounts finally intervene between lung and chest wall. In favorable and uncomplicated cases, 250 c.c. of fluid in an adult should not escape detection. In infants 100 c.c. may be discovered.

Inspection.—Herpes is uncommon. Inspiratory dilatation of the alæ nasi is less frequent than with pneumonia. The position of the patient is variable. If there is dyspnea, the patient may be more comfortable sitting upright, from the greater mechanical advantage and from the removal of the weight of the effusion on the lung which this position affords. With small effusions, without orthopnea, the patient may be more comfortable on the unaffected side. The explanation of this is not clear. It may be due to the relief of pain from removal of pressure on sensitive nerves in the affected pleura. With large effusions, the patient usually chooses a position on the affected side, thus allowing the sound lung full play and diminishing pressure on the mediastinum. It is not uncommon, even with large effusions, to find the patient lying comfortably on the back. At times an ambulant patient presents himself with a large effusion.

In the early stages of the disease, when there is pain and only a small amount of fluid, the appearance of the thorax does not differ from that described under Fibrinous Pleuritis. With increase in the amount of pleural fluid, there is progressively less expansion and elevation of the affected side. The presence of pain always still further limits thoracic motion. Diminished motion may often be apparent as a delay in expansion of the lower parts of the chest during the first part of inspiration. With large amounts of fluid, expansion and elevation may be absent. The intercostal spaces in spare individuals may be seen to have lost their normal depression and may even be widened and fuller than normal. An increase in size can be confirmed by the tape, even as much as an inch or an inch and a half greater than the opposite side. The skin may appear somewhat shiny and smooth from obliteration of normal furrows and depressions. Edema of the skin and dilatation of the superficial veins may occur, but are rare with serous effusion. Weisz[1] finds that the phonation phenomenon (visible voice vibrations) is transmitted through fluid and may separate its lower limit from the upper border of the liver.

In consequence of the fulness of the affected side, the distance between the median line and the nipple in front and the scapula behind may exceed that on the normal side. With large effusions the cor-

[1] Prag. med. Woch., 1905, xxx, 261.

responding hypochondrium may be fuller. The shoulder and with it the outer end of the clavicle stand at a higher level. Following partial or complete absorption or withdrawal of fluid, the affected side may be somewhat diminished in size and the intercostal spaces narrowed. Slight lateral deviation of the spine may accompany this retraction. Retraction and scoliosis are much less marked after serous than after purulent fluids.

The diaphragm shadow is absent on the side of the effusion. It usually remains absent after recovery, but may return, although practically always of diminished amplitude. The position of the cardiac impulse should be inspected. Evidence of pleuropericardial adhesions may be obtained by systolic depression of the intercostal spaces in an abnormal position in the cardiac region.

Rarely *pulsation* of the chest wall may be observed with serofibrinous effusion, but is more common with pus. The pulsation may be confined to a locally bulging area; it may be circumscribed without tumor or may be diffuse. Instances have been reported, among others, by Cruveilhier, Flint, Broadbent, and Osler. Cases of *pulsating hemothorax* have been observed by Vialle and Braun, Montégre, McPhedran, and Sailer,[1] who gives an account of the literature to 1904. In Sailer's case there was true expansile pulsation of the whole thorax.

Palpation.—This may confirm the results of inspection. A difference in the expansion of the two sides of the chest, the condition of the intercostal spaces, the degree of separation of the ribs, the position of the cardiac impulse and pulsations in other parts of the chest may be more evident to the hand than the eye. Pulsation, indeed, may be so slight as to be appreciated only by the hand. A narrowing and a more marked resistance to pressure in the interspaces may occur early in the disease from spasm of the intercostals, and is an important sign. The interspaces may be narrowed even when the affected side is increased in size. A friction rub may be felt before the onset of effusion; it may be palpated outside the limits of fluid during the course of the disease and may return following absorption. The temperature of the affected side is higher. Edema and fluctuation are rare with serous effusion. The liver or spleen may be displaced downward. The diaphragm may be so far depressed as to be felt below the costal margin.

The tactile fremitus is practically always absent; it is rarely present, but usually even then diminished, in children, with adhesions between the visceral and parietal pleura, or with small effusions. This is one of the most important signs of fluid. The dividing line between lung and fluid can often be sharply drawn at the level at which the voice vibrations are lost. The tactile fremitus above the fluid may be diminished, maintained, or increased, depending on the condition of the pleura and the lung. Unfortunately, fremitus cannot always be

[1] Amer. Jour. Med. Sci., 1904.

obtained in women or children, owing to the high pitch of the voice or the presence of an abundant layer of subcutaneous fat. Acute or chronic inflammatory thickening of the pleura diminishes, although it practically never abolishes, the fremitus. In the performance of thoracentesis a localized area where fremitus is maintained should not be chosen, because of the possibility of pleural adhesions at this place.

Percussion.—Light is far superior to heavy percussion in bringing out slight changes in the pleura. Early in the disease, when there is only a small amount of fluid, no change in the percussion note may be detected. As the fluid increases there is dulness at the base. As the fluid rises, the note becomes less resonant and finally flat. The region of flatness and absent tactile fremitus correspond. The percussion note over effusions of considerable size is of short duration, lacking in volume, of high pitch, very nearly like the note obtained on percussing the thigh. It is very difficult to mark on the chest the exact upper limit of fluid. With considerable fluid, three zones with well-marked differences in the percussion note can be made out in the anterior and more often in the posterior thoracic regions. Normal or diminished vesicular resonance may be obtained in the uppermost parts of the chest. Between this region and the fluid the note is dull, but has a tympanitic quality (Skoda's resonance), due to retraction or compression of the lung and vibration of air in the bronchi or trachea. Below, there is flatness from fluid. The intermediate dull or dull and tympanitic area is usually most marked behind, in the interscapular region, but with large effusions may be detected in front, under the clavicle. If an arbitrary distinction be made between resonance and dulness and dulness and flatness, a triangular area of dulness or dull tympany can be marked out in the interscapular region, between the relatively normal lung above and the fluid below. This triangle has for its base the vertebral column, for its lower side the lower limit of lung, corresponding to the beginning of flatness, for its upper limit the beginning of dulness. The triangle represents the retracted or compressed lung, which may be apposed to the chest wall in this region. Its recognition is important for the correct determination of the upper limit of the effusion. The tympanitic note observed above the layer of fluid, as over pulmonary cavities, may change in pitch with the mouth open and closed (Williams' tracheal tone) during inspiration and expiration (Friedreich's phenomenon), and on changing the position of the patient (Gerhardt's phenomenon). A cracked-pot sound also may be heard in the absence of cavity.

With right-sided effusion, the dulness merges below with that of the liver. On the left, the tympany from inflation of the stomach with gas may be confusing and mask slight changes in the note from fluid. With considerable fluid in the left pleura, the normal tympany of the semilunar space between liver and spleen (Traube's semilunar space) may be obliterated.

Curved Line of Flatness in Pleural Effusions.—The limitation of fluid by dulness by some observers, and flatness by others is responsible for much confusion in the description of the line assumed by the upper border of pleural fluid. If the dull triangle mentioned above be included, the upper limit of fluid is nearly horizontal behind. With a small or medium effusion, however, the line of flatness only should be regarded as indicating its upper limit.

Damoiseau was the first to note that the upper limit of flatness was a curved and not a straight line. Ellis, of Boston, correctly traced the curve, which Garland[1] verified clinically and explained by a series of experiments.

For the demonstration of the curve the patient must be in the upright position. It is best indicated by light percussion, in parallel lines, perpendicular to the upper line of the effusion, which, in general, is transverse about the chest. With small or medium effusions, the general shape of the curve is that of an elongated "S," lowest behind, advancing upward and forward to the axillary region, where it is highest, thence sloping gradually downward. With large effusions the curve may be flattened out to assume a more nearly horizontal line. The curves of the line of flatness correspond to the line of apposition between the lower border of the lung and the pleural fluid. It is thus the shape of the lower border of the lung which gives to the line the shape of the elongated letter "S." The elastic retraction of the lung supports a certain volume of fluid and prevents its upper limit from assuming a hydrostatic level.

The curve may be of diagnostic value as a confirmatory sign of pleural effusion. It cannot be demonstrated in circumscribed effusions, in the presence of adhesions, or in other than the upright position. Pulmonary infiltration, by diminishing the elasticity of the lung, may render difficult or prevent the demonstration of the curve. It makes no difference whether the fluid be serum or pus. The curve is more pronounced with fluids undergoing absorption or after partial removal by tapping, a possible explanation for which may be the presence of pleural adhesions in the lateral thoracic region, maintaining the lung at a higher level here, while posteriorly, where fluid collects in greater amount, its intervention between lung and chest wall may prevent the formation of adhesions.

Shifting Dulness.—Dulness due to pleural effusion shifts on changing the position of the patient. This is especially true of small and recent effusions. With the patient upright, then in the horizontal position the upper border of fluid changes its level. It is absent in the presence of encapsulating adhesions and may be slight or absent with large effusions. Due allowance in noting shifting dulness must be made for normal changes in the percussion note over the chest in different positions. The posterior inferior parts of the lung, where the test is

[1] Boston Med. and Surg. Jour., September 17, 1874, and Pneumono-dynamics, Boston, 1878.

usually made, normally become more resonant when the patient assumes a horizontal position, as in bending forward or lying face downward. The maintenance of one position during the development of an effusion is capable, to a certain extent, of modifying the location of the fluid. If the patient has been constantly on his back, the upper limit of fluid is likely to be higher behind, and small effusions may be confined to the back and posterior axilla. It should be remembered in testing shifting dulness that the fluid may change its position only slowly.

Sense of Resistance.—In addition to the lack of resonance or other peculiarities of the percussion note appreciated by the ear, the lack of vibration and sense of resistance may be apparent to the finger as well.

Auscultation.—Early in the disease, a friction rub may be heard. Its presence does not exclude fluid, which may exist between lung and diaphragm or in the neighborhood of apposed pleural surfaces. With small effusions, the rub not infrequently persists in the lower anterior or lateral portions of the chest. The disappearance of this sign as fluid accumulates is probably due not so much to intervention of fluid between lung and chest wall as to the mechanical obstruction to the expansion of the lung. The re-appearance of friction in cases with pleural effusion is favorable, indicating diminution or disappearance of fluid, provided extension of fibrinous pleuritis to previously uninvolved parts be excluded.

Crepitation, resembling that in the early stage of lobar pneumonia, and audible at the base of the lung, may also be heard in cases which later develop demonstrable fluid. Its explanation is not clear. It may be ascribed to fine pleural friction, to air entering fluid in alveoli underlying an inflamed pleura, and to expansion, during inspiration, of a slightly retracted and atelectatic lung, giving rise to crepitation coincident with the separation of previously apposed alveolar walls. A similar sound may also be heard at the termination of the disease, and may indicate that the pleural layers are again approximated, or that air is again admitted to the base of the lung.

Breath Sounds.—Changes in the breath sounds in uncomplicated pleural effusion are due to several factors, more than one of which usually operate in any given case. They depend on diminished expansion of the lung, from spasm or paralysis of the respiratory muscles, to changes in the lung itself from retraction or pressure, and to the presence in the pleural cavity of fluid which modifies or may even abolish the variations conducted from the lung to the chest wall.

Early in the disease irritation of the pleura and pain diminish the respiratory murmur from spasm of the respiratory muscles and fixation of the side. Even slight exudation without pain may do likewise from the mechanical obstruction of fluid. In the presence of fluid, however, the retraction and increased density of the lung may give rise not only to a diminution in the intensity of the respiration, but to a change in its character. With small effusions, the inspiration is

merely diminished, while expiration is abnormally long, somewhat higher pitched, and slightly bronchial in character. As the fluid increases in amount, the breathing over the base of the lung may have a distinctly tubular quality. This is often most marked in the interscapular region above the level of the fluid. With large effusions the breathing is vesicular in the upper part of the chest. It may be bronchial above and absent below the level of the fluid. When the lung is completely retracted and compressed, there may be almost no respiratory murmur over the affected side. At times the breathing may have an amphoric character in the upper part of the chest. Rales, as well as bronchial breathing, may have a metallic quality and thus suggest cavity. In children the breathing is more likely to be bronchial than in adults. With the subsidence of the effusion the vesicular breathing returns, but may for long or even permanently remain somewhat diminished. As the atelectatic lung expands, rales can usually be heard. An accompanying catarrh or edema of the lungs may give rise to rales on the side of the effusion which may have a consonating quality from pulmonary compression. The breathing over the unaffected lung is often increased with prolongation of expiration.

Voice Sounds.—The voice sounds are often increased above, diminished or absent below the level of the fluid. The voice may have a peculiar nasal or bleating quality, the so-called ægophony. It is most often heard in the posterior and lower thoracic regions. The whisper is variable, but in general is increased over the region where bronchophony is heard, and may have a bronchial character. It is usually diminished or absent over the fluid. It is said by Bacelli to be transmitted through a serous and not through a purulent exudate, but the sign is not reliable.

Examination of the Heart.—Dislocation of the heart is one of the most important signs of pleural effusion. The position of the visible cardiac impulse should be noted. It may be seen at either side of the sternum. If the apex is behind the sternum, there may be no visible pulsation. At times an impulse is seen below the ensiform in the upper epigastric region. Palpation for the systolic impulse in the spaces on either side of the sternum may furnish more definite information. In some cases pulsation can be neither seen nor felt, and reliance must be placed on auscultation. Greene[1] finds that rhythmic lateral displacement of the heart is a sign of unilateral pleural fluid. It may be demonstrated by inspection, auscultatory percussion, or the fluoroscope. A systolic murmur is not infrequently heard over the displaced heart, and is probably due to pressure on the great vessels, especially the pulmonary artery.

Special Physical Signs.—1. **Displacement of the Heart.**—(*a*) *Away from the Affected Side.*—An accumulation of air, fluid, or other foreign

[1] Amer. Jour. Med. Sci., 1906.

material in one pleural sac allows the lung on that side to contract, and thus exhausts a part of its elastic force. The intrapleural tension on the affected side is correspondingly increased, while that on the unaffected side is still maintained at, or nearly at, its former level. The mediastinum is thus subjected on either side to unequal pressure, and seeks a position of equilibrium between the two. Because of the firmness with which the mediastinum as a whole is held in place by ligamentous bands and bloodvessels branching in various directions, its displacement is less marked than that part of it occupied by the heart, which is attached above to the relatively immobile aorta, but is elsewhere capable of considerable lateral motion within the elastic parietal pericardium. It seems more in accordance with the mechanical factors to regard cardiac displacement as due to a thrust or "push" of the relatively higher intrapleural pressure in the diseased sac than a "pull" from the relatively lower pressure in the normal side.

Provided the heart is free to move laterally, its displacement may be one of the first signs of an accumulation in the pleural sac. The intrapleural pressure on the diseased side need not be actually positive. Apposition of fluid or other material to the heart is not a necessary factor. Because of the normal position of the heart on the left, it is always displaced a greater distance to the right with left-sided pleural disease than to the left with disease of the right pleura. To judge from Carrière's observations and experiments, the amount of fluid in the left chest may reach 700 c.c. without displacement of the heart. The writer has seen slight cardiac displacement develop under observation in a girl of fourteen, from whose left pleura 250 c.c. of pus were evacuated by operation. Cardiac dislocation may be noted before dilatation of the side is evident. As much as 1000 c.c. of fluid may be present in the right pleura without evident displacement of the heart to the left. In such diseases as pneumonia, in which pleural fluid may occur as a complication, or in cases in which its presence is suspected, a careful record of the position of the heart may be of unexpected value later in the course, when a slight deviation from its originally recorded position may be a deciding factor in a diagnosis, otherwise doubtful because of pulmonary changes complicating the physical signs. Since cardiac displacement depends not only on a loss of retractile force in the lung on the diseased side, but also on the maintenance of elastic tension in the opposite lung, any interference with the latter from disease will correspondingly limit the cardiac excursion toward that side. Thus pleural adhesions, pneumonic infiltration, emphysema, or other structural changes may so diminish the elastic power of the uncontracted lung as to limit or even prevent cardiac displacement.

(*b*) *Toward the Affected Side.*—Occasionally in the course of long continued pleural disease, absorption may lead to an increase of negative pressure on the diseased side. The heart may then be pushed toward this side by the relatively greater but still negative pressure in

the unaffected pleura. Thus far mention has been made only of cardiac displacements from differences of intrapleural pressure. The heart may, however, actually be pulled to one side by the contraction of adhesions between it and neighboring structures.

(*c*) *Position of the Displaced Heart.*—The studies of Powell, Ferber, Bard, Pitres, and others show that in the displacement to the right with left-sided effusions the heart practically always maintains its position with the apex to the left of the base, pulsation to the right of the sternum arising at the base of the heart. In Lafforgue's[1] case, however, with a large effusion of blood in the left pleural sac, the heart was found at autopsy pointing to the right.

2. **Diaphragm Phenomenon.**—Gerhardt[2] referred to this, but thought it of rare occurrence and limited, for the most part, to emaciated individuals. Litten[3] observed its presence in all normal individuals, more accurately described its clinical appearance, and emphasized its importance in pathologic conditions. He found it represented in Michael Angelo's figure of the dying Adonis in the court of the Bargello at Florence.

With the patient and the observer correctly placed, one may see in practically all normal individuals a transverse shadow descending with inspiration and ascending with expiration over a narrow zone in the lower anterior and lateral regions of the chest. It begins above in the region of the seventh rib, intersecting the ribs at an acute angle as it descends on deepest inspiration a distance of two to three spaces, or about 6 to 7 cm., to ascend to its original position with expiration. On superficial respiration, its amplitude is about one to one and a half spaces. It is best seen between the axillary and mammary lines, but may be followed through the axilla and the back, with the patient lying on the abdomen. It is highest in front, descends somewhat toward the axilla, then runs in a nearly horizontal line toward the spine, and is lost between the angle of the scapula and the spinal column. During inspiration, the differences of pressure in the thorax and abdomen are expressed on the thoracic wall as a horizontal furrow. A short interval elapses between the beginning of inspiration and the appearance of the phenomenon.

The sign is of value in unilateral pulmonary or pleural disease. It is absent in pneumonia of the lower lobes, is diminished in amplitude or absent and abnormally low in the presence of pleural fluid or air. The excursion is diminished, distorted, or irregular in the presence of pulmonary infiltration (as in tuberculosis), thoracic retraction, following pleural or pulmonary disease, pulmonary or pleural tumors, and with pleural adhesions. With enlargement of the liver or spleen, with abdominal fluid or tympanites, it may be diminished in amplitude and abnormally high. The sign may be of assistance in the diagnosis of subphrenic abscess, simulating suppuration in the lower

[1] Gaz. des hôp., 1902. [2] Der Stand der Diaphragmas, Tübingen, 1860.
[3] Deut. med. Woch., 1892, and Verhandl. d. Cong. f. inn. Med., 1895.

thoracic region. The presence of the shadow above the involved area, although of diminished amplitude, may indicate the subdiaphragmatic site of the lesion. It is also of value in distinguishing pneumothorax from diaphragmatic hernia, being absent in the former, but present in the latter.

3. **Paravertebral Triangle of Dulness.**—The presence of a normal triangle of dulness at either side of the spinal column in the anterior thoracic region makes the pathologic triangle more difficult of interpretation and somewhat limits its value as a diagnostic sign. On percussion of the spinal column from above downward, the note becomes progressively duller as its lower thoracic limit is approached. The degree of normal dulness in this region can be appreciated only by experience.

Korányi's[1] and Grocco's observations on this sign have since been confirmed by many observers. Specially noteworthy are the observations of Baduel and Siciliano[2] on its explanation and the series of clinical cases studied by Thayer and Fabyan.[3]

Having determined the limits of a suspected effusion by percussion and similarly outlined the lowest limit of pulmonary resonance on the unaffected side, the spinous processes of the vertebræ are percussed from above downward and the point noted where relative dulness begins. This usually corresponds to the level of relative dulness on the affected side, and somewhat higher than the level of flatness. Percussion of the unaffected lung in horizontal lines toward the spinal column discloses a paravertebral area of relative dulness of a triangular shape. The vertical side of the triangle coincides with a line drawn through the spinous processes of the vertebræ, the base with the limit of pulmonary resonance on the sound side. Its outer side is formed by a line extending obliquely downward and outward. The height of the vertical and the width of the base line vary with the size of the effusion. The base may thus vary from 2 to 7 cm. in length. The triangle is somewhat larger in right-sided effusions. It may differ from the normal triangle only in the degree of dulness. In Thayer and Fabyan's series a small but distinct triangle was detected with a left-sided effusion, which on tapping disclosed only 250 c.c. of serofibrinous fluid. On changing the position of the patient from the upright to the horizontal, the dull triangle nearly or quite disappears unless the fluid is encapsulated. The respiratory murmur, the voice sounds, and fremitus are diminished over this area, but the changes are less marked than on the affected side. The character of the fluid appears not to influence the triangle.

[1] The triangle was first noted by Korányi in 1897 (in the fourth volume, p. 717, of Belgógyàszat Kezikönyze, and again in Eulenberg's Realenzyklopädie der gesamtem Heilkunde, vol. xiii). It was independently rediscovered and more fully described by Grocco (Riv. crit. di clin. med., Firenze, 1902).

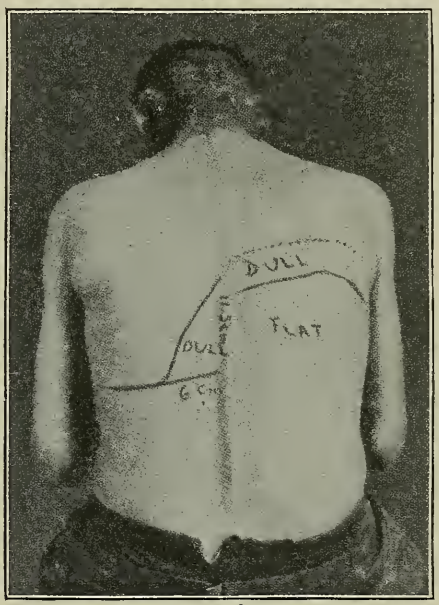
[2] Riv. crit. di med., Firenze, 1904, v, 5, 21, 37.

[3] Amer. Jour. Med. Sci., January, 1907.

The dull triangle is practically constant in the presence of free pleural fluid or of encapsulated fluid in contact with the spinal column.

In explanation of the phenomenon, Baduel and Siciliano[1] suggest that fluid intervening between the spine and resonant lung inhibits the capacity of the former for sonorous vibrations, thus acting as a mute. The diminished resonance extends into the paravertebral region and increases in width from above downward, since the fluid at its base comes into wider contact with the spinal column and extends farther toward the opposite side. Displacement of the mediastinal contents and compression of the sound lung may play a part in its production.

Fig. 79



Aortic insufficiency; hydrothorax on the right side; paravertebral triangle of dulness on the left. (Thayer and Fabyan.)

Paravertebral Dulness on the Affected Side.—Free pleural effusions distend the pleural sac and interrupt spinal vibrations with the production of dulness on one or both sides of the spine according to the size of the effusion. If the effusion is small, the dulness may be limited to the paravertebral region on the affected side without evidence of Grocco's triangle on the other. With pneumonia affecting the lower lobes and uncomplicated by an effusion, on the other hand, a zone

[1] Riv. crit. di med., Firenze, 1904, v, 5, 21, 37.

of relative resonance about two fingers' breadth in width can usually be demonstrated in the paravertebral region on the affected side.[1] This strip of relative resonance may be obvious only in the presence of extensive lobar pneumonia and absent or doubtful with small areas of consolidation from other causes. It is probably due to uninterrupted spinal vibrations reinforced by compensatory emphysema of the unaffected lung. A zone of dulness in the paravertebral region on the affected side with pleural effusion and relative resonance in this region, with lobar pneumonia may be of some value in differentiating the two conditions.

Blood.—The number of red cells and the amount of hæmoglobin present no striking features beyond usually not more than slight grades of secondary anæmia.

White Cells.—In general, it may be said that the leukocytes in primary serofibrinous pleuritis are only rarely above normal in the absence of complications. Infectious pleuritis, on the other hand, is usually accompanied by leukocytosis. The white count, therefore, may be of value in distinguishing the two forms of the disease.

Tuberculous Effusion.—Of 33 cases of primary serofibrinous pleuritis in which tubercle bacilli were found in the fluid by inoscopy or animal inoculation the white count was above 12,000 in only 3 (9 per cent.), of whom 2 showed a leukocyte count of 14,000 to 15,000, and the remaining case 20,400. A complicating pulmonary tuberculosis may raise the white count, for of 32 cases in this group 7 (21.8 per cent.) were 12,000 or over. In 301 primary cases, of probable tuberculous nature, the white count was 12,000 or over in 57 (18.9 per cent.). Of these 57 cases the leukocytes numbered 12,000 to 13,000 in 22; 13,000 to 14,000 in 9; 14,000 to 15,000 in 8; 15,000 to 16,000 in 3; 16,000 to 20,000 in 10, and 20,000 to 24,000 in 5. The leukocytosis was doubtless transient in many.

In 224 separate counts, in 20 cases of primary pleurisy, daily until discharge or disappearance of the fluid, Morse[2] found that only 13 counts went above 10,000. Of these, 9 were in 1 case showing pneumococcus infection at autopsy. The other 4 were in 2 cases, and the counts were but little above 10,000. He concludes from his study that there is no evident relation between the duration of the disease, the temperature, the presence of blood or few pus cells in the fluid, the amount of fluid or its variation and the leukocyte count.

Infectious (non-tuberculous) Pleuritis.—The *metapneumonic* effusions, are, as might be expected, accompanied by an increase of the white cells. Of 28 cases in this class the leukocytes were above 12,000 in all but 6 (78.5 per cent.). They numbered 12,000 to 16,000 in 4; 16,000 to 20,000 in 6; 20,000 to 50,000 in 12. Pneumonia is not a necessary factor in raising the white count, however, and infection of the pleura alone in apparently uncomplicated cases with serofibrinous

[1] Lord, Boston Med. and Surg. Jour., February 12, 1914, p. 245.
[2] Amer. Jour. Med. Sci., 1900, cxx, 658.

effusion may raise the white count, as in 2 streptococcus infections with 19,600 and 35,400 white cells.

Serofibrinous effusions complicating arthritis showed an increase of white cells in all of 3 cases, but it must be a question whether the leukocytosis can be ascribed to the one or the other lesion.

Differential Count.—Aside from the occasional presence of eosinophilia in hemorrhagic effusions, there appears to be nothing characteristic in the differential count in serofibrinous effusion. Of 17 cases, the relative proportion of white cells showed nothing remarkable with the exception of a relative increase in the polynuclear cells in cases with leukocytosis and an eosinophilia of 20 per cent. in 1 of 5 cases with bloody fluid.

Spleen.—This is rarely, if ever, enlarged unless some complication exists. It may be palpable from dislocation with left-sided accumulation.

Axillary Glands.—Due allowance must be made for the presence of small palpable glands in a large proportion of normal individuals. Rarely the axillary glands on the affected side may be enlarged by extension of the pleural disease, whether simple, tuberculous or malignant.

Inequality of the Pupils.—This may in rare instances occur from involvement of the sympathetic nerve. The difference in size is usually slight.

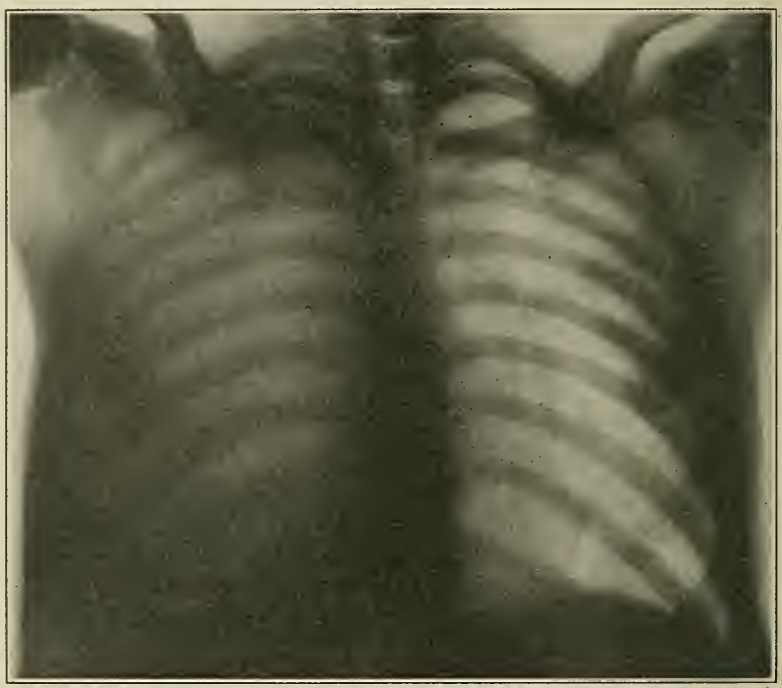
Blood-pressure.—This is usually normal with pleural effusions, compensation for intrathoracic pressure being maintained by increased respiration. When this compensation fails, however, there may be a fall of pressure. Capps[1] noted an increase of blood-pressure during the excitement preceding thoracentesis. There was a constant fall during the withdrawal of the fluid, the average in 19 observations being 20 mm. Hg. Evacuation of large amounts of fluid, rapid withdrawal, long duration of the effusion, senile changes in the blood-vessels and heart, increased the fall of pressure.

Radioscopy.—This may confirm the results of physical examination, showing the limits of the effusion, the position of the displaced heart and the diaphragm. It may also show the presence of unsuspected pulmonary processes. It is especially valuable in locating an encapsulated effusion. The fluoroscope admits of examination from different points of view in rapid succession, but the radiograph is, in general, to be preferred. Permanent records, for study and comparison, are thus secured. The plates are most satisfactory if the patient can hold his breath during the exposure. Pleural adhesions may be suggested by a lack of diaphragmatic excursion. Thick pleura without fluid may be indicated by a lack of uniformity, by irregular limitation of the shadow and an absence of depression of the diaphragm and dislocation of the heart. The shadow is less dense than with fluid. In

[1] Jour. Amer. Med. Assoc., January 5, 1907.

the presence of pleural fluid, the shadow is more uniform, more sharply outlined, and when the fluid is free occupies the lower part of the pleural space. Its upper border is curved, unless pneumothorax is present, when it assumes a hydrostatic level. A comparison of plates taken with the patient upright and lying down confirms the clinical observation of the mobility of fresh serofibrinous effusions. The shadow produced by serous is less dense than by purulent or hemorrhagic fluid.

Fig. 80



Pleurisy with left-sided purulent effusion. The entire left side of the chest is opaque on comparison with the right. Displacement of the heart to the right. (No. 188,395.)

Complications.—Lesions having an etiologic relation with the disease have already been considered. It is difficult oftentimes during life or even at the postmortem table to separate them from conditions dependent on the pleuritis. These secondary processes, only need be considered here. Tuberculosis may rarely extend from pleura to uninvaded lung. The progress is usually, however, from lung to pleura. Acute miliary tuberculosis may rarely complicate or follow serofibrinous effusion. Infection may extend to the opposite pleura, the pericardium, peritoneum, or other parts of the body. Perihepatitis or perisplenitis may thus arise. Thrombosis of the pulmonary vessels, the venæ cavæ, heart, iliac, femoral, saphenous, or other veins may

be associated with increased intrathoracic pressure and infection. Embolism may be rapidly fatal. Edema of the lungs is a constant danger in large accumulations and with untapped effusions is probably due to cardiac insufficiency. Perforation of the lung or thoracic wall complicates purulent effusions with unfortunate frequency, but is rare with the serofibrinous form. Serous expectoration without relation to thoracentesis has been noted by Scriba,[1] Sahli,[2] and Appel.[3] Nephritis probably bears only a chance relation to pleuritis. It arose under observation in only 1 of 500 cases in the writer's series.

Causes of Sudden Death.—Death may be due to associated and independent lesions to which the pleuritis is secondary. Such causes need not be considered here. Of causes dependent on the serofibrinous effusion, thrombosis and embolism are among the most frequent. The pulmonary vessels, the auricles, the venæ cavæ, iliac and femoral veins often contain thrombi, which may give rise to emboli, with rapidly fatal pulmonary embolism, as in 5 of 14 autopsies in this series. Cerebral embolism is less common. Edema of the lungs may be the only associated lesion found, as in one case with a double effusion. Postmortem examination does not always disclose the immediate cause of death, which has then been thought to be due to compression of the aorta (Trousseau), or to a kink or twist in the inferior vena cava (Bartels), but Osler in a number of observations was unable to substantiate the latter. Cerebral anemia, from a mechanical hindrance to the circulation, is a possible cause. Pressure on the venæ cavæ, and the heart itself, especially the auricles, may embarrass the cardiac mechanism, resulting not only in cyanosis, rapid, feeble pulse, and dyspnea, but even syncope and death. Various factors may operate in individual cases. Large double or left-sided effusions are more dangerous. Death may follow sudden changes of position, an attack of pain, deep respiration, or a paroxysm of cough. Many more lives are sacrificed by hesitation and delay in thoracentesis than by the operation.

Duration.—Of 369 cases of primary serofibrinous pleuritis, the time from the beginning of symptoms to discharge from the hospital was less than three weeks in 53, three to six weeks in 167, six to nine weeks in 60, nine to twelve weeks in 43, three to six months in 31, six months to one year in 12, two years or over in 3. Thus, about 60 per cent. ran their course within six weeks, about 87 per cent. within three months. The duration is longer with large effusions, in old and debilitated patients, in the presence of complications, in untapped cases or those in which evacuation is delayed. It is shortest in primary effusions, in young and otherwise apparently healthy individuals, treated by early tapping.

[1] Deut. Arch. f. klin. Med., 1886, xxxvi, 329.
[2] Mitth. a. klin. u. med. Inst. d. Schweitz., 1894.
[3] Münch. Annalen, 1897, Fall 15.

Relapse.—Although it is not uncommon after withdrawal of fluid for it to reaccumulate under observation and necessitate one or more tappings, it is rare for a serofibrinous effusion to reappear on the same side after it has been fully absorbed or removed. In one of my series, nine months elapsed between the removal of fluid and the appearance of the patient with an accumulation on the same side, but it is not certain that the fluid was fully removed at the first operation. The obliteration of the pleural sac following serofibrinous effusion is probably responsible for the rarity of true relapse.

