

## PULMONARY TUBERCULOSIS

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The origin of tuberculosis probably dates back to the days when men first began to live in compact social groups. Through studies of Egyptian mummies, Derry, Wood, Jones, Armand Ruffer, and Elliott Smith have shown how this scourge wrought havoc among the people even in the time of the Pharaohs. The Veda of India, the Zend-Avesta, sacred book of the Parsees, the works of Hippocrates, of Celsus, of Aretaeus of Cappidocia in 70 B.C., and the writings of Avicenna all abound in discussions of phthisis. The American Indians of pre-Columbian times apparently were free from tuberculosis, for no indication of its existence is to be found in any of the thousands of well-preserved skeletons of the various tribes. This is conclusive evidence that the continental peoples were later responsible for the development of the disease in North America.

It was not until the eighteenth century that the disease received the name by which it is now known—tuberculosis. Reid, the English physician, in 1782, and Baille in 1793, called attention for the first time to granulation and tubercles which increase in size, coalesce, and develop perfect cavities. However, Laennec, who at the age of 35 was himself a victim of the malady, laid the real foundation for our understanding of the pathological anatomy of tuberculosis. He said: "Tuberculous matter can develop in the lungs and other organs in two principal forms: as isolated bodies (granulation, miliary tubercle, non-caseous tubercle, caseous tubercle, ulceration or cavity), and an infiltration." Laennec was the originator of the method of mediate auscultation by which he learned to detect the development of tubercles in the living subject, and humanity will always be grateful to him for having created the first means of diagnosing the disease. The infectious nature of tuberculosis was obvious to him, for he wrote, "There is perhaps no organ which is immune against the development of tubercles," and "Pulmonary tuberculosis is the result of secondary extension, glands being a primary foci."

In 1865, Villemin furnished positive proof of the inoculability of the tubercle and of caseous material. In his address before the Academy of Medicine in Paris, December 5, 1865, he drew the following conclusions:

"Tuberculosis is a specific affection.

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“Its cause lies in an inoculable virus, and it should be classed with syphilis or near glanders.”

It then remained to demonstrate the virulent agent by the methods originated by Pasteur. This was done by Robert Koch (1843-1910), a German district physician in Wallstein, Germany, whose name remains gloriously associated in the literature with the study of tuber-

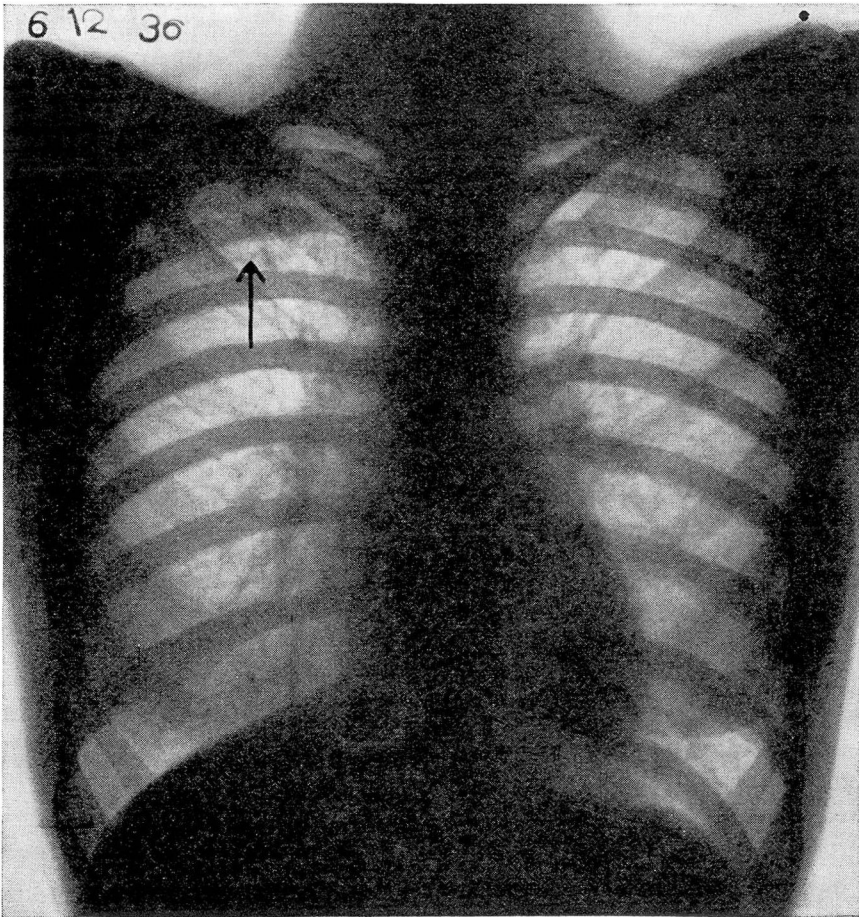


FIGURE 1.—Incipient pulmonary tuberculosis.

culosis. He published a paper on the “Etiology of Anthrax,” which is memorable as the starting point of a new method of research into the causation of infectious diseases. He demonstrated the constant presence of germs in cattle dying from this disease, but the epoch-making advance of Koch was to grow those organisms in a pure culture outside the body, and to produce the disease artificially by inoculat-

ing animals with the cultures. Koch is really our medical Galileo, who, by means of a new technique—pure cultures and isolated staining—introduced us to a new world. Upon these two memorable researches made by a country doctor rests the modern science of bacteriology. Before Koch's discovery of the tubercle bacillus, we were helpless and hopeless; in an Oriental fatalism we accepted with folded hands a state of affairs which use and wont had made bearable. Today, look at the contrast! We are both helpful and hopeful.

