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THE RADIOGRAPHIC DIAGNOSIS AND CLASSIFICATION OF EARLY PULMONARY TUBERCULOSIS.

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It is acknowledged by nearly all physicians that in making the early and positive diagnosis of pulmonary tuberculosis lies the only hope of permanent cure. Much time and energy have been expended in the search for a specific when the specific was at hand and free to all, and very positive in cases in which the diagnosis is made as early and positively as it may be made by radiographic examination.

Symptomatology. If pathology is the foundation of all diseases, then symptomatology is the superstructure that we all see and feel and causes the patient to consult the physician. The subjective symptoms vary extensively on account of the observation of the patient and his methods of description, and there are great variations of symptoms caused by similar pathological lesions. Leading questions are asked by the physician, and some will record one symptom and some another. The history often resembles the physician who records it, rather than the patient who makes it.

Objective Symptoms. Objective symptoms depend very largely on the observations of the physician. Routine examination will often improve one's power of observation, but a "Sherlock Holmes," though a layman, may observe many symptoms that escape the attention of even a trained "Dr. Watson," but the careful observer may not be able to attribute the proper value to the symptoms.

Hemoptysis. Hemoptysis is such an important symptom that it deserves special mention. It may be one of the first symptoms of acute infection, or it may be caused by old calcified tubercles scratching through the bronchial membrane (Fig. 20, I).

Physical Signs. Very closely associated with the objective symptoms are the physical signs. They have been, and always will be, the sheet anchor of pulmonary diagnosis; and on account of its being a tool that every physician has, it should be used to its utmost capacity. I have made several series of radiograms of cases that had previously been examined by some of the most eminent physical diagnosticians in New York, and I think that all of them admit the value of the *x*-rays. Some of them rely very largely on the radiographic findings to determine whether radical treatment is necessary in border line cases; and one of the most eminent diagnosticians has modified his interpretation of the physical signs, especially the "harshness of breath sounds."

Physical signs may be divided into distinct classes: (1) Those which are directly the result of tuberculous infiltration, such as, dulness, increased fremitus, and changes in voice and breathing. These are the real physical signs of tuberculous infiltration and consolidation, and naturally do not occur until the process has passed out of