Sequelæ.—It is rare for serofibrinous effusions to change from serous to purulent fluid. Of 1185 cases, empyema developed in only 16 (1.3 per cent.). When empyema follows serofibrinous effusion, the fluid has usually been turbid, with an excess of polynuclear cells from the beginning. Spontaneous or artificial pneumothorax may occur, and, if the communication is through the lung, infection may follow. Imperfect technic in tapping may cause empyema. Slight dulness, diminished expansion, breathing, and fremitus last for a variable period after the disappearance of serofibrinous fluid. The intercostal spaces may be slightly narrowed and the affected side somewhat smaller. These changes may be permanent, but are less common and less marked than after empyema. The heart usually returns to its normal position. Rarely it may be fixed by adhesions in an abnormal position toward the sound side or slightly displaced toward the affected pleura. Slight lateral deviation of the spine may accompany these changes.

Diagnosis.—This is usually easily made from the onset with pain, the diminution or disappearance of which is accompanied by increasing dyspnea, the diminished expansion of the affected side, initial narrowing, with later enlargement of the side and widened interspaces, the character and distribution of the dulness, diminished or absent breathing and fremitus, and the displacement of neighboring organs.

Diseases with Which an Effusion may be Confused.—1. *Intrathoracic.* (*a*) *Thick Pleura.*—Following the partial or complete absorption or removal of pleural fluid, the thickened pleura may give rise to some confusion. There may be slight dulness, diminished breathing and fremitus. The side is not flat, however, the breathing only slightly altered, without bronchial character, and the fremitus, although it may be diminished, is not absent. The paravertebral triangle of dulness opposite the affected side is absent and the heart is not displaced.

(*b*) *Pneumonia.*—Typical lobar pneumonia is easily differentiated by its more severe onset, with chill and rapid rise of temperature, cough with rusty sputum, dulness (not flatness), bronchial breathing, increased voice, whisper and tactile fremitus, and consonating rales. The signs are often confined to parts or the whole of one or more lobes. Atypical pneumonia may closely simulate effusion. Cough and expectoration may be absent. Partial or complete involvement of the lower lobes with occlusion of the bronchi by secretion

(massive pneumonia) may give rise to signs of effusion. If the bronchi can be emptied by cough, the signs of pneumonia may then become clear. The absence of cardiac displacement is important. A narrow strip of relative resonance in the paravertebral region on the affected side with croupous pneumonia and dulness in this region with pleural effusion is of some value in differentiating the two conditions. Small amounts of pleural fluid often complicate pneumonia. Small effusions are more often serofibrinous, large amounts more commonly purulent. In doubtful cases exploratory puncture should not be delayed. Chronic suppurative changes in the lungs, with multiple bronchiectatic cavities, interstitial pneumonia and thick pleura, may closely resemble pleural effusion. The vocal fremitus may be diminished; in rare instances it may be absent, if the dilated bronchi are filled with secretion. Evacuation may be followed by a return of fremitus. The dulness is often greater in some places than in others, and is not as marked as with fluid. The side may be contracted, the interspaces somewhat narrowed, and the heart in normal position or slightly displaced toward the affected side. The diaphragm may be elevated, the diaphragm phenomenon diminished in amplitude or absent. Exploratory puncture is attended with some danger of perforating the elevated diaphragm and infection of the peritoneum, of bleeding from injured bloodvessels or granulation tissue, or the infection of an intact pleura in the withdrawal of the trocar. If pus is found, it may come from pulmonary cavities.

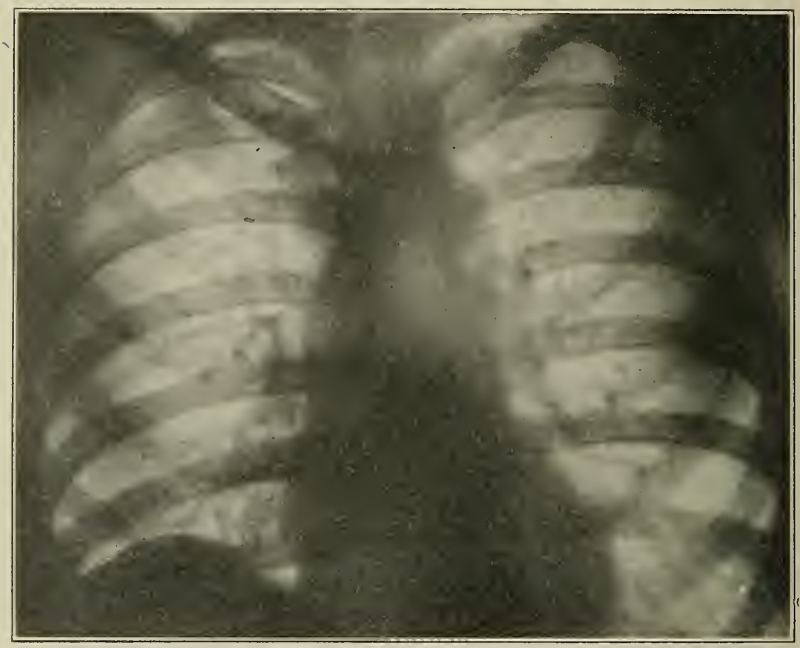
(*c*) *Tumors of the Lung and Pleura.*—Tumors which reach the periphery of the lung may give rise to some confusion. There may be flatness, diminished or absent breathing, and fremitus. The site and contour of the process may differ from pleural fluid. Bloody sputum, dyspnea, stridor, paralysis of the vocal cords, dysphagia, dilatation of the cervical or thoracic veins and superficial metastases may be suggestive. If the pleura is invaded by the new growth, an effusion is common and this may mask the pulmonary process. Exploratory puncture may evacuate bloody fluid. Echinococcus of the lung or pleura may simulate serofibrinous pleuritis.

(*d*) *Pericarditis with Effusion.*—This may offer some difficulty of differentiation from an encapsulated pleural effusion in the left anterolateral region. The same symptoms—pain, cough and dyspnea—may be present in both conditions, and on inspection the left side of the chest may show restricted expansion. Dulness or flatness, diminished or absent respiration, voice, whisper and tactile fremitus may be present over the left anterolateral part of the chest. The following features, however, may serve to suggest pericardial rather than pleural effusion: a history of rheumatism preceding or accompanying the onset of the affection, a greater degree of cyanosis than might be expected with a pleural effusion of similar size, dilated cervical veins, paradoxical pulse, feeble or absent cardiac shock, an obtuse cardiohepatic angle on percussion, a pyriform or oval contour

to the dull area with dulness at the left of the sternum as high as the second rib, declining sharply toward the left axillary region, dulness in the left infrascapular region, pericardial friction and feeble heart sounds. Examination by means of the *x*-rays may be of great value in the differentiation.

2. *Abdominal Affections.*—Subdiaphragmatic abscesses and tumors, especially echinococcus cysts, may simulate an accumulation of pleural fluid. Abdominal pain, tenderness, and muscular spasm may be due to diaphragmatic pleurisy.

FIG. 81

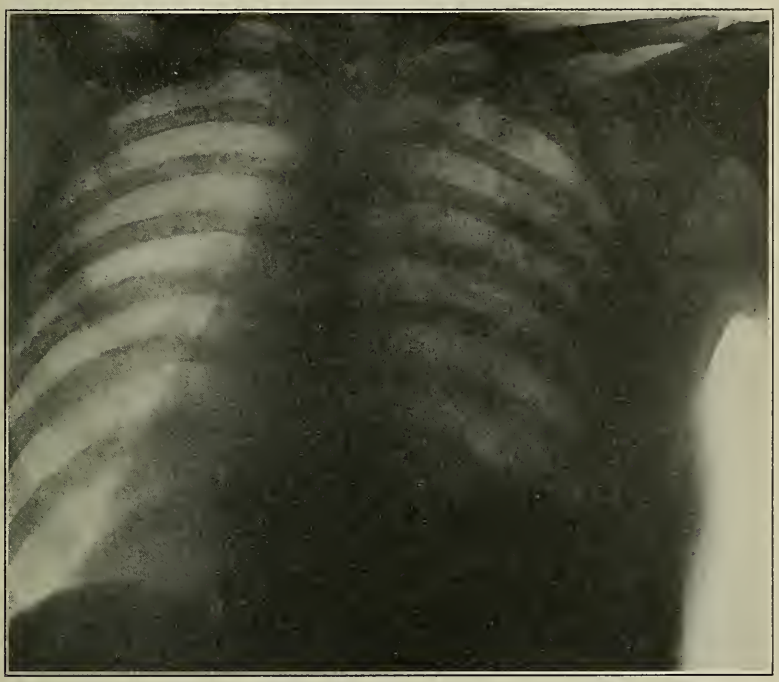


Subdiaphragmatic abscess of the right side. The dome-like elevation of the diaphragm is indicated as an opaque shadow with convex upper margin at the base of the right lung. The costophrenic sinus is obscured by a slight accumulation of pleural fluid. (No. 191,899.)

Subdiaphragmatic abscess may present special difficulty of differentiation. Preceding abdominal symptoms may suggest the possibility of abdominal suppuration. Among the numerous causes, appendicitis, pylephlebitis, hepatic abscess in connection with cholangitis with or without gall-stones, tropical abscess and actinomycosis, perforated gastric or duodenal ulcer, suppuration in or about the pancreas, salpingitis and disease of the kidney or spine may be mentioned. In some cases preceding abdominal symptoms are lacking. Cough and expectoration are likely to be absent. The right side is more often affected than the left. The diaphragm may be elevated

far into the chest or intrude only slightly into the lower thoracic aperture. In cases uncomplicated by pleural effusion, the dome-like elevation of the diaphragm may be outlined on percussion as a dull area at the base of the lung with convex upper margin. An important feature in the percussion outline is the maintenance of resonance on the affected side in the paravertebral region which is dull in the presence of free pleural effusion. Over the dull area the breathing is

FIG. 82



Subdiaphragmatic abscess complicated by secondary pleurisy with purulent effusion. The entire right side is more opaque than the left. The more transparent apical portion shades gradually into a more dense middle zone representing pleural fluid. In the lower third of the right side is a dense opaque shadow with convex upper margin, representing the subdiaphragmatic abscess. The upper margin of the elevated diaphragm is partially obscured by the pleural effusion. Displacement of the heart to the left. (No. 187,058.)

diminished and may have a bronchial quality from pulmonary retraction or compression. The voice sounds are diminished, but do not have the ægophonic quality so often heard with pleural effusion. The tactile fremitus is diminished but not absent. A friction rub may be heard if fibrinous pleurisy is present. The heart is less displaced than with pleural effusion of corresponding size. If a complicating pleural effusion is present, the signs are those of this condition. Exploratory puncture may demonstrate the presence of pus. Sero-

fibrinous fluid may be obtained from the pleura and pus from below the diaphragm. Inspiratory depression of the point of the needle may indicate that the diaphragm has been perforated. If the respiratory changes of tension are noted, an increase of pressure may be demonstrated during inspiration and a diminution of pressure during expiration. X-ray examination furnishes the most important evidence. By this means an abrupt dome-like elevation of the diaphragm may be seen as a dense shadow with convex upper border at the base of the lung (Fig. 81). In the absence of a complicating pleural effusion a clear space is observed at the costophrenic sinus and toward the mid-chest. Fluoroscopic examination usually shows a greater degree of inspiratory depression and expiratory elevation of the diaphragm than is present with pleural effusion. If a complicating pleural effusion is present the *x*-ray picture is obscured, but the outline of the elevated diaphragm may still be seen through the shadow caused by the effusion (Fig. 82).

Determination of the Character of Pleural Fluid.—This is impossible in most instances without exploratory puncture, but certain suggestive features may be mentioned. Hydrothorax is most easily distinguished from the presence of cardiac or renal disease or both, bilateral fluid, which shifts more readily on changing the position of the patient, and edema elsewhere, as well as absence of pain, fever, leukocytosis, and friction rub. In unilateral hydrothorax without general dropsy the distinction may be impossible. Hemorrhagic fluid may be suspected following trauma, when the effusion is secondary to malignat disease, or with an eosinophilia in the circulating blood. Chylothorax can hardly be distinguished, but may be suspected with the known presence of chylous ascites. Empyema, in typical cases, may be differentiated. It is more likely to be secondary and metapneumonic, while serofibrinous effusion is much more likely to be primary. If the patient is a child and under five years, the chances are much in favor of pus. The symptoms are of little assistance in individual cases, but in general are more severe in empyema, with higher and more irregular fever, chills, sweats, and more rapid loss of flesh, strength and color. Edema of the skin, dilatation of the superficial veins, thoracic pulsation, perforation of the lung or other organs may suggest empyema. A leukocytosis above 12,000, unexplained by other features, suggests an infectious process and usually means pus.

Exploratory Puncture.—This may be done without pain as follows: The site of the puncture is frozen with ethyl chloride spray. The syringe is filled with about 2 c.c. of sterile water containing gr. $\frac{1}{3}$ (0.021 gm.) novocain and gr. $\frac{1}{2000}$ (0.00032 gm.) adrenalin and the needle introduced through the frozen area. The needle is thrust inward by degrees, perpendicular to the surface, each advance being preceded by the injection of a small amount of the fluid into the tissue in front of the point. The rib is passed close to the upper margin to avoid the intercostal artery. After the pleural sac is reached, the

syringe should still contain some fluid which may then be used to dislodge from the lumen of the needle any fibrin or other material preventing aspiration. Thick pus may fail to flow through a small needle.

In addition to the determination of fluid, the operator may appreciate any unusual thickness or density of the pleural or pulmonary tissue by the amount of resistance encountered by the instrument (palpatory puncture). In rare instances a diagnosis between pleural and subdiaphragmatic fluid may be made. By the removal of the syringe and the attachment of a rubber tube to the needle, the apparatus is converted into a siphon and the amount of pleural pressure may be determined, as suggested by Krönig. The normal depression during inspiration and elevation during expiration of the column of fluid may be reversed in subdiaphragmatic collections. The withdrawal of small amounts of fluid by exploratory puncture is occasionally followed by rapid spontaneous absorption of what remains.

In rare instances, if the needle is used for exploratory puncture, the microscopic examination of a piece of tissue caught in the lumen may furnish the diagnosis. In one of my series a tubercle was thus demonstrated. Prentiss[1] made the diagnosis of sarcoma and Steele and Girvin[2] of carcinoma of the pleura by this means.

Examination of Pleural Fluids.—Under normal conditions there is merely enough pleural fluid to lubricate the apposing surfaces of the pleuræ, and as yet no chemical analysis of this has been made.

1. *Chemistry.*—Pleural fluid may be *serous;* it may contain varying amounts of fibrin, when it is known as *serofibrinous;* it may also vary in its content of blood and pus and may then be termed *hemorrhagic, fibrinopurulent,* or *purulent.* The presence of chyle justifies the term *chylous;* of fat not due to chyle, *chyliform.* Clear serous fluids are usually yellowish, often reddish from the admixture of blood, and at times somewhat greenish in color. Large quantities of blood or pus are usually sufficiently obvious from the gross appearance.

Transudates and Exudates.—It is customary to make a clinical distinction between fluids resulting from hydremia and stasis or transudates and those arising in the course of inflammatory processes or exudates. Such fluids may be due to one or more different factors, as in similar accumulations elsewhere. It will suffice here merely to refer to the probable influence of filtration and osmosis and an increased permeability or possible secretory power of diseased capillary walls, concerning the ultimate bearing of which, however, little is definitely known. The chemistry is of principal interest in furnishing data which may confirm a clinical diagnosis of hydremia, stasis, or inflammation as a cause.

In general, transudates are of relatively low specific gravity and

[1] Trans. Assoc. Amer. Phys., 1893. [2] Proc. Path. Soc. Phil., 1901.

contain a small amount of albumin, *i. e.*, a specific gravity of 1010 or under for hydremic fluids, with traces to 1 per cent. of albumin; and 1010 to 1015 in venous transudates, with 1 to 3 per cent. of albumin. The albumin is principally serum albumin, serum globulin, and a trace of fibrinogen. Only a very slight precipitate follows the addition of a few drops of acetic acid to the fluid. It coagulates slowly or not at all, unless mixed with blood. The specific gravity of exudates, on the other hand, is usually 1018 or higher, with 4 per cent. or more of albumin. They show a more abundant precipitate on the addition of acetic acid, contain a larger amount of fibrinogen, and usually coagulate rapidly with or without the presence of blood. For the estimation of albumin Esbach's test may be used, but is only approximately accurate, and for more exact determination more complicated methods must be employed, such as the weight of the precipitated proteid or the total nitrogen (Kjeldahl).

2. *Cytology.* — *Cytodiagnosis.* — By this is understood the determination of the cause of the effusion from the character and numerical relation of its cellular elements.

Technic.—The fluid should be examined as soon as possible after withdrawal. To prevent spontaneous coagulation and the entanglement of cells in the meshes of fibrin, it may be placed at once in a sterile flask containing about one-third to one-half its volume of 1 per cent. sodium citrate in 0.85 per cent. salt solution. If coagulation has already occurred, Widal recommends agitation with glass beads to dislodge entangled cells, but such a procedure may give less accurate results than the examination of fluid in which clotting has not taken place. The sediment is obtained by centrifugalization, the supernatant fluid carefully decanted, and thin smears made with the platinum loop. These are allowed to dry in the air or over the Bunsen flame. Care must be taken not to burn the preparation. Wright's[1] blood stain is allowed to remain on the cover-glass from one-half to one minute, then diluted with 8 to 10 drops of water, and allowed to stand one to two minutes. The preparation is washed in a gentle stream of tap water, dried over the Bunsen flame, and mounted in balsam.

Red cells are of relatively little importance in the microscopic examination. A differential count should be made of the white cells, which may be classed as follows:

A. Polynuclear: (*a*) Neutrophiles; (*b*) Eosinophiles; (*c*) Mast-cells.

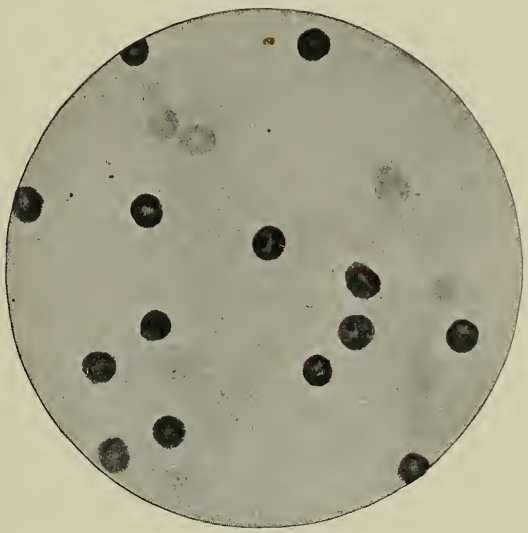
B. Mononuclear: (*a*) Lymphocytes; (*b*) Endothelial cells; (*c*) Cells intermediate and indistinguishable from (*a*) and (*b*).

Polynuclear neutrophiles correspond to similar cells found in the circulating blood. Degenerative processes may lead to the formation of isolated nuclear fragments, with or without a granular protoplasm,

[1] Jour. Med. Research, January, 1902.

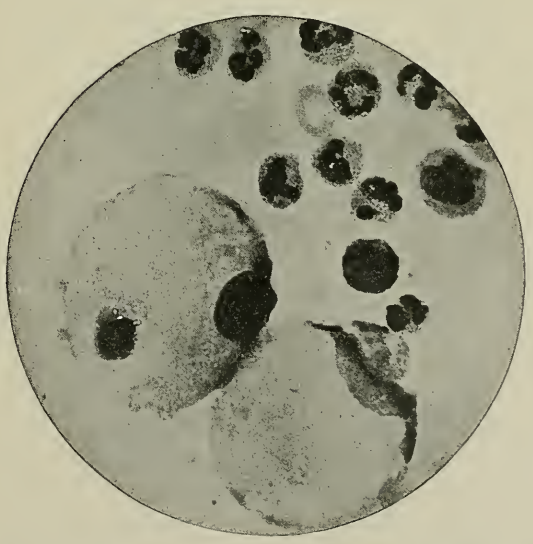
contraction of the nucleus alone or both nucleus and protoplasm, and vacuolization. Such changes, however, seldom modify the character of the cells to such an extent as to prevent their recognition. Eosino-

FIG. 83



Lymphocytosis. Case of primary tuberculous pleurisy. × 750. (Musgrave.)

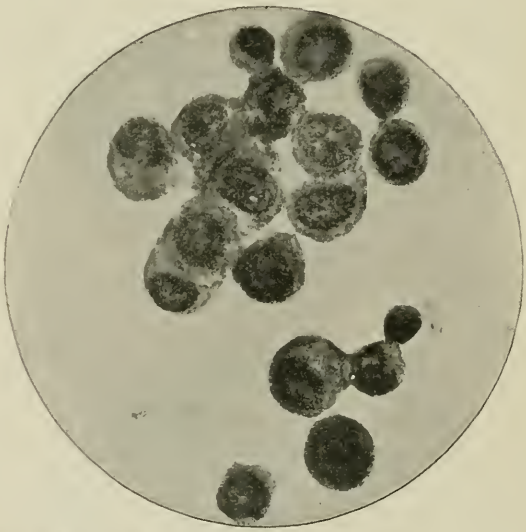
FIG. 84



Large phagocytic endothelial cells and polynuclear leukocytes. Case of acute infectious pleurisy. × 750. (Musgrave.)

philes are often found in small numbers, mast-cells less often. Both are in most instances readily classified. Of the mononuclear cells, typical examples of lymphocytes and endothelial cells are easily differentiated. The lymphocytes correspond to similar cells in the blood. At times, no rim of protoplasm can be detected about them. Endothelial cells are large, flat, irregular, round, or oval in contour, with a round or oval blue nucleus, which is poor in chromatin and often vacuolated. They may be isolated or in plaques, the so-called "Placards endothéliaux." Such an arrangement as the latter plainly indicates their origin from the pleural wall. They are phagocytic, and have in consequence been called macrophages. Considerable variation is common in nucleus and protoplasm. Either or both may be markedly vacuolated and one or the other may be absent.

Fig. 85



Endothelial plaques and cells. Case of hydrothorax due to cardiac disease. × 750. (Musgrave.)

Unfortunately, between typical examples of lymphocytes and endothelial cells there are atypical forms of mononuclear leukocytes which cannot be fairly classed with either of the two groups. Such atypical cells, however, usually comprise but a small proportion of the white cells, and may thus introduce a negligible error in the differential counts. In some cases, the classification of the cellular elements is impossible because of degenerative changes.

Cytologic Formulæ.—The varying character of cells in pleural fluids was first noted by Ehrlich. Further observations were made, among others, by Quincke and Wolff. In 1900, Widal[1] elaborated the

[1] Widal and Ravaut, Compt.-rend. de la Soc. de Biol., 1900, p. 648.

method, formulated a classification of pleural diseases, based on the varying proportion of different cells in pleural fluids, and suggested the term "cytodiagnosis." Widal stated that (1) a predominance of polynuclear leukocytes means an effusion of infectious origin (pneumococcus, streptococcus, staphylococcus); (2) of lymphocytes, a tuberculous effusion; and (3) of endothelial cells, especially if in plaques or sheets, an effusion of mechanical origin.

More recent observations make it probable that the character of the cells in pleural fluids depends not only on the cause of the process, but also on the intensity of the pleural reaction. The predominance of one type of cell, therefore, cannot be regarded as a specific indication of an infectious, tuberculous, or mechanical origin, although Widal's formulæ have been sufficiently verified to warrant a probable diagnosis, provided the clinical character of the case accords with the microscopic findings. The method is thus a valuable accessory in diagnosis, but must not be expected to establish the diagnosis of itself alone.

Various exceptions to the above formulæ must be noted. They limit the diagnostic value of the procedure. An excess of polynuclear leukocytes in infectious pleuritis is subject to least variation. Concerning the lymphocytosis of pleural tuberculosis, it should be noted that a transient excess of polynuclear neutrophiles has been found by Widal and others in its early stages. The secondary infection of a pleura already the site of tuberculosis may likewise modify the character of the cellular elements, with an increase in the relative proportion of polynuclear cells. In regard to the predominance of endothelial cells in mechanical effusions, it has been noted that they are relatively most numerous in the early stages of the disease. In long-standing transudates, Naunyn[1] has shown that the proportion of endothelial cells may diminish and lymphocytes may be in excess. Lymphocytosis has been present without a reaction to tuberculin and in transudates shown by autopsy not to be tuberculous. As in fluids with lymphocytosis, so, also, in those with an excess of endothelial cells, an infection may raise the number of polynuclear cells.

In malignant disease of the pleura, the cellular elements conform more nearly to those found in mechanical effusions, with an excess of endothelial cells, but large numbers of spindle cells may suggest sarcoma, as in Warthin's case. Examination of the fluid in conjunction with the history and physical examination may confirm an otherwise doubtful diagnosis.

In experiments on animals, a lymphocytic pleuritis has been produced by the injection of diphtheria bacilli and diptheria toxin. The bearing of such experiments on cytodiagnosis is still an open question.

3. *Bacteriology.*—For the demonstration of the pneumococcus, the pyogenic cocci, and other organisms capable of cultivation, smear preparations should be made and suitable media inoculated.

[1] Deut. med. Woch., 1903, 18 V. B., p 140.

Tubercle Bacillus.—Special methods, the results of which have already been mentioned under Etiology, have been devised for its demonstration.

Inoscopy.—Jousset,[1] in 1903, proposed a simple method for the demonstration of tubercle bacilli in coagulable fluids. After withdrawal, the fluid, at least 100 c.c. in amount, is allowed to clot. The clot is removed and washed free of serum on sterile gauze, with sterile water, then placed in a flask containing 10 to 30 c.c. of the following digesting fluid: Pepsin, 1 to 2 grams, pure gylcerin and strong hydrochloric acid of each 10 c.c., sodium fluorid 3 grams, and distilled water to 1000 c.c. The flask is placed in the incubator at 38° C. until the clot is digested. Two to three hours are usually needed. Frequent agitation of the fluid hastens the process. The digested fluid is sedimented, the supernatant fluid decanted, and from the precipitated material smears are made with the platinum loop. These are dried and stained for tubercle bacilli.

Sedimentation.—Zebrowski[2] takes at least 100 c.c. of fluid, adds an equal volume of 1 per cent. sodium flourid to prevent coagulation, and allows the solution to stand in a cool place for twenty-four hours. The supernatant fluid is decanted and the precipitate centrifugalized. Smears made from the material thus obtained are investigated for tubercle bacilli, as already described. The greatest care should be taken that bacilli in fluids previously examined are not left clinging to the apparatus.

Animal Inoculation.—All instruments must be sterilized. Intraperitoneal inoculation of guinea-pigs is most successful. For the demonstration of tubercle bacilli, large amounts of fluid must be injected, but in divided doses. If the animal lives, three months should be allowed to elapse before the examination is made. Le Damany[3] made injections each week of 10 to 50 c.c. of fluid, varying the amount according to the toxicity of the fluid, and was thus able to inoculate as much as 300 c.c. The fluid was preserved in test tubes of small caliber, then transferred to a medium-sized tube, open at both ends, one of which was drawn to a blunt extremity and inserted through a small abdominal incision. Escape of fluid about the incision was prevented by a U-shaped suture. If the fluid failed to flow, the free end of the tube was plugged with cotton and carefully heated, thus insufflating the contents. In this way both clot and sediment were inoculated.

Prognosis.—In general, the immediate prospect in serofibrinous pleuritis is good. Large or double effusions may, however, be suddenly fatal. Of 500 cases in the writer's series, 4 (0.8 per cent.) died without other obvious cause than the effusion. In one, large amounts of fluid rapidly reaccumulated, conforming to the uncommon variety known as pleuritis acutissima. No autopsy was obtained. The three remain-

[1] La semaine méd., 1903, p. 22. [2] Deut. med. Woch., 1905, Nr. 36.
[3] La presse méd., November 24, 1897, p. 329.

ing patients were not tapped. Two had double effusions, in one of whom autopsy showed that death was due to pulmonary embolism; in the second no other cause of death was found postmortem than edema of the lungs. In the last patient there was a large unilateral accumulation, and examination after death showed pulmonary embolism. Thoracentesis might have been life saving in these cases. If an infectious and non-tuberculous cause can be established, the prognosis is favorable.

Prophylaxis.—In a large majority of the cases this embraces measures for the prevention of infection with the tubercle bacillus and other organisms.

Treatment.—1. **The Natural or Spontaneous Cure.**—The large proportion of cases coming to autopsy with pleural adhesions, associated with fibrocaseous or calcified pulmonary lesions, shows that pleural disease, directly or indirectly dependent on the tubercle bacillus, is frequently arrested or healed. Tuberculous nodules in the pleura, as elsewhere, may be walled off by a dense envelope of fibrous tissue, and thus prove of little danger to the individual, forming latent foci. Calcification may take place, as in 5 of 27 cases (M. G. H.), with obsolete tuberculosis as a result. Tuberculous granulations in a part or the whole of the pleura may finally be converted into firm, fibrous tissue, ending in obliteration of the pleural sac and no further trouble from the process. The clinical history of cases of certain or probable pleural tuberculosis shows that recovery is not infrequent.

2. **General Measures.**—For purposes of treatment, it is best to assume every case of primary serofibrinous pleurisy to be tuberculous, unless there is good reason to believe otherwise. Fortunately, many patients are still in fair health when they first come under observation. The course of the disease is often slow and spontaneous recovery frequent, which, indeed, too often fosters half-way measures in its care. As in tuberculosis elsewhere, we must rely chiefly on rest, fresh air, and the improvement of nutrition. It must be constantly in mind that the pleural disease is usually secondary to tuberculosis of the lung or thoracic glands, as is shown by autopsy, although the primary focus often escapes detection during life.

If we are to secure the hearty coöperation of the patient, he should be frankly told the seriousness of his condition. We can otherwise hardly secure his acceptance of the necessary restrictions on his mode of life. The chances with primary serofibrinous effusion are about 3 or 4 in 10 that pulmonary or other tuberculosis will appear within a period of six or seven years. These figures have this hopeful aspect, however, that they are for the most part gathered from cases in which treatment terminated with the disappearance of the effusion. They probably, therefore, represent the natural evolution of the disease, and a longer or even a permanent arrest may be expected in patients who can and will consent to more careful supervision and regulation of the daily life.

During the acute stage, while there is fever, *rest* in bed should be enforced and maintained until the temperature is normal. After the acute symptoms have subsided, the patient may cautiously be given greater liberty, careful watch being kept meanwhile on the temperature. The supply of fresh air should be continuous and abundant, by night as well as by day. Means similar to those in pulmonary tuberculosis may be taken to secure this. In undernourished individuals an increase in weight should be sought from the beginning and for such patients extra feeding must be employed. The food should be simple and nutritious and extra feedings of milk or eggs may be given between the regular meals. Fat is important and is best given in the form of cream or fresh butter.

The treatment should not end with the subsidence of fever and the disappearance of fluid. Patients who have apparently recovered should be kept under observation, and every effort made to maintain the general condition at a high level. Country is better than city life. The occupation should be carefully chosen. Overcrowded, dusty, or badly ventilated places should be avoided. Indiscretion and neglect may bring the patient under observation a second time with pulmonary or other tuberculosis too late for successful treatment. Loss of weight, fever, cough, or other suspicious symptoms should receive immediate attention, and, if necessary, a further course of rest, outdoor life, and extra feeding.

3. **Local Applications.**—These are for the alleviation of symptoms. The ice-bag, hot-water bottle, and hot applications repeated every two hours may efficiently relieve pain, for which, however, morphin may be necessary. It is doubtful if blisters have other than a harmful effect, making the patient uncomfortable and adding to the danger of thoracentesis, if the skin becomes infected. Strapping the affected side only further displaces the lung and other organs. It may actually hinder absorption by compressing the lymph channels.

4. **Special Measures.** — *Thoracentesis.* — *Indications.* — In general, the opinion of the present time is in favor of tapping serofibrinous effusions (1) with pressure symptoms, such as severe dyspnea, cyanosis, or rapidly developing cardiac weakness; (2) of large amount, with dislocation of heart and mediastinum, even without pressure symptoms; and (3) of medium amount when other means have failed to bring about absorption and two or three weeks have elapsed.

With *pressure symptoms and large effusions, thoracentesis is imperative* and should be done without delay. It has been the unfortunate experience of many physicians to decide on evacuation in such cases within a given time, before the expiration of which the patient has suddenly died. The presence of fever is not a contra-indication. Left-sided effusions are somewhat more dangerous. Bilateral fluid, of only medium amount, should likewise be immediately evacuated. The removal of medium and small effusions is not immediately necessary and a short delay may promote repair or furnish evidence of

spontaneous absorption. It is customary to wait two to three weeks, but earlier removal may well be considered. It alleviates symptoms from pressure and may prevent the formation of venous thrombi and the danger of pulmonary infarction. The withdrawal of fibrinous material, hindering absorption, may shorten the course of the disease. The danger of adhesions, permanent fixation of the lung in an abnormal position and persistent reaccumulation of fluid increases with the duration of the effusion.

Selection of Cases for Tapping.—The character of the fluid is important in the decision between thoracentesis and thoracotomy. With clear fluid, thoracentesis is the operation of choice. Open incision is followed by suppuration, which is to be avoided. With turbid fluids the decision is more difficult. They are on the border line between serofibrinous and purulent effusion. Of 27 cases in the writer's series with turbid fluid containing an excess of polynuclear cells, 15 were cured by thoracentesis alone. In 12, pus was found at later tapping and thoracotomy was performed. The tendency of pleural fluid to sediment within the chest must be remembered. A sample from the upper layer may be turbid, while pus may exist below. Turbid fluids secondary to lobar pneumonia or due to the pneumococcus are relatively favorable for thoracentesis. With merely an excess of polynuclear cells in the differential count, tapping alone may be considered. Pneumococci may be found in such exudates, but are often incapable of cultivation. With abundant or necrotic leukocytes and pneumococci on cultivation, operation is usually necessary. Streptococcus infections are usually purulent, or rapidly become so, and generally demand open incision. The general symptoms, the amount of fluid and rapidity of reaccumulation must also be considered.