The tubercle bacillus is a slender, non-motile, rod-shaped organism having an average diameter of one-half to one-quarter of the diameter of a human red blood cell. It is reproduced by elongation and transverse division of the rods, and not by sporation. The organism is particularly resistant to cold and may retain its vitality at the temperature of liquid air. Moist heat at 95° C. for a period of at least one minute is necessary for its destruction. Dried sputum on slides or gauze, when left in dark places at a low temperature, has been virulent after from two to four months. Gaertner found the organism alive and active in the cadaver 167 days after burial. The chemical resistance also of the organism is interesting, a 1:100 solution of potassium iodide, a 1:900 solution of boracic acid or a 5 per cent solution of carbolic acid for a period of five minutes being necessary for its destruction. A 1:1000 solution of bichloride of mercury for one hour or a 1:10,000 solution for twenty-four hours will kill the organism.

The reaction of the human body to the invasion of the tubercle bacilli is usually evidenced by the presence of a tubercle. It is evident that the tubercle is not formed by proliferation of fixed tissue elements in response to irritation, but its formation is a uniform attack upon an invading enemy carried out in a uniform manner no matter what organ or tissue is invaded. The tubercle always attacks a lymphatic cell. First, the bacillus is taken up by the polynuclear leukocytes which soon undergo degeneration and death, and these form groups which are surrounded by large mononuclear leukocytes and in turn fuse to form the typical giant cell.

In the lung there is an early exudation of lymphatic elements into the alveoli which are analogous to those found in the intralymphatic tubercles. Coalition of these tubercles produces an increase in size of these areas and results in tuberculous pneumonia which may be followed by resolution or caseation. This caseation of tubercles is believed to be due to the direct and localized toxic action of the bacilli and their diastatic or toxic secretions upon the giant cells which contain them. This action produces an isolated area of tuberculous pneumonia which is followed closely by caseous bronchopneumonia as the fixed

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cells of the lung succumb, and cavitation may result. A tuberculous tubercle, therefore, is truly a lymphatic production, the fixed cells in the organ in which the tubercle develops playing no part in its histogenesis.

Pulmonary tuberculosis is the type which is of most frequent occurrence in man as well as in cattle. This does not imply that this type is

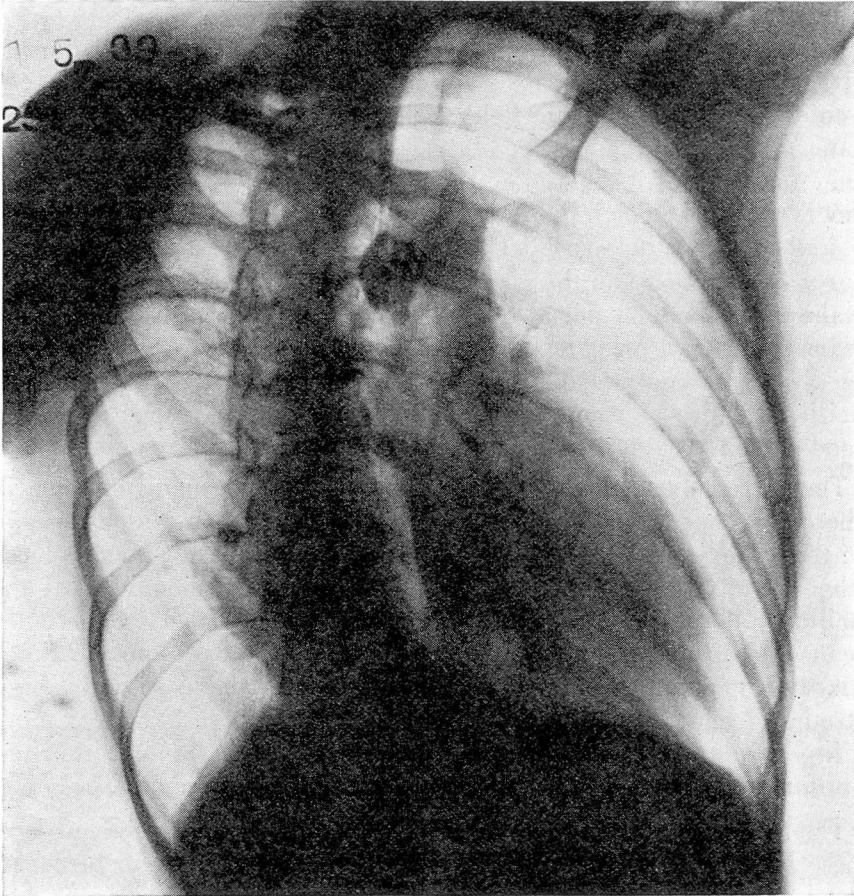


FIGURE 2.—Quiescent tuberculosis.