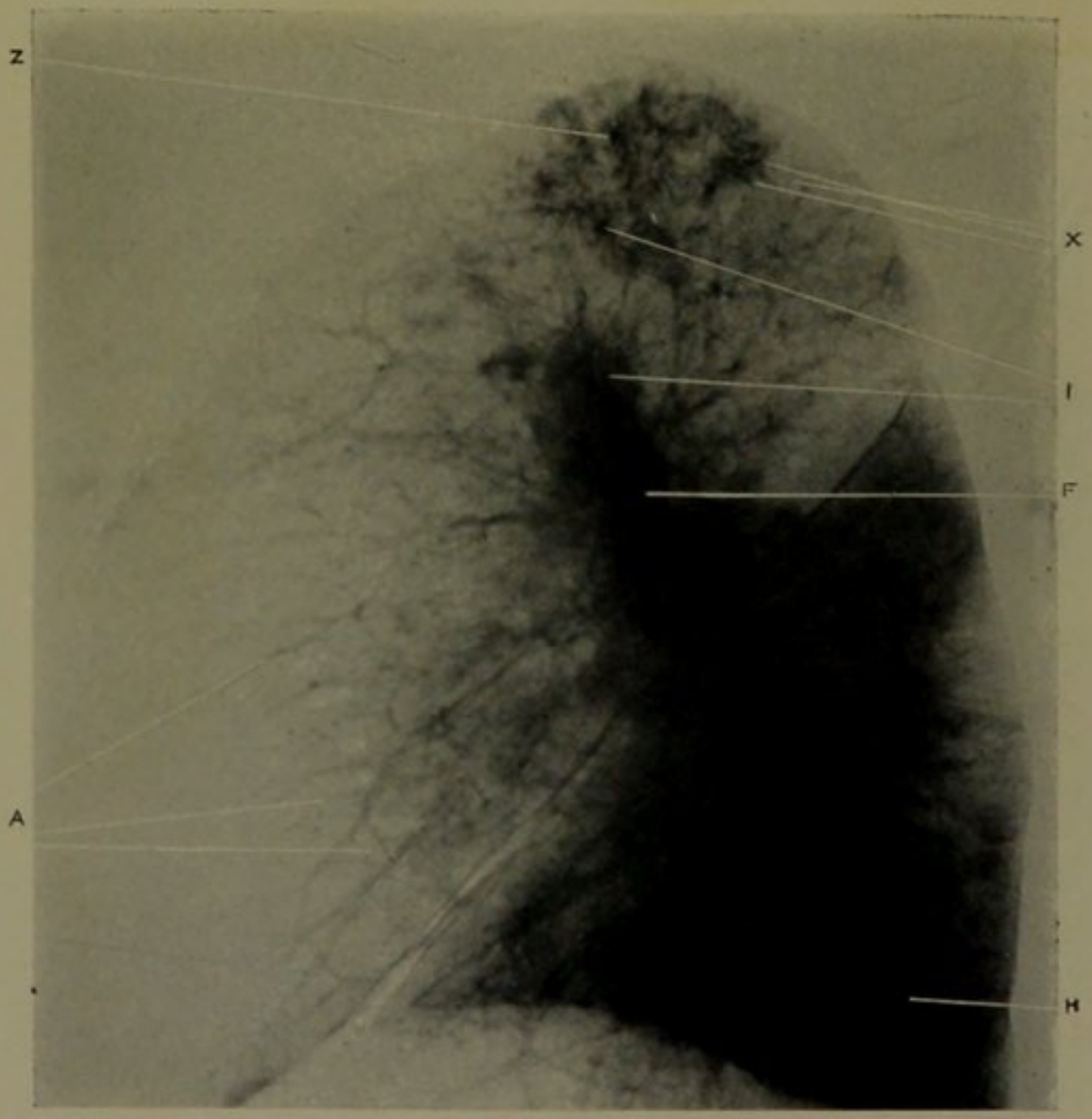


FIG. 1.—Radiogram of a lung which had been removed from the body and inflated to about the normal extent. The lower lobe shows the earliest stage of congestion, preceding a pneumonic process which had extended from the opposite side. *A*, normal markings of the lung; *F*, thickening around the root; *I*, old calcified tubercles. The apex shows infiltration, and isolated (*X*) and conglomerate (*Z*) tubercles, and (*H*) consolidation. This figure shows about the same detail which one is able to obtain in a favorable living subject.

the stage of incipiency. (2) The physical signs on which the diagnosis of incipient tuberculosis is based, such as slight localized rales, or "clicks," as they are sometimes called; these are not the physical signs of infiltration or consolidation, but the signs of a localized pleurisy or bronchitis which may or may not be of tuberculous origin. On the other hand, this localized bronchitis or pleurisy may not occur until the tuberculous process has reached

such an advanced stage that it is accompanied by dulness and increase of voice and breathing, and by that time the process has reached a stage in which pathologically or radiographically it could not be considered in its incipiency.

About once in three or four times, in equivocal cases, we find a patient in whom the bronchitis has not developed, or at least has not been discovered, until the infiltration is well marked radiographically,