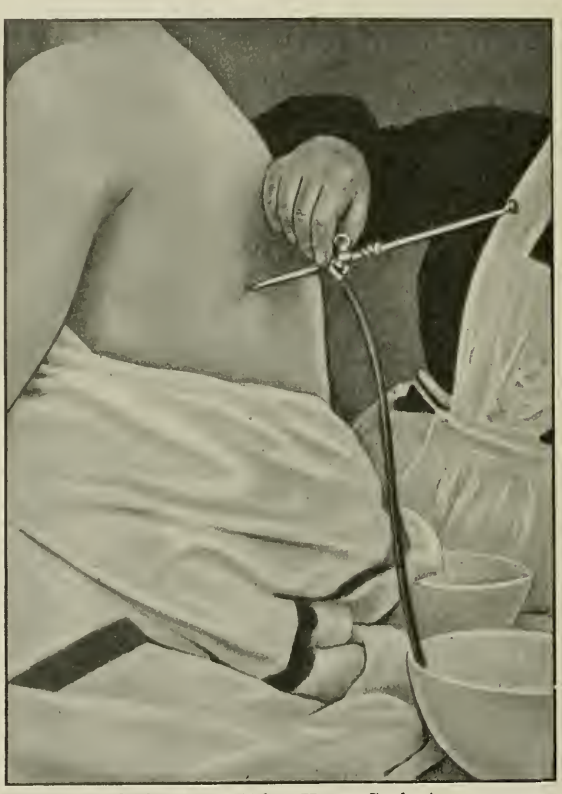
Apparatus.—Needle or Trocar?—The *needle* is simple and less expensive, but has two drawbacks. Its unprotected point may wound the expanding lung or the diaphragm. More important than this, however, a bit of tissue punched out during insertion or a small mass of fibrin may effectually occlude its lumen. To dislodge such particles, the needle must be withdrawn, if the danger of pneumothorax and possible infection of the pleura are to be avoided. Krönig[1] has devised a satisfactory needle, the point of which is rendered harmless by thrusting foreward an enclosed and blunt-pointed cannula. The *trocar* with lateral outlet presents a harmless, blunt end after the removal of the stylet and can be thrust farther in, elevated or depressed without danger to neighboring structures. If plugged, the obstruction is readily removed by the insertion of the stylet and without danger of pneumothorax, if the packing is tight, as it should be, about the stylet. A negative puncture with an ordinary needle is less reliable than with the trocar.

Various trocars have been devised. The cannula should be at

[1] Med. Klinik., Berlin, 1906, ii, 131–135.

least 7 cm. long. In general, the internal diameter should not exceed 1.5 to 2 mm. It is advantageous to have several sizes at hand. The stylet should fit tightly at the extremity of the cannula, which should taper gradually to a thin edge to avoid difficulty and pain in its introduction. A lateral outlet is needed for thoracic puncture, in order that the stylet may be moved in and out without disturbing the connections. A stop-cock on the lateral outlet is useful.

Fig. 86



Siphonage. (After Hoppe-Seyler.)

Toward the proximal end of the instrument and this side of the lateral outlet there should be a stop-cock, to guard against leakage of air about the entrance of the stylet and to maintain the instrument air-tight if the latter is removed. The stylet should run through a compartment capable of air-tight connection with the instrument, and the play of the stylet through this compartment should also be air-tight in order that it may be moved in and out without danger of producing pneumothorax. The proximal end carrying the stylet is the weak part of the apparatus, since it is difficult to secure an air-tight all-metal connection without making the instrument too cumber-

some and without the use of oil. The introduction of rubber washers, although they need to be frequently changed, is the most satisfactory solution. The writer uses an air-tight trocar,[1] constructed on the principles mentioned, with stop-cock on lateral outlet and cannula. (Figs. 87 and 88.)

Fig. 87

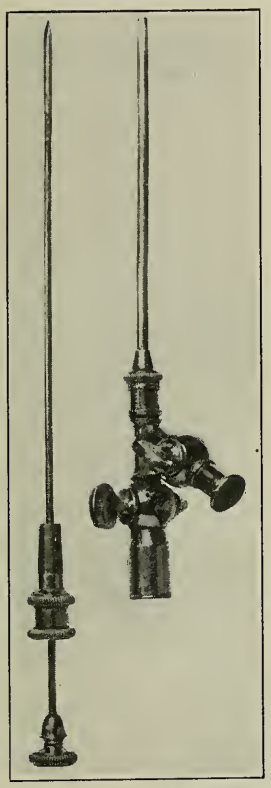


Fig. 88

Air-tight trocar for thoracentesis.

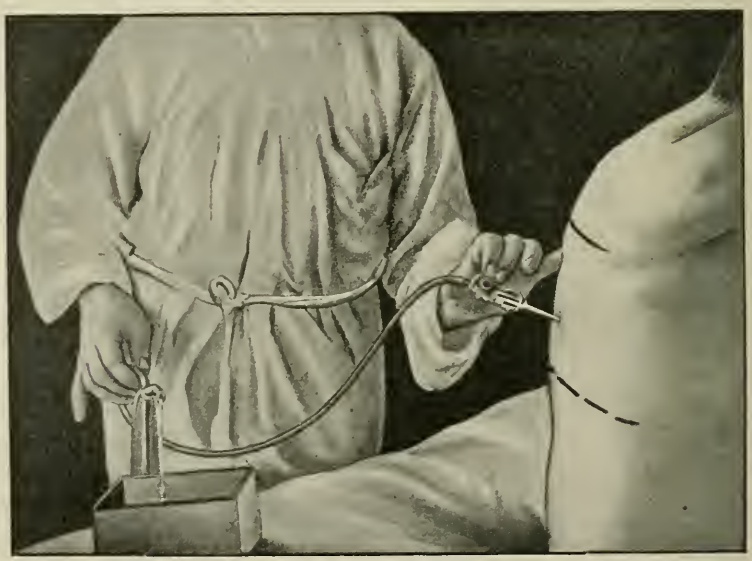
Methods.—In general, there are only two safe and reliable methods, *i. e.*, siphonage and aspiration.

1. *Siphonage.*—This is readily carried out. A trocar such as that described above or Krönig's needle may be used. A rubber tube about 75 cm. long, a clamp for the tube, a glass funnel, sterile water or salt solution are also needed. If the trocar is used, one end of the tube is fastened to its lateral outlet, the other to the glass funnel, by means of which the apparatus is filled with the sterile solution. When the instrument is full, escape of the solution is prevented by fastening the clamp on the rubber tube or closing the stop-cock on the lateral outlet. The tube now contains a column of water, which, on the release of the clamp or stop-cock, is capable of exerting sufficient

[1] An air-tight trocar for thoracentesis, Jour. Amer. Med. Assoc., 1908.

aspiratory force to overcome a negative pressure in the thorax under any ordinary conditions. The trocar is inserted into the chest while the free end of the rubber tube is held beneath the surface of the sterile solution, thus preventing aspiration of air, provided the negative pressure within the chest should be greater than the weight of the column of water in the rubber tube. By this method there is no danger of an excess of negative pressure, which may be varied at will by simple elevation and depression of the free end of the tube. Krönig attaches the free end of the rubber tube to a glass tube passing nearly to the bottom of a flask partly filled with sterile solution, and with a curved outlet at the top (Fig. 89). There is no danger of the entrance of air or of reflux of contaminated fluid. The pressure of the pleural fluid may be measured by elevation and depression of the flask, noting the difference between its upper level in the flask and the chest, when equilibrium is established.

Fig. 89



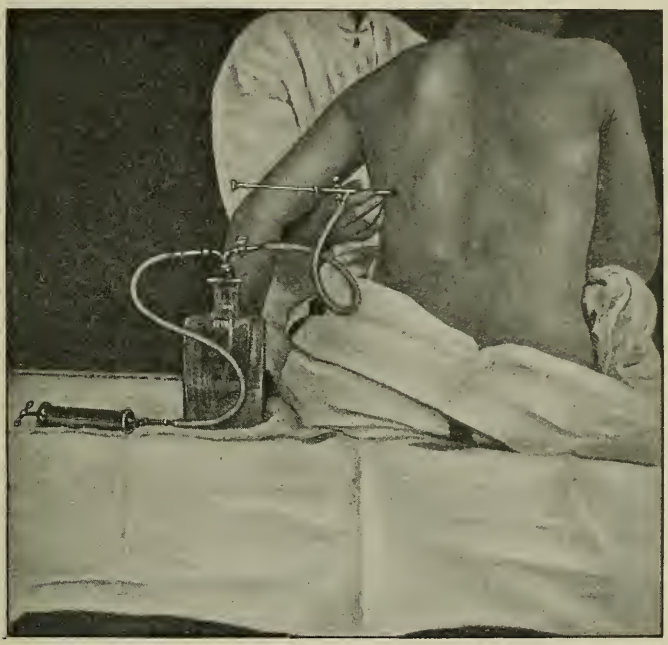
Krönig's method.

2. *Aspiration.*—The most satisfactory method is by means of a bottle, connected on the one hand with the chest and on the other with an aspirator by means of rubber tubing. Aspiration may be effected by means of a pump, as in Potain's method. A rubber bulb may be used, as in Alexander's[1] modification of Unverricht's method. Fürbringer[2] secures negative pressure in the bottle by aspiration with the mouth, which can hardly be recommended. In Dieulafoy's rack aspirator[3] the evacuated fluid flows directly into the vacuum apparatus.

[1] Deut. med. Woch., 1893, Nr. 10, S. 241.
[2] Berl. klin. Woch., 1888, Nr. 13, S. 254.
[3] A Treatise on Pneumatic Aspiration, London, 1873.

Stinzing[1] recommends a tall, graduated flask for the reception of the fluid. In both Stinzing's and Fränkel's[2] articles a full description and discussion of various instruments will be found.

Fig. 90



Aspiration with Potain's apparatus. (After Hoppe-Seyler.)

Potain's apparatus is in most general use. The pump is capable of a dangerous degree of aspiratory force. Only sufficient aspiration should be used to just maintain the flow. The rubber tubing should be thick and all connections must be air-tight. A piece of glass tubing inserted between the trocar and bottle will be of assistance in noting the result of aspiration. If desired, a mercury manometer may readily be connected with the bottle, thus measuring the negative force. An extension of the inlet to the bottom of the bottle will prevent any back flow of air, provided the negative pressure within the thorax becomes greater than within the bottle. As a receptacle for the fluid a bottle of the proper size to fit the rubber stopper, graduated at different levels by marks of a file and capable of holding from 1500 to 2000 c.c., should be chosen. The glass should be of such a quality as to stand sterilization without breaking.

[1] Handbuch der Therapie innerer Krankheiten, 1902, Bd. iii.

[2] Handbuch der physikalischen Therapie, Theil ii, Bd. i, Goldscheider und Jacob, 1902.

Technic.—The instruments should be sterilized just before use. The trocars, all rubber tubing, rubber stopper to the bottle, scissors, and hypodermic syringe, if this is used, should be boiled. Disinfection with antiseptics is uncertain, and may interfere with subsequent bacteriologic tests of the fluid. The operator's hands should be scrubbed clean and disinfected with alcohol. The patient's side should be prepared over a wide area with soap and water, using a piece of sterile gauze in place of a brush. It is then dried with sterile gauze and disinfected with alcohol. If operation is not at once undertaken, a pad of sterile gauze should be applied. The apparatus should be set up, tested by the aspiration of sterile water, and the air in the bottle should be under negative pressure before the puncture is made. The site chosen for puncture will vary with the amount and position of the effusion. The position of the heart must be known. An encapsulated exudate must be sought with due regard to anatomical landmarks. With large or medium and free effusions, the puncture may be made in the fifth or sixth intercostal space in the midaxilla, with small effusions in the seventh space between the scapular and posterior axillary lines. The choice of the latter situation has certain advantages, in that the patient is not disturbed by seeing the procedure and the trocar will be nearer the lower level of the fluid. As the dome of the diaphragm rises normally as high as the fourth interspace in the nipple line, the sixth rib in the midaxilla and the eighth rib in the scapular line, a lower level cannot safely be chosen. In fresh effusions, the lung, the heart, and the diaphragm are displaced away from the selected site, and there is little danger of their injury, but with chronic cases, with narrowing of the interspaces, contraction of the side and elevation of the diaphragm, a higher level should be selected. The interspaces should be carefully counted before the operation is undertaken. A thickness of 2 to 4 cm. or more under ordinary conditions must be allowed for the thoracic wall. In fat subjects, or in the presence of a thick layer of fibrin, the trocar may fail to find fluid even at this distance. The patient is best placed on the bed to avoid unnecessary exertion after the operation. The puncture may be made with the patient in the sitting position or reclining on the affected side. The intercostal spaces may be widened by placing the hand of the affected side on the opposite shoulder. *Local anesthesia*, as for exploratory puncture (see p. 498), should precede the operation. The subcutaneous injection of morphin has been advised, but may inhibit symptoms which would otherwise warn the operator of approaching danger.

As a guide for the *introduction of the trocar*, the selected interspace is palpated by the fingers of one hand, while in the other the trocar is held with the blunt end of the stylet firmly against the palm and the end of the index finger about 4 cm. from the point, thus guarding against too deep an initial puncture. The instrument is slowly and carefully introduced, perpendicular to the surface, just above the rib, to avoid the intercostal artery. It is pushed in until from the

lack of further resistance the operator may judge that the point has reached fluid.[1] Insertion during forced inspiration may depress the diaphragm out of danger when a low site is chosen. Preceding *withdrawal*, the operator may conveniently appose a piece of sterile gauze, inclosing the trocar, firmly against the region of puncture. The cannula should be quickly withdrawn. Rarely pleural fluid may continue to flow from the wound. Slight bleeding from the injury of small bloodvessels may occur. Pressure usually suffices to stop this, but, if necessary, a stitch may be taken through the wound. A *dressing* may be made from a small pad of sterile gauze cut to an appropriate size and held in place by adhesive plaster or collodion.

The trocar and rubber tubing should be cleaned at once after the operation. This is conveniently done by running first cold water, then alcohol, and finally ether through the apparatus, which should be dry when put away.

Symptoms and Difficulties during Evacuation.—Faintness and vertigo are not uncommon, and are usually due to psychic disturbance. They may be relieved by placing the patient in the reclining position. An occasional slight cough is frequent toward the end of the evacuation. If severe, the operation should be stopped. Cough may be due to pleural irritation, to hyperemia, or edema of the expanding lung. If it persists, morphin may be given. Blood may rarely be expectorated during evacuation. It may arise from the rupture of small bloodvessels in the lung, from congestion, or from puncture of the lung with the trocar, and when it occurs it is best to discontinue the operation. Pain is not common, but, if severe, is a contra-indication to continuance, as it may indicate undue tension on pleural adhesions. There may be a feeling of dyspnea and general discomfort, perhaps cardiac in origin, and severe enough to warrant a halt in the operation.

The operator may have difficulty in inserting the trocar between narrow interspaces and a smaller instrument may be necessary. Unexpected movement on the part of the patient may direct the point of the trocar against a rib. After introduction and the withdrawal of the stylet, no fluid may follow. A bit of fibrin may have closed the opening, or if, after reintroduction of the stylet, the puncture is still negative, the trocar may need to be inserted farther, in a different direction, or partially withdrawn. The presence of firm tissue in the track of the instrument can usually be appreciated as a resistance against forward or lateral motion. Introduction elsewhere may be more successful. Finally, there may be no fluid, but negative punctures never positively exclude it. Interruption of the

[1] It is convenient to know that at the level of junction of the third costal cartilage with the sternum (sixth dorsal vertebra), the distance from the skin to the bloodvessels at the root of the lung in an average adult male was found by Piersol (Musser, Jour. Amer. Med. Assoc., January 5, 1907) to be 7 cm. in the midaxillary line on the left side and at a greater depth in other regions of the same transverse section.

flow during evacuation may be due to fibrin, apposition of lung or diaphragm against the end of the cannula, or equalization of pressure within and outside the chest. The last may happen even with considerable fluid remaining, provided the lung is firmly bound down in a retracted position.

Amount of Fluid to be Withdrawn.—This depends on the size of the effusion. Absorption may follow removal of very small quantities. The rare occurrence of serious symptoms, and even of death, following the evacuation of large amounts of fluid is a warning not to be safely disregarded. With large effusions, as much as 1500 c.c. may be withdrawn, provided no unfavorable symptoms arise during the process. Much larger quantities are often removed without an unfavorable result, and with very large effusions, in which the fluid runs without aspiration or symptoms, as much as 2000 c.c. may be evacuated. If danger is to be avoided, however, this amount should only rarely be reached and never exceeded. The remaining fluid will probably be absorbed; if not, the procedure can be repeated. With small effusions it is unnecessary to evacuate the last drop. Small amounts of fluid remaining are usually readily absorbed. The longer the effusion has lasted and the older the patient, the smaller the amount of fluid which can be safely withdrawn. More abundant adhesions and less elastic lung then increase the danger. In the presence of pulmonary tuberculosis, especial care should be exercised in the removal of fluid to avoid rupture of adhesions and artificial pneumothorax.

Duration of the Operation.—It is safer to evacuate fluid slowly. A half-hour may be consumed in the removal of 1500 c.c. in order that neighboring structures may gradually readjust themselves.

Injections.—The replacement of the evacuated fluid by air has been recommended. Filtered air, oxygen, and sterile salt solution have more recently been used. Air is said to be of advantage in the rare chronic cases in which adhesions prevent reëxpansion of the lung following evacuation, or with bloody fluids in which negative pleural pressure only leads to renewed hemorrhage. Absorption of the air takes place slowly. Barr[1] replaces the evacuated fluid by about two-thirds to three-fourths of the original volume with filtered air, and finally injects 4 to 8 c.c. of a solution of adrenalin hydrochloride (1 to 1000). Injections of air may favor fixation of the lung in an abnormal position by delaying reëxpansion. Infection from organisms present in the air is a possible danger.

Repetition of Tapping.—One tapping suffices in about 75 per cent. of the cases. In about 20 per cent. of the remaining cases there is no more fluid after the second operation. In some cases evacuation must be frequently repeated. It is often difficult to determine the presence of fluid in cases which have been tapped, owing to the changes

[1] British Med. Jour., 1904, p. 1003.

in the pleura. Percussion often gives dubious results and more reliance may be placed on the absence of tactile fremitus, the respiratory murmur, and cardiac displacement.

Dangers of Thoracentesis.—There is some danger in the performance of thoracentesis. This is reduced to a minimum by the strictest asepsis, the use of an air-tight trocar, rather than an ordinary needle, the slow withdrawal of only moderate amounts of fluid without forcible aspiration, and a careful selection of cases. Unavoidable accidents are extremely rare. Patients are more often sacrificed by hesitation and delay than by its use.

The danger of converting a serous into a purulent effusion appears to be insignificant. Of 553 tappings in my series, turbid fluids were found in 27, and of these 12 later became purulent, but the suppuration was probably spontaneous. In one instance a fluid showed 88 per cent. of lymphocytes at the first tapping and 78 per cent. polynuclear cells when the thoracentesis was repeated four days later. In a second case a fluid at first contained 96 per cent. lymphocytes. The patient was discharged without evidence of effusion, to return one month later with empyema. Whether a similar change would have taken place without puncture is uncertain.

Pneumothorax is a more frequent result. In rare instances it may be due to puncture of the lung or to the rupture of adhesions, pulmonary cavities, or emphysematous blebs during expansion. It is not infrequently due to the entrance of air through an unguarded needle or trocar, as Sears[1] has emphasized. It may also result from accidental inflation of the pleural sac with the aspirating pump, if the tubing is misapplied. Infection of the pleura may follow the admission of air.

Subcutaneous emphysema may occur if the lung is wounded and air enters the track of the trocar. It may be local or involve the greater part of the body, and is more common after exploratory puncture. Extension of malignant growth or tubercle along the track of the needle occasionally occurs. The removal of pleural fluid may lead to the detachment of thrombi in the heart or intrathoracic vessels, with monoplegia or hemiplegia as a result. Delirium and hysterical and epileptic attacks have been observed. Urticaria has been noted after thoracentesis, and should always suggest echinococcus disease.

Albuminous expectoration is of rare occurrence. Terillon[2] collected 21 cases. Riesman[3] has reviewed the literature and reported an additional instance. Osler observed the condition twice in 195 cases. It occurred once in my series. The albuminous expectoration usually begins during or shortly after the withdrawal of fluid. Its appearance may be delayed, however, for as long as eighteen hours, as in Pepper's case. It is accompanied by cough and often by

[1] Amer. Jour. Med. Sci., December, 1906, p. 850.
[2] L'expectoration albumineuse, Thèse de Paris, 1873.
[3] Amer. Jour. Med. Sci., 1902.

dyspnea, which varies much in intensity and may be extreme, with cyanosis and rapid, feeble pulse. Rales may be heard over the lung during the attack. Its duration and intensity are very variable. It may last for as long as forty-eight hours, and the patient may die of suffocation. The fluid may amount to as much as a quart in two hours, but smaller quantities are more common. The expectorated fluid is serous and contains a variable amount of blood, frothy mucus, and albumin. In most instances an excessive amount of fluid (more than 2000 c.c.) has been removed. The condition has been more often noted in acute effusions, but Riesman's case was chronic. In the case in my series only 1000 c.c. of fluid were withdrawn. The expectoration began a few minutes after the tapping, and lasted for four hours, during which time about 500 c.c. were expectorated. The pulmonary symptoms completely subsided, but the patient died some weeks later, and at autopsy cirrhosis of the liver and associated lesions were found, but no explanation of the expectoration. In fatal cases edema of one or both lungs, cardiac disease, fibrinous plugs in the bronchi, and adherent pericardium have been found (Riesman). The condition has been ascribed to evacuation of pleural fluid by way of the bronchi. This may happen if the lung has been perforated during the puncture. Spontaneous rupture or filtration through the lung has been suggested. It is more probably due, however to pulmonary congestion, with edema, for which Riesman suggests the term "congestion by recoil." It may be conjectured that compression of the lung is followed by changes in its bloodvessels, and that in the congestion after reëxpansion there is a transudation of serum. Of 51 cases of albuminous expectoration which I have reviewed[1] 13 were fatal. A consideration of the postmortem reports on 14 in whom death immediately followed the operation or occurred after an interval, suggests that pulmonary inelasticity from pleural adhesions or complicating cardiac, pulmonary or mediastinal disease is probably an important contributing factor.

Death, in rare instances, has followed even simple exploratory puncture. Leichtenstern,[2] Russell,[3] Sears[4] and others have called attention to the occurrence in rare instances of sudden death in the course of thoracic puncture. Postmortem examination of such cases may fail to disclose the cause. Symptoms indicating a varying degree of shock are not very uncommon. Although the cause cannot be definitely determined, yet the demonstration by Capps and Lewis[5] that in man and in dogs irritation of an inflamed pleura often gives rise to a reflex of cardio-inhibitory or vasodilator type, with lowering of the blood-pressure, offers a suggestive explanation. The inflamed

[1] Lord, Boston Med. and Surg. Jour., April 15, 1909.
[2] Deut. Arch. f. klin. Med., 1879, vol. xxv.
[3] St. Thomas' Hosp. Rep., London, 1899, xxviii, 465.
[4] Amer. Jour. Med. Sci., December, 1906.
[5] Ibid., December, 1907.

pleura appears to be especially susceptible, and the nervous shock thus induced in dogs may even be fatal. Such experiments plainly indicate the wisdom of avoiding any unnecessary play of even a blunt-pointed cannula against the inflamed pleura.

Artificial pneumothorax has occasionally been fatal. Sudden death during or after the evacuation of pleural fluid may be due to embolism. Thrombi in the pulmonary veins or the venæ cavæ are the most frequent source. Syncope and death may occasionally be due to cerebral anemia, from afflux of blood to the reëxpanded lung. Fatal hemoptysis has followed the wounding of vascular granulation tissue in the lung or of bloodvessels lining the walls or traversing the lumen of pulmonary cavities. Such vessels may be also ruptured during expansion of the lung. Perforation of the diaphragm has been followed by fatal peritonitis or hemorrhage from the spleen. Miliary tuberculosis may, in rare instances, arise from infected thrombi set free from pulmonary vessels by the evacuation of tuberculous fluid (Fränkel). If the lung is adherent, fatal hemorrhage from pleural vessels may follow forcible aspiration. Injury of an atheromatous intercostal artery has been followed by fatal bleeding (Naunyn).

Results of Thoracentesis.—Following the removal of fluid, there is usually a marked improvement in the breathing and cardiac action. The color is better and there may be an increase in the amount of urine. The heart returns to its normal position unless prevented by adhesions or marked indurative processes. The temperature may fall at once, but gradual defervescence is more frequent. The duration and intensity of the pleuritis appear to be lessened. Reëxpansion of the lung is more rapid, absorption of the remaining fluid takes place, and subsequent deformity with contraction of the side, narrowing of the intercostal spaces, and displacement of the diaphragm and heart are less frequent. It is a mistake to regard such patients as cured, however, for too often the subsequent history shows that the pleural symptoms have been relieved, but that an underlying tuberculous process continues to extend.

In some cases thoracentesis is actually life-saving. This applies more often to the cases in which early diagnosis of the tuberculous process puts both patient and physician in possession of evidence without which only half measures would have been carried out in further treatment. It also applies to cases with alarming pressure symptoms in which evacuation of fluid is immediately life-saving.

After-treatment.—The operation of thoracentesis affects the general management of the case very little. If the patient has been in the reclining position, following the operation, a bed-rest may first be given, then a change from the bed to a chair, and the patient may be up and about by the end of a week, provided no contra-indications are present. This interval of quiet is wise even if all goes well, to allow time for readjustment to the changed intrathoracic conditions and repair in the inflamed pleura.

Autoserotherapy.—Gilbert,[1] Fede[2] and following them many others have treated pleurisy with serofibrinous effusion by the subcutaneous injection of a small amount of aspirated fluid. The usual method has been to inject 1 to 2 c.c. and if necessary repeat the injection every second day until as many as four to six injections have been given. Improvement in the patient's general condition and absorption of fluid within a short interval have been observed in some cases and have been ascribed to entrance into the circulation of antitoxic and bactericidal substances contained in the effusion. The results have not in general been sufficiently striking to suggest curative action by the serum. Unfavorable effects have not been observed. Wider dissemination of tubercle bacilli is a possible outcome of the procedure.

ACUTE PURULENT PLEURITIS.

Etiology.—Certain differences between the etiology of this and other forms of pleuritis may be mentioned.

Primary Form.—The proportion of cases in which empyema is apparently primary is relatively small compared with fibrinous and serofibrinous pleuritis. Of 252 cases with empyema in this series, 83 (32.9 per cent.) may be classed in this group, against 64 and 63 per cent., respectively, for the fibrinous and serofibrinous form. Primary empyema is said to be more common in children, but expectoration is often absent and an effusion may make the detection of a pulmonary process difficult or impossible.

Secondary Form.—As in other varieties of pleuritis, disease of the lung occupies first place and can be demonstrated in a larger proportion of cases, since the pulmonary lesions leading to suppuration, in the pleural sac are more easily detected. Of 252 cases, 158 (62.6 per cent.) appeared to be pulmonary in origin, including 140 cases of pneumonia (136 lobar pneumonia, 4 bronchopneumonia), 15 of pulmonary tuberculosis and 3 of abscess or gangrene. Gangrene leads to putrid exudates. The disease may arise by extension from the abdomen, the pericardium, or the other pleura; it may complicate the infectious diseases (influenza, typhoid fever, etc.) or suppurative lesions in any part of the body, as has been mentioned for the other forms of pleuritis. It may be caused by trauma and may follow the serofibrinous form.

In children empyema is, in general, more frequent than serofibrinous effusion. There is, however, considerable variation in statistics on this point. Of 169 cases under ten at St. Bartholomew's Hospital analyzed by Gee, 84 were non-purulent, 85 purulent. The younger the child, the more likely is the exudate to be pus. Thus, of Gee's 78 cases under five, 53 were purulent. Of 116 cases under five in Carpenter's series, 77 were empyema. In adults, on the contrary, serofibrinous effusions are much more common.

[1] Gaz. d. hôp., 1894, p. 560.

[2] Riforma medica, vol. xxii, No. 39.

1. **Pneumococcus.**—This appears to be the most frequent organism occurring as a pure infection. Of 109 empyemas investigated by Netter, it was present in 53.6 per cent. of 28 cases in children, while in 81 cases of adults it was found in 17.3 per cent. Of 137 cases in my series, the pneumococcus was found in 54 (39.4 per cent.). It is the most common cause of metapneumonic effusions, but may also be found in primary empyema and shows a marked tendency to die out. It may be found in smears from the pus, but cultures from the same fluid are not infrequently sterile. To this is probably due the relatively favorable course of pneumococccus empyema. It may be a cause of suppuration in tuberculous empyema, in which tubercle bacilli are found on inoculation, but cultures are sterile from the disappearance of the pneumococcus.

2. **Streptococcus.**—Netter found this in 51 cases (46.7 per cent.). It was present in 28 (20.4 per cent.) of my series. Serofibrinous effusions containing streptococci are likely to become purulent.

3. **Tubercle Bacilli.**—This has not been shown to be as frequent a cause of purulent as of serofibrinous effusions. Of Netter's 109 cases, 12 were found to be tuberculous. The finding of other organisms does not exclude the tubercle bacillus nor does the presence of the tubercle bacillus alone exclude other organisms such as the pneumococcus, which may have died out.

4. **Staphylococcus.**—This is relatively infrequent. It was present in only one of Netter's cases. In my series it occurred in 5 (3.6 per cent.).

5. **Mixed Infections, etc.**—Infection with more than one organism was found in 22 (16 per cent.). The pus may be sterile, as in 25 cases (18.2 per cent.), and infection with the tubercle bacillus or the pneumococcus may be suspected. Other organisms than those already mentioned are uncommon. Influenza bacilli, typhoid bacilli, bacillus mucosus capsulatus, streptococcus capsulatus, diphtheria bacillus, colon bacillus, actinomyces, etc., have been found. Mixed infections are usually present with putrid exudates. The investigations of Guillemot, Hallé and Rist,[1] Lorrain,[2] Niosi[3] and others suggest that anaërobic organisms may be concerned in the production of putrid pleural exudates.

Types of the Disease.—The purulent pleurisies have been separated into different groups according to their bacterial etiology. Mixed infections with one or more organisms are common, and the tubercle bacillus may coexist, but elude detection. Sterile exudates are difficult to place; they are usually due to the tubercle bacillus, rarely to the pneumococcus. As yet no distinctive clinical picture can be formulated for the various forms, and with few exceptions the clinical and pathologic similarity of the different infections is more striking than their dissimilarity. It seems best to consider the various infec-

[1] Arch. d. méd. exp., 1904. [2] Ibid., 1902.
[3] Centralbl. f. Bakt., etc., i, Abt. Orig., 1911, Bd. lviii, H. 3, p. 193.

tions together and refer to such differences as can be noted under the separate headings.

Pathology.—The pleura is the site of a fibrinous or fibrinopurulent layer. It is grayish-white or yellowish in color, and may be greatly thickened. The inflammation may be general or circumscribed. The saceulation of fluid is not infrequent. Erosion, ulceration, or even perforation of the visceral or parietal pleura may be found. These destructive processes may be single, but are more commonly multiple and limited to the pulmonary layer. After long-standing empyema, allowed to run its course untreated, calcification and the formation of bony plates may take place in rare instances.

In fatal cases other organs are seldom uninvolved. The lung is the most frequent site of changes, from which the pleural disease has usually arisen secondarily. Lobar pneumonia, bronchopneumonia, abscess, and gangrene may be the source of the process. After long-standing empyema, chronic interstitial changes may occur about the lung and penetrate the pulmonary tissue along the interlobar septa, the so-called pleurogenous interstitial pneumonia. Suppurative pulmonary lesions and bronchiectasis are likely to coexist. It is often difficult to tell whether the lung is primarily or secondarily invaded. In some instances, pleural suppuration extends to the pericardium, peritoneum, or the mediastinum, from which the opposite pleura may become infected. Endocarditis is not uncommon. The spleen may be large and soft. Thrombosis of intrathoracic or other vessels may be present. Cerebral abscesses may occur. Tuberculosis of the pleura, lungs, or bronchial glands was present in 9 of 38 cases at autopsy in my series. Tuberculous lesions in more remote parts of the body were found in 2. Thus, about 30 per cent. showed tuberculosis in some part of the body.

Location.—Of 248 cases, the right side was affected in 122, the left in 121, and both in 5. Purulent are more often encapsulated than serofibrinous fluids. Encapsulation was discovered in 8 cases. When empyema complicates pneumonia, the effusion is usually at the bases irrespective of the site of the pneumonic process.

The Effusion.—No sharp dividing line can be drawn in gross appearance between serofibrinous and purulent fluids. The fluid may be merely turbid, with a few fibrinous flocculi and contain an excess of polynuclear cells on microscopic examination. It must be remembered that pus may sediment within as well as outside the chest. At operation or autopsy tolerably clear serum may be found above with a layer of pus at the bottom of the pleural sac. The effusion may be serofibrinous at first and become purulent later. There is often, however, an excess of polynuclear cells in such fluids from the beginning. The fluids may be yellowish, with varying shades of greenish, reddish or even frankly red, brownish or chocolate colored from the presence of blood. With large amounts of pus they are grayish, greenish-yellow, or cream colored. They may be without odor,

sweetish, or fetid. In gangrene of the lung or pleura they often have a horribly offensive odor. The specific gravity is higher than in serofibrinous fluids. It may reach 1030 or more. The amount of solids is often 60 to 70, but may reach 90 to 100 p. m. (Hammersten).