first from the standpoint of priority of infection, as it is in reality of a later date and is consequent to the formation of a gland in the cervical, tracheobronchial, or mediastinal group. Circulation is less rapid in the loose connective tissue which surrounds the alveoli and small bronchi, the lymph spaces, and the capillaries than is the case in any other organ. This is particularly true of the apices and the smaller vessels which have a lesser degree of elasticity, and adherence to the walls of

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the lymph and blood capillaries occurs here with greater intensity than elsewhere. The presence of pleural effusion without a definite logical cause should be considered an evidence of tuberculosis. Frequent attacks of pleurisy in cases of pulmonary tuberculosis are undoubtedly due to the presence of a direct communicating pleural lymphatic system with the lungs.

### MECHANISM OF THE INFECTION

The skin may be a portal of entry for the organism. Holt collected forty-one cases of tuberculosis following circumcision. The mucous membrane is a very fertile field, especially the ocular mucous membrane. The nasal mucous membrane is not a common source of infection on account of its continuous, active phagocytosis. The respiratory tract is not of as much importance as a means of transmitting the disease as was formerly believed. The tonsils probably form an important source of infection and the gastro-intestinal tract may be considered to be the most common portal of entry. Infection by any of the above means results in a primary tubercle bacillus septicemia, except possibly the disease is contracted by direct air inhalation when the tubercle bacilli may also be transmitted subsequently by the lymphatics or the blood stream.

The extremely frequent occurrence of pulmonary manifestations in tuberculosis has led to the belief that this disease is transmitted through the respiratory passages. Primary pulmonary tuberculosis may occur either by way of the air passages, that is, by direct inhalation of the bacillus in the air, or by way of the blood stream. We believe the latter means of transmitting the infection is by far the more frequent. Some leukocyte containing its parasitic bacilli, which have recently been introduced into the body or derived from a focus of infection of more or less long standing, is arrested in the interalveolar or peribronchial capillaries and becomes the point of departure for a giant cell.

The lung is divided into lobules, each having a capacity of about 1 cc. These lobules are surrounded by connective tissue which in turn surrounds lymphatic spaces. Early involvement of these spaces was observed by Dunham and resulted in the "Dunham Fan," which may be demonstrated on the roentgenogram as a fan-shaped infiltration.

Albrecht and Anton Gohn concluded that an involvement of the bronchial lymph nodes is always accompanied by a corresponding lung lesion, the latter being the primary site of inoculation. Marfan, Weigert, Bollinger, Calmette, and others, however, have proved definitely by inoculation through the mucous membrane of the eye that the glands of the hila are involved first and that the lung lesion is a secondary manifestation. It is evident that a true Gohn primary infection must

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be only air-borne. It is contrary to the present consensus of opinion that an air-borne infection is of as easy accomplishment as an infection by other routes.

If it happens, however, that the infecting bacilli are isolated, if they are few in number, or not very virulent, the leukocytes by which they