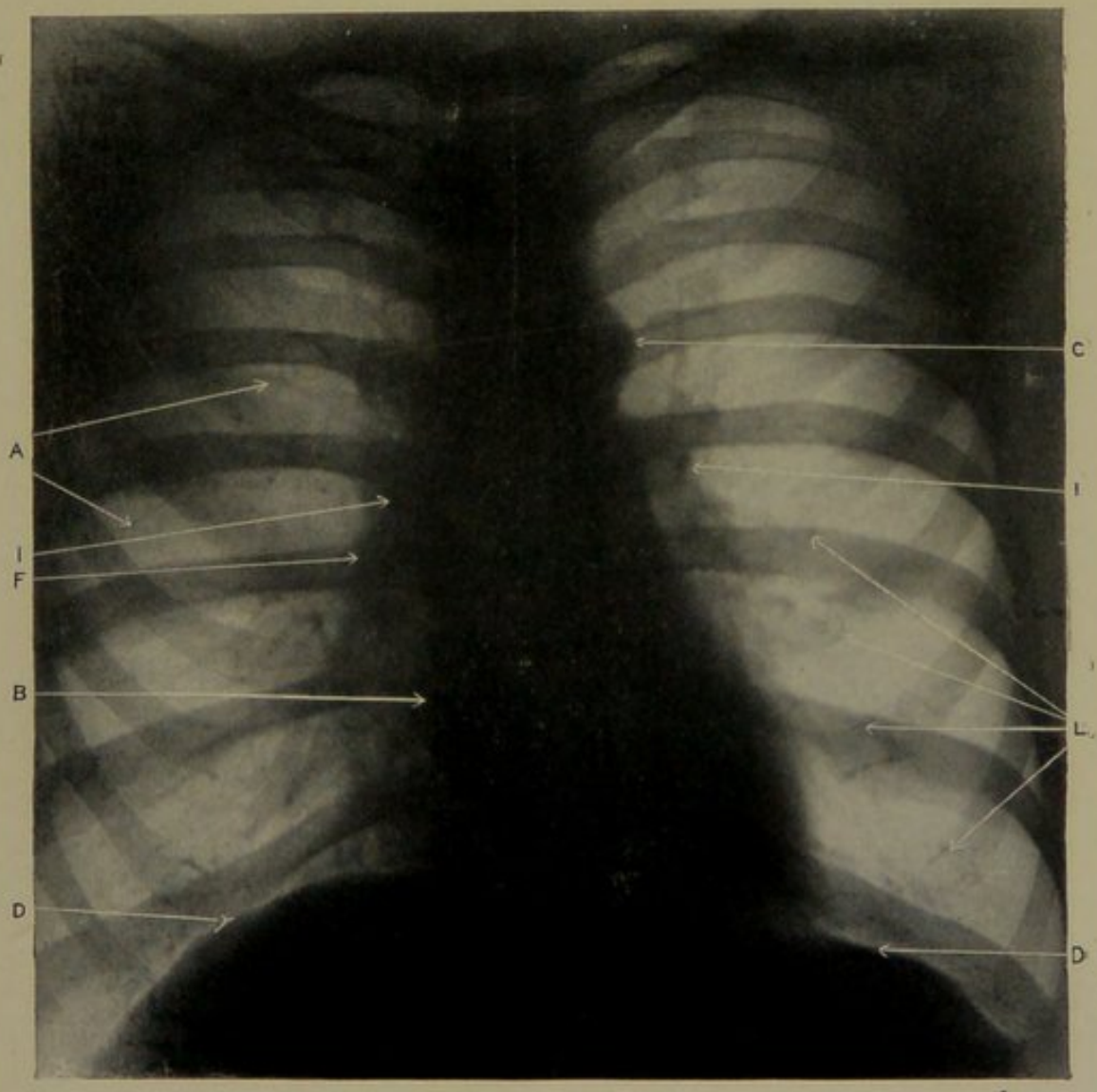


FIG. 2.—Radiogram of a lung which is as nearly normal as any I have ever seen, and shows the followng detail (both lungs being equally aërated): *A* normal markings of the lungs; *B*, border of heart, shows distinctly, normal in size, shape, and position; *D*, dome of diaphragm; *F*, root of lung; *I*, calcified tubercles; *L*, calcified costal cartilages. It is possible to obtain this detail in a patient of moderate size, when the aëration of the lung is complete.

and yet the process has not reached a stage that will give dulness or increase in voice or breathing. This is especially true when the process is a direct extension from the root or is located posteriorly under the scapula.