Symptoms.—These are usually the same as in the serofibrinous form and only certain differences need be mentioned. They are not distinctive of empyema. The onset is likely to be more acute. An insidious onset and latent course are less common than in the serofibrinous form. Toxic symptoms are more common and more severe. In general, the temperature is higher; of 145 cases only 2 ran an afebrile course. From 101° to 103° is an average pyrexia, but the temperature reaches 104°, 105°, or even higher in a larger proportion of cases, with wider variation between the morning and evening elevations. The respiration and pulse are likely to be more rapid. Recurring chilliness or chills, a more rapid loss of strength and weight and increasing pallor may be mentioned. Between the various infections there are no constant differences. Pneumococcus empyema may be relatively mild. Streptococcus infections are more severe, and putrid exudates are accompanied by most marked disturbances. In the latter, bad taste in the mouth, foul breath, and foul sputum may be present. Uncomplicated tuberculous effusions may run an afebrile and long course without marked general symptoms. In rare instances empyema may persist without symptoms for months or years. In Faisans and Audistère's case the disease may have lasted for forty years. At autopsy there was sterile fluid contained in a space, the walls of which were transformed into cartilaginous and osseous tissue.

Physical Signs.—These are such as have been considered under Serofibrinous Effusion. The affected side may be more prominent, with wider intercostal spaces which may actually bulge. Edema of the chest wall is uncommon, but more frequent with purulent than with serous fluid. The subcutaneous veins may be dilated. Whispered pectoriloquy (Bacelli's sign) has proved an uncertain differentiation from serofibrinous pleuritis. A disproportion between the amount of fluid and the severity of the symptoms may be suggestive. The displacement of the heart and the liver is relatively greater with purulent than serofibrinous fluid, due probably to the greater weight of the former. In children the breath sounds may be loud and bronchial over a purulent effusion. The axillary glands are occasionally enlarged on the affected side, as in 2 of the 145 cases in my series. In 1, suppuration was present. The spleen may be enlarged. In long-standing cases, especially in children, clubbing of the fingers may occur.

Pulsating Empyema.—This condition is more commonly associated with suppuration in or about the pleural sac. Of 95 cases analyzed by Sailer[1] there was pus in the pleural sac in 71, and of these there

[1] Amer. Jour. Med. Sci., 1904, cxxviii, 225.

was tumor (empyema necessitatis) in 38. In 13 there was intrapleural or extrapleural abscess. The remaining cases were nonpurulent or their condition was not definitely known. The condition appears to be more common in males and in early life. Pulsations may be diffuse or localized, single or multiple, and are more often seen on the left side. They are most common in the parasternal regions, but may occur in the lower lateral and posterior parts of the chest. Pulsation is probably due to an accumulation under pressure of fluid which is apposed to a lung made inelastic by collapse or pathologic changes in or about it, and to some local or general weakness of the thoracic wall.

The Blood.—White Cells.—In 28 cases of primary empyema the white count was above 12,000 in all but 6, *i. e.*, between 12,000 and 16,000 in 3; 16,000 to 20,000 in 7; 20,000 to 24,000 in 4; 26,000 to 35,000 in 3, and 35,000 to 50,000 in 5. The 6 cases with a low white count recovered after operation. No conclusion can be drawn from the white count in this small number of cases concerning the prognosis or the character of the infecting organism. The white count may, however, be of great value in distinguishing uncomplicated tuberculous serofibrinous effusion from empyema, only 3 of 33 cases with the former showing a white count above 12,000.

Complications.—These are much the same as for serofibrinous pleuritis.

1. **Extension to Neighboring Organs.**—This is more common in empyema. (*a*) *Perforation of the Lung.*—This may be *latent* and indicated only by the expectoration of mucopurulent sputum. Evacuation of small amounts of pleural pus by this means is frequent. The complication is frequently overlooked and pneumothorax only rarely occurs. In other cases the perforation is *obvious*. In this form pneumothorax is more common, but does not necessarily occur. There is a sudden paroxysm of cough, with the evacuation of a large amount of pus. If perforation occurs while the patient is asleep or if the lung is suddenly flooded, death may take place from suffocation. Single or multiple fistulous tracts may connect the pleura with the bronchi, and pneumothorax may thus arise. Invasion of the lung usually leads to multiple abscesses connecting with the bronchi. In some instances the affected lung may present a honeycombed appearance. Single pulmonary abscesses are less common. It is difficult to tell in individual cases at autopsy whether the lung has been primarily or secondarily involved. Of 11 cases with pulmonary suppuration and empyema at autopsy, abscesses were multiple in 8, single in 3. Pulmonary gangrene may occur, but is less common. Chronic interstitial pulmonary changes are likely to follow if the patient recovers. Perforation of the lung was absent in 41 cases of pneumococcus empyema; present in 2 of 19 streptococcus cases. It is a serious event. Of 145 cases, obvious perforation occurred in 5. One patient recovered. A second had persistent cough, with abun-

dant purulent sputum and frequent attacks of hemoptysis, but was otherwise well six years after the operation. The 3 remaining patients died, 1 from suffocation, the others from sepsis. Evacuation by the lung does not obviate the necessity of thoracotomy, which should be done to spare the lung from further damage. Pulmonary perforation may occur at any time, but is uncommon before the third or fourth week.

(*b*) *Perforation of the Thoracic Wall* (*Empyema Necessitatis*).—This is less common than pulmonary perforation. It is more favorable and may be followed by complete evacuation and recovery. The abscess may point in any part of the chest, but more often in the parasternal region or in the fifth interspace outside the nipple line, the thinnest regions of the chest. The perforation may be single or multiple. It seldom occurs before the end of the first month, but may take place at any time after this period. The abscess usually forms an irreducible fluctuating tumor, becoming more tense with forced expiration or cough. It is dull or flat on percussion. In one case a reducible resonant tumor was present in the left second interchondral space, shown by operation to be due to pyopneumothorax. The opening into the thorax may be at some distance from the site of the tumor, the rupture of which may be followed by discharge of a large amount of fluid. Forced expiration and cough may hasten, inspiration may diminish the flow. The tumor may pulsate. Evacuation by spontaneous perforation is usually incomplete. The fistula is likely to close and the pleural pus to reaccumulate, with subsequent perforation in the same or other places. Cure by this means is rare and thoracotomy is indicated. Caries of the ribs and necrosis of the soft parts may arise from the perforation. Erosion of an intercostal artery may lead to fatal hemorrhage. Perforation is more common in streptococcus, tuberculous, mixed, or putrid infections. Actinomycosis should always be considered in the presence of abscesses of the chest wall arising by extension from within. Simple thoracic abscesses may be unaccompanied by pulmonary or pleural changes and are uninfluenced by changes in intrathoracic pressure. The distinction may, however, be impossible before exploration by operation. Suppuration in the tissue between costal pleura and thoracic wall (peripleuritis) leading to external perforation may simulate encapsulated empyema necessitatis.

(*c*) *Perforation of the Diaphragm.*—This is more serious. It may lead to local or general peritonitis. As in perforation of the lung, it is often difficult in individual cases to tell whether the infection has spread from the pleura to peritoneum or in the opposite direction. Obvious gross lesion of the tissue may be absent. In other cases the site of the perforation may be readily found. Peritonitis was present in 9 of 38 autopsies on cases of empyema in my series. It was general in 7, localized in 2. Streptococci were present in 7, either alone or mixed with other organisms. In one case an encapsulated diaphrag-

matic empyema pointed in the right hypochrondrium; recovery followed operation. In a case of pneumococcus empyema and general pneumococcus peritonitis seen with C. L. Scudder, recovery followed repeated abdominal operations and costatectomy. An abdominal abscess, starting from the pleura, may perforate the stomach, the intestines, or the kidney. It may extend along the spine to the iliac fossa and simulate psoas or lumbar abscess.

(*d*) *The esophagus may be perforated,* as in the cases reported by Voelcker, Thursfield, and Osler, with the formation of pleuro-esophageal fistulæ.

(*e*) *Infection of the pericardium* is probably more often present than statistics show. It was recognized during life in 4 of 145 cases, but was present at autopsy in 6 of 38. Inflammation may also extend to the mediastinum.

2. **Metastatic Lesions.**—It is uncertain in individual cases whether suppurative lesions in remote parts of the body are primary or secondary. They may arise by extension of the pleural infection to the intrathoracic veins or the endocardium. From an infected thrombus thus formed, emboli may be carried to the brain, kidney, spleen, or other organs, with the production of infarct or abscess. Cerebral abscesses are among the most dangerous complications, and are usually multiple, as in 3 of 38 autopsies in my series. Pulmonary abscesses were associated in 2. In 1 the cerebral abscesses were unaccompanied by suppurative foci elsewhere than in the pleura. Septicemia is common in empyema.

3. **Amyloid Degeneration** may complicate long-continued suppuration.

Causes of Death.—The same danger of sudden death and similar causes obtain in purulent as in serofibrinous effusion. It is uncommon in fatal cases not to find suppurative processes in neighboring or other parts of the body. Peritonitis is one of the most frequent of coincident infections, and was present in 9 of 38 fatal cases, but the complicated character of fatal cases makes it difficult to judge between principal and contributing causes. Pneumonia, pulmonary abscess and gangrene, pericarditis, endocarditis, thrombosis of intrathoracic veins or the auricles, with or without infarction, cerebral abscesses, and meningitis, may be regarded as important factors, either singly or combined. The streptococcus is the most frequent organism, but pneumococci are often present and other organisms may be found.

Relapse.—Recurrence of empyema in the same place after complete recovery does not occur, because of the almost constant obliteration of the pleural sac. Incomplete absorption or removal may, however, be followed by a return of symptoms and an increase in the amount of fluid. Incomplete evacuation, insufficient drainage, encapsulation, the presence of undiscovered pockets of pus or the development of empyema elsewhere may be responsible for a second accumulation of fluid. Pitt[1] reported the unusual postmortem finding of a

[1] British Med. Jour., 1908, ii, 1075.

smooth pleural surface without adhesions in a child who had empyema one year before.

Sequelæ.—It is rare, on physical examination of patients who have recovered from empyema, not to find signs of the previous disease. There is diminished expansion of the affected side, which often looks smaller, and measurement shows that it is contracted. The interspaces are relatively narrow. Toward the base is slight relative dulness, its upper limit often being highest behind and extending in a nearly horizontal line toward the axilla, where it gradually descends to the inferior pulmonary margin in the anterolateral thoracic region. The extent of dulness is variable and may involve half the chest. The tactile fremitus may be diminished over the dull area. The breathing, voice sounds, and whisper may be diminished, but are often unchanged. In cases which have run a long course before evacuation takes place, with abundant connective-tissue formation about the lung or within its substance, the lung may be partially or wholly incapable of reëxpansion. A space is left which is filled by fibrous tissue, by the collapse of the chest wall, dislocation of the mediastinum and heart toward the affected side, displacement upward of the diaphragm and partial expansion of the lung, depending on the changes which have taken place in and about it. In rare cases, with dulness, there may be signs suggestive of slight degrees of pulmonary solidification. These may be due to interstitial changes in the lung, or, if marked retraction has taken place, to proximity of the larger bronchi to the chest wall. In the young, with less resistant thoracic walls, marked deformity with retraction of the side, drooping of the shoulder and lateral deviation of the spine may result.

Pain of variable and usually slight intensity may persist in the affected side. Of 26 patients investigated on this point, 8 still had pain for periods of one to seven years after discharge.

Diagnosis.—The diseases with which pleural effusion may be confused, the differentiation of pleural fluids of different character, the method of employing exploratory puncture and the examination of pleural fluids have already been discussed under Serofibrinous Pleuritis.

Certain additional features in the diagnosis of empyema may be emphasized with special reference to exploratory puncture, exploratory incision, and the examination of purulent fluid.

Exploratory Puncture.—This is indicated if pus is suspected. By hesitation and delay, the disease may be converted into a chronic and incurable affection. In acute cases, with typical signs of fluid, it is practically devoid of danger, and, if present, pus can usually be demonstrated by this means. In some cases, however, it is missed by the trocar or is too viscid to flow. A negative puncture does not exclude pus.

Cases in which Exploratory Puncture is Dangerous.—In cases of empyema of long standing, in which there is contraction of the side,

elevation of the diaphragm, and secondary, suppurative lesions in the lung, or in cases in which empyema complicates pulmonary abscess, gangrene, bronchiectasis, and interstitial pneumonia, the conditions are less favorable for exploratory puncture. The pleural pus is often small in amount, and may be encapsulated between lung and diaphragm or in other parts of the chest. The diagnosis of pleural involvement in the cases under consideration can usually be made. The history may afford important evidence. Lobar pneumonia and infection of the thorax from without never spare the pleura. There may be a history of pain characteristic of pleural invasion or symptoms consistent with the rupture of empyema into the lung. The physical signs may be atypical, but if the pus reaches the chest wall, localized tenderness, dulness or flatness on the affected side and the opposite paravertebral region, diminished or absent breathing and voice sounds, with ægophony, and the absence of tactile fremitus, whispered pectoriloquy and the diaphragm shadow may disclose the presence of an effusion. It is well to confirm the results of physical examination by radioscopy. Exploratory puncture is not without danger in cases thus complicated. Bloodvessels lining the walls or traversing the lumen of pulmonary cavities or fresh granulation tissue, if injured by the trocar, have been the source of fatal hemorrhage. Perforation of the elevated diaphragm has caused fatal peritonitis. In the presence of such complications, with typical signs of fluid and displacement of the heart, exploratory puncture may be made, but with care not to introduce the instrument too far or through the diaphragm, the position of which should be determined by *x*-ray examination. In similarly complicated cases, in which from the history, the physical signs, and the *x*-ray examination there is good reason to suspect pus, the demonstration of which with the trocar has failed or cannot be safely undertaken, it is better to resort to exploratory incision.

Exploratory Incision.—This is indicated, as already mentioned, when there is good reason to suspect pus which cannot be demonstrated by exploratory puncture or in complicated cases in which it is a less dangerous procedure. It should be entrusted only to an experienced surgeon. The technic of operation cannot be considered here. The chief danger is artificial pneumothorax, which may arise if the lung is free. Incision and costatectomy, with care not to wound the pleura, will disclose the condition of the underlying tissue.

Examination of Pleural Pus.—Fluids on the border line between the serofibrinous and purulent variety may be examined as already indicated in the preceding section. Cultures should always be made. With frank pus, tubercle bacilli may be demonstrated by the following means: A few cubic centimeters are transferred to a flask and diluted with 10 volumes of water. A few drops of strong alkali (KOH or NaOH) are added and the solution is gently heated. After the cellular elements are dissolved, the solution may be centrifugal-

ized and the precipitate investigated for tubercle bacilli. Animals cannot be inoculated with large amounts of pus or intraperitoneally, without a too rapidly fatal termination for the demonstration of tuberculosis. It is best, therefore, to inject only 1 to 2 c.c. of pus under the skin.

Prognosis.—Absorption of empyema rarely, if ever, occurs. Spontaneous disappearance of pus has been noted in isolated cases by Fürbringer, Gerhardt, Fränkel, Schede, and others. It may be due to latent perforation of the bronchi. Recovery may follow obvious perforation of the lung, but usually with most distressing and dangerous complications. After perforation of the chest wall recovery may follow. Most cases, if untreated, end in death. Of 252 cases in my series 56 (22.2 per cent.) died in hospital.

Treatment.—In general, pleural pus should be evacuated as soon as the diagnosis is made. *Constant, free drainage is essential for prompt and permanent cure.*

1. **Thoracotomy with Costatectomy.**—This is the operation of choice. The incision is best made in a dependent part of the pleural cavity, with resection of the seventh or eighth rib in the posterior axillary line. Pus should be evacuated slowly. Irrigation of the cavity is seldom necessary and may be dangerous. With empyema necessitatis, enlargement of the perforation in the chest wall may suffice if this is in a favorable position for drainage. Otherwise, a second opening in a more suitable position should be made. If the pus is encapsulated, the incision must be made where drainage will be most effective. Thoracotomy alone often affords insufficient drainage and costatectomy is often necessary later.

2. **Other Methods.**—These are less efficient since drainage is often neither constant nor free, but they may be used in selected cases, as a preliminary to the radical operation or as palliative procedures.

(*a*) *Thoracentesis.*—This may be considered for effusions on the border line between the serofibrinous and purulent forms. It is indicated for the evacuation of an exudate of large size, with or without pressure symptoms, as a life-saving measure or a preliminary to operation, thus avoiding the danger of more rapid evacuation, and as a palliative procedure in empyema complicating advanced pulmonary tuberculosis. Although repeated puncture has been advised for pneumococcus empyema, especially in children, it is uncertain, likely to be followed by re-accumulation, and leads to complications and greater deformity of the chest. It frequently delays operation, which is often necessary later, and subjects the patient to an unjustifiable risk.

(*b*) *Siphon Drainage* (*Bülau*).—By this method[1] drainage is afforded, but evacuation is often neither constant nor free. Slow

[1] A trocar 6 to 7 mm. in diameter and armed with a stop-cock is inserted through the seventh or eighth axillary space. Through this a rubber catheter is passed and the trocar withdrawn. One end of a short piece of glass tubing is inserted into the free end of the catheter, the other into a rubber tube, leading to a receptacle, attached to the bed or placed on the floor.

evacuation, avoidance of narcosis, and a large operation wound, no danger of pneumothorax, and better expansion of the retracted lung are advantages claimed for the method. The apparatus requires constant attention, pus is less likely to be completely evacuated, and masses of fibrin may readily obstruct the tube. Fluid may escape or air enter about the tube. It is, therefore, more suitable for hospital patients or where constant attention is possible. It may be tried at the extremes of age, in weak patients unable to stand the radical operation, in relatively benign pneumococcus empyema, without much fibrin, and in double empyema, in which collapse of the lung from pneumothorax is to be avoided.

Tuberculous Empyema.—In this form the indications are less clear and considerable difference of opinion exists concerning the appropriate treatment. In an advanced stage of the disease a radical operation can hardly be considered, and such palliative measures as repeated puncture or siphon drainage may be tried. The decision is more difficult when empyema complicates early pulmonary tuberculosis. If the exudate is sterile or contains tubercle bacilli alone, aspiration may be tried. If the fluid reaccumulates, aspiration may be repeated. Thoracotomy and costatectomy are likely to be followed by the formation of a persistent sinus. If the fluid contains pyogenic cocci, thoracotomy combined with costatectomy is the operation of choice. Of 31 cases of tuberculous empyema operated by Küster, 9 recovered, 6 were not cured, and 16 died. In Schede's collective investigation of 45 cases, 10 were cured and 35 died, a mortality of 77 per cent. In general, tuberculous empyema is the most unfavorable form. Of 12 cases, with sterile exudates, in my series, only 1 of whom showed tubercle bacilli in the sputum, 3 died in hospital. Of the remaining 9 patients, 6 have been traced. All have died except 1, who had a discharging sinus, seven years after operation, but was otherwise well. Sterile exudates are usually, but not necessarily, tuberculous.

After-treatment.—Expansion of the lung may be favored by various devices, permitting the outflow of pus and air through the drainage tubes during expiration, but preventing the reëntry of air during inspiration. A thin layer of impervious material (mackintosh, protective silk) may be applied over the opening of the tubes. The dressing itself, when soaked with secretion, may suffice. A vacuum apparatus may be used as in Perthes' method. After closure of the sinus, respiratory exercises are valuable. Throughout the illness, every means should be taken to build up the general health.

Vaccination.—The subcutaneous inoculation of vaccines, according to Wright's method, may be considered in the absence of autoinoculation and for the treatment of a persistent sinus. Their value must be left for the future to decide. According to present indications and my own experience, the control of the dosage by the opsonic index is unreliable.

Results of Operation.—The mortality of the operation itself is very low. In patients already near the end, it may hasten the fatal termination, but even in the most desperate cases evacuation by some means is justifiable.

1. *Immediate Results.*—The success or failure of operation is largely dependent on the period at which the disease is discovered, the character of the underlying process, and the infecting organisms. Too much reliance, however, cannot be placed on these factors in individual cases. In general, the results are much more favorable when the empyema is detected early. Concerning the character of the underlying disease, tuberculous cases are most unfavorable. Of 45 operations on tuberculous empyema in Schede's collected cases, there was a mortality of 77 per cent. and an average duration of 136 days from operation to recovery in favorable cases. Judging from Schede's cases, secondary and metastatic empyema stands next in the number of fatalities, with a mortality of 32 per cent, in 50 cases. Of 288 metapneumonic empyemas, the mortality was 13 per cent. with an average of 83 days for recovery, while idiopathic empyema was most favorable with a mortality of 7.9 per cent. among 101 cases and 66 days for recovery. In regard to the relation between the immediate results and the infecting organisms, the duration of the process, the character of the underlying disease, the presence of complications and various other factors must be considered. Large series of cases are lacking. To judge from my small series, excluding obviously tuberculous cases, the mixed infections seem to be most favorable. Of 27 cases in this group (mostly pneumococcus and streptococcus, and including 8 primary, 18 metapneumonic, and 1 with abscess of the lung), 5 (18.5 per cent.) died in hospital. Of the fatal cases, 1 was primary, the others metapneumonic. The pneumococcus cases appear to stand next in the number of fatalities, for of 35 cases (including 6 primary, 26 metapneumonic, 2 following trauma, and 1 complicating measles), only 4 (11.4 per cent.) died in hospital. Of the fatal cases, 1 was primary, 3 were metapneumonic. The mortality of the streptococcus cases was even lower. Of 17 pure streptococcus infections (8 primary, 9 metapneumonic), only 1 (5.8 per cent.) metapneumonic case died in hospital. Streptococcus cases are usually considered especially unfavorable. Judging the severity of the different infections by the average stay in hospital from operation to discharge,[1] there is no striking difference between the different groups. For the mixed infections the average duration was forty-five days, for the pneumococcus cases thirty-five days, and for the streptococcus thirty-eight days.

2. *Remote Results.*—The chief interest lies in the possibility of tuberculosis. Of 13 cases of primary empyema 4 have died—2 of "empyema" at intervals of six and eleven months after discharge,

[1] Fatal cases are not included. The duration is short, for patients with sinus are discharged to a convalescent home.

1 of an unknown cause after one year and the last from intussusception. The remaining 9 patients are well at an average interval of four years after discharge. Of 26 patients with metapneumonic empyema, 7 have died—2 of "empyema" after one and four years, 1 of "pneumonia," 1 of "tuberculosis," and the remaining patients from causes unconnected with this disease. Of the remaining 19 patients, 1 is known to have pulmonary tuberculosis, 2 others have had hemoptysis, and a third has a persistent pleural sinus, seven years after discharge. The patients who are still alive have been followed for an average period of about five years.

CHAPTER XXX.

SPECIAL FORMS OF PLEURITIS.

(1) **Diaphragmatic Pleurisy.**—Pleuritis may be limited to the diaphragmatic region. It may be partial or general, fibrinous, serofibrinous, or purulent. Large collections of fluid are rare. Owing to its inaccessible site, physical signs are often lacking and the diagnosis may rest on symptoms alone. The pain may present features already described under Fibrinous Pleuritis, but is more likely to be referred to the lower thoracic or abdominal region. This may be due to implication of the lower intercostal nerves which supply the skin and muscles of the abdominal wall, as well as the parietal and diaphragmatic pleura. In my series, abdominal pain was noted in 5 of 82 cases with primary fibrinous, in 5 of 374 cases with primary serofibrinous, and in 2 of 33 cases of primary purulent pleuritis. It may be associated with muscular spasm and tenderness, and the picture may simulate an acute abdominal affection for which laparotomy has been performed. Herrick[1] has emphasized its importance as a symptom of pleural and pulmonary disease. W. B. James suggests that aggravation of pain, following fixation of the thorax with straps, and its relief when the abdomen is similarly immobilized, may indicate the diaphragmatic site of pleurisy. There may be tenderness over the phrenic nerve in the neck or at the intersection of a vertical line parallel to the outer margin of the sternum and a horizontal line continuous with the termination of the tenth rib (De Mussy's Bouton Diaphragmatique). The breathing may be partially or wholly thoracic in type and the diaphragm phenomenon absent on one or both sides of the chest. Dyspnea may be marked and attacks simulating angina may be observed (Andral). Obstinate singultus may occur. In a recent patient with diaphragmatic pleurisy, it was the principal trouble for which relief was sought. The phrenic and pharyngeal branches of the vagus nerve are implicated and probably through irritation of the former in the diaphragm. The swallowing of food may cause pain.

(2) **Encysted Empyema.**—Encapsulation of uncomplicated transudates does not occur. It is rare with serofibrinous fluid, but more common with pus. In occasional instances fluid may be serous in one and purulent in another pocket. Sacculation was discovered in only 1 of 1085 cases of serofibrinous effusion, but in 8 (3.2 per cent.) of 248 empyemas in this series. It is, however, probably much more common that these figures show, for in 38 autopsies on

[1] Illinois Med. Jour., 1903–04, N. S., v, 603.

patients with empyema it was noted in 12 (31.5 per cent.). Sacculation is more likely to occur in small or medium effusions and in those in which the fluid is at a standstill. Encapsulation may occur between (1) diaphragm and lung, (2) the lung and chest wall, and (3) the lobes of the lung.

(*a*) **Encapsulation of Pus between Diaphragm and Lung** is more common than in other situations. In most instances the empyema is at first free, but is *later* walled off by adhesion of inflamed and apposed pleural surfaces in the posterior and inferior thoracic region. This was noted in five autopsies in the present series. Sacculation of fluid above the diaphragm without apposition to the thoracic wall may occur. The effusion may be bounded by lung and diaphragm, or by lung, diaphragm, and the mediastinum. Perforation of lung or diaphragm may be the first objective sign of the disease. The symptoms may suggest diaphragmatic pleurisy. The heart and the organs below the diaphragm may be dislocated, expansion of the affected side may be deficient, and on systematic examination of the chest an area of impaired resonance several inches above the base of the lung may be discovered. In this region diminished breathing, voice sounds, and tactile fremitus may be suggestive. Pleuritic friction may occur. If, as is often the case, more extensive pleuritis has preceded the sacculation, the physical signs may be difficult of interpretation.

(*b*) **Sacculation between Lung and Chest Wall.**—This is not uncommon and is likely to occur in cases in which a previous pleuritis has obliterated the diaphragmatic portion of the pleural sac. It is occasionally observed in empyema in which, following operation, the sinus has been allowed to close too quickly. Such encapsulation is more common over the base, but may be observed over other parts of the lung.

(*c*) **Interlobar Empyema.** — Inflammation of the interlobar pleura occurs as part of a general pleuritis. An effusion of fluid may be limited externally by the thoracic wall, internally by the lobes of the lung between which it lies. In rare instances the effusion may not extend to the chest wall, and is bounded on all sides by the lung. The symptoms are not distinctive and the diagnosis is difficult. Examination may be negative and perforation of the lung may be the first indication. Rupture may take place as early as the fourteenth (Potain) or the nineteenth (D. Gerhardt) day. Dislocation of the heart may occur. In the affected region there may be dulness, diminished or absent breathing, voice sounds, and tactile fremitus. The localization of the process in the region of the interlobar septa and the absence of signs above and below this region are most likely to suggest the diagnosis. Examination by means of the *x*-rays may be of great assistance. Sacchonaghi[1] has reviewed the literature.

[1] Gesamt. geb. d. prakt. Med., 1910, x, 151.

Diagnosis.—Laënnec regarded ægophony as an important sign. Localized tenderness may be elicited by firm and deep pressure in the interspaces. Sacculated and especially interlobar empyema is likely to be confused with pulmonary abscess. The gross character of the sputum may be suggestive. The sudden expectoration of a large amount of homogeneous pus, little mixed with mucus, may suggest empyema. The discovery in the expectoration of elastic tissue with an alveolar arrangement is diagnostic of pulmonary abscess, but does not exclude a complicating empyema. Tumors of the lung must also be considered. Exploratory puncture is usually recommended for the diagnosis, but its danger has already been noted (p. 525), and exploratory incision may be safer.

Treatment.—Perforation of the lung has been followed by spontaneous recovery. If perforation has already occurred when the patient comes under observation, the decision between an expectant policy and operation must be made on the exigencies of the individual case. If the empyema can be reached, its evacuation is indicated.

(3) **Actinomycosis and Streptothricosis of the Pleura.**—Two kinds of parasites must be recognized, *i. e.*, Actinomyces bovis and Streptothrix. Although the two parasites present well-marked biologic differences, the clinical and pathologic picture in infection is, in general, quite similar.

Actinomycosis.—In a large proportion of the cases this arises by extension from the lung. Pleural invasion may also occur from the esophagus; by extension downward from the neck to the mediastinum and thence into the pleura, or from abdominal lesions which perforate the diaphragm. Metastasis is a possible mode of origin. The pleura overlying the involved tissue is the site of a fibrinous exudate. If adhesion of the visceral and parietal layers does not take place, a serofibrinous effusion or, more commonly, an empyema may result. The manifestations on the part of the pleura may mask the primary focus of the disease. Perforation of the chest wall is a characteristic feature. If, as often happens, pleural adhesion precedes the perforation, extension takes place through an obliterated pleural sac and the pleural changes are merely an incident in a more obvious disease of other organs. The thoracic wall may be involved without extensive changes in the pleura, or suppuration may similarly perforate the diaphragm by extension downward from the lung or upward from the abdomen, without invasion of the general pleural space. It is the site of single or multiple indurated and suppurating areas, connecting by means of sinuses with the pleura or the pleura and lung. Perforation may take place at any part of the thorax, but is more common in the lower thoracic region. Erosion of the ribs may occur. Amyloid degeneration may follow long-continued suppuration.

There is no distinctive clinical picture. Actinomycosis should be suspected in empyema, especially when associated with chronic pul-

monary suppuration, interstitial pneumonia, abscess, gangrene, or empyema necessitatis. The diagnosis can be made only by finding granules with branching, Gram-staining filaments and radially disposed club-shaped, eosin-staining peripheral bodies. The prognosis is very unfavorable. A few arrested or apparently cured cases have been reported. The treatment is surgical, combined with the internal administration of large doses of iodid of potassium.

Streptothricosis.—This appears to be much less common. Infection of the pleura takes place by extension from the lung. The changes are similar to those in actinomycosis, and may closely resemble tuberculosis. The diagnosis is made by finding thread-like, branching organisms, which, in most cases, resist decolorization with weak acids and alcohol, but are less "acid-fast" than the tubercle bacillus, do not form granules or masses of closely packed interlacing filaments with the characteristic "clubs" at the periphery and are much more readily cultivated than either tubercle bacilli or actinomyces. In Birt and Leishman's case[1] an "acid-fast" streptothrix was recovered from the lung and the pleural pus. Lebram[2] reports a case which appears to belong in this group. There were multiple pulmonary abscesses and bilateral pleuritis. The left pleura contained gray, pearl-gray, or white nodules, resembling miliary tubercles, in which, as well as in the lungs, branching threads were found, but no tubercle bacilli. There were no typical granules. Cultures are not mentioned.

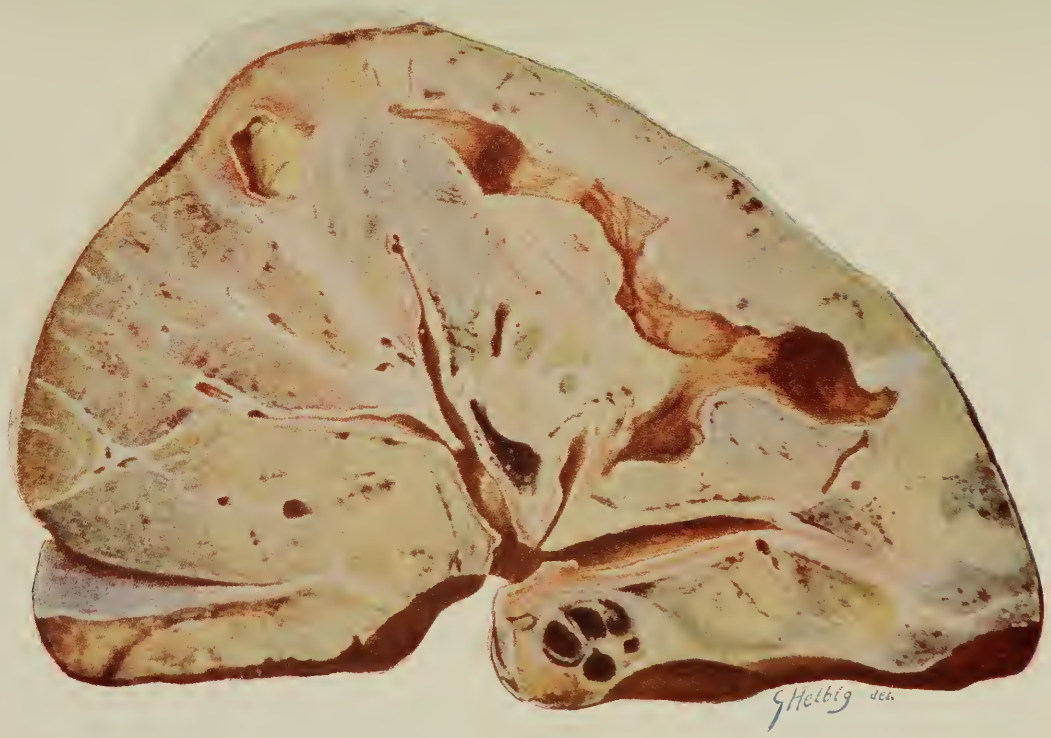
(4) **Peripleuritis.**—Secondary inflammation of the peripleural tissue is associated with all pleural and many parapleural infections. A primary form has been described, in which, independent of neighboring disease, there is inflammation and suppuration of the tissue between the costal pleura and the chest wall. Wunderlich, Billroth, Bartels, Riegel, and others have described and recorded cases, but, as Martin suggests, with reliance on the clinical picture for the establishment of the group. Vogel[3] has reported cases in which at operation the disease appeared to be primary. Idiopathic peripleuritis is rare. It is usually localized and may be acute or chronic. Extension inward is uncommon; while perforation of the chest wall is frequent. There are the usual symptoms of suppuration. Movement of the affected side may be restricted. The tissue overlying the inflamed area is swollen. The involved region is dull, the breathing and fremitus diminished or absent. Fluctuation may be established. The diagnosis may be impossible before operation, and even then it may be difficult to distinguish between an encysted empyema and a peripleural abscess. A history of preceding pleural disease may suggest the former. The absence of signs of disease at the base of the chest, slight or failing dislocation of the heart and the lack of shifting dul-

[1] Jour. of Hygiene, 1902, ii, 120.