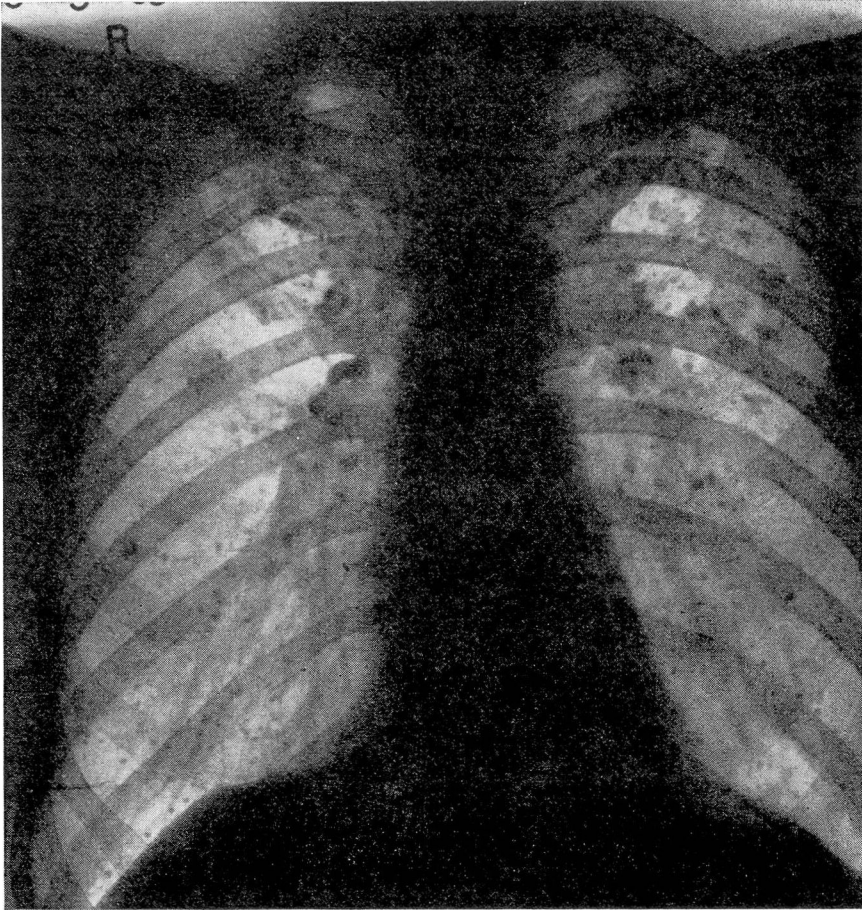


FIGURE 3.—Miliary type of tuberculosis, calcified.

are ingested remain unharmed for a long period despite the presence of these undigested parasites in the cell protoplasm; they preserve their motility and continue their migrations in the lymph or blood circulation throughout the various organs up to the time when, sooner or later, they die. Then at the point where the dead cells form a capillary embolus, perhaps far removed from an obscure portal of entry of the bacilli, a tuberculous lesion develops. Thus, following a nonmassive

infection, no matter of what origin—whether produced by an excoriation of the skin, occurring in a healthy mucous membrane, or transmitted by way of the respiratory passages or by the intestine—there appears occasionally an isolated localization of tubercle bacilli—in the lung, pleura, joint, kidney or other serous membrane, bone, testicle or ovary, or the larynx. The lung, however, is most likely to be the seat of this localization because of the immense surface which it presents for the development of a blood and lymph capillary system which, in the lungs, is more extensive and delicate than in any other organ.

The frequent occurrence of so-called primary tuberculosis of the lung is due, therefore, to the fact that primary tuberculosis represents the first manifestation of a bacillary infection which may have occurred by way of any lymphatic or blood route, often long before the appearance of other signs of the disease, and which may possibly have remained dormant for years.

#### DIAGNOSIS

Time was, and this within memory of the living, when a diagnosis of consumption in an adolescent patient was rightly regarded as a sentence of death. The “churchyard cough” was the inevitable prelude to the grave. If we may judge this period by the novelist, consumption was the normal fate of a youth attended by beauty, but the lady of the Camellias might have looked forward to a disreputable old age had she lived today.

It was a pupil of Corvisart, Rene Theophile Laennec, who laid the foundation of modern clinical medicine. The story of his life is well known. A Breton by birth, he had a hard, uphill struggle as a young man—a struggle with tuberculosis of which we have only recently been made aware by the publication of a charming book by Professor Rouxeau of Nantes—“*Laennec avant 1806.*” Influenced by Corvisart, he began to combine the accurate study of cases in the wards with anatomical investigations in the deadhouse. Before Laennec, the examination of a patient had been largely by sense of sight, supplemented by that of touch, as in estimating the degree of fever, or the character of the pulse. Auenbrugger’s “*Inventum Novum*” of percussion, recognized by Corvisart, extended the field, but the discovery of auscultation by Laennec, and the publication of his work—“*De l’Auscultation Mediäte,*” in 1819, marked an era in the study of medicine. The clinical recognition of individual diseases had made really very little progress; with the advent of the stethoscope began the day of physical diagnosis. The clinical pathology of the heart, lungs, and abdomen was revolutionized. Laennec’s book is in the category of the eight or ten greatest contributions to the science of medicine. His description

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of tuberculosis is perhaps the most masterly chapter in clinical medicine. This revolution was effected by a simple extension of the Hippocratic method from the bed to the deadhouse and by correlation of the signs and symptoms of a disease with its anatomical appearances. The method of diagnosis of pulmonary tuberculosis by evaluation of the history and physical findings, namely auscultation and percussion,