I have been criticised for stating that certain plates showed individual miliary tubercles. That there may be no misunderstanding of the term "miliary tubercles," I quote the definition of

miliary tubercles from Delafield and Prudden:[1] "Miliary tubercles are small nodules of irregularly spheroidal shape, the smallest hardly visible to the naked eye, the largest as large as a pea." "The term miliary tubercle, which arose from the crude coincidence in size between small foci of tuberculous inflammation and some forms of millet seeds, is now liberally applied to tubercles which are much larger as well as those which are much smaller than millet seeds."

In speaking of miliary tubercles, I refer to those of moderate size, which on cross section of the lungs appear as grayish-white

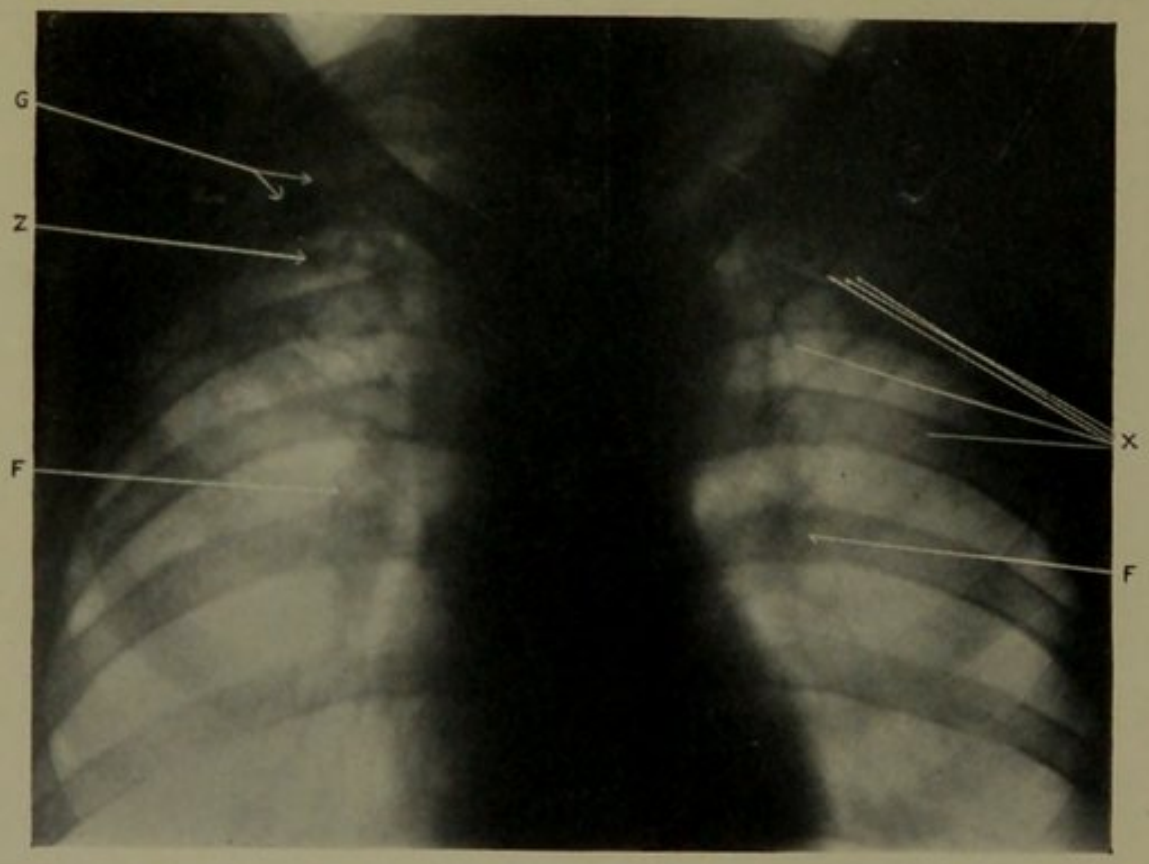


FIG. 3.—Symptoms were classical of a tuberculous process. Physical signs indicated an incipient lesion at the left apex; the right apex was *normal*. There was diminished aëration of both apices; the heart was normal in size, shape, and position; the diaphragm is not shown. *F*, thickening around both roots, typically tuberculous; *G*, infiltration of both apices with large, soft, isolated (*X*) and conglomerate (*Z*) tubercles, indicating an exudative type of infection. The process is a little more advanced on the left side, where the physical signs were found, but more extensive in the right, where there were no physical signs. *X*, isolated tubercles; *Z*, conglomerate tubercles.

nodules about the size of a pin head. Pathologically these are composed of exudate or productive tissue in a number of adjoining air cells. In studying them radiographically they are compared in density with the air which should normally fill those cells, instead of tissue of similar density, as is the case in tuberculous infection in any other part of the body. This is the reason why individual tubercles show in the lung and not in any other tissue in the body. It is universally admitted that the larger necrotic and calcareous

[1] Pathology, p. 216.

tubercles show; I do not claim to show the microscopic ones. But it is the intermediate tubercles, the smallest ones that are clearly discernible by the naked eye on the cross section, those that give the "shotty" feeling to the cut surface of the lung, that show distinctly in a radiogram having sufficient detail. It is on these tubercles that the positive diagnosis of incipient pulmonary tuberculosis by the *x*-rays depends.

Sputum Examination. The diagnosis is absolutely positive if the tubercle bacilli are found in the sputum, but they are usually not found until physical signs have developed and the disease has passed