[2] Ueber Miliar-Actinomykose der Pleura, Arbeiten auf dem Gebiete de Pathologischen Anatomie und Bacteriologie, Baumgarten, 1904, Bd. iv, H. 3.

[3] Deut. Zeit. f. Chir., 1902–03, vol. lxvi.

PLATE I



Syphilis of Right Lung.

Involvement of upper, middle, and lower lobes. Interstitial pneumonia. Bronchiectasis. Thickening of bronchial walls. (Koch.)

ness may distinguish between peripleural abscess and ordinary empyema. The prognosis has been regarded as unfavorable. Early diagnosis followed by prompt and appropriate surgical treatment may be expected to give favorable results in simple (non-tuberculous) and uncomplicated cases.

(5) **Syphilis of the Pleura.**—Cases of pleurisy with positive Wassermann test on the blood and pleural fluid have been reported from time to time. In some instances negative inoculation tests in animals have failed to show tuberculosis in such cases, but thus far the syphilitic character of pleurisy has not been established.

(6) **Chronic Pleuritis.**—1. **Dry Pleurisy.**—This occurs as a sequel to fibrinous, serofibrinous, or purulent pleuritis. Even in the mildest cases of fibrinous pleuritis the pleura rarely escapes some damage. The pleura overlying a pulmonary process may be merely thickened. Adhesions between the pulmonary and parietal layers are common. On postmortem examination these may consist of delicate, thread-like connections, or as circumscribed or general synechiæ on one or both sides of the chest. The lung may be extensively torn in removal unless a dissection is made. The pleura may reach a centimeter or more in thickness and enclose single or multiple pockets of serous or purulent fluid. Deposition of lime-salts may have taken place. The neighboring lung is often contracted and fibrous in character. Bronchiectatic or abscess cavities are frequently found. The interstitial pulmonary changes may be due to extension from the pleura, but it is difficult in individual cases to exclude their independent origin. The pleural changes may be simple or tuberculous. In the latter instance, small tubercles, fibrocaseous or calcified areas may be found in the indurated tissue. The site of the process is usually at the bases, when it follows pleurisy with effusion. In tuberculous cases it is frequently at the apices, and extensive pleural thickening may complicate slight pulmonary infections.

There may be no symptoms. Pain of varying and usually slight intensity may be present. Pleuritic friction may exist without subjective symptoms. Adhesions usually prevent the rubbing of the two pleuræ together, however, and the signs are such as have been mentioned under Sequelæ in the preceding sections. Chronic apical pleuritis may give rise to depression of the supra- and infraclavicular fossæ, to contraction of the apex, dulness, diminished breathing, voice sounds, and tactile fremitus, but coexistent pulmonary lesions may make the signs of thick pleura atypical. An apical process is tuberculous in a large proportion of the cases. If pulmonary tuberculosis is suspected, suitable treatment should be instituted. In non-tuberculous cases, with retraction of the side and fixation of the lung, pulmonary gymnastics may be prescribed to favor expansion and improve the breathing capacity.

2. **Pleurisy with Effusion.**—In rare instances serofibrinous or purulent fluid continues to reaccumulate after repeated thoracentesis or operation.

(*a*) *Serofibrinous Form.*—Persistent reaccumulation may be due to failure of the retracted and adherent lung to expand and a neglect of early tapping may be responsible. In some cases this appears not to be the cause, and West[1] noted in two instances, with a duration of eighteen months, that the lung was still capable of reëxpansion. In the absence of malignant disease and obvious pulmonary tuberculosis, a resort to operation may be considered after other measures have been tried. It should be advised with caution, however, for it necessarily induces empyema, which may also fail to heal, if the lung is adherent.

(*b*) *Empyema.*—In this, as in the serofibrinous form, after pus has remained long in the chest, the lung may be partially or wholly incapable of reëxpansion from the presence of abundant connective-tissue formation in and about it. After operation and the evacuation of pus, a space is left, and in the young, with less resistant thoracic walls, marked deformity, retraction of the side, and lateral deviation of the spine may result. At times, from the stiffness of its walls, the abscess cavity refuses to close, and cure can be effected only by more extensive operative procedures. In many cases the first operation has been too long delayed. Multiple costatectomy (Estlander's operation) may be considered in persistent partial, but is not likely to succeed in large or total empyema, in the presence of greatly thickened parietal pleura or in old patients with unyielding thoracic walls. In such cases, Schede's "Thoraxresection" may be successful.

[1] Lancet, March 25, 1905.

CHAPTER XXXI.

HYDROTHORAX.

Transudation of serous fluid into the pleural sacs occurs in the course of many diseases, but when in sufficient amount to be detected during life is usully secondary to renal or cardiac disease. Renal disease gives rise to only small amounts of pleural fluid, but is often combined with cardiac insufficiency. Local stasis is probably a contributing factor in connection with new-growths of the pleura, lung, or diaphragm. Occlusion of the azygos veins from pressure or thrombosis is a possible cause.

Cardiac insufficiency may give rise to fluid in one or both pleural sacs, with or without general dropsy. Cardiac hydrothorax is commonly unilateral and right-sided, and when both pleuræ are affected the amount of fluid is usually greater on the right. Fetterolf and Landis[1] suggest that cardiac hydrothorax is due to pressure on and partial occlusion of the pulmonary veins by dilatated portions of the heart. The more common dilatation of the right auricle is responsible for the greater frequency on the right. Of 30 cases of cardiac hydrothorax the effusion was bilateral in 8, in 6 of which the amount of fluid was greater on the right and equal on the two sides in the remaining 2. It was unilateral and right-sided in 16, and confined to the left side in only 6. The predominance of right-sided accumulations is too constant to be accidental or to be explained by previous pleuritis and obliteration of the left pleura, which can account for only a small proportion of the cases. Hydrothorax from renal disease alone is usually bilateral. If, as often happens, the heart is insufficient, the accumulation may be unilateral and right-sided or double, with an excess on the right. Of 15 cases in my series, the effusion was bilateral in 7, in 2 of which the amount was greater on the right, in 3 on the left, and equal on the two sides in the remaining 2. It was unilateral and right-sided in 6, of which 5 were complicated by cardiac lesions. The effusion was confined to the left side in 2 cases.

If the decubitus is prevailingly lateral, a larger amount of fluid may collect in the dependent pleura. The pleura may be smooth or slightly clouded and swollen. Old adhesions may limit the accumulation to single or multiple pockets. The fluid is usually clear and yellowish, but may be reddish from admixture of blood. It clots slowly or not at all, and fibrin is absent in uncomplicated cases. The specific gravity

[1] Amer. Jour. Med. Sci., 1909, cxxxviii, 712.

in venous transudates is usually from 1010 to 1015, with 1 to 3 per cent. of albumin, while hydremic fluids are below 1010, with traces to 1 per cent. of albumin. The sediment usually shows an excess of endothelial cells. In rare instances lymphocytes may predominate. A complicating pleuritis is not uncommon, and polynuclear cells may then outnumber the other elements.

Symptoms.—The symptoms are those of the underlying disease. Pain is absent. If there is fever, it cannot be ascribed to hydrothorax. Cough and expectoration may be due to edema of the lungs. There may be gradually increasing dyspnea, which may amount to orthopnea. The signs are the same as with pleural fluid of other character. Pleuritic friction is absent. Shifting dulness is more readily obtained. Rosenbach and Pohl[1] find that even small amounts of iodine or its salts given by mouth can be demonstrated in transudates, but not in exudates. The test is performed by adding fuming nitric acid to fluid obtained by puncture and agitation with chloroform, which is turned red if the test is positive.

Treatment.—This is that of the underlying disease. Removal of the fluid by thoracentesis is indicated, if necessary, for the relief of an embarrassed circulation or breathing.

[1] Berl. klin. Woch., 1890, No. 36.

CHAPTER XXXII.

HEMORRHAGIC PLEURAL FLUIDS.

Microscopic blood is always present in pleural fluids. Small amounts of blood may arise from puncture of the lung in thoracentesis. Larger quantities of fresh blood color the fluid reddish or even blood red. Dieulafoy estimates that 5000 to 6000 red cells per c.c. are necessary to give the fluid a definitely red color. Only cases with frankly hemorrhagic fluid are considered here. In old extravasations the fluid may be reddish-brown, yellowish, or greenish. Clinically, it is convenient to divide bloody fluids into hemoserothorax (hemorrhagic pleurisy), hemohydrothorax, and hemothorax.

(1) **Hemoserothorax (Hemorrhagic Pleurisy).** — **Primary.** — (*a*) *Tuberculous:* An apparently primary disease of the pleura with the production of serohemorrhagic fluid is tuberculous in a great majority of cases. (*b*) *Malignant:* In a relatively small proportion of cases it is due to carcinoma, rarely sarcoma. A discussion of these causes will be found elsewhere. In both groups it is not infrequently observed that the effusion becomes more bloody with successive tappings. (*c*) *Simple Hemorrhagic Pleurisy:* There is no sound pathologic evidence in support of this group, as a primary affection, although hemorrhagic fluids of secondary and infectious origin are not uncommon. The clinical cases with an apparently primary hemoserothorax, of simple origin, practically always run a clinical course consistent with tuberculosis or malignant disease, or show one or the other of these conditions at autopsy. There are a few striking exceptions as regards a more favorable clinical course. Osler[1] refers to a large, able-bodied man, with hemorrhagic exudation, who was healthy and strong eight years afterward. Cheesman and Ely[2] reported a most remarkable instance in a woman aged forty-seven years, with bloody fluid first in the right, then in the left chest, and finally, following the disappearance of this fluid, with bloody serum in the abdomen. The pleural accumulations continued for about eighteen months, and no chest difficulty arose in the following seven years, but in this interval the abdomen was repeatedly tapped. The abdominal fluid ceased to reaccumulate after about five years, and at the date of the report twenty months had elapsed without recurrence. There was a large fibroid in the uterus. In all, two hundred and seventy-nine pints of fluid were removed.[3]

[1] Prac. of Med., 1905, p. 651. [2] Amer. Jour. Med. Sci., August, 1899.
[3] I am informed that the patient is entirely well twenty-three years from the onset.

Secondary.—This is a much more common form. Cases due to tuberculosis, although they may seem clinically to be primary, are usually secondary. So, also, in hemorrhagic pleurisy due to malignant disease, the primary form is rare, that from metastasis relatively common. Cases not included in these two groups may be classed, as in the primary form, as simple hemorrhagic pleurisy. Hemorrhagic serofibrinous effusions of this sort are perhaps most common in pneumonia, and are usually due to the pneumococcus. Of 57 cases of croupous pneumonia, showing pleural effusion at autopsy in the Massachusetts General Hospital, in 6 the exudate was bloody. In none of these was there evidence of tuberculosis of the pleura. An inflammation of the pleura in the course of malignant fevers (variola, typhoid) in purpura hemorrhagica or complicating such asthenic conditions as accompany malignant disease, nephritis, cirrhosis of the liver or chronic heart disease, may be of the hemorrhagic variety, whatever the cause of the process in the pleura. Some prove to be tuberculosis; others are simple and due to the pneumococcus or pyogenic organisms, the blood in the exudate being due to passive congestion or the intensity of the local process.

An interesting feature of the hemorrhagic pleural fluids is the high percentage of eosinophiles which they may contain and the presence, also, of a large number of eosinophiles in the circulating blood. In Klein's case[1] (autopsy but no microscopic examination of the tissue) the pleural fluid showed 76.4 per cent. eosinophiles (small lymphocytes, 23.6 per cent.), the systemic blood 40 per cent. of eosinophiles. In Harmsen's case[2] the pleural fluid showed 8.64 per cent. eosinophiles (small lymphocytes, 87.65 per cent.). In a case of apparently primary disease of the pleura in my series, the bloody pleural fluid showed no excess of eosinophiles, but contained enormous numbers of cholesterin crystals, while the systemic blood showed 6400 white cells, of which 20 per cent. were eosinophiles.

Hemohydrothorax.—Transudates may have a hemorrhagic character in cardiac or renal disease. Thrombosis of the thoracic veins or their occlusion by pressure of tumors is a possible cause. In Zahn's[3] case there was thrombosis of the azygos and intercostal veins and hemorrhage. Zahn was unable to cause similar changes by experimental obliteration of the azygos veins.

Hemothorax.—This may be due to the rupture of intrathoracic vessels following the development of aneurysm, their erosion by disease or injury by trauma. In the rupture of the aorta or its ulceration, the left pleura is more often the site of the hemorrhage. The pulmonary veins and the vena cava may rarely be the source. The rupture of pulmonary vessels from destructive pulmonary processes occasionally leads to hemorrhage into the pleural sac. The intercostal artieries may, likewise, be eroded in disease of the pleura. There is

[1] Cent. f. innere Med., January 28 1899.
[2] Quoted from Klein.
[3] Virchow's Archiv, 1885, p. 345.

a specimen (No. 2159) in the Warren Museum from a patient with empyema, in whom erosion of an intercostal artery led to fatal hemothorax. The lungs showed tuberculosis.

(2) **Traumatic Hemothorax.—Etiology.**—This may arise from contusions of the chest, more often from fracture of the ribs, and most commonly from incised or penetrating wounds. The bleeding may come from injured vessels in the thoracic wall, more rarely from small branches of these parietal vessels. Owing to the unprotected position of the intercostal arteries, their injury is relatively uncommon. In a large proportion of cases the hemorrhage is from a wound of the lung, superficial injuries of which may lead to varying and usually insignificant hemothorax, deeper wounds to abundant hemothorax, if an important vessel is involved. The injury of vessels accompanying bronchi of the second or third order may be followed by hemorrhage compatible with survival.[1] Wounds of vessels about the hilus of the lung and the larger mediastinal vessels are followed by rapidly fatal hemorrhage.

Special Pathology.—(*a*) *Onset of Hemorrhage.*—Following the injury of the larger bloodvessels, fatal hemorrhage into the pleura may occur within a few minutes. An effusion of blood from the parietal vessels and the lung usually begins at once and is slowly continuous. In the more favorable cases the bleeding usually stops after twenty-four to forty-eight hours. Delayed hemorrhage is rare. In Nélaton's series of 94 cases a secondary and fatal hemorrhage followed a gunshot wound of the chest, in 4 cases, on the second, the tenth, the twelfth, and the thirty-sixth day respectively. In Vaille and Braun's case, following a knife cut in the second left intercostal space, hemothorax due to the rupture of a traumatic aneurysm of the internal mammary artery occurred on the nineteenth day.

(*b*) *Time of Coagulation.*—In experimental work the introduction of artificial conditions limits the value of the observations. Nélaton caused hemothorax in animals by injuring the lung with a knife, and found that the extravasated blood coagulated within twenty-four hours, as shown by autopsy. His experiments were not performed under aseptic precautions. Penzolt[2] found, in fourteen experiments, that the blood at first remains fluid, that large effusions coagulate after two hours, and that small amounts of blood coagulate at the latest after twenty-four hours. Pagenstecher[3] found, in nine experiments, that blood injected into the pleural cavity is still fluid after about two hours, while clots and uncoagulated fluid are present after about six hours. The reports of surgical interference and the autopsy table, although not numerous, suggest that coagulation of the effused blood invariably occurs in man and probably within an equal period. It is frequently noted that hemorrhagic pleural fluid does not coagu-

[1] Nélaton, "Des épanchements de sang dans les plèvres, etc.," Thése de Paris, 1880.
[2] Deut. Arch. f. klin. Med., 1876, p. 542.
[3] Beiträge zur klinischen Chirurgie, Tübingen, 1895, xiii, 264.

late on removal, and this is probably due to its previous coagulation within the chest.

(*c*) *Absorption.*—In favorable and uncomplicated cases the fluid is wholly absorbed. The blood clot becomes adherent to the pleural surfaces, softening and organization take place, and after small extravasations, nothing but a few adhesions may remain. With large hemorrhages and much clot, more extensive adhesions and thickening of the pleura persist. The affected side may show diminished expansion.

(*d*) *Occurrence of Pleuritis.*—The blood is not in itself a cause of pleuritis, and when infection occurs in hemothorax, it is due to bacteria which have invaded the pleural sac from without, through the thoracic wound or the lung. The incidence of suppuration in traumatic hemothorax is uncertain, from the lack of any series of unselected cases of sufficient number dealing with this point. Its occurrence can, therefore, be formulated only in a general way. It is less frequent in small effusions, and is less likely to occur following injuries of the parietal vessels or the superficial parts of the lung, without an external wound. Large effusions of blood, those arising from incised or penetrating wounds, and hemorrhage from the deeper parts of the lung, often become purulent.

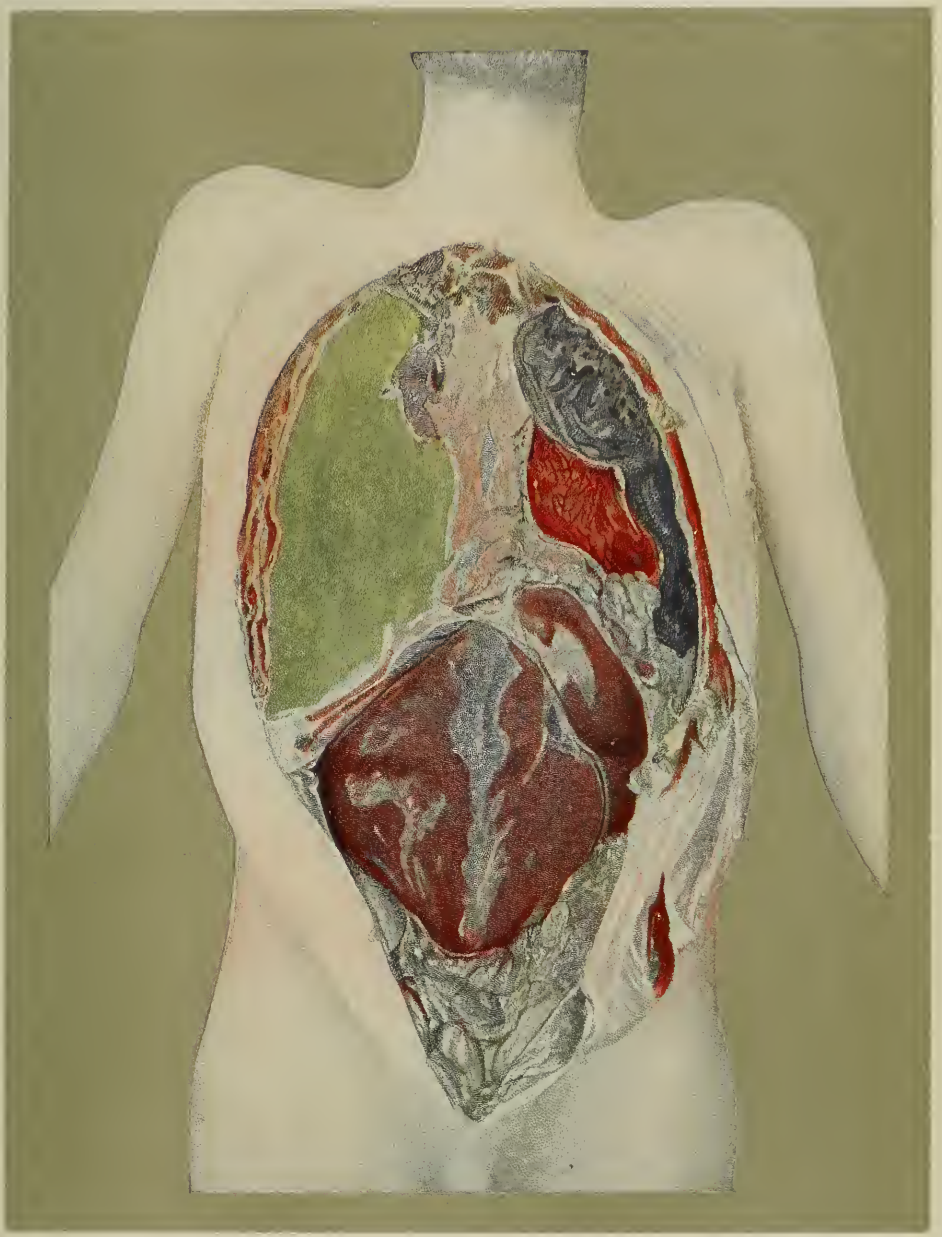
(*e*) *Examination of the Pleural Fluid Obtained by Puncture.*—Observations are rare on this point. The number of red cells progressively diminishes in the effused blood. This is partly due to the dissolution of red cells in the fluid, to phagocytosis by endothelial cells, and to sedimentation, counts in fluid taken from different levels showing fewer reds and a larger number of white cells above, while the opposite is true below. In judging the presence of an infection from an enumeration and differential count of the white cells, due allowance must be made for the number of polynuclear cells in the effused blood. In De Gery and Froin's case of traumatic hemothorax, a differential count of the white cells in the effused blood showed: large mononuclear cells, 90.42 per cent.; lymphocytes, 2.12 per cent.; polynuclears, 3.72 per cent.; eosinophiles, 3.72 per cent. Three days later the eosinophiles numbered 28.76 per cent. In Harmsen's case there was a marked systemic leukocytosis with eosinophiles in both systemic and pleural blood.

(*f*) *Relation to Tuberculosis.*—Hemorrhagic pleural effusion following trauma may rarely be tuberculous. Lustig[1] relates the case of a laborer, aged forty-three years, with tuberculous antecedents, in whom a left-sided hemorrhagic effusion followed a fall, in which the left chest struck against a wheel. Death occurred one month later. Autopsy showed tuberculosis of the left pleura.

Symptoms.—In small and slowly accumulating effusions there may be no symptoms. Shock is a variable feature. Pressure symptoms

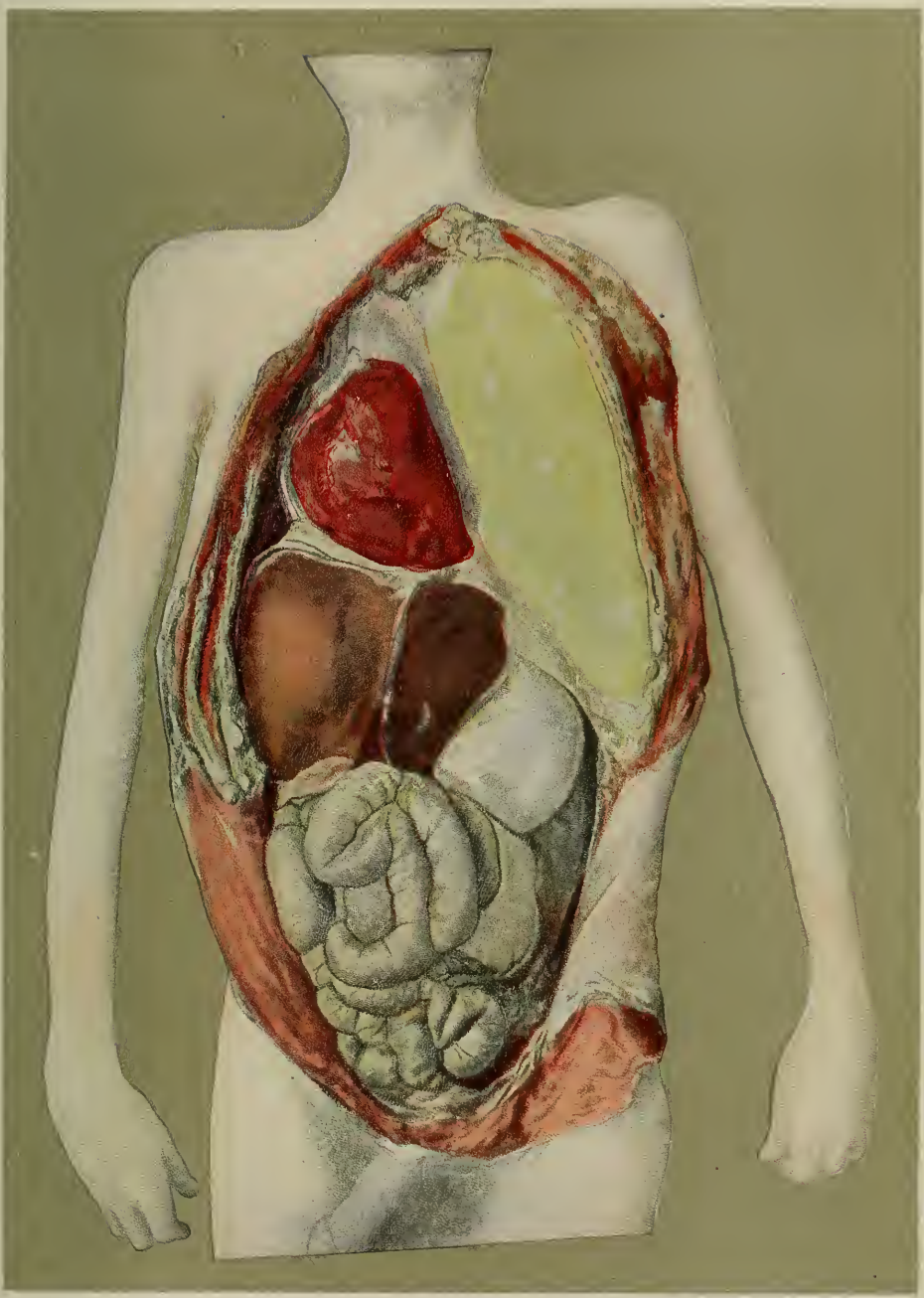
[1] Quoted from Trouvé, Thése de Paris, 1902.

PLATE II



Pyopneumothorax.—Right Side. (James.)

PLATE III



Pyopneumothorax—Left Side. (James.)

usually occur within twenty-four hours and are rarely delayed for forty-eight hours. In one of Nélaton's cases the hemorrhage was delayed for thirty-six days. With the rapid accumulation of a large amount of blood, death may ensue within a few minutes. In most cases there is slowly increasing dyspnea, which is the most constant symptom, due to collapse of the lung and consequent dislocation of the mediastinum. Pain may be present, and is usually referred to the affected side. Cough is an inconstant symptom. If the lung is wounded there is likely to be hemoptysis. Blood in the sputum may consist of blood streaks, or there may be frank hemoptysis. In addition, with the more rapid accumulation, there are symptoms due to loss of blood, pallor, progressive elevation of the pulse, with alteration in its quality, coldness of the extremities and body, and sweating. Syncope or delirium may occur. The temperature may be subnormal at first, and in favorable cases may not exceed normal limits. In a considerable proportion of cases the temperature rises, after the first or second day, a degree, a degree and a half, or even two degrees Fahrenheit, and remains thus elevated for several days. Although such an elevation of temperature naturally occasions much anxiety, such cases not infrequently progress favorably. The rise in temperature may be due to absorption. The physical signs differ in no respect from those with pleural fluids of other character.

Complications and Sequelæ.—Infection of the effused blood is most to be feared. There are no trustworthy statistics concerning the frequency with which empyema develops, but it appears from Nélaton's 94 collected cases that the effusion became purulent with more or less certainty in 21. Hemopneumothorax is common, and may become pyopneumohemothorax. Pneumonia, pulmonary abscess, or gangrene may arise from the injury or follow as a result of neglected empyema. The rupture of traumatic aneurysm of the internal mammary artery was the apparent cause of hemothorax, which developed nineteen days after the injury in Vialle and Braun's case. Recovery followed ligation of this artery. An unruptured aneurysm of the same artery was found after death in DeMontegre's case. In both there was localized pulsating tumor, and in the former a systolic murmur.

Diagnosis.—A careful physical examination should be made when the patient first comes under observation. A neglect of this precaution may lead to unnecessary delay in the diagnosis of an empyema. A pleural effusion developing within a few hours of a thoracic injury means hemothorax with practical certainty; a delayed effusion is usually inflammatory, rarely hemorrhagic. The early detection of infection is most important. Evidence of its occurrence is usually afforded by elevation of temperature, which commonly takes place from the third to the fifth day, and is accompanied by other symptoms of sepsis, such as are ordinarily seen in empyema. Symptoms of sepsis may develop, however, only after days or weeks have elapsed. The presence of an infection may be suspected when, even without

fever, there is a delay in the absorption of the fluid, which in most cases progressively diminishes in amount, and moderate effusions may be fully absorbed within a month. Any increase of a fluid which has previously reached a standstill should likewise be regarded as due to inflammation and not recurrent hemorrhage, which is relatively uncommon. An enumeration at intervals of the white cells in the systemic blood may be of value in the early recognition of suppuration. An initial leukocytosis may be due to hemorrhage alone.

Exploratory puncture and the withdrawal of sufficient fluid for diagnosis should be done if empyema is suspected. If the puncture is made at a distance from the original injury there is less danger of dislodging an occluding thrombus. The needle should be inserted toward the upper rather than the lower level of the fluid, to avoid a dry tap from penetration of the clot. If properly performed, and under rigidly aseptic precautions, the procedure is practically devoid of danger. An infection may be sufficiently obvious from inspection of the fluid. In developing or mild infections microscopic examination of the sediment may show an excess of polynuclear cells and also that degenerative processes are at work, from their necrotic appearance. Cultures should be taken.

Prognosis.—Traumatic hemothorax is always serious. The site, extent, and character of the original injury, the rapidity with which the hemorrhage takes place and the amount of effused blood are important factors. In some cases the effusion may be small, and pneumothorax may be the significant feature. To these dangers that of infection is added. Of Nélaton's 94 cases of traumatic hemothorax, gathered from the older literature, 49 died from immediate or remote causes. The seriousness of chest injuries, in general, can be gathered from the cases collected from the literature by Garrè.[1] In 37 cases of pulmonary rupture the mortality was 63 per cent.; in 100 cases of punctured wounds, 38 per cent.; in 535 bullet wounds, 30 per cent. Hemorrhage, pneumothorax, or infection are the principal causes of death.

Treatment.—The cases come within the province of the surgeon. Aside from the surgical care of external wounds an expectant policy should be followed in cases without alarming symptoms. The patient should be absolutely at rest. Immobilization of the affected side by strips of adhesive plaster may favor cessation of the hemorrhage. The administration of lactate of calcium, 15 gr. (1 gram), four times a day, may be of value. The hemothorax if uninfected will be absorbed. If suppuration occurs, the empyema should be opened and drained. The large proportion of deaths from hemorrhage, from suffocation by hemothorax or pneumothorax, and the frequency with which the pleura becomes infected, leaves much to be desired from surgery in the care of such cases.

[1] Archiv f. klin. Chir., 1905, lxxvii, 209.

Although the cleaning and disinfection of external wounds may be secured, and doubtless eliminates a small measure of infection, there still remains the considerable danger of infected material already carried into the thorax or arising in consequence of a communication between the lung and the pleura. In cases with alarming symptoms, as a life-saving measure, a more active surgical intervention may properly be considered. A source of the hemorrhage in a parietal vessel may at times be determined from the site of the injury. The lung itself is, however, more often the source, and then surgery is less likely to be successful. The lung is likely to be partly or wholly collapsed and the bleeding wound difficult to find or to reach. Suture of the lung has as yet been too infrequently performed to furnish trustworthy statistics.

Thoracentesis and the slow withdrawal of blood has been advised, for the most part by French surgeons, for alarming pressure symptoms following hemothorax. Bourgeois[1] was able to collect 9 cases in which thoracentesis was performed on the first to the fourth day, with recovery. No unfavorable cases are mentioned. The measure is regarded not only as palliative, but also as curative, on the theory that the collapsed lung is congested and thus bleeds more readily than otherwise. In cases obviously suffering from pressure and without marked symptoms of hemorrhage, the procedure may be tried.

[1] "Traitement par la ponction de l'hemothorax traumatique," Thèse, Lyon, 1905.

CHAPTER XXXIII.

CHYLOTHORAX.

Chylous and Chyliform Pleural Fluids.—Much confusion exists in the classification of milky fluids which may accumulate in the serous sacs. Quincke,[1] in 1875, grouped the cases into those with chylous fluid (hydrops chylosus) in which the appearance was due to the presence of true chyle, and a second class with fluid of a chylous appearance (hydrops chyliformis seu adiposus), the milky character being due to cells undergoing fatty degeneration. The distinction is often difficult and at times impossible. The two types of fluid may be present in different cases, both of which are due to a similar cause, and a single sample of fluid may likewise present features common to both forms. The differentiation from the presence of sugar, which, in more than questionable traces, Senator[2] regarded as an indication of the chylous nature of the fluid, cannot be relied upon, since Rotmann[3] showed that serous fluids (without chyle) may also contain from 0.055 to 0.112 per cent. of sugar. Rotmann believes that sugar is a differential sign of importance only when present in an amount exceeding 0.2 per cent.

Such fluids are white and milky in appearance, but may be reddish from the presence of blood or show varying shades of yellow or green. In the last instance they may readily be mistaken for purulent fluid. They are usually colorless, but may be slightly sweetish. Thin layers are opalescent. On standing, a creamy layer of fat collects at the surface. They are resistant against putrefaction. Their milky appearance is maintained after filtration or centrifugalization, but they can be cleared by shaking with ether. From 0.06 to 3.71 per cent. of fat has been extracted. The amount of albumin is variable; from 3.36 to 7.37 per cent. has been reported, with traces of casein in one instance. Solids are present from 5 to 10 per cent., inorganic substances (salts and extractives) about 1 per cent. Fibrin is variable, present in some, absent in other cases. Cholesterin, lecithin, calcium, magnesium, potassium, sodium, chlorin, and carbonic, sulphuric, and phosphoric acids have been found. Microscopic examination discloses a large number of minute fat droplets about the size of micrococci, but readily differentiated from microörganisms. In the chylous fluids the fat granules are very numerous, with only few formed elements, while the chyliform fluids contain less numerous

[1] Deut. Arch. f. klin. Med., Bd. xvi, pp. 121 to 139.
[2] Charité-Annalen, vol. xx, p. 263. [3] Zeit. f. klin. Med., 1896, xxxi, 416.

fat granules, of larger size, and more numerous cells in different stages of fatty degeneration.