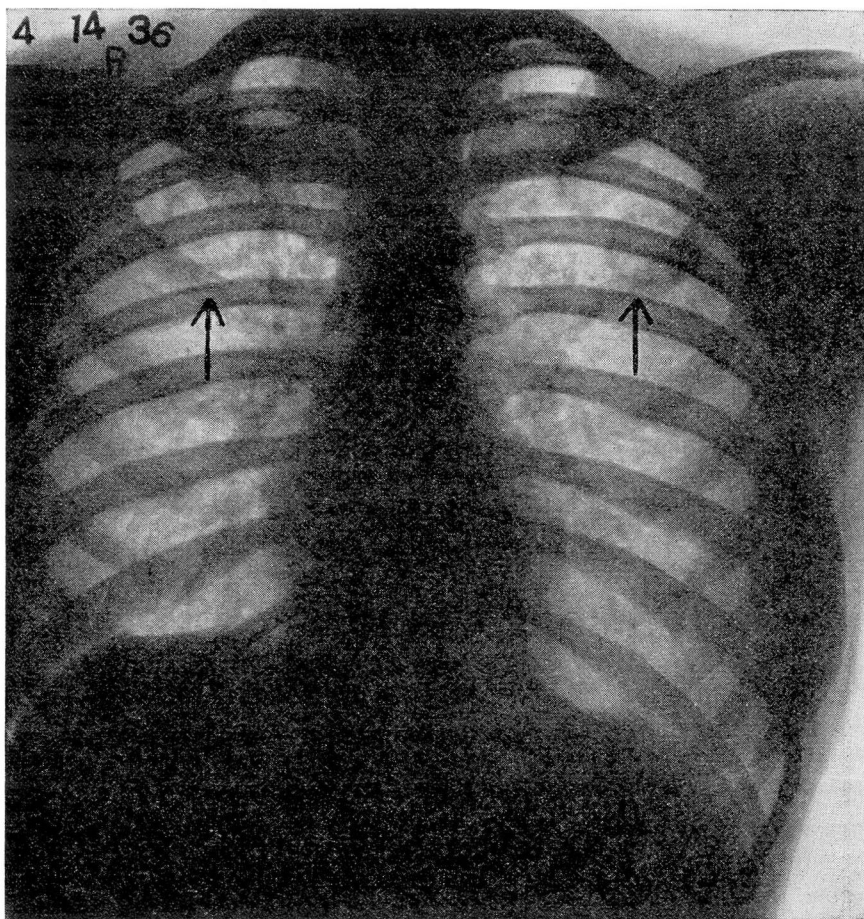


FIGURE 4.—Active pulmonary tuberculosis with cavitation.

was used for many years. Then came the discovery of the x-ray which resulted in earlier recognition of the disease and greater accuracy in diagnosis.

*Roentgen examination:* In 1896, Wilhelm Conrad Röntgen discovered the x-ray and it was learned soon after this that roentgenograms of the chest were of the greatest value in the diagnosis of pulmonary tuberculosis. Fortunately, not all infections of the chest terminate in



caseous bronchopneumonia and cavitation. The vast majority of the infections result in fibrosis, calcification, or both, and thereby the process is arrested. We feel this is the proper expression, as many calcified lesions contain live bacilli and may show exacerbation of the disease at any time. Fibrous and calcific deposits may be well demonstrated by roentgen examination.

Miliary tuberculosis is evidently a blood stream infection and the lesions are interstitial in character, and part of a general infection in which many other organs are involved. This type of tuberculosis usually produces little or no physical signs and the characteristic, small, soft, nodular infiltration observed on the roentgenogram is of the utmost importance in diagnosis. We might well quote here, "Tubercles must be seen and not heard." (Dr. James Alexander Miller.)

This method of chest examination is the most important single factor in the determination of the presence and extent of pulmonary tuberculosis. Since the chest is an air-containing cavity, it can readily be examined by use of the roentgen ray. However, the interpretation of roentgen films of the chest in many cases, particularly in children, is extremely difficult and no attempt at such a diagnosis should be made unless a physician has had proper training. The first and most important basis for such a training is an understanding of all the changes which may take place after a tuberculous infection has been established in the chest.

The first change with which the roentgenologist should be familiar is exudative infiltration. This is nature's first reaction to the infection and always means an active lesion. This may continue for a considerable time before any physical signs can be elicited. These exudative, infiltrated areas may be single tubercles or groups of tubercles; if such grouping or coalescing of tubercles takes place, the presence of a caseous bronchopneumonia will occur and this is often followed by cavitation if the disease is not arrested. The early exudative lesion produces a soft shadow on the roentgen film; it is a rather soft, slightly dense, rather circumscribed area of varying size, while many grouped together constitute a large conglomerated shadow of the same character. The location of such chest shadows is of extreme importance. In the vast majority of cases, they will be found in the infraclavicular region or the apex of the lungs and well out toward the periphery, and in children, they are always accompanied by enlarged hilus lymph glands. Occasionally, this pathological change is located at the hilus and constitutes a typical hilus tuberculosis. Occasionally, the lesion may be primarily at the base, and such a lesion is extremely difficult to diagnose. Pleurisy frequently accompanies a chest infection due to tuberculosis, and most

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cases of pleurisy with effusion of questionable etiology, particularly when there are repeated attacks, are due to this disease. Many times, no other signs in the chest can be elicited, either by physical or roentgen examination.