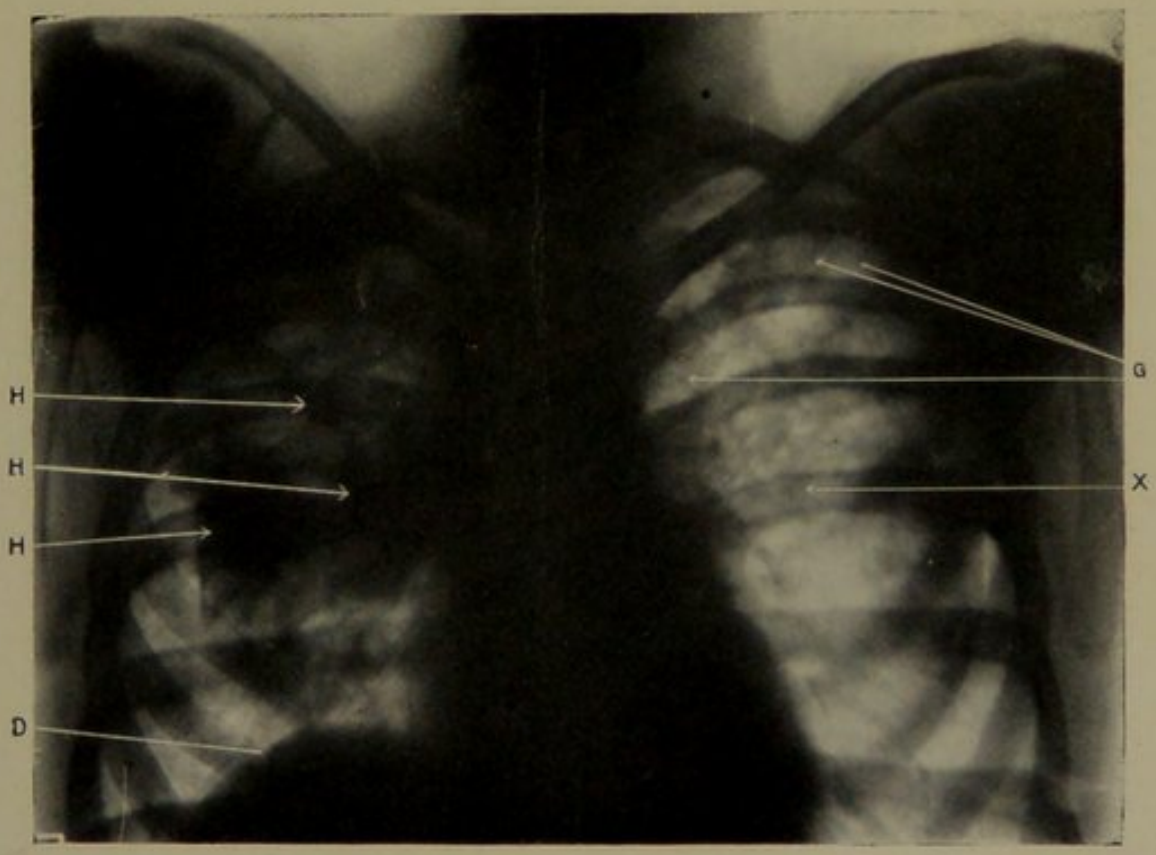


Fig. 4.—The symptoms and physical signs were classical in this case, and there were tubercle bacilli in the sputum. The plate is shown only to illustrate a typical exudative process in the stage of consolidation. There was diminished aëration of both lungs. The heart was normal in size, shape and position. *D*, diaphragm retracted on the right side (Williams' sign); *G*, infiltration of the left lung; *H*, three small areas of complete consolidation of the right lung; *X*, isolated tubercles in the left lung.

out of the stage of incipiency. One is certainly not justified in waiting until they are found before making a diagnosis.

Tuberculin Tests. The tuberculin tests are the greatest aid in determining the presence of a tuberculous process somewhere in the body. It is manifestly not within the scope of this paper to discuss the dangers and value of these tests except as compared with radiography.

Von Pirquet states that during a year and a half he made a cutaneous test on all the children who were admitted to the children's clinic of Professor Escherich in Vienna, and that 93 per cent. of the children, fourteen years of age, reacted to the tests, and in only

13 per cent. was there manifest tuberculosis. This corresponds so accurately with the radiographic findings that it would be interesting to know what part of the 87 per cent. that showed no manifest lesion would have shown a distinct lesion around the root of the lung on radiographic examination. Unfortunately the tuberculin tests do not show the activity, location, or extent of the lesion.

The search for a specific which has resulted in the tuberculin tests led out of the rut of symptomatology and physical diagnosis, opened up a new field of laboratory tests, and created a demand for more accurate methods of diagnosis.