Pseudochylous Fluids.—Pleural fluid without fat may have a milky appearance. Quincke showed that albumin in fine subdivision may cause a milky appearance. Lion,[1] in 1893, showed that fat was absent in a milky abdominal fluid which he studied. An albuminous body was found, the nature of which was uncertain. Such substances have been regarded as lecithin, globulin, casein, or a compound of globulin and lecithin. These pseudochylous fluids are distinguished from the chylous and chyliform fluids by the separation of the latter into two layers on standing, while the former remain homogeneous. The microscopic examination of chylous or chyliform fluids shows the presence of fat, which may be stained black with osmic acid or removed by shaking with ether. In gross appearance chylous and chyliform fluids may resemble purulent fluids, from which they can be differentiated by more careful examination.

Occurrence.—Chylous or chyliform pleural fluids are of infrequent occurrence. It is probable that they are more common, however, than the number of reported cases indicates, since chylous may be readily confused with purulent fluid, unless carefully examined. Bargebuhr[2] was able to collect 41 cases, reported from 1633 to 1894, an incidence of 1 case reported about every six years. Rotmann in 1896 brought the number to 49.

Etiology.—Of 40 cases in Rotmann's series, in which the cause could be determined, 27 were classed as chylous, 13 as chyliform. Of the chylous cases, 8 were due to trauma; 5 to cancer of the pleura; 4 to occlusion of the left subclavian vein. Two cases were ascribed to each of the following causes: compression of the duct by tumors, disease of the lymph vessels (sclerosis, lymphangiectasis), and malignant lymphoma, and 1 case to each condition as follows: occlusion of the thoracic duct, excessive exertion and parasites (filaria?). The presence of chyliform fluid, with admixture of fatty degenerated cells, was due to cancer of the pleura, lymph vessels, etc., in 5; tuberculous pleuritis in 3; exudative (non-tuberculous) pleuritis in 3; and pulmonary abscess (?) in 1. One case was regarded as the result of an abnormal amount of fat in the blood (lipemia?).

Diagnosis.—The chylous or chyliform character of a pleural fluid can be determined with certainty only by an examination of the fluid. Its presence may be suspected, however, following trauma, with malignant disease of the pleura, glands, or lymphatics, and with thrombosis of the left subclavian vein. The association of pleural fluid with the known presence of chylous ascites may suggest a chylous character to the former. Uncomplicated cases of chylous or chyliform pleural fluid are usually afebrile. Such an accumulation may occur at any age and in either or both pleural sacs.

[1] Archiv de méd. experiment., 1893, No. 6, p. 826.
[2] Deut. Arch. f. klin. Med., 1895, vol. liv.

Prognosis.—*Chylous Fluids.*—The transudation of chyle into the pleura adds to the danger of the underlying disease, the additional tax on the patient from the loss of food which would otherwise be utilized in the system. Thus the course of an affection steadily progressing toward a fatal termination may be hastened. The rapidity and extent of the accumulation are important for the estimation of its effect on the patient. Small accumulations, the removal of which is unnecessary, probably add little to the danger of the original disease. The prognosis becomes more unfavorable when the frequent recurrence of alarming pressure symptoms necessitates the repeated withdrawal of large amounts of chylous fluid. The underlying cause is usually of so grave a nature that in general the prognosis must be considered unfavorable. Of 22 cases (11 classed as chylous, 11 probably chylous) in Rotmann's series only 4 recovered. Of these, 2 were due to trauma, 1 to probable disease of the lymph vessels, and the last to an uncertain cause.

Chyliform Fluids.—The prognosis in cases with chyliform pleural fluid is more nearly that of the underlying cause, such cases being due to the fatty degeneration of existing cells.

In cases with chylothorax in which recovery has followed, it is probable that the chylous transudation has come from branches of the main thoracic duct or that the occlusion of the latter is compensated by an abundant collateral circulation. Slight lesions of the thoracic duct may heal and the duct remain patent.

Traumatic Chylothorax.—Such cases present features of special interest from their rarity and more favorable prognosis. Of 11 cases, recorded in the literature, the chylothorax was double in 1 case (Henssen), left-sided with right hemothorax in 1 (Handmann's first case), right-sided with left pneumothorax in 1 (v. Thaden), and confined to the right side in the remaining 8 cases (Quincke, Kirschner, Krabbel, Helferich, Handmann, Hahn, Dietze, and Lindstrom). The traumatic cases may be fatal from the original injury plus the mechanical effect of the pleural fluid, or in time from loss of lymph.

In 1 of the reported cases (Dietze) an injury to the thoracic duct followed a self-inflicted bullet wound. In the remaining cases the chylothorax was due to severe mechanical injury to the thorax, with certain or probable fracture of the ribs. In 2 of the 5 fatal cases the thoracic duct was found to have been injured by fragments of the tenth and eleventh dorsal vertebræ respectively. The mechanism of the injury to the duct in the other cases is uncertain. It may have been lacerated or ruptured by bony fragments of the ribs or vertebræ, or compressed between the mediastinal structures and the vertebral bodies with sufficient force to injure it, without injury to the more resistant neighboring structures (aorta, azygos vein, esophagus). In these cases the implication of the parietal pleura in the injured structures is indicated by the presence of chylous fluid in the pleural sac. Rupture of the thoracic duct may, however, lead to an accumu-

lation of chyle outside the pleural sac provided the parietal pleura is uninjured. Under these circumstances the mediastinum may be infiltrated or the parietal pleura dissected up from the thoracic wall, as in Eyer's case.

Treatment.—This presents a somewhat different problem from other pleural fluid, since the diminution of pleural pressure favors reaccumulation and changes in pressure interfere with the healing of lesions of the lymphatic vessels. The repeated loss of large amounts of such fluid is a severe drain. It is best, therefore, in the presence of small amounts of fluid to keep the patient under observation after sufficient material has been withdrawn for diagnostic purposes. Strapping the affected side may prevent an increase of the fluid by diminishing the respiratory changes in intrapleural tension. In the traumatic cases an expectant policy was followed by spontaneous absorption of the fluid in two instances (cases of Henssen and Handmann). When an excessive amount of fluid has accumulated it must be evacuated with the trocar. This was done in 6 cases, with 3 deaths (cases of Quincke, v. Thaden, and Hahn) and 3 recoveries (cases of Kirschner, Handmann's second case, and Dietze). In Hahn's fatal case, twenty-nine liters of fluid were removed within twenty-six days. Dietze's patient recovered after the withdrawal of twenty-seven liters in thirty-one days. If possible, operation should be delayed until the level of the fluid has ceased to rise. It is better to remove small amounts frequently than a large amount at one time. In 1 case (Krabbel) the fluid, six liters in amount, was first discovered at autopsy. Because of the inaccessible site of the thoracic duct an attempt at its ligation is hardly likely to prove successful. An increase of intrapleural pressure to that of the atmosphere, following resection of a rib, may effect a cure. Thoracotomy was followed by recovery in one case (Helferich) and death in another (Lindstrom).

CHAPTER XXXIV.

TUMORS OF THE PLEURA.

BENIGN TUMORS.

These are rare and without a distinctive clinical picture. They usually run their course undetected during life, and are first discovered at autopsy. In general they consist of tumors arising in neighboring organs which invade the pleura by encroachment, usually remaining extrapleural, at times projecting into the pleural space, but enveloped by its visceral or parietal layer.

Aberrant lung tissue may project into the pleural space. In a case described by Muus,[1] a smooth tumor the size of a walnut was found in the left pleural cavity, attached to the diaphragm and covered by diaphragmatic pleura. The tumor showed on section an alveolar arrangement. The alveolar septa contained vessels and fine muscle fibrillæ. Connective tissue, cartilage, elastic fibers, and ciliated cylindrical epithelium were also present. Small single or multiple cysts of the pleura are described by Stilling[2] and Zahn.[3] Their walls contained cartilage and acinous glands, lined with ciliated epithelium, suggesting their origin from the bronchi. Emphysema may give rise to cyst-like structures projecting into the pleural cavity (bullous marginal emphysema). A specimen in the Warren Museum (No. 2142) shows such a bleb, the size of a horse-chestnut, its walls composed of thickened pulmonary pleura, lined with delicate trabeculæ and connecting with the bronchi. They may reach a much larger size. Their rupture may give rise to pneumothorax. Pulmonary adenoma, angioma, or osteoma may invade the pleural sac. Fibroma may arise in the lung and similarly invade the pleura.

Lipoma.—Fatty tumors may in rare instances arise from the subpleural fatty tissue and project into the pleural sac. They are usually too small to give rise to symptoms or physical signs, and are discovered postmortem, growing from the costal, diaphragmatic, or mediastinal fatty tissue as rounded or flattened, sessile or pedunculated masses. Fitz[4] reviewed the literature and reported a case. In rare instances, lipoma of the thoracic wall may communicate with the subpleural space and project into the pleural sac, as in the cases of Czerny,[5] Plettner,[6]

[1] Virchow's Archiv, vol. clxxvi, p. 180.
[2] Ibid., Bd. cxiv, p. 557.
[3] Ibid., vol. cxliii, pp. 173 and 416.
[4] Trans. Assoc. Amer. Phys., 1905, vol. xx.
[5] Wien. med. Woch., 1875, xxv, 166.
[6] Inaug. Diss., Halle, 1889.

Gussenbauer,[1] and Krönlein.[2] Such possible communication through the thoracic wall with the thoracic cavity should be borne in mind in operations for the removal of subcutaneous lipomas, as infection of the wound may readily lead to infection of the pleura. In Krönlein's case, a female infant aged one year, a lipoma occupied a large part of the front of the right chest; at operation it was found to be continuous by a pedicle the size of the thumb, passing through the third interspace 1 cm. from the right sternal margin, with a similar growth, as large as a child's head, almost entirely filling the anterolateral portion of the left thoracic cavity. In Fitz's case a lipoma about the size of a newborn child's head was found at autopsy in the inferior and lateral portion of the left pleural cavity and apparently continuous with the fat tissue of the superior mediastinum. It was apparently covered by the pleura, and was adherent to the diaphragm, pericardium, and parietal pleura. The mass obscured an acute purulent pericarditis arising in the course of lobar pneumonia.

PRIMARY MALIGNANT TUMORS.

Carcinoma.—Synonyms.—Endothelioma; endothelioma lymphangiomatosum; pleuritis carcinosa; lymphangitis carcinomatodes; lymphangitis prolifera; sarcocarcinoma. Although the term endothelioma has been most commonly applied, carcinoma seems more appropriate. The general character and histologic appearance of the tumor do not, in general, sufficiently differ from carcinoma in other regions, and its origin in the surface epithelium or lymphvessel endothelium is too uncertain to warrant a more distinctive term.

Occurrence.—This is a rare affection, of which some 40 to 50 cases are sufficiently well recorded to permit of acceptance.[3] I have had the opportunity of studying sections from 3 cases. It is probable that the condition has not infrequently escaped detection because of the readiness with which it may be confused with chronic pleuritis, without a microscopic examination of the tissue. The disease is more common between forty and fifty years, but the ages of the reported cases vary from ten to seventy-four years. Men are somewhat more frequently affected. In rare instances it has followed trauma to the chest wall.

Pathology.—The disease is usually unilateral and occurs about equally on the two sides, although the right pleura has been somewhat more commonly involved. Rarely both pleuræ are invaded. The entire pleura of one side may be increased in thickness to 1, 1.5, or even to 2 cm. In other cases only a part of the pleural sac is diseased.

[1] Arch. f. klin. Chir., 1892, xliii, 322. [2] Ibid., 1877, xxi, Suppl., 157.

[3] Cases reported to 1897 have been collected by Glockner, Zeit. f. Heilkunde, 1897, vol. xviii; to 1905 by Bloch, Les Néoplasmes malins primitifs de la plèvre, Paris, Vigot Frères.

The affected region is usually diffusely invaded, is gray or grayish-yellow in color, and studded with discrete or confluent white, grayish or yellowish nodules, varying in size from a pinhead to a pea. More rarely the pleura is the site of larger, multiple and isolated masses of growth. At times there are no nodules; the pleural surface is merely uneven and apparently diffusely involved. The tissue is hard and tough on section. Ulceration is not found. Adhesions are common. A variable amount of bloody, less commonly serous, rarely purulent fluid is usually present.

On microscopic examination the thickened pleura is found to be made up of aggregations of cells, of an epithelial character, and connective tissue, each in varying proportions in different parts of the sections. In places corresponding to the nodules seen on gross inspection, the tumor cells are closely packed together, forming small groups, separated by a thin stroma. In the intervening tissue and in places where the growth is more diffuse the stroma may predominate with scattered round, oval, or elongated groups of epithelial-like cells in alveolar arrangement, in few or many of which a lumen may be seen and a resemblance to tubule formation. Small areas of necrosis are occasionally present. The connective tissue is usually poor in cells, but in places is infiltrated with varying numbers of small round cells. The epithelium of the free surface of the pleura is usually absent over the whole or greater part of the sections, and in most of the cases has not apparently taken part in the new growth. The bloodvessels, which may be increased in size and number, have likewise been uninvaded in most of the cases. The lymph vessels and spaces appear to be the principal site of the new growth, and to many observers their endothelium its points of origin. An apparent transition from the flat cells lining the lymph channels to the larger polymorphous epithelial-like tumor cells, with vesiculated nuclei and variable amount of granular protoplasm, has frequently been noted. In some of the reported cases and in places in sections I have studied, the groups of tumor cells partly or wholly fill lymph channels, the endothelium of which appears quite normal. Rarely, the surface epithelium of the pleura appears to have participated in the proliferation. In Benda's case[1] the pleural surface was beset with small nodules; on microscopic examination it presented a villous-like appearance, and he observed an apparent transition from surface epithelium to the tumor cells. It seems, however, quite impossible to judge whether the tumor cells arise from proliferation of cells already existing in the part or are invading the tissue through the lymph channels.

Metastases have been observed in the supraclavicular glands (Fränkel and Bonheim), the axillary glands (Neelsen), and the thoracic muscles (Neelsen, Perls, Pirckner, Glockner, and Schulz), spontaneously or along the needle track, after withdrawal of pleural fluid (Podack and

[1] Deut. med. Woch., 1897, No. 21, p. 324.

Scagliosi). The disease has usually invaded other organs when death occurs. The most frequent site of secondary deposits is in the lungs. The bronchial, tracheal, mediastinal, retroperitoneal, and mesenteric glands, the viscera, other serous membranes, etc., may be the site of metastases. In six of the reported cases (Wagner, Böhme, Teixeira de Mattos, Benda, Scagliosi, and Bonheim) no metastases were found. In the presence of carcinoma elsewhere than in the pleura and especially with the disease in the lungs, it is never certain that the pleural disease is primary.

Symptoms.—The disease usually begins like an ordinary pleuritis, and in its course closely resembles pleural tuberculosis. Pain is usually a prominent symptom and is often increased by a long breath and cough. Dyspnea and cough are not usually striking features at first, but may be present without invasion of the lung. In the presence of pleural fluid, dyspnea may be extreme and orthopnea may be present. If the lung is involved the sputum may contain blood. Fever is usually absent. Loss of flesh and strength is usually progressive.

An accumulation of pleural fluid is almost constant and the physical signs are such as are commonly found with pleural fluid from other causes, although certain additional features may permit a probable diagnosis. The progressive loss of flesh and strength will naturully suggest a severe disturbance. The absence of signs pointing to disease in the apices of the lungs, the failure to find tubercle bacilli in the sputum, and the afebrile course may argue against tuberculosis; a negative tuberculin injection may positively exclude it. The presence of metastases in accessible regions may be an important sign. Inoculation metastases in the course of the needle track are especially important and suggestive and should always be sought in suspected cases. They are usually small, flat, hard, slightly movable, and painless. Invasion of the needle track with tuberculous material from the pleura may likewise occasionally give rise to similar nodules and thus their excision and microscopic examination may be necessary to establish the diagnosis.

On examination of the thorax, diminished expansion of the affected side may be a striking feature. During the early part of the disease the side may be more prominent, to appear somewhat smaller later, with relatively narrow and less depressed interspaces. With effusion, the heart may be displaced, returning at first to its former position after the withdrawal of the fluid. As the new growth gradually invades a larger territory and as the pleura becomes thicker and less elastic, with the formation of adhesions, the heart often fails to return to a position which it might be expected to assume after the removal of such an amount of fluid. For similar reasons, the thoracic distress and sense of pressure are afforded progressively less relief from the evacuation of the fluid, which reaccumulates more rapidly. The operator may also be able to appreciate the much thickened and tough pleura by the resistance offered in the introduction of the trocar. The

physical signs may show little if any change after the removal of even large amounts of fluid.

Examination of the pleural fluid may afford important data for diagnosis. It is often serous at first, becoming blood-tinged or even strongly hemorrhagic after the first or the first few tappings. This is due to the inelastic character of the pleural walls, and probably, too, as examination of sections shows, to the not infrequent presence of bloodvessels near the free surface of the pleura, from which under the influence of increased negative pleural pressure following removal of the fluid, blood is readily extravasated. With the progress of the disease and the frequent repetition of tapping, the fluid may resemble pure venous blood or have a chocolate color. That its bloody character is associated with the use of the trocar is suggested by the more frequent bloody character of the fluid in cases in which fluid has been withdrawn and the occurrence of serous fluid in cases which have been allowed to run their course without such interference. The specific gravity, when taken, has usually been 1018 or under. Microscopic examination of the sediment may assist in a decision between malignant disease and tuberculosis. In carcinoma of the pleura there is usually a much larger proportion of endothelial cells, with a relatively small proportion of lymphocytes, the cytologic formula thus conforming to that in fluids due to stasis. There is no reason to believe that the large cells, with vesiculated nuclei and vacuolated protoplasm, not infrequently found in plaques, are other than desquamated cells from the free surface of the pleura. In my opinion there is no striking or constant difference between these large cells in cases of stasis and in malignant new growths of the pleura. The glycogen reaction is found in cells from pleural fluid of other than malignant origin. The presence of many cells showing typical or atypical mitoses has been thought diagnostic of malignant disease.

It may rarely happen that the microscopic examination of a small piece of tissue removed with the needle may establish the diagnosis.

Prognosis.—The disease usually terminates fatally within six months of the discovery of the pleural invasion. A period of eighteen to twenty months may elapse between the beginning of symptoms and the fatal termination.

Treatment.—This is largely symptomatic. Removal of the pleural fluid usually affords only temporary relief. At times it has been followed by marked improvement, especially in the early stages of the disease. As the disease progresses, distressing pressure symptoms usually necessitate more frequent withdrawal, and not infrequently with less and less relief. At times, with much thickening of the visceral pleura, removal of fluid may only aggravate the symptoms, from increased tension on a retracted and adherent lung. Morphin in sufficient doses is of value and may prolong the necessary intervals between the tappings. The repeated removal at short intervals of a very bloody fluid may hasten the fatal termination, but in considera-

tion of the relief of distressing symptoms its evacuation seems justifiable if other means fail. It is better to withdraw small amounts frequently than to empty the cavity at each tapping. Free drainage of the pleural cavity by resection of a rib has been followed by a change in the character of the pleural fluid from bloody to serous.

Sarcoma.—Primary sarcoma is even less common than primary carcinoma in the pleura. Although in some of the reported cases a distinction has not been made between the two groups, this is justified from the general character and histologic appearance. Twelve cases will be found referred to and summarized by Bloch.[1] Mehrdorf[2] has reviewed the literature. Bernard[3] found 24 reported cases. Only one case[4] has come under my observation. Of 14 cases which I have analyzed 9 occurred in males. The ages varied from seven to seventy-six. Of the remaining patients, 2 were from ten to twenty, 4 from twenty to thirty, 2 from thirty to forty, 1 from forty to fifty, 2 from fifty to sixty, and 1 from sixty to seventy. The two sides are about equally affected. In their clinical course they resemble primary carcinoma of the pleura. A collection of pleural fluid practically always accompanies the new growth, and this is usually bloody, rarely serous. Its hemorrhagic character may first appear only after tapping. The presence of spindle cells in the sediment may suggest spindle-celled sarcoma of the pleura, as in Warthin's case.

In gross character at autopsy, primary sarcoma of the pleura usually presents a different appearance from primary carcinoma. In rare instances, however, as in primary carcinoma, the pleura may be diffusely and homogeneously invaded. Rarely, there are innumerable small nodules, but the new growth is commonly single, hard, or soft, its surface smooth or lobulated, in color white, gray, or reddish, of variable and usually considerable size, even at times reaching that of a man's head. The pleura may cover the growth which appears to arise in the subserous tissue. In other cases no traces of pleura can be found, and the tumor itself forms the lining of the pleural sac, yet ulceration is uncommon. Invasion of neighboring organs by extension or metastases in the lungs, the neighboring glands, ribs, vertebræ, liver, spleen, or superficial parts of the body has occurred. In 3 cases no metastases were found. From their microscopic appearance the tumors have been classed as simple sarcoma, round, spindle-celled, fibrosarcoma, and myxosarcoma. Garrè[5] successfully removed a spindle and round-celled sarcoma weighing 1250 grams from the left pleura.

[1] Les Néoplasms malins primitifs de la plèvre, Paris, Vigot Frères, 1905.
[2] Virchow's Arch., 1908, Bd. cxciii.
[3] Ibid., 1913, ccxi, 156.
[4] An unpublished case of H. A. Christians.
[5] Verhandl. d. deut. Gesellsch. f. Chir., 1909, 2 Th., xxxviii, 121.

SECONDARY MALIGNANT TUMORS.

Malignant disease of the pleura is more commonly secondary than primary. The tissue may be invaded by metastases from a primary malignant tumor in any part of the body, but pleural invasion is more common in malignant disease of the lung, mediastinum, thoracic wall, or stomach. Metastatic new growths of the pleura do not usually produce a diffuse infiltration of the tissue. There are commonly several isolated nodules or masses and more rarely the pleura presents a generally nodular appearance. Pleural fluid may or may not be present, and this may be serous, but is more commonly bloody. In cases of pleural carcinoma secondary to the disease in the breast, the clinical picture, course, and termination may resemble primary carcinoma of the pleura.

Of 178 cases coming to autopsy at the Massachusetts General Hospital with carcinoma in various regions, 10 showed secondary deposits in the pleura. Of 10 cases with carcinoma of the breast, the pleura was invaded in 4. Of 58 cases in which the disease was primary in the stomach, only 3 showed pleural metastases. In this series, carcinoma of the pleura was also secondary to the disease in the thymus and ovary. Of 42 cases of sarcoma, primary in various regions, the pleura was secondarily invaded in 9.

CHAPTER XXXV.

ECHINOCOCCUS DISEASE OF THE PLEURA.

Etiology.—Following the ingestion of the egg of Tænia echinococcus, the embryo, liberated from its shell in the stomach, may migrate to the pleura. The course pursued in reaching the pleura is uncertain, but the more frequent infection of the right pleura suggests a migration by way of the portal blood stream or biliary channels to the liver, thence through the diaphragm to the pleura. Infection may also be direct or by way of the lymph channels or the systemic circulation.

Special Pathology.—It is convenient to divide cases into those in which the disease apparently arises within the pleural sac or the pleural tissues: (*A*) *Pleural Echinococcus:* The difficulty of distinguishing cysts of the pleura from those developing in its neighborhood and the frequency with which the latter lead to disturbances in the pleura, justifies a further division of cases into (*B*) *Parapleural echinococcus*, in which the primary infection has taken place in a neighboring organ, but in its growth the cyst encroaches upon and develops at the expense of the pleural space.

(1) **Pleural Echinococcus.**—(*a*) PRIMARY.—The exact site of the primary infection is uncertain, as cases come under observation with the cysts already developed to a considerable size. The number of cases in which the disease is primary in the pleura is small. In the combined statistics of Neisser and Madelung, among 1179 cases, echinococcus was primary in the pleura in only 18 (1.5 per cent.). This report is based on 43 cases.[1] The right pleura was involved in 25, the left in 10; in 8 the site was not given.

The cyst is usually situated at the lower, but may be confined to the upper part of the pleural cavity. The local reaction leads to the formation of a connective-tissue envelope, which is usually very thin,

[1] Neisser, Die Echinococcus Krankheit, Hirschwald, Berlin, 1877, 17 cases; Madelung, Beiträge zur Lehre von der Echinococcen-Krankheit, Stuttgart, 1885, 2 cases; Maydl, Ueber Echinokokkus der Pleura, Wien, 1891 (cases 8, 9, 11), 3 cases; Theophil Rosenthal, Diss., 1881 (quoted from Winzerling), 5 peripleural cases; Winzerling, Ein Beiträg zur Casuistik des primären Pleuraechinococcus, Inaug. Diss., Jena, 1892, 3 cases; Mosler and Peiper, Nothnagel's Spec. Path. u. Ther., Bd. vi, 1 case mentioned; Ascoli, Rendiconto della Società Lancisianà (quoted from Orlandi), 4 cases; Vannini, Bulletino delle scienze Mediche di Bologna, 1896, p. 240, 1 case; Pasca, Rendiconto Società Lancisianà degli Ospedali, Roma, 27 giugno, 1896, 1 case; Orlandi, Gazetta medica di Torino, 1898, p. 49, 1 case; von Bókay, "Festschrift" in honor of Abraham Jacobi, New York, 1900, 1 case; Cary and Lyon, Trans. Assoc. Amer. Phys., 1900, vol. xv, 1 case; Blechmann, Ueber primären Echinococcus der Pleura, Inaug. Diss., Kiel, 1901, 1 case; Hauser, Primärer Echinococcus multilocularis der Pleura und der Lunge mit entwicklung multipler Metastasen im Gehirn, Erlangen u. Leipzig, 1901, 1 case; Ransom and Willis, British Med. Jour., 1903, i, 302, 1 case.

but may be thick. Pleuritis is uncommon. Enlargement of the sac gradually compresses or displaces neighboring organs. Perforation may occur into the lungs with evacuation through the bronchi; or erosion of the ribs and intercostal spaces may lead to rupture through the chest wall. Both are rare. The cyst may become infected, and presents the appearance of an encysted empyema. The most common type is a single cyst or one sac containing daughter cysts (endogenous echinococcus). Rarely more than one cyst is found. A pleural cyst with multiple external budding (exogenous echinococcus) is described by Cary and Lyon, and an alveolar echinococcus (Echinococcus multilocularis), apparently primary in the pleura and with coincident or metastatic multilocular cysts in the lung, the diaphragm, psoas muscle, and brain is reported by Hauser. The localization of cysts in the peripleural tissue, between the costal pleura and the thoracic wall, is difficult to determine. Their separate consideration is hardly justifiable, as they probably represent cysts arising in the pleural or subpleural tissue, the development of which toward the lungs is prevented by dense adhesions.

(*b*) SECONDARY.—1. *By Metastasis.*—It is still an open question whether an echinococcus cyst, primary in the pleura, can give rise to metastases in other and remote parts of the body. It is likewise uncertain whether unruptured cysts in parts distant from the pleura can lead to secondary pleural invasion. The weight of opinion is rather that multiple and isolated cysts are due to infection with more than one Tænia echinococcus embryo at the same or at different times.

2. *By Extension.*—Auto-infection through rupture of the mother cyst, the evacuation of daughter cysts into neighboring tissues and their further development is established for abdominal echinococcus. A similar secondary infection of the pleura from the rupture of pulmonary or hepatic cysts may take place, but pleural infection with bacteria usually precedes or so quickly follows the rupture that unless operation is undertaken, death almost always occurs within a variable and usually short period.

(2) **Parapleural Echinococcus.**—(*a*) *Intact Cysts.*—In this class may be included cases in which the disease develops in neighboring organs, but encroaches upon and grows at the expense of the pleural space. The cases comprise for the most part those in which cysts are present in the peripheral parts of the lung, the upper part of the liver, or the region between the liver and the diaphragm; and more rarely echinococcus disease of the mediastinum, spleen, or kidney. The clinical picture may be quite indistinguishable from primary pleural echinococcus. Subdiaphragmatic and especially hepatic cysts are most common and the diaphragm may be elevated to the second rib and even to the clavicle. In both the subdiaphragmatic and pulmonary forms of the disease the heart may be displaced laterally, the liver dislocated downward. The condition of the pleura in the presence

of an echinococcus cyst in its neighborhood is variable and depends to some extent on the presence or absence of suppuration in the cyst. The visceral and parietal layers may be free, serous or purulent pleural fluid may be present, but partial or complete adherence of its layers is more common and more favorable, as rupture of the cyst may then fail to infect the pleura.

(*b*) *Perforated Cysts.*—According to Neisser's statistics, echinococcus disease of the liver breaks through into the respiratory apparatus in about 11 per cent. of the cases. Disturbances of the pleura from parapleural echinococcus are more common than from the primary disease. Depending on the previous condition of the pleura and the character of the cyst contents, rupture is followed by free or encysted, cystic, serous, or purulent fluid. Suppuration is practically a constant feature. The perforation of an adherent pleura with invasion of the lung or bronchi is most common. Of 30 cases in Davaine's series only 9 ruptured into the pleura, 21 into the lung or bronchi. In Neisser's 60 cases the pleura was invaded in 16, the lung in 12, and the bronchi in 32. Hepatopleural or hepatobronchial fistulæ may result, and bile may be found in the pleural cavity or even be expectorated. An echinococcus cyst of the lung may likewise lead to free or encysted and usually purulent pleural fluid, following rupture. If the pleuræ are adherent the pulmonary cyst may evacuate externally. Rupture into the bronchi is, however, more common.

Symptoms.—In rare instances there may be no symptoms. In cases in which the disease is primary in the pleura the symptoms are usually those of a slowly growing intrathoracic tumor. Cough may be absent or present, with scanty mucoid sputum from an accompanying bronchitis. Dyspnea is usually present and is progressive. There may be pain with respiration, but this is not a striking feature unless pleuritis is present. Fever is usually absent. Emaciation is not common in uncomplicated cases. The perforation of pleural cysts into the lung is rare. Septic pneumonia and even abscess and gangrene may follow. If there is free communication with the bronchi, clear cystic fluid may be expectorated. In this or in evacuated pus, hooklets or bits of cyst membrane may be discovered. Rupture may occur through the chest wall, following atrophy of the intercostal muscles and erosion of the ribs. Spontaneous rupture is likely to occur if the cyst has suppurated. The perforation of parapleural echinococcus into the pleura is less common than into the lung. Rupture may take place without symptoms; in other cases the patient may be conscious of the rupture, which is followed by pain of a severe character, and if suppuration is present, as is commonly the case, there is chill and fever. Rupture may be spontaneous, or may be induced by exertion or trauma. If sinuses connect with the liver, biliary coloring matter may be expectorated. Hepatic echinococcus cysts may perforate the pleura and be evacuated through the lung without characteristic elements in the sputum, in case the bile passages fail to connect with the cyst.

Urticaria may follow the rupture of pleural echinococcus into the pulmonary or other tissues or of parapleural cysts into the pleura. Severe symptoms of intoxication, even delirium, collapse, and death may likewise follow the rupture.

The duration of pleural echinococcus is difficult to determine. To judge from its growth in accessible regions it may take from six months to a year for it to reach the size of the fist. Symptoms may arise only after it has attained a large size.

On examination the signs are usually those of encysted pleural fluid. There is diminished expansion of the affected side, which is likely to be prominent, with obliteration of the normal intercostal depressions. The side may be dull or flat on percussion and in some cases it is possible to note an irregular or evenly curved arching of the upper border of dulness, the convexity of which is directed upward. The tactile fremitus and breathing are diminished or absent; the latter may have a bronchial quality. The voice sounds are diminished and ægophony may be present. The signs are likely to be atypical. Between the involved area and the lung there may be an abrupt transition on auscultation to normal vesicular breathing. In the presence of a large cyst fluctuation may possibly be made out, but the hydatid fremitus or quivering of jelly sensation has not been observed. The liver or spleen may be displaced downward, the heart to the right or left. The presence of echinococcus cysts elsewhere in the body may suggest a similar affection of the pleura.

Blood.—The presence of eosinophilia in the circulating blood may be confirmatory. Cabot collected 30 cases of hydatid of the liver, only 2 of which were negative. Of 20 cases in Welsh and Barling's series, all but 5 exceeded the average in health.

Diagnosis.—Infection with echinococcus is rare in North America and Great Britain, and cases which occur are for the most part in foreigners. A previous residence where the disease is prevalent, and contact with dogs used for herding sheep, may be suggestive. Positive data for diagnosis are furnished by the discovery of scolices, hooklets, or cyst membrane. If perforation has occurred into the lung, such material may be present in the expectoration. An urticarial rash following thoracentesis is very suggestive. The examination of the fluid obtained by pleural puncture may furnish suggestive chemical features. It is usually clear, transparent, and varies from 1009 to 1012 in specific gravity. Sodium chloride is present. Albumin is usually absent or present only in traces. Traces of inosit, succinic acid, and grape-sugar may be found, and although suggestive are not distinctive of the disease. In some cases the specific gravty is high and the amount of albumin considerable. If degeneration has taken place, cholesterin crystals may be found. If infection has occurred, it may mask the appearance of the fluid. Specific antibodies in the blood of patients with echinococcus disease may be demonstrated by the complement fixation test. The antigen may

be made from the cyst fluid or an alcoholic extract of the cyst membrane. Kreuter[1] has reviewed the literature.

A resort to thoracentesis for the diagnosis of pleural or pulmonary echinococcus is attended by considerable danger, for perforation of the enveloping connective-tissue sac and the cyst membrane may result in the evacuation of the cyst fluid into the pleura or the lung, if erosion of its substance has already occurred. As the perforated cyst membrane is subjected to changes of intrathoracic pressure with respiration or cough, the contained fluid may find its way between the connective-tissue envelope and cyst membrane to the bronchi. Urticaria, symptoms of severe intoxication, with gastro-intestinal disturbances, faintness, collapse, delirium, and even coma, and death may result. Pulmonary or pleural suppuration or suffocation from mechanical obstruction by fluid or cysts may occur. Maydl reports 11 cases of pleural or pulmonary echinococcus in which a fatal result followed thoracentesis. When we consider the infrequency of the disease, this is a warning which cannot be safely disregarded. If the diagnosis can be made without puncture it is better to resort to operation without previous exploration. If thoracentesis is done, a small trocar (not a needle) is less dangerous, and if the case proves to be echinococcus, operation should be at once undertaken.