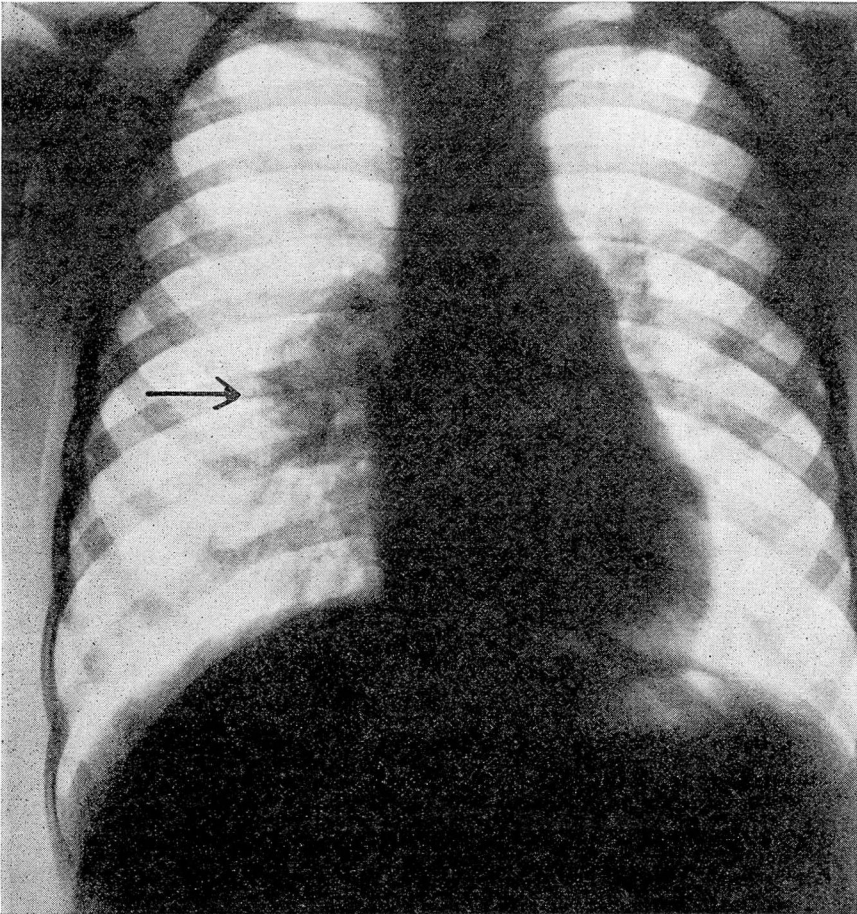


FIGURE 5.—Hilar pulmonary tuberculosis, glandular type.

Cavities may be well seen on roentgenograms of the chest and usually they have a thick, indurated wall and may contain some secretion. It is now a well established fact that so-called annular shadows seen on the roentgenogram are all evidence of a tuberculous process. A thickened pleura and the presence of fluid produces a homogenous shadow which is well visualized on the roentgenogram. It is essential that films be made of the mediastinum for the demonstration of mediastinal tuberculosis and enlarged glands. Allergy may result from tuberculosis,

producing a soft infiltration of the exudative type and giving the appearance of an extensive tuberculous lesion. This should always be considered as it will clear up very promptly in many cases and show only a small primary tuberculous area of involvement. This should not be mistaken for extensive healing of a pulmonary tuberculosis and cause the physician to curtail adequate rest and proper management of the patient. Likewise, large tuberculous glands and extensive fibrous infiltration, of which we will speak subsequently, may obstruct a bronchus and result in varying degrees of atelectasis, which also may be mistaken for an extension of the involvement. All these factors should be borne in mind and considered carefully before an opinion of the extent of the lesion is offered.

The roentgen appearance of various types of tuberculosis is shown in figures 1 to 7.

*Tuberculin:* The use of tuberculin in the diagnosis of tuberculosis was first suggested by Richard Koch and has been in use for forty years. This test is perhaps most valuable in children and if the reaction is positive in a child under five years of age, it should be considered of greater significance than in older children, although there are exceptions to this rule. The number of children with positive reactions varies in different localities—in rural areas sometimes as low as ten per cent and in congested areas, as high as forty per cent. If the reaction is positive, a roentgen examination of the chest should be made to ascertain whether an active involvement is present. If abnormal changes in the lung are found, members of the family, schoolmates, and associates should be examined, and further contact of the infected individual with normal children should be terminated. The disease may often be found in persons who present no symptoms whatever.

*Blood Sedimentation Rate:* This test has no definite diagnostic value in the presence of pulmonary tuberculosis, as it may be elevated in diseases other than tuberculosis, particularly in lesions of the inflammatory type. If a patient has a positive sputum, no further diagnostic test is necessary. The sedimentation rate is of value, however, in determining the activity of the lesion and may be helpful in giving information about the progress of the disease. If the rate becomes lower or normal, this information is helpful in governing the management of the patient.