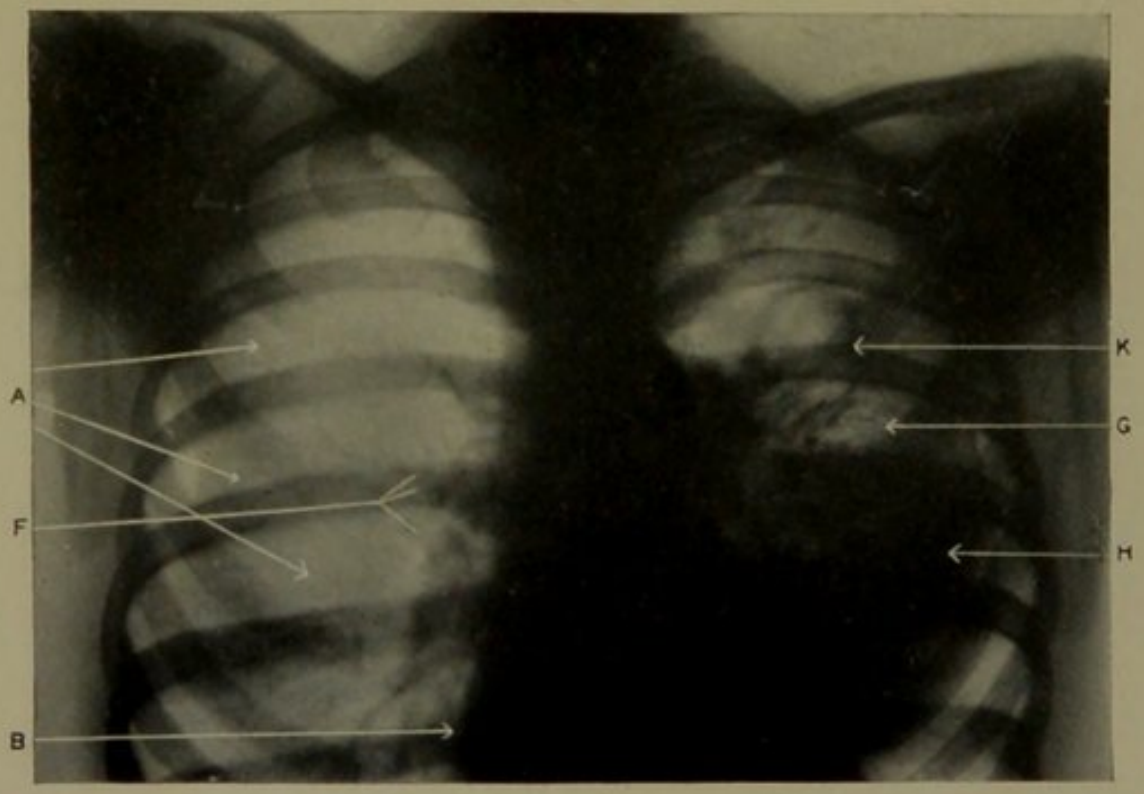


FIG. 5.—Is one of a patient with typical symptoms of pulmonary tuberculosis. Physical signs indicated only a slight involvement. The radiogram, however, showed the following detail: *A*, normal markings of the lungs show fairly distinctly; *B*, heart normal in size, shape, and position; *F*, typical mottled infiltration around the right root, which is the only indication of infection on the right side; *G*, infiltration of the middle of the left lung, below which the process has reached the stage of consolidation (*H*), and above which is a cavity (*K*) about 3 cm. in diameter.

The Röntgen rays presented themselves as a candidate before the technique of making radiograms was perfected; attempts were made to use them either fluoroscopically or radiographically in the diagnosis of pulmonary lesions, and much was claimed for them that could not then be substantiated. The whole field of Röntgenology savored just enough of the magic art to be a fertile field for fakirs and charlatans. Many physicians who had failed in other branches of medicine flocked into this without any instruction or experience; and many of them did not know the first principles of electricity or photography, and only a moderate amount of medicine. Some general practitioners, with little or no experience, would look

in a fluoroscope and claim to see things that an experienced operator knew could not be seen; while others would make radiograms of advanced lesions that could readily be diagnosticated by other methods.

During the evolution of Röntgenology its advocates were divided into two camps—those who favored fluoroscopy, and those who favored radiography; strange as it may seem, few were successful with both methods. The Austrians are the most ardent supporters of the fluoroscopic method. Dr Williams, of Boston, is one of the greatest devotees in this country, and Dr. Minor,[2] of Ashville, Tenn., has just written an article on this method of chest examination. The advantages of this method, as enumerated by Dr. Minor, are as