The pleural, pulmonary, or subdiaphragmatic site may be difficult to determine and the different forms may coexist. In Patella's case[2] the diagnosis before operation was pleural, after operation hepatic, and at autopsy pulmonary echinococcus. Centrally placed pulmonary cysts may be without signs. The cyst is usually single and in the lower lobes, more commonly the right. With a cyst in the peripheral parts of the lung the signs are usually the same as in pleural echinococcus. Pain is less often present, dyspnea may be more paroxysmal, cough is likely to be more troublesome, and the sputum may be bloody. Rupture into the bronchi is more common in pulmonary than in pleural cysts. The differentiation is often impossible during life, and even at autopsy it may be uncertain whether the growth started in the lung or the pleura. Subdiaphragmatic cysts which may be confused with the pleural or pulmonary form usually involve the liver at its upper part or the space between liver and diaphragm. In either case the diaphragm is elevated, the lung compressed, the heart displaced to the right or left, and the liver depressed. The clinical picture may then resemble pleural echinococcus, but the depression of the liver and the lateral dislocation of the heart are less marked. Cough may be absent and dyspnea less troublesome. The greater vertical excursion of the lower pulmonary margin and the presence of the diaphragm phenomenon, with subdiaphragmatic cysts, may be important differential signs. The

[1] Beitr. z. klin. Chir., vol. lxxvi.

[2] Quoted from Maydl, loc. cit., p. 71.

distinction between an intrathoracic and intra-abdominal cyst is important for surgical interference.

Echinococcus cysts may be confused with benign or malignant new growths of the pleura and encysted or free pleural fluid. Benign tumors are so rare as to need no special consideration. Aside from the history of opportunities for infection in echinococcus and the presence of cysts elsewhere, the differentiation can hardly be made. Secondary pleural carcinoma or sarcoma can usually be excluded by the presence of a primary focus elsewhere. In primary malignant disease the course is more progressively downward, with loss of flesh and strength. Superficial metastases may be found. Pain is a more prominent symptom. Owing to the diffuse character of the process, the whole or a greater part of one side of the chest may be dull. The percussion note is more board-like, and if free fluid is present its upper border may show a characteristic curve. In the later stages of malignant disease the affected side is more often somewhat contracted. If inflammatory fluid is present there is often the history of an acute onset with pain and fever. There may be evidence of pulmonary or other disease to which the pleural fluid is secondary. The pain is likely to subside as the fluid accumulates. Such processes seldom last as long and the accumulated fluid does not as slowly and steadily increase. With free fluid the line of demarcation between it and the lung, determined by auscultation and percussion, is less abrupt than in echinococcus disease, the upper limit of flatness may have a characteristic curve, and changes in level may be made out on changing the position of the patient. If encysted fluid is purulent, its character may be suggested by symptoms of sepsis. The appearance, chemical character, and microscopic examination of fluid obtained by puncture afford valuable data for differential diagnosis. Urticaria following exploratory puncture should suggest echinococcus disease.

Prognosis.—This is practically hopeless for cases of echinococcus cysts of the pleura or the parapleural tissue rupturing into the pleura, and allowed to run their course without treatment. Of 31 unoperated cases in Neisser's "statistics," including 12 pleural, 7 pulmonary with pleural perforation, and 12 hepatic with pleural perforation, all died. The prognosis is much worse for pleural than pulmonary echinococcus in which perforation into the lung may be followed by recovery. The prospect in operated cases is much more encouraging. Of 13 operated cases of pleural echinococcus in Maydl's statistics, 4 (30 per cent.) died.

Treatment.—Evacuation of the cyst contents with the trocar, with or without the injection of solutions containing iodine or other substance, has been followed by cure, but is uncertain and too dangerous to recommend. The high mortality following puncture of the cyst has been mentioned. A radical operation only can be considered. Costatectomy is better than simple incision. If possible, the cyst

should be removed without rupture. If too large to be removed entire, the cyst membrane may be drawn into the wound of operation and aspirated. It may then be shelled out from its capsule. As it is often difficult to be certain that the cyst is not pulmonary or subdiaphragmatic, the pleura should be carefully approached. If suppuration of the sac has taken place, the abscess should be opened and drained as in other suppurative pleural affections. Subdiaphragmatic cysts projecting into the thorax are best approached through the pleura.

CHAPTER XXXVI.

PNEUMOTHORAX.

By this is understood the presence of atmospheric air or gas in the pleural cavity. There is frequently also a liquid exudate, hence the terms hydropneumothorax with serous, pyopneumothorax with purulent, and hemopneumothorax with bloody fluid.

Historical Note.—The splashing sound produced by succussion is mentioned in the works commonly ascribed to Hippocrates and is frequently spoken of as "Hippocratic succussion," but the condition in which it was noted was regarded as empyema, the distinction between empyema and pneumothorax not being clearly appreciated. A few cases were described, usually of the traumatic variety, and the mechanics of pneumothorax were fairly understood in the seventeenth and eighteenth centuries, but the thesis of Itard[1] in 1803 is commonly regarded as the starting-point of the modern conception of the disease. Itard named the condition Pneumothorax and recognized its relation with tuberculosis. In 1819 Laënnec published the most important contribution up to that time. He described the causes, symptoms, and physical signs, and his account of the auscultatory phenomena left practically nothing to be added by those who have since written on this subject. He was the first to give the succussion splash its true significance. Emerson[2] in 1903, published the most elaborate and complete treatise on the disease and here may be found an abstract of many important articles. Renewed interest has recently been aroused in artificial pneumothorax as a therapeutic measure in the treatment of pulmonary tuberculosis.

Pathologic Physiology.—An appreciation of the mechanical factors is essential to a clear understanding of pneumothorax.

The thorax is capable of rhythmic changes in volume during inspiration and expiration. Inspiratory enlargement is accomplished by the contraction of muscles applied to the bony framework and the descent of the diaphragm. Within the thoracic cavity the lungs, in communication with the atmosphere through the trachea, hang free and unattached, although everywhere in close apposition to its walls. Since the pleural sac is without communication with atmospheric air and since the lungs are easily distensible, with each inspiratory enlargement of the chest, air enters the trachea and inflates the lungs

[1] Dissertation sur le pneumothorax ou les congestions gazeuses qui se forment dans la poitrine, Thesis, Paris, 1803.

[2] Pneumothorax: an Historical, Clinical, and Experimental Study, Johns Hopkins Hosp. Rep., 1903, vol. xi.

much as one fills a hand-bellows with air by separating its handles. The lungs are not only easily distensible but are elastic and are stretched in both phases of respiration beyond the volume they would assume if the pleural cavity were open and in free communication with the external air. Expiration is passive and due to the elastic recoil of the lungs and the thoracic and abdominal walls. Owing to the constant elastic tension of the lungs there is in the potential pleural space a negative pressure which is greater during inspiration than in expiration.

Many attempts have been made to measure this normal intrapleural tension after death in man and on living animals, but the results of such observations cannot be regarded as indicating the condition in healthy man. The most trustworthy figures appear to be those of Aron,[1] who found as an average of 36 observations the maximum reading for quiet inspiration −5.09 and the minimum for expiration −2.54 mm. Hg. in a healthy individual willing to allow a manometer to be inserted into the chest. This normal tension thus demonstrated probably varies within wide limits in different individuals. In the fetus and the new-born the lungs fill the chest even after the pleural space is perforated and there is no pressure difference, which first shows itself with increasing growth, probably because the thorax grows more rapidly than the lungs.[2] Pleural adhesions or disease in the lung and mediastinum are also likely to influence the pleural pressure and may serve to explain the wide differences obtained in the measurement of intrapleural tension by different observers and in the clinical behavior of cases of pneumothorax.

The contention of West,[3] that between the pleural surfaces a cohesive force exists sufficient to overcome the pulmonary elasticity, has been the subject of much controversy. Those who uphold this view maintain that the so-called normal negative intrapleural tension has no real existence, but is latent and first manifest only when the pleural surfaces are separated in an effort to demonstrate it. To Brauer[4] the negative pressure determined by the manometer in the normal pleura is a symptom of pneumothorax. No conclusive evidence for or against this hypothesis has yet been offered.

Owing to the elastic tension of the lung and the consequent negative pressure in the potential pleural space, the admission of air to the pleural cavity is followed by collapse of the lung. The mechanical conditions differ somewhat, depending on whether the communication of the pleural space with the outside world is open, valvular, or closed.

Intrapleural Pressure in Pneumothorax.—Observations are not numerous. Among them Aron reported three cases illustrating each form. In a patient operated on for empyema with an open external

[1] Die Mechanik und Therapie des Pneumothorax, 1902.
[2] Hermann, Pflüger's Arch., 1879, xx, 365.
[3] British Med. Jour., August 20, 1887.
[4] See Mosheim, Beiträge z. Klinik der Tub., 1905, vol. iii.

fistula the pressure oscillated about the zero point, with an average of −2.62 mm. Hg. during inspiration and +1.01 during expiration. In a case of valvular pneumothorax, the average pressure at the height of inspiration was +7.93 mm. Hg., during expiration +10.48. In a patient with closed pneumothorax the pressure in inspiration was +0.4, in expiration +5.0. A positive pressure at the height of inspiration as in this case suggests the diagnosis of closed pneumothorax. Among West's[1] 20 cases of pneumothorax the highest pressure was 9 inches of water (17 mm. Hg.).

Incidence.—The cases occur more commonly in early adult life, between twenty and thirty, corresponding to the period when pulmonary tuberculosis is most frequent. The condition is occasionally observed in children, but is rare under three years of age. It may occur as the result of trauma in efforts to resuscitate the newborn. Males are more frequently affected, probably because subjected to greater physical exertion. Among Drasche's[2] 198 cases, 158 were males. In James'[3] series of 125 cases, 103 were males. Statistics vary as to the frequency with which the two sides are affected. It seems to be somewhat more common on the left.

Etiology.—There are three groups: (1) The air may come from a perforation of the pulmonary pleura and the lung, bronchi, trachea, esophagus, stomach or intestines, forming an internal fistula. (2) Air may gain entrance to the pleura through a perforating wound of the outer chest wall, forming an external fistula. In both groups atmospheric air is admitted to the pleura. (3) Gas may be generated by decomposition of a pleural exudate and without demonstrable external or internal fistula.

The commonest cause is disease of the lung, and in the majority of the cases there is tuberculosis. Among Biach's[4] 918 cases from three Vienna hospitals 715 (77 per cent.) were due to pulmonary tuberculosis. Of Weil's[5] 55 cases, 46 (84 per cent.) were tuberculous. In Drasche's[6] 230 cases, 198 (86 per cent.) were ascribed to this cause; of Mosheim's[7] 50 cases, 42 (86 per cent.). Thus from 80 to 90 per cent. may be regarded as tuberculous.

The incidence of pneumothorax among patients with pulmonary tuberculosis was 36 (10.1 per cent.) among 355 cases which came to autopsy in Weil's series. West[8] estimates it as 5 per cent. of the fatal cases. In large series of clinical cases the proportion is lower, as among Drasche's[9] 10,212 cases of pulmonary tuberculosis in which there were 198 (1.93 per cent.) with pneumothorax.

[1] Intrapleural Tension, Allbutt's System of Medicine, 1899.
[2] Wien. klin. Woch., 1899, Nos. 45 and 46.
[3] Osler's Mod. Med., 1st ed., vol. iii, p. 870.
[4] Zur Aetiologie des Pneumothorax, Wien. med. Woch., 1880, vol. xxx.
[5] Deut. Arch. f. klin. Med., May 30 and July 13, 1882.
[6] Wien. klin. Woch., 1899, No. 45.
[7] Beiträge z. Klinik der Tub., 1905, vol. iii.
[8] A Contribution to the Pathology of Pneumothorax, Lancet, May 3, 1884.
[9] Wien. klin. Woch., December 21, 1899, No. 51.

Pneumothorax occurs more often in active than in latent, inactive or arrested tuberculosis. Most cases are due to the rupture of small subpleural tubercles which break down before communication with the pleural cavity is prevented by the formation of adhesions. Its infrequency in connection with large cavities and the more chronic types of the disease is due to the more extensive and firmer pleural adhesions in these forms. The apex of the lung, though the most common site of cavity formation, is seldom the seat of the rupture owing to the frequency with which pleural adhesions obliterate the pleural sac in this region. Rupture of the pleura may occur during a violent effort, as coughing, lifting or sneezing, but in many cases there is no apparent immediate cause and the patient may be at rest in bed. In 23 cases with sudden onset at the Massachusetts General Hospital the pneumothorax occurred while the patient was sitting still or in bed in 14.

Of other diseases of the lung in which pneumothorax may occur, abscess or gangrene and bronchiectasis as a group stand next in frequency, but the cases are rare. Pulmonary infarction may be the underlying cause. Bach[1] reports 3 cases and collected 31 from the literature in which emphysema was a certain or probable cause. There were 15 autopsies, and pulmonary tuberculosis was present in 5. Tumors of the lung and echinococcus disease are rare causes. Abscess and hydatid disease of the liver, ulcer or cancer of the stomach, cancer of the esophagus, and perforation of the esophagus by a fish bone have been recorded as causes of pneumothorax. Spontaneous erosion and perforation of the lung or the chest wall by an empyema in rare instances cause pneumothorax.

Pneumothorax may be caused by a *penetrating wound* of the chest wall or of the lung, such as stab or gun-shot wounds, but it is surprising how seldom this complication occurs. Among 21 cases of penetrating wounds of the chest in Bach's series there were no instances of pneumothorax. Otis[2] states that pneumothorax was a troublesome complication in less than a half dozen cases among the vast number of chest wounds during the war. In fractures of the ribs a fragment of bone may injure the lung and produce pneumothorax. In James' series of 127 cases 11 were due to this cause. Occasionally a marked concussion of the body may rupture the lung and thus cause pneumothorax without external wound or fracture of a rib. Hemothorax is a frequent complication in traumatic pneumothorax. Empyema operated in the ordinary way is converted into open traumatic pneumothorax.

The operation of *thoracentesis* may be responsible. A considerable number of cases have been reported. Sears[3] in 1906 was able to find

[1] Ueber das Vorkommen des spontanen Pneumothorax bei Emphysem, Beiträge z. Klinik d. Tub., 1910–11, xviii, 21.

[2] The Medical and Surgical History of the War of the Rebellion, Part I, Vol. I.

[3] Amer. Jour. Med. Sci., 1906, cxxxii, 850.

references to 50 cases. Injury to the lung by the point of the instrument is rarely a cause. Faulty technic and the entrance of air through the cannula or needle is common, radiographic examination not infrequently indicating the presence of pneumothorax after the partial aspiration of pleural fluid. The amount admitted in this way is ordinarily small and no unfavorable symptoms usually ensue. The use of an air-tight trocar diminishes this danger. Misapplication of the tubing to the aspirating pump of Potain's apparatus so that air under positive pressure is blown into the chest has caused immediate death. The rupture of pleural adhesions, an emphysematous vesicle or superficial pulmonary cavity by an excess of negative pressure during the aspiration of pleural fluid is probably the most common cause of the more serious types of pneumothorax in this group. It has been assumed that the reduction of pleural pressure by aspiration may liberate gas from the pleural bloodvessels and give rise to a so-called "pneumothorax ex vacuo." Although the possibility of this must be admitted in a cavity with rigid walls, yet the amount of gas must be small and of no practical importance.

There is a small group of cases in which pneumothorax occurs in apparently healthy individuals after some unusual exertion, at times after laughing, crying, coughing, sneezing or yawning, and in rare instances while at rest and even asleep. There may be nothing in the history or physical examination to suggest tuberculosis and the pneumothorax is rarely complicated by an effusion. This is the so-called spontaneous or idiopathic pneumothorax. Fussell and Riesman[1] reported 2 and collected 56 cases from the literature. Young adults are most frequently affected. Death rarely follows and the pathology is not definitely known. Latent tuberculosis, the rupture of an emphysematous vesicle or the tearing of pleural adhesions are to be considered in explanation. The frequency of tuberculosis as a cause of other types of pneumothorax makes it necessary to exclude it more rigorously than has hitherto been done before any other explanation can be accepted. In cases in which other evidence of tuberculosis is lacking, negative tests should be obtained with sufficiently large doses of tuberculin before the non-tuberculous character of the disturbance can be regarded as established.

Finally there are a few cases in which pneumothorax appears to be due to the development in pleural fluid of a gas-producing organism. In Levy's[2] case, Fränkel's anërobic gas-producing organism was found; in May and Gebbard's[3] case an unidentified gas-producing organism; in Hamilton's[4] the Bacillus aërogenes capsulatus; and in Findley's[5] the colon bacillus.

[1] Amer. Jour. Med. Sci., August, 1902.
[2] Arch. f. exper. Path. u. Pharm., 1895, xxxv, 335.
[3] Deut. Arch. f. klin. Med., 1898, vol. lxi.
[4] Montreal Med. Jour., December, 1898.
[5] Ibid., 1899, xxviii, 759.

Pathology.—If there are no pleural adhesions and the opening into the pleura is large, the lung collapses and retracts to a varying degree toward the root and may be found at autopsy as a more or less shrunken mass lying against the spinal column. In long standing cases it may be tough, fibrinous, and practically airless with little resemblance to the normal lung. Areas of tuberculosis with cavity formation are usually present. Pleural adhesions may bind the lung at one or more places to the chest wall over a greater or less extent. In some instances air is confined to a portion only of the pleural space, giving rise to partial pneumothorax. Confinement to an interlobar space without contact with the periphery of the lung was observed at autopsy in the case reported by Monnier.[1] Such instances are extremely rare.

The perforation can usually be demonstrated without trouble and commonly leads into a large or small tuberculous cavity at the periphery of the lung. The hole may be several centimeters in diameter or so small as to be visible and first discovered only after the inflated lung is submerged in water. The perforation is usually single, but in rare instances two or more are found. In Roe's[2] case a left-sided pneumothorax was due to perforation of the right lung through an adherent mediastinum. In some instances, an inflammatory exudate occludes the perforation, converting an open into a closed pneumothorax.

Experiments on animals and observations on man have shown that air alone does not act as an irritant to the pleura, but since pneumothorax usually arises under conditions in which bacteria readily gain entrance to the pleura, it is only in exceptional instances, such as spontaneous pneumothorax or in rapidly fatal forms, that pleurisy fails to complicate the process. A fluid exudate usually forms and according to West[3] is serous, seropurulent or purulent, each in about one-third of the cases. Purulent exudates are common in children and following rupture from the alimentary canal. Hemothorax is not infrequent in traumatic cases.

Displacement of the thoracic and abdominal organs takes place and usually to a degree proportional to the amount of air and fluid in the pleura. The mediastinum and the heart are moved to the opposite side unless held by adhesions. According to James' observations and contrary to the general impression, the heart is not rotated or swung from its point of attachment at the root of the great vessels, but carried bodily across to the opposite side, its long axis maintaining about its normal relation to the long axis of the body. Encroachment on the sound lung follows the displacement of the mediastinum. Dislocation of the heart is greater with left than with right-sided processes. The diaphragm is depressed on the affected side at times to such a degree that it projects downward and presents a convex surface toward the abdomen into which the movable viscera are also crowded. The

[1] Gaz. méd. de Nantes, November 2, 1907.
[2] Med. Times and Gaz., April 7, 1866.
[3] Lancet, 1887, i, 1264.

position assumed by the heart and abdominal organs is well shown in the accompanying plates from photographs taken at autopsy. (See Plates II and III.)

Symptoms.—Sudden onset is relatively uncommon. In 68 of Saussier's[1] 196 cases it was with violent pain and dyspnea. Of 64 certainly or probably tuberculous cases at the Massachusetts General Hospital the onset was sudden in 23. Much depends on the local conditions. The initial symptoms are most severe when there are no pleural adhesions and the lung and mediastinum are free from disease, permitting complete collapse of the lung and dislocation of the mediastinum toward the sound side. The most alarming onset is therefore likely to be observed in early tuberculous cases, in traumatic or in spontaneous pneumothorax. Noteworthy symptoms are usually lacking when it occurs as a complication of empyema rupturing through the lung or following thoracentesis for the removal of pleural effusion.

Symptoms when present are most commonly pain in the affected side and sudden and severe or rapidly progressive dyspnea. In uncomplicated cases there is slight and unproductive cough. If there is considerable purulent material in an infected lung more abundant sputum may follow its expression from pulmonary cavities or the bronchi. The rupture may be felt as in Stokes'[2] case or it may be even audible to the patient as reported by Banks.[3] The symptom complex may simulate angina pectoris. In Beardsley's[4] case with extensive left pneumothorax there was sharp, severe pain with muscular spasm in the left side of the abdomen suggesting peritonitis, but none was found at autopsy.

A typical severe attack like the following is occasionally observed. Thus, in a person previously in apparent good health there may be sudden, sharp pain in the chest, an immediate intense feeling of suffocation and fear of impending death, air hunger, and great restlessness; the face at first pale and later cyanotic; the hands and feet cold and blue; the skin bathed in cold sweat. The alæ nasæ dilate, the respirations are rapid, and the accessory muscles of respiration are brought into play. The patient is usually found in the sitting position and if able to speak may plead in a weak and scarcely audible voice to be taken to the open window. The pulse is rapid, small, feeble, or imperceptible. In 5 of 83 cases (Massachusetts General Hospital) the attack was followed by unconsciousness, which terminated in death in one instance.

In milder cases there may be only slight pain and an increase of dyspnea, the patient meanwhile not being incapacitated. In four cases (Massachusetts General Hospital) the succussion splash was the first intimation to the patient and the principal symptom of which

[1] Thésis, Paris, 1841.
[2] Diseases of the Chest, 1837.
[3] Dublin Quart. Jour. Med. Sci., 1854, vol. xvii.
[4] New York Med. Jour., 1911, xciii, 529.

he complained. In the majority of cases the occurrence of pneumothorax leaves no striking impression on the clinical aspect or is indicated only by an aggravation of existing symptoms. This is due to its usual occurrence late in the course of pulmonary tuberculosis when the lung is already considerably involved and the pleural sac partially obliterated by adhesions. In many cases the condition is unsuspected and discovered only in the course of the routine physical examination.

Signs.—These are commonly striking and distinctive. Small amounts of air may readily escape detection, however, and be first noted in the *x*-ray examinations.

Inspection.—Immediately following the entrance of a large amount of air into the pleura the patient usually finds the sitting or half-sitting position most comfortable. In rare instances, as in Garde's[1] remarkable case the knee-elbow position is assumed, probably to prevent the disturbances incident to backward displacement of the heart. In this instance it was maintained for about fifty-six days (!). The decubitus in the more severe cases is likely to be on the affected side. Immobility, distention, flattening or fulness of the intercostal spaces, and absence of the diaphragm shadow may be noted. Weil reported edema of the hand on the affected side, Zahn,[2] of the chest wall. Subcutaneous emphysema, at times of an extreme grade, is occasionally seen in traumatic cases or following thoracentesis. Dislocation of the heart away from the affected side is an important early sign and may be indicated by a visible cardiac impulse to the right or left of its normal position, the displacement being most marked in left-sided cases.

Palpation.—Vocal fremitus is much diminished or abolished over the involved region. In 70 of James' series in which this was noted above the level of fluid, it was diminished in 52 and absent in 18 cases. Vocal fremitus is usually absent over fluid. With a large amount of air the intercostal spaces may be felt to be wider than on the unaffected side. Palpation may also establish the position of the displaced cardiac impulse and that of the depressed liver or spleen. Depression and inversion of the diaphragm can hardly be determined by palpation alone.

Mensuration.—This may show enlargement of the affected side; but the side may look larger and this fail of confirmation with the tape or the affected side may measure less than the other.

Percussion.—The percussion note is largely dependent on the size, shape, and tension of the air-holding cavity, the position of the retracted lung, the presence of adhesions, character of the pneumothorax, whether open or closed, and the presence or absence of fluid. The condition of the pleura appears to have no striking or constant influence on the percussion sound and it is sometimes difficult or impossible to explain variation in different cases or in different parts of

[1] Arch. gén. de Méd., 1828, xvii, 345.

[2] Virchow's Arch., 1891, p. 123.

the chest. The percussion note is usually strikingly loud, of low pitch, and may be described as hyperresonant and such as is obtained over an emphysematous lung. If the pneumothorax is large and the pleura free from adhesions hyperresonance may be determined to extend beyond the limits of the normal lung, exceeding the middle line toward the unaffected side over the mediastinum and invading or abolishing the hepatic or splenic dulness. The cardiac dulness also disappears or changes its position. In open pneumothorax there may be a tympanitic note. In some cases the resonance is defective or dull. The percussion note may have an amphoric quality.

With total pneumothorax, the retracted lung lies along the spine and is not demonstrable by percussion but if adhesions bind it over a larger or smaller extent to the chest wall the percussion note is impaired over the adherent area. Defective resonance from this cause is frequently demonstrable at the apex, may be found along the spine posteriorly, and at times in other parts of the chest. The occasional presence of areas of tympanitic resonance below the level of fluid may be due to pleuritic adhesions.

Other modifications are at times observed. A cracked-pot sound may be obtained, due either to proximity of a pulmonary cavity to the chest wall or communication of a large open fistula with the pleural cavity. Inconstant changes in the percussion note with the mouth open or closed, on assuming the erect or recumbent posture, during inspiration or expiration, and before or after aspiration may also be noted.

A small amount of pleural fluid complicating pneumothorax and concealed in the hollow of the diaphragm may not be demonstrable by percussion although readily detected by succussion. Dulness or flatness is generally present over large effusions but the amount is frequently underestimated, and Skoda's suggestion, *i. e.*, to estimate the amount of fluid in pneumothorax double that indicated by percussion, if followed, will prevent some mistakes. The upper level of fluid is not always easy of determination and is likely to be placed too low, so that an instrument introduced for the removal of air may be found to be below the level of fluid. Marked mobility of the dulness over fluid and the constant maintenance of a horizontal upper border, in whatever position the patient is placed, are important and characteristic features of pneumohydrothorax, in striking contrast to the relative immobility and curved upper limit of dulness in pleural effusions without air. In two of Emerson's cases with a large amount of fluid a small amount of air could constantly be demonstrated in the uppermost point of the chest with the patient in different positions.

Auscultation.—Suppressed or absent breathing combined with hyperresonance on percussion is usually the first indication in the course of the examination that pneumothorax exists, and this diminution in the respiratory murmur is the more striking in contrast to the exaggerated breath sounds over the uninvolved lung. Diminished bronchial

breathing may also be heard. The voice sounds and the whisper are diminished or absent. Among 90 of James' cases in which the character of the respiratory murmur was noted it was found to be diminished in 41, amphoric in 31, absent in 12, and bronchial in 6 cases.

Amphoric Phenomena.—The breathing not infrequently presents a peculiar metallic quality resembling the sound produced by blowing over the mouth of an empty decanter and hence spoken of as amphoric. This was first described by Laënnec as "bourdonnement amphorique," and ascribed to the motion of the air in and out of the pleural cavity through an open fistula. In support of this explanation it may be said that an open fistula exists in most of the cases in which amphoric breathing is heard and the point of maximum intensity of the amphoric breathing over the chest is occasionally observed to coincide with the position of the fistula found at autopsy. The factors leading to the production of this sound have been the subject of much controversy and cannot yet be regarded as settled. The report of cases by Maréchal,[1] West[2] and Emerson[3] in which amphoric respiration was present yet the fistula was certainly or probably closed, Powell's[4] observation of amphoric respiration over a distended stomach and Hoover's[5] finding of amphoric respiration over a loop of distended intestine in the left hypochrondrium suggest that a communication with the pleural cavity is unnecessary. The most probable explanation seems to be that the sound is due to the resonating properties of the pneumothorax cavity and is produced by the vibration of air within the cavity itself or by vibrations propagated from neighboring parts of the lung or bronchial tree. The presence of fluid is unnecessary for its production. It is variable in its location, intensity and pitch. Not only the respiratory murmur, but also in occasional instances the percussion note, cough, vocal resonance, whisper, the heart sounds, rales, pleural friction and deglutition sounds may have a metallic and amphoric quality.

Metallic Tinkle.—This is impressive and characteristic, and described by Laënnec as resembling the sound produced by gently striking with a pin or dropping sand into a glass, metal, or porcelain vessel; or like the vibration of a metallic cord touched by the finger. Several explanations of this curious phenomenon have been offered. Agitation of the fluid against the walls of the pleural cavity, the bursting at the surface of fluid of bubbles of air which enter through a submerged fistula, the falling of drops from the walls of the cavity above to the surface of the fluid below or the modification by a suitable resonance chamber, such as the pneumothorax cavity, of rales produced in its vicinity have been suggested. The finding of metallic tinkling in cases in which from the absence of the succussion splash there was

[1] Jour. hebdom. de méd., Paris, 1829, vol. ii.
[2] Trans. Clin. Soc., London, 1884, vol. xvii.
[3] Johns Hopkins Hosp. Rep., 1903, vol. ii.
[4] Lancet, March 4, 1882.
[5] Cleveland Jour. of Med., February, 1898.

reason to believe that fluid was absent, as in those reported by Finney[1] and Maillart and Laserre[2] lends support to the last mentioned view, but as small amounts of fluid may fail to give this sign this explanation cannot be accepted without more conclusive evidence of the absence of fluid. The failure of Forbes[3] to find on dissection any communication between the bronchi and the pleural fluid in a case in which metallic tinkle was most distinct suggests that the open fistula is unnecessary. The sound may be heard during respiration, speaking or coughing or after change of position. In some instances a cough may be needed to produce it and in doubtful cases this should be tried. At times metallic tinkling is audible to the patient and in Allbutt's[4] remarkable case it could be heard for two hours in all parts of a large room. In James' series it was present in 30, absent in 5 of 35 cases. Amphoric breathing may or may not be present with it. The sign is not distinctive of pneumothorax but may be heard also over large pulmonary cavities. Hérard[5] heard metallic tinkling over a dilated kidney containing pus and gas. The ureter was patent.

Unverricht[6] described a peculiar phenomenon heard after withdrawal of part of the air in pyopneumothorax. With each inspiration there were sounds like those heard on smoking a Turkish water pipe ("Wasserpfeifengerausch") and ascribed to the bursting at the surface of the fluid of bubbles entering through an open pulmonary fistula. Riegel (quoted from Unverricht) heard a similar sound, unassociated with aspiration and only when the patient assumed such a position that the fistula opened under the fluid.

Succussion Sound.—In the works formerly ascribed to Hippocrates it is recommended "Seat him on a seat which will not stir. Let some one hold him by the arms while you shake him by the shoulders and listen to hear on which side the sound is produced." The sound resembles that produced by shaking a flask half full of water, and like other sounds heard in the chest in the presence of pneumothorax may have a metallic or amphoric quality. It is the earliest and most important indication of the presence of fluid and gas in the pleural cavity and may be obtained long before fluid can be demonstrated by other means. Small amounts of fluid may fail to give the splash. Its intensity is variable. It may be heard only by the most attentive auscultation, readily audible to the examiner and even to the patient or in some instances appreciated in all parts of a large amphitheatre, as in James' case of left pyopneumothorax (Plate III). At times it may be heard only with the patient erect, or again only in the recumbent position. In 54 of James' cases in which it was mentioned it was present in 41, absent in 13 cases. Similar splashing sounds may be

[1] Dublin Jour. of Med. Sci., April, 1898.
[2] Rev. méd. de la Suisse Rom., November 20, 1902.
[3] Translation of Laënnec's De l'Auscultation Med., 1834.
[4] See Finlay, Pneumothorax, Allbutt's System of Med., 1899, vi, 378.
[5] Bull. de la Soc. Anat., 1850, xxv, 98.
[6] Deut. Klinik, 1903–07, p. 208.

obtained from the stomach, the intestine or the peritoneum if fluid and air are present, but the site of maximum intensity and other clinical evidence will usually serve to exclude errors from these sources. In some instances it may be necessary to be sure that the stomach is empty when the test is made. The churning "mill-wheel" murmur of pneumohydropericardium can hardly be a cause of confusion. Some difficulty is occasionally experienced in differentiating pneumohydrothorax from a pulmonary cavity containing air and fluid.

Coin Sound.—This is known also as the bell sound and Bruit d'Arain. It was first described in an anonymous article,[1] which attributes its discovery to Trousseau. The test is usually made by having an assistant place on the front or back of the chest a coin against which another coin is struck, while the examiner listens with the ear or the stethoscope at a point on the chest wall directly opposite. If present, a clear, musical, bell-like tone is produced, resembling in its quality the amphoric phenomena previously described and quite different from the sound obtained for comparison over the unaffected side. Among 25 of Emerson's cases in which it was mentioned it was present in 20, absent in 3, suggestive in 2. In 37 of James' series, it was present in 25, absent in 12. This sound, like amphoric breathing, is probably due to the peculiar resonating qualities of the pneumothorax cavity. It is not absolutely distinctive of pneumothorax. Osler[2] reported its presence over a large cavity in the right upper lobe.

Gas Analysis.—In his experiments on dogs, Emerson found that if air be introduced into the chest there is an almost immediate accumulation of CO_2 and diminution of O in the pleura, but the N remains remarkably constant until a point is reached at which one may suppose that absorption is well under way, when the N rises about 8 per cent. and then remains quite constant. The composition depends on the gases of the blood and on the local respiration of the tissues. Ewald[3] determined in man that the percentage of CO_2 is greater in the presence of an inflamed pleura and greatest when there is pus. Analysis of the gas is of little assistance in judging the condition of the fistula, but an increasing amount of oxygen in portions of gas successively removed suggests an open fistula as in Leconte and Demarquay's[4] case.

Air or gas which has gained entrance to the pleural cavity is absorbed, the rate of absorption varying with the condition of the pleura and the composition of the gas. Absorption is most rapid when the pleura is normal. According to Szupak's[5] investigations on dogs atmospheric air, O and CO_2 are absorbed at about the same rate, while N is taken up only about one-half as rapidly. In his review of clinical

[1] Pneumothorax, Nouveau signe pathognomique de cette affection, Gaz. des Hôp., April 4, 1857.

[2] Montreal Med. Jour., 1895, xxiv, 969.

[3] Arch. f. Anat. u. Physiol., 1876, p. 422.