#### TUBERCULOSIS IN CHILDREN

Autopsies usually show that there is involvement of the bronchial glands in nearly 100 per cent of all children less than one year of age who die from tuberculosis. The lungs are found to be involved in 97 per cent of cases. Therefore, it may be stated that tuberculosis in infants

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involves (1) the right pretracheobronchial group, (2) the intertracheobronchial group, and (3) the peribronchial group. All these groups communicate freely among themselves and also with the lymphatics of the trachea, bronchi, lungs, and pleura, with the small subpleural glands, with the cervical gland chain, and with the sub- and supradiaphragmatic group. The lymph which passes through them ebbs and flows

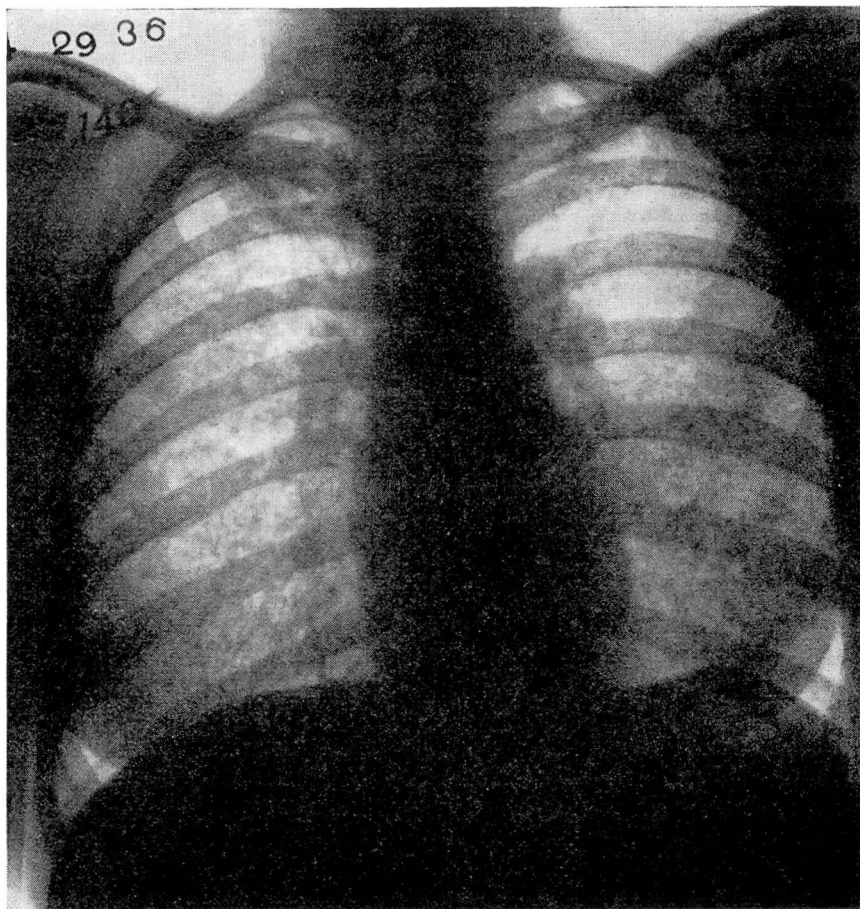


FIGURE 6.—Miliary pulmonary tuberculosis.

like a tide between the center and the periphery. Their whole principal mass, to repeat the simile of Weleminsky, is like a lymphatic heart, alternately dilated and contracted by the movements of the lung and the pulsations of the aortic arch.

In tuberculosis of childhood it is fair to assume that consequent to a tracheobronchial infection, whether of primary or secondary origin,

there almost always appears a more or less discrete or confluent eruption of tubercles in one or several of the innumerable lymph follicles in the zones of pulmonary parenchyma which are bathed by lymph—these are the so-called “Gohns.” These in turn may go through the stages of repair and leave isolated calcific areas in the periphera, or may be entirely removed.

### CHRONIC OR SENILE TUBERCULOSIS

This disease is not uncommon in patients past sixty years of age and statistics derived from postmortem studies show it to be of frequent occurrence. It usually takes a particular form of chronicity which is often termed essential asthma, emphysema, or chronic bronchitis. The disease is insidious, tending to progress slowly, and the symptoms are mild. Care should be taken to rule it out in most of the chronic lung infections of advanced life, as many times these individuals are carriers of the disease. In all elderly individuals with a chronic cough, a roentgen examination of the chest and careful examination of the sputum should be made, as open cases of chronic tuberculosis are a great danger to the health of our population, particularly the unrecognized case.

### TREATMENT

There have been many advances in the treatment of tuberculosis and it might be profitable to review a few of these. Rest in bed is perhaps the basic method of treatment as well as the oldest of all the remedial measures. It might be better to consider this as the first step in the management of a patient with pulmonary tuberculosis. In many patients with early manifestations, the disease will be arrested and cured by this method alone, and a small number of cavities may be spontaneously healed by such management. This treatment, however, is wholly inadequate for a large group of patients with pulmonary tuberculosis.

At the present time, artificial pneumothorax is probably the most useful procedure in addition to rest in bed. By this method, active lesions are compressed and the sputum is rendered free from bacteria. This not only expedites the cure of the patient, but also does much to prevent spread of the disease. Phrenic exeresis which is done either by resection of the phrenic nerve or crushing, puts the lung completely at rest and has produced very beneficial results in many cases. Both these methods of treatment are particularly applicable in unilateral lesions as it is not usually practical to destroy both phrenic nerves or do a bilateral collapse. The use of a foreign substance such as an oil preparation known as oleothorax has been employed in the pneumothorax cavity. Large masses of paraffin have also been introduced to continue the compression and keep the lung collapsed permanently.

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In the more advanced cases, thorocoplasty is sometimes resorted to. By this operation the ribs are removed on one side and the lung is completely and permanently collapsed.

### ROENTGENOTHERAPY

The treatment of pulmonary tuberculosis by roentgenotherapy has not been successful in the usual type of pulmonary tuberculosis. How-

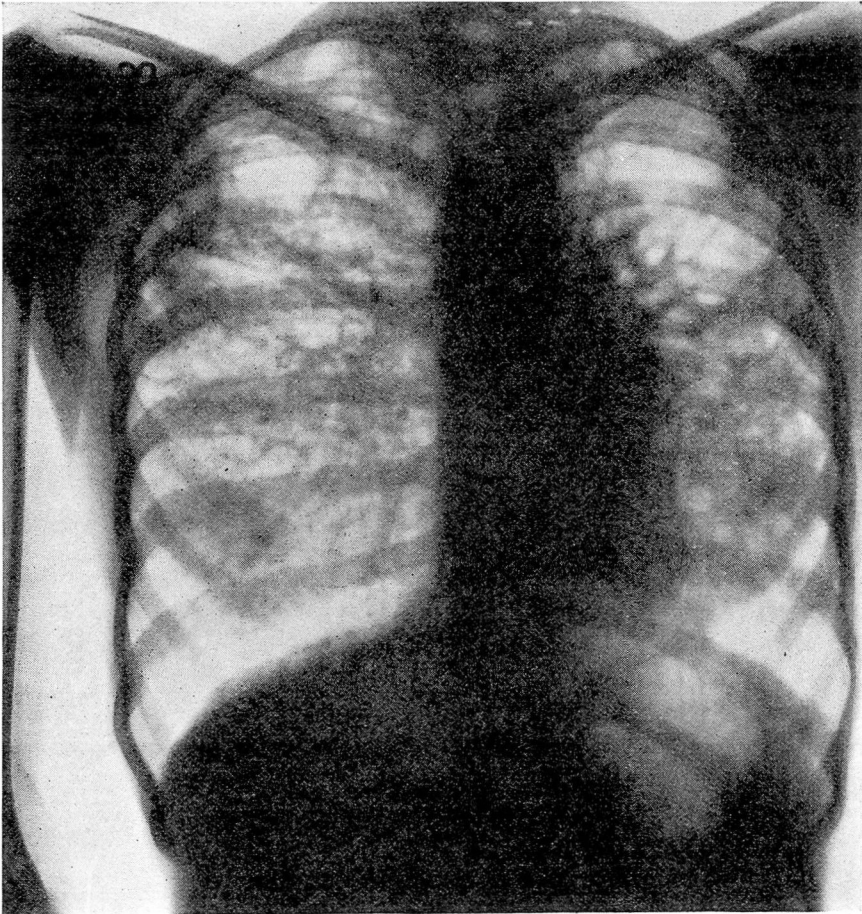


FIGURE 7.—Pulmonary tuberculosis, fibroid type.

ever, in tuberculosis of the hilus glands, particularly in children, we have secured splendid results in reduction of the glands and relief of the cough and other accompanying symptoms. This result is, we believe, akin to the treatment of tuberculous glands of the neck, a disease which has almost been eradicated by the elimination of tuberculous cattle from public milk supplies.

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*Climate:* The question of the choice of a suitable climate always comes up in the treatment of tuberculosis. If we consider that the vast majority of cases of pulmonary tuberculosis occur in persons who live in congested areas—a penalty perhaps for our collective mass civilization—we could then believe that any area rather remote or isolated with an equitable climate would be most suitable; that is, a place more or less free from bacteria. This must be taken into consideration because, undoubtedly in most patients suffering from tuberculosis, a mixed infection sooner or later develops which probably accounts for the fatal termination in the majority of cases. Therefore, in many instances, patients under carefully supervised management may do well at home or in a well organized sanitarium irrespective of the climate.

In closing, we would like to emphasize the fact that the two most important factors in the diagnosis of both early and advanced pulmonary tuberculosis are the finding of pulmonary tubercle bacilli in the sputum or properly made and correctly interpreted, positive roentgenograms of the chest, or even more conclusive evidence is a combination of these. Many times, however, the sputum test has to be repeated a number of times before the organisms are found, while only a single roentgen examination is necessary. The physician should keep this disease in mind at all times and, if this is done and if individuals known to have been exposed to the infection are properly examined, much may be done to eliminate pulmonary tuberculosis.