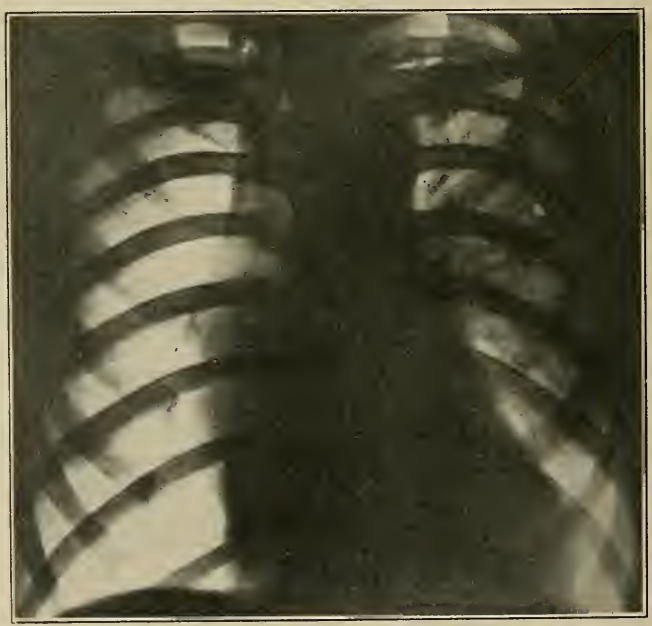
[4] Gaz. méd. de Paris, 1863, third section 1, xviii, 114.

[5] Experimentelle Untersuchungen über den Pneumothorax, Dorpat, 1891.

Fig. 91

Pneumothorax of right side following stiletto wound. Retracted lung appears as dense shadow at lung root. (Dr. W. J. Dodd.)

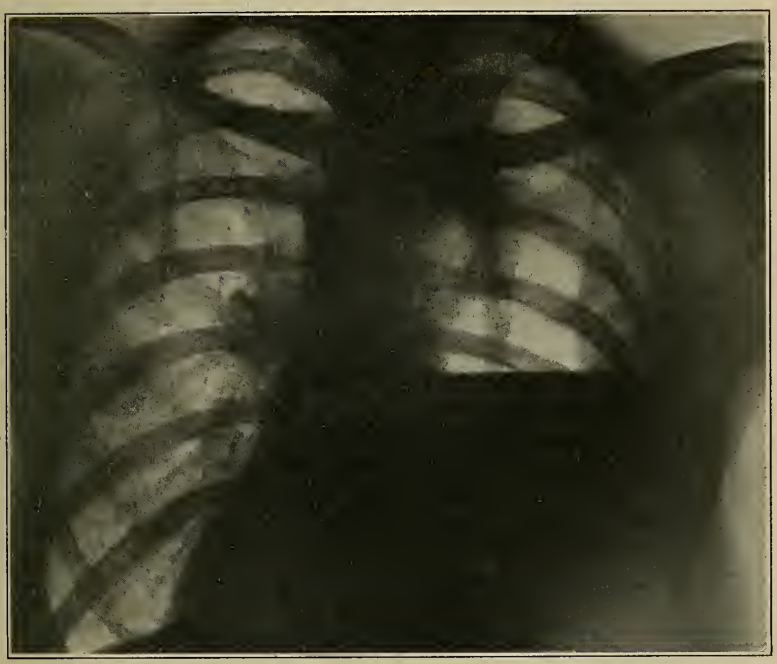
Fig. 92



Pneumothorax of the right side. Displacement of the heart to the left. Note the definition of the ribs, the clearness of the intercostal spaces and the absence of the normal lung markings on the right in comparison with the left side. The collapsed lung is seen as a dense, sharply outlined shadow in the mid-chest. Pleural adhesions probably account for the failure of the apical portion of the right lung to completely collapse. In the first right interspace is seen a small, dense, round shadow which probably represents a calcified area of tuberculosis. (Private case of Dr. L. H. Newburgh's.)

cases he finds that the time required for absorption in cases without friction rub or fluid exudate was from twenty-six days to two months. In one case the air was absorbed in six days and in another after three years. The possibility of slow leakage of air through the fistula or of inhibition from inflammation of the pleura must be considered and are probably largely responsible for wide differences in the apparent rate of absorption.

FIG. 93



Pneumopyothorax of the right side. The fluid is indicated by the opaque shadow with horizontal upper border. Displacement of the heart to the left. The presence of air above the fluid is indicated by the clearness of the intercostal spaces and the absence of the normal lung markings. The collapsed lung is seen as a less dense, sharply outlined shadow with vertical margin above the fluid. (No. 188,816.)

X-ray Examination.—This not only serves to confirm the results of physical examination but may show small collections of air not otherwise to be detected. Both the fluoroscope and the radiograph should be used. Examination in the erect posture is usually most satisfactory. The position of the displaced heart, fracture of the ribs. and depression of the diaphragm may be noted. An accumulation of air is seen as an abnormally clear zone, over which the normal lung markings are absent and the ribs more sharply defined than at other parts of the chest. For the detection of small bubbles of air above pleural effusions Kraus recommends examination with

the body inclined at an angle of about 45 degrees and finds that air can thus be detected when nothing is seen in the erect position. The collapsed lung is seen as a relatively dense, sharply limited, irregularly oval shadow in the mid-chest, in the region of the root of the lung. An incompletely retracted normal lung is less dense. Infiltration of the tissue may be responsible for failure to retract and may add to the density of the shadow. Adhesions may account for irregularities in the contour of the lung and appear as linear or band-like connections between the lung and the chest wall. Inspection of the other lung may disclose suggestive evidence of tuberculosis.

The presence of pleural fluid adds much that is interesting, instructive, and distinctive to the picture. It appears as an opaque shadow at the bottom of the chest and what is most significant, with its upper border constantly horizontal, independent of the patient's position. With the patient upright the upper border is transverse. When he lies on his side it is parallel to the long axis of the body. The upper border is most sharply defined when the tube is in line with the level of the surface of fluid. Examination with the fluoroscope shows a wavy motion of the surface on shaking the patient, tapping the abdomen with the fingers, percussion of the chest, or during cough. Careful inspection when the patient is still discloses also a depression of the level of the fluid during expiration and elevation during inspiration, a paradoxical phenomenon probably due to lack of diaphragmatic tone on the affected side, in consequence of which respiratory changes in abdominal pressure are transmitted to the fluid. Inspiratory elevation and expiratory depression from contraction of a diaphragm which is inverted and convex below seems a less likely explanation. Still another motion is synchronous with cardiac systole, coincident with which very small waves start from the mediastinal region and travel across the surface to the chest wall.

Varieties.—Open Pneumothorax.—In this the mechanical relations are simple. An open fistula connects the pleura with the outside air and atmospheric pressure exists in the pleural space with respiratory oscillations about the zero point. If the fistula is wide open the collapsed lung takes little or no part in respiration and the intrapleural pressure remains nearly constant at zero. If the fistula is small the respiratory oscillations are greater and the pressure may become negative in inspiration and positive in expiration. In order to maintain its patency the fistula in the collapsed lung must usually be large, with rigid walls, and run in a direction perpendicular to the pulmonary surface; hence it is uncommon as a result of perforation of the lung, but occurs more often in advanced pulmonary tuberculosis, occasionally in empyema rupturing through the bronchi, and may follow thoracotomy.

Respiratory embarrassment is due to collapse of the lung and displacement downward of the diaphragm and of the mediastinum toward the sound side. Mediastinal displacement limits the excursion of

the sound lung and the efficiency of respiration. Instability of the mediastinum aggravates the symptoms. If free to move, it is drawn toward the sound side during inspiration and moves toward the affected lung during expiration, in consequence of which a part of the expired air may be forced into the collapsed lung. During inspiration air is drawn not only from without into the trachea but also from the collapsed lung. The oscillation from one lung to the other of a volume of used air, the so-called "pendulum-air" of Brauer, still further reduces the efficiency of respiration. During forced expiration with cough, inflation of the collapsed lung is increased.

Valvular Pneumothorax.—This is the commonest form and is due to valve-like action of the fistula, which permits entrance of air into the pleura, but prevents its escape. Rupture of a small pulmonary cavity may connect the bronchi and pleura by way of a long, narrow, sinuous passage. Inspiration inflates the partially collapsed lung and draws air into the pleural cavity, but with the collapse of the lung during inspiration the fistula is closed by apposition of its walls and the imprisoned air cannot escape. The deeper the inspiration the more air enters. Cough with closed glottis greatly increases intrapulmonary pressure, inflates the collapsed lung, opens the fistula, and further distends the pleura. Tuberculosis is the cause in a large proportion of such cases.

The high degree of pressure which may be produced makes this form especially dangerous and encroachment on thoracic space and dislocation of the mediastinum may become extreme, with displacement of the heart, kinking of the great vessels, narrowing of the principal bronchi and diminished volume, elasticity, and effectiveness of the sound lung. Mobility of the mediastinum increases the danger and thus the condition is more serious in young and healthy persons. The outcome depends on the behavior of the fistula. Total collapse of the lung favors healing of the fistula, but at times after partial absorption of air and reinflation of the lung the fistula again opens.

Pneumothorax Acutissimus.—This is also known as suffocative pneumothorax and the term is applied to cases in which death results within a few hours. A valvular fistula with the rapid development of a high positive pressure or grave complications in the lung or other organs may be responsible.

Closed Pneumothorax.—This is only a phase of the open or the valvular form and is favorable, since closure of the fistula is the necessary forerunner of recovery. The orifice of the fistula may be sealed by pleural inflammation or adhesion and union of the walls of the fistula. Collapse of the lung favors closure of the fistula and small perforating wounds or slight pulmonary lesions in a comparatively healthy lung may readily close in this way. This form is common in spontaneous pneumothorax, in relatively early tuberculous cases and after thoracentesis.

Double Pneumothorax.—This is uncommon. Death usually follows within a few hours. Life can be maintained only when the collapse of one or both lungs is incomplete. Hellin[1] has collected a number of cases.

Partial Pneumothorax.—In this form adhesions limit the air to a circumscribed area. Any portion of the pleural sac may be the site. An apical localization may readily lead to confusion with a pulmonary cavity. Monnier's[2] case in which the position of the pneumothorax in the interlobar septum was proved by autopsy is of especial interest because of its rarity.

Artificial Pneumothorax.—In 1882, Forlanini[3] suggested the possibility of treating pulmonary tuberculosis by establishing artificial pneumothorax on the affected side and in 1894 reported that he had used the method and described his technic. In 1898, Murphy[4] reported 5 cases thus treated. The method attracted little attention and received no encouraging support until within the last few years, during which a rapidly increasing number of publications have appeared. Forlanini[5] has recently considered the method at length and reviewed the literature.

Theories.—The method is based on the assumption that, as for tuberculous processes elsewhere, immobilization is favorable for the arrest of a tuberculous process in the lung and may be secured by the insufflation of pure nitrogen into the pleural sac on the diseased side, this gas being used because of the slowness with which it is absorbed. Compression of the lung is also regarded as an important factor, by diminishing the size, evacuating the contents and approximating the walls of pulmonary cavities, lessening the amount of infectious material and thus retarding the activity of the tuberculous process. Changes in the lymph circulation following the compression are supposed to diminish the absorption of toxic material and favor the development of connective tissue.

Concerning the effects of the immobilization and compression of one lung upon the other, which must of necessity work harder, it is further assumed that the tuberculous lesions, almost invariably present although of less extent, are favorably affected by an increase in respiration, blood and lymph circulation, and improvement in nutrition.

Indications.—This method is regarded as indicated in cases of pulmonary tuberculosis, after unsuccessful trial of other well-known methods, and in unilateral cases with freedom of the pleura from adhesions. Some would include the predominantly unilateral cases with slight and relatively inactive processes in the opposite lung. The treatment is also recommended for intractable hemoptysis when

[1] Mitt. a. d. Grenzgeb. d. Med. u. Chir., 1909, vol. xvii.
[2] Gaz. méd. de Nantes, November 2, 1907.
[3] Gaz. d. osp., 1882, vol. iii; Gaz. med. di Torino, 1894, vol. lxv.
[4] Jour. Amer. Med. Assoc., 1898, vol. xxxi.
[5] Ergebnisse der inneren Med. u. d. Kinderheilk, 1912, ix, 621.

its source from one or the other lung can be determined with tolerable certainty. Selected cases of bronchiectasis and pulmonary abscess or gangrene are also considered suitable. Obliteration of the pleural sac, acute bilateral processes and grave cardiac or renal lesions are looked upon as contra-indications. An *x*-ray examination is a necessary preliminary in the selection of cases.

Apparatus.—The apparatus used by Forlanini[1] or its modifications by different workers[2] consists of two glass receptacles connected by glass or rubber tubing. Out of one receptacle nitrogen can be forced into the pleural sac by water or air pressure in the other, the water meanwhile acting as a seal to prevent the escape of nitrogen in other than the right direction. A manometer is so arranged that it can be brought into or out of connection with the nitrogen system and the pleura. A special needle is used for the puncture. The nitrogen should be chemically pure and filtered through cotton on its way to the chest.

Methods.—In choosing the site for the injection, freedom from pleural adhesions is the most important determining factor and the injection is made wherever the pleura seems most likely to be free, although the lower parts of the chest least covered with muscular tissue are regarded as points of election. Freedom of the pleura from such a degree of adhesions as would be likely to prevent the production of pneumothorax is suggested by mobility of the pulmonary margin over a part or the whole of its extent as determined by *x*-ray examination, percussion of the complementary space during forced inspiration and expiration, and observation of the diaphragm shadow. Diminution in amplitude or total absence of respiratory motion suggest partial or complete obliteration of the pleura, but may also be due to such other causes as immobility of the lung from disease, weakness of the respiratory muscles, and increased intra-abdominal pressure. A history of pleurisy on the affected side, lobar pneumonia as a cause of the process or pleural pain during the development of the disease may suggest pleural adhesions.

In the performance of the injection, two methods are in use: in the Murphy-Brauer method, preceding the first injection an incision is made to the parietal pleura through which the needle is obliquely introduced, in that of Forlanini, thoracentesis is performed without preliminary incision. The incision method diminishes the danger of puncture of the lung and gas embolism, but is likely to result in a greater or less degree of subcutaneous emphysema. After the first injection it is customary to give subsequent treatments by the puncture method.

Preceding the puncture the skin should be frozen with ethyl chlorid.

[1] Apparate und Operationstechnik für den kunstlichen Pneumothorax, Deut. med. Woch., December 14 and 21, 1911. For detailed descriptions of the apparatus the reader is referred to the article quoted.

[2] Robinson and Floyd, Arch. Int. Med., 1912, ix, 452; Balboni, Med. Comm. of the Mass. Med. Soc., 1912, vol. xxiii.

The skin and underlying tissues are then thoroughly anesthetized with 1 per cent. novocain, containing 1 to 10,000 adrenalin (Robinson). The needle, unconnected with the apparatus and with the stop-cock on the lateral outlet closed, is introduced to what seems a proper depth, the trocar is removed, and the needle-cock closed. The needle is now connected with the manometer of the apparatus, the nitrogen system meanwhile remaining closed. The position of the point of the needle just within the two layers of the pleura is indicated by the appearance of *negative pressure and marked respiratory oscillations* in the manometer, in the absence of which it is never safe to proceed with the injection, which must be abandoned or another site chosen. If the point of the needle is in the thoracic wall, in a bloodvessel or in an adherent pleura, negative pressure and respiratory oscillations are absent, if in the lung, respiratory oscillations may be present but there will be no constant negative pressure. If the point of the needle lies in the endothoracic fascia, *slight* negative pressure and respiratory oscillations may be present. Aspiration by means of a syringe attached to the needle may help to exclude the possibility of puncture of a vein.

If the desired negative pressure and respiratory oscillations are obtained, the manometer is excluded and the nitrogen system brought into connection with the needle, through which nitrogen is allowed to flow into the pleural sac under very slight pressure, to an amount varying usually from 50 to 500 c.c. Small amounts are reinjected at intervals, commonly at first each week. The amount and frequency are determined by the conditions in individual cases, the indication being to maintain the affected lung completely immobile. Distress or pain during the injection indicates a dangerous degree of tension on adhesions and makes it wise to terminate the procedure. The length of time over which the treatment is to be carried out cannot be definitely stated and will depend on the result obtained. It has been maintained for as long as ten years in one of Forlanini's cases.

In cases in which there is reason to believe there may be pleural adhesions at the site of the puncture, Forlanini is not deterred, but believes that the procedure can be accomplished by a modified technic. The adherent pleural space cannot be detected in the manner already described and the nitrogen must be introduced under pressure to forcibly separate the adhesions. With the needle in place minimal amounts of nitrogen are injected by pressure upon the rubber tubing. By pressure with the thumb and forefinger of the right hand the tube is closed at a point about 3 cm. from the connection with the needle. Compression of the short section of tubing thus isolated with two fingers and the thumb of the left hand expresses from the point of the needle about one-half cubic centimeter of nitrogen. If pressure on the tubing is now released and the tension tested, the behavior of the manometer will disclose the presence of the expressed nitrogen in a

closed vesicle within the tissue, its more diffuse distribution between the layers of the pleura or entrance into a vessel.[1]

Dangers.—Embolism is the most immediate danger and when it occurs is commonly fatal if large amounts of gas have entered a vein. Of 98 cases treated by Forlanini, this accident occurred with a fatal result in 2 during a repetition of the injection. Three fatal cases by the puncture method were reported to Brauer[2] by other operators and 1 occurred in his own experience. Many isolated examples are reported in the literature. Hemiplegia has followed. Sudden death apparently due to irritation of the pleura ("eclampsic pleurisy") is occasionally observed, but may follow puncture of the pleura for any reason. Thorough local anesthesia previous to the injection will probably largely prevent it. Infection may follow the introduction of organisms from within or without. Fagiuoli[3] noted the development of pleurisy with effusion in 10 of 23 cases in which he had produced artificial pneumothorax. It has been estimated that an exudate complicates about half the cases. Weiss[4] was always able to demonstrate tubercle bacilli in the effusion by animal inoculation. Such an extension of the tuberculous process cannot be regarded as desirable.

The effect of maintaining the lung in a collapsed condition for a long period is an important consideration. In collapse of the lung in consequence of pleurisy with effusion, the formation of extensive pleural adhesions and of dense connective tissue on the surface and within the substance of the lung may develop in the course of time and prevent reëxpansion. Such indurative changes are more common with empyema than with serofibrinous effusions and are more pronounced the longer the lung is allowed to remain in a contracted and atelectatic condition. They constitute an important argument for the early removal of inflammatory and especially purulent fluid. Similar changes in the pleura and lung have been observed as a complication of artificial pneumothorax. Graetz[5] demonstrated dense fibrous thickening of the pleura over the collapsed lung. Weiss[6] observed such changes in the pleura in two cases at autopsy. Bruns[7] found thickening of the pulmonary pleura and an increase in the peribronchial and perivascular connective tissue after experimental pneumothorax in animals. Kaufmann's[8] findings are still further confirmatory and suggest great

[1] On releasing the pressure, the nitrogen ordinarily fails to reënter the tubing and the proximal branch of the manometer indicates a corresponding elevation. Immobility of the manometer even with forced breathing suggests that the nitrogen has diffused itself into the tissues or penetrated a vessel, while respiratory oscillations suggest its presence in a closed vesicle or between the layers of the pleuræ. The degree of negative pressure and the amplitude of the respiratory oscillations permit of a decision between its entrance into a closed vesicle and the pleural sac. If the latter is the case, the negative pressure and the oscillations are much more marked.

[2] Verhandlungen des Congresses f. innere Med., 1908, vol. xxv.

[3] Münch. med. Woch., May 7, 1912. [4] Beitr. z. Klinik d. Tub., 1912, xxiv, 333.

[5] Ibid., 1908, Bd. x, p. 249. [6] Loc. cit., p. 348. [7] Ibid., 1909, xii, 1.

[8] Ueber die Veränderung d. Pleura u. Lungen gesunder Hunde mit künstlichen Pneumothorax, Ibid., 1912, Bd. xxiii, p. 57.

caution in the adoption of the method. He found the lung incapable of reëxpansion in consequence of such changes. Pulmonary collapse is likely to be more complete in those parts of the lung which are little or not at all involved and it may be regarded as questionable whether the risk of materially diminishing or even abolishing the function of sound parts can be safely taken.

Emphysema of greater or less extent is common after the Murphy-Brauer incision method but is more annoying than dangerous. It was observed in 60 per cent. of Robinson and Floyd's cases. It is less frequent when Forlanini's puncture method is used. The rapid evacuation of the contents of tuberculous cavities under compression may lead to further infection in near-by or remote parts of the lung. Dyspnea and collapse from displacement of the mediastinum and heart, pain from the stretching of adhesions and gastric symptoms from displacement downward of the diaphragm may follow.

It is difficult to understand how if immobilization of one lung is of value in checking a tuberculous process, overwork is good for the other, and the arguments in its favor seem invalid.

Results.—Among the more immediate effects are diminution of fever and disappearance of night sweats. This is ascribed to diminished absorption of toxic material. The amount of sputum may at first increase, with later diminution in the cough and amount of expectoration. In a few instances, apparent arrest of the tuberculous process has been secured but detailed statements concerning the late results in any large series are not yet published.

Should the method be used? Artificial pneumothorax as a means of treatment for pulmonary tuberculosis is not theoretically sound. Bilateral infection with tubercle bacilli is almost constant and immobilization of one lung must of necessity impose a greater amount of work on the other. The dangers are considerable and sufficient to discourage support of the method, unless results so favorable as to justify the risks can be demonstrated. The results thus far are not highly promising.

Diagnosis.—When in the course of chronic pulmonary tuberculosis there is sudden pain in the side, immediately followed by severe dyspnea, pneumothorax should be suspected. *Resonance on percussion with suppression or absence of the respiratory murmur* often gives the first intimation of the nature of the trouble. The determination of displacement of the heart away from the affected side is confirmatory and the diagnosis may be regarded as established if the succussion splash of pleural fluid is heard. Other signs of importance are diminished or absent tactile fremitus, voice sounds and whisper, the amphoric phenomena (amphoric breathing, rales, cough, vocal resonance, whisper, and heart sounds), metallic tinkle, coin-sound, and movable dulness at the base with horizontal upper border irrespective of the position of the patient. The auscultatory phenomena are essential for the diagnosis. With mild symptoms and a small

pneumothorax, especially if uncomplicated by fluid, the diagnosis is difficult and the condition is probably frequently overlooked. Examination by means of the *x*-rays furnishes valuable data and may make a diagnosis possible when other means fail.

There may be difficulty in differentiating pneumothorax from the following conditions:

A *large pulmonary cavity,* in common with pneumothorax, may show resonance or tympany on percussion, cracked-pot sound, changes in the percussion note with the mouth open or closed, on changing the position of the patient and during inspiration or expiration. If the cavity is large and contains thin fluid, there may be movable dulness with horizontal upper border below the resonant area. Amphoric breathing, metallic tinkle, the coin-sound and succussion splash may also be present. With cavity, however, the symptoms are likely to be gradually progressive, without a history of sudden pain and severe dyspnea. With cavity also the affected side is likely to be retracted and the intercostal spaces narrowed. The upper lobes or the apex are likely to be affected over a less extensive and more definitely circumscribed area over which there is loud bronchial breathing, increase of voice, whisper and tactile fremitus and abundant rales. The heart is drawn toward the affected side and the diaphragm elevated rather than depressed. In cases where there is a large loss of pulmonary substance involving the greater part or the whole of one lung the differentiation may be difficult. Examination by means of the *x*-rays may be of assistance. The absence of the shadow of the retracted lung at the root and the presence of a shadow with a central clear area are suggestive of cavity.

Subphrenic pyopneumothorax, first accurately described by Leyden[1] may offer great difficulty. A collection of air and pus is present between the diaphragm and the liver or between the diaphragm and the spleen, stomach, and colon. Perforation of a gastric or duodenal ulcer or the appendix are the usual causes, but in rare instances, as in the case reported by Umber,[2] gas may be formed by the colon bacillus and without evidence of perforation of the intestine. The right or left side may be affected and the diaphragm elevated as far as the third or even the second rib with displacement downward of the liver and other abdominal organs. Over the cavity containing air and fluid, occupying the lower part of the chest, there are the physical signs of pyopneumothorax. There may be resonance or tympany on percussion above, movable dulness below, diminished and amphoric or absent respiratory murmur, vocal and tactile fremitus and whisper and metallic tinkle, coin-sound, and succussion splash. Absence of cough and expectoration and a history of preceding abdominal symptoms may suggest an abdominal origin, the heart is only slightly displaced, the intercostal spaces may show inspiratory depression, the

[1] Ztschr. f. klin. Med., 1880, vol. i, and Berl. klin. Woch., 1892, vol. xlvi.
[2] Mitth. a. d. Grenzgeb. d. Med. u. Chir., 1900, vol. vi.

vesicular breathing terminates abruptly where the signs of pyopneumothorax begin and respiratory mobility of the pulmonary margin may be determined. Foul pus with a fecal odor may be demonstrated by exploratory puncture and an increase in the tension during inspiration and decrease during expiration, as suggested by Pfuhl, may be determined. Examination with the *x*-rays may furnish important evidence. In cases in which the pyopneumothorax is circumscribed and the upward dislocation involves only a part of the diaphragm, an abrupt dome-like elevation of the shadow may be noted, with evidence of air above and fluid below. With larger accumulations the diaphragm may be elevated as a whole although still maintaining its oval contour with persistence of a relatively clear space in the costophrenic sinus. If, as not infrequently happens, pleurisy with effusion complicates the process, the *x*-ray picture is obscured. On examination with the fluoroscope inspiratory depression and expiratory elevation of the diaphragm may be seen and the diaphragmatic excursion is usually greater than with pneumothorax.

Diaphragmatic hernia may closely resemble pneumohydrothorax. Lacher[1] and Grosser[2] have reviewed the reported instances which comprise for the most part autopsy cases. The diagnosis is seldom made during life and in the more chronic cases has been established in only about a dozen instances.

True diaphragmatic hernia may in rare instances be congenital (the much discussed eventratio diaphragmatica being of this sort) but is more commonly acquired as the result of stab or gun-shot wounds, a fall, contusion or concussion. The left side is usually involved and the stomach protrudes into the chest. With a large defect in the diaphragm the transverse colon, the omentum, small intestine, and even the liver or spleen may be contained in the sac. In common with pneumohydrothorax, there may be enlargement of the side, diminished respiratory excursion, diminished amplitude or absence of the diaphragm shadow, immobility of the pulmonary margin as determined by percussion, dislocation of the heart and mediastinum, tympany on percussion above with dulness shifting with change of position below, coin-sound, diminished respiratory murmur, voice sounds and tactile fremitus and succussion splash. On examination with the *x*-rays, an area suggesting air above and fluid below may be seen, and, as in pneumohydrothorax, the fluid may be seen to maintain a horizontal upper border on changing the position of the patient. Waves of surface motion may also be observed during respiration and with cardiac systole.

A history of trauma, such gastro-intestinal symptoms as pain, attacks of colic, nausea, and vomiting and, in rare instances, hematemesis and the absence of cough and expectoration may call attention to the abdomen as a source of the disturbance. Changes in the physical

[1] Deut. Arch. f. klin. Med., 1880, vol. xxvii.
[2] Wien. klin. Woch., 1899, p. 655.

signs dependent on a full or empty stomach, sounds over the chest resembling the movement of flatus in the intestine and the absence of stomach tympany at its normal position after inflation with gas may serve to suggest the diagnosis. The *x*-ray examination may show inspiratory depression and expiratory elevation of the fluid (unlike the paradoxical mobility in pneumohydrothorax) and after a bismuth meal the position and outline of the stomach or intestines in the thorax.

In *pneumonia* over and beside the consolidated area and in *pleurisy with effusion* over the collapsed lung the percussion note may have a tympanitic and metallic quality, and amphoric auscultatory phenomena may be present, but in the former the history and clinical course and in both the increase of voice, whisper, and tactile fremitus and the absence of metallic tinkle, coin-sound and succussion splash and movable dulness with horizontal upper border usually serve to make the differentiation.

Recognition of the *type* of pneumothorax is not always easy nor is it usually of practical importance. In the valvular form the dyspnea is likely to be severe and persistent or gradually increasing with distention of the side and marked dislocation of the heart, mediastinum, and diaphragm. Intrapleural tension is likely to be persistently positive. With open pneumothorax, the dyspnea, distention of the side, and dislocation of organs is less marked. Changes in the percussion note with the mouth open and closed are more likely to be present. Intrapleural tension is that of the atmosphere with respiratory oscillations about the zero point and there is a rapid return to atmospheric pressure after aspiration. A gas analysis which shows 5 per cent, or less of CO_2 or a persistent increase in O in successive portions removed suggests an open fistula. When the pneumothorax becomes closed the dyspnea diminishes, displaced organs return, positive pressure may persist at the height of inspiration and gas analysis may show a large percentage of CO_2. The determination of the cause is important. A history of preceding hemoptysis out of a clear sky or a primary pleurisy, cough for several months, night sweats, fever and failing weight and strength usually indicate tuberculosis, which owing to the compression of the lung oftentimes can be established by the finding of tubercle bacilli in the expectoration. The fact that from 80 to 90 per cent. of all cases are of tuberculous origin may well influence a decision in doubtful cases, and all cases should be regarded as tuberculous until proved otherwise.

Course and Prognosis.—This depends for the most part on the underlying disease. The pneumothorax is of itself usually of relatively little importance, as the patient soon develops a tolerance of the condition. Air alone does not irritate the pleura and is usually absorbed in the course of from one to two months.

As a complication of pulmonary tuberculosis, however, it introduces very definite dangers and hastens the fatal termination. The rupture of a small subpleural tubercle, a tuberculous cavity or a pleural

adhesion usually leads to tuberculous or pyogenic infection of the pleura, with the formation of a serofibrinous or purulent effusion, in consequence of which the fever becomes more marked and emaciation progresses more rapidly. West[1] finds the mortality highest in the first few days, 10 of 39 cases dying on the first day, 18 during the first week. Among 74 cases, 45 died in the first month. The general mortality was about 70 per cent. Among Drasche's 198 cases, 71 per cent. died within the first fourteen days. Death may be ascribed to suffocation from the pneumothorax itself or flooding of the opposite lung with pus, to rapid extension of tuberculous or septic material into the pleura or to the original disease, phthisis. Hughes'[2] remarkable patient lived at least three years and two months after the occurrence of pneumothorax, was able to attend his regular business and amused his friends by the succussion sound. In a small proportion of the cases an effusion fails to develop, or if present is absorbed or successfully evacuated and the patient's recovery is permanent and complete.

Spengler[3] has reported 10 cases of tuberculous pneumothorax with recovery and in 6 there was simultaneous arrest of the pulmonary tuberculosis, but his experience has been very unusual and contrary to that of most observers. To the time of his report a total of 38 cases of healed tuberculous pneumothorax could be found in the literature. The favorable outcome in these cases has been used as an argument in favor of artificial pneumothorax in the treatment of pulmonary tuberculosis, but it must be remembered that recovered cases comprise only a small proportion of the total number. West estimates complete recovery at not over 10 per cent. and this may be regarded as a conservative estimate.

The prognosis of the spontaneous cases, unless of the suffocative type, is favorable, only one death occurring in 58 cases studied by Fussell and Riesman. Uncomplicated traumatic cases usually also do well. Suffocative pneumothorax is rapidly fatal unless relieved by operation.

Treatment.—The indications are, on the one hand, to promote closure of the pulmonary fistula and prevent infection of the pleura and on the other to relieve a dangerous degree of embarrassment to respiration and the unfavorable consequences of pleural effusion more especially of the purulent form. Inasmuch as removal of air or fluid by decreasing intrapleural tension tends to reinflate the collapsed lung, reopen a pulmonary fistula and aspirate infectious material from the lung or bronchi into the pleura the indications are mutually conflicting and a conservative middle course is often the wisest plan.

In ordinary and other than urgent cases immediately following the rupture the patient should be absolutely at rest in bed. Irritative and unproductive cough should so far as possible be suppressed and

[1] Lancet, 1897, i, 1264.
[2] Guy's Hosp. Rep., 2d S., vol. viii.
[3] Beitr. z. klin. Chir., 1906, xliv, 68.

deep respiration avoided in order to hasten closure of the fistula and prevent further entrance of air into the pleura. Strapping the affected side with adhesive plaster may help and morphin may be of assistance in quieting cough. In mild and moderately severe cases no further treatment is usually needed. The patient should be absolutely quiet for two or three weeks or until there is reason to believe that the fistula is closed. Traumatic and spontaneous cases usually do well under such conservative management.

In cases in which the pneumothorax rapidly increases, with urgent dyspnea, cyanosis and great displacement of the heart, immediate relief must be offered. Pneumothorax acutissimus and certain cases of the valvular form are of this type. Puncture may prove life-saving. Aspiration should be avoided for fear of reopening the fistula. With valvular pneumothorax the pleural sac is likely to be reinflated and the puncture may need to be repeated or the cannula left in place for a time. Infection through the chest wall is to be avoided by the strictest asepsis. Thoracotomy with insertion of a drainage tube, converting the valvular into open pneumothorax with external fistula, is occasionally necessary.

With hemopneumothorax and hydropneumothorax with a small or moderate amount of fluid and without pressure symptoms, it is best to leave the fluid undisturbed for at least two or three weeks or until closure of the fistula is established. With large fluid accumulations or those with pressure symptoms it may be necessary to tap, but it is best to withdraw only small amounts at frequent intervals and without forcible aspiration. The indications are essentially those with uncomplicated serofibrinous effusions with the exception that here the danger incident to the fluid must be weighed against that of opening the fistula, and the latter justifies a delay in doubtful cases.

Spengler regards an exudate as desirable to promote closure of the fistula, further compression of the lung and arrest of the tuberculous process, and would allow the patient to be up and about as soon as possible to deepen respiratory motion and induce pleural infection. Such an extension of tuberculous or pyogenic infection to the pleura seems to me undesirable and to lead to more rapid progress of the disease.

With seropurulent and sterile purulent effusions in which symptoms of sepsis are absent or slight, it is best if possible to wait until the fistula is closed. If removal is indicated simple aspiration and the repeated removal of from 500 to 700 c.c. may suffice. With frankly purulent fluid containing pyogenic organisms and with marked symptoms of sepsis, further regard for the fistula must be abandoned and free drainage established as for ordinary empyema. With putrid exudates an immediate operation is demanded.

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