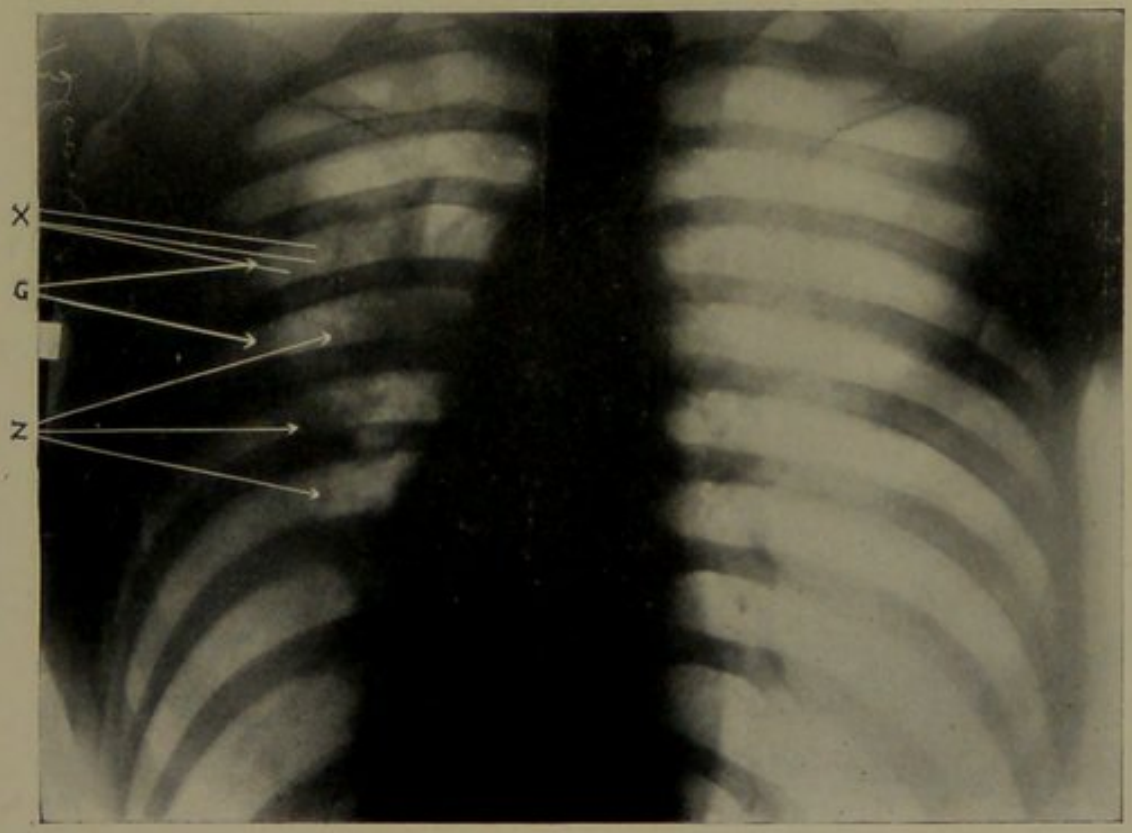


FIG. 6.—Posterior view of the same patient as shown in Fig. 5; the cavity, being nearer the anterior wall of the chest, does not show in this figure. The infiltration has not reached the stage of consolidation posteriorly, but shows the typically mottled appearance of a tuberculous infiltration, (*G*); *X*, small, isolated tubercles; *Z*, large, conglomerate tubercles.

follows: Fluoroscopy is much less work, can be done by any general practitioner who has a static machine or small coil, only requires one tube which may be used for any number of exposures, and is, therefore, much less expensive. There are no plates to be developed, and it does not show the normal markings of the lung, which he says are so confusing to one unfamiliar with such examination.

Dr. Minor states that tuberculous processes are detected about as soon by this method as by a keen physical examination. He admits that radiograms may be made that show a tuberculous process much earlier than can be shown fluoroscopically or by physical examination,

[2] The American Treatise on Tuberculosis, edited by Arnold Klebs.

but he also says that such radiograms must be made and interpreted by one who is experienced in this line of work. I believe all his points are well taken, but would call attention to the following disadvantages of fluoroscopy: The risk to the operator is too important to be disregarded; he has only the impression gained from a few seconds, or minutes at most, and the personal equation of what he sees and what he does not see is an important factor. Only the grossest and more advanced lesions may be diagnosticated by this method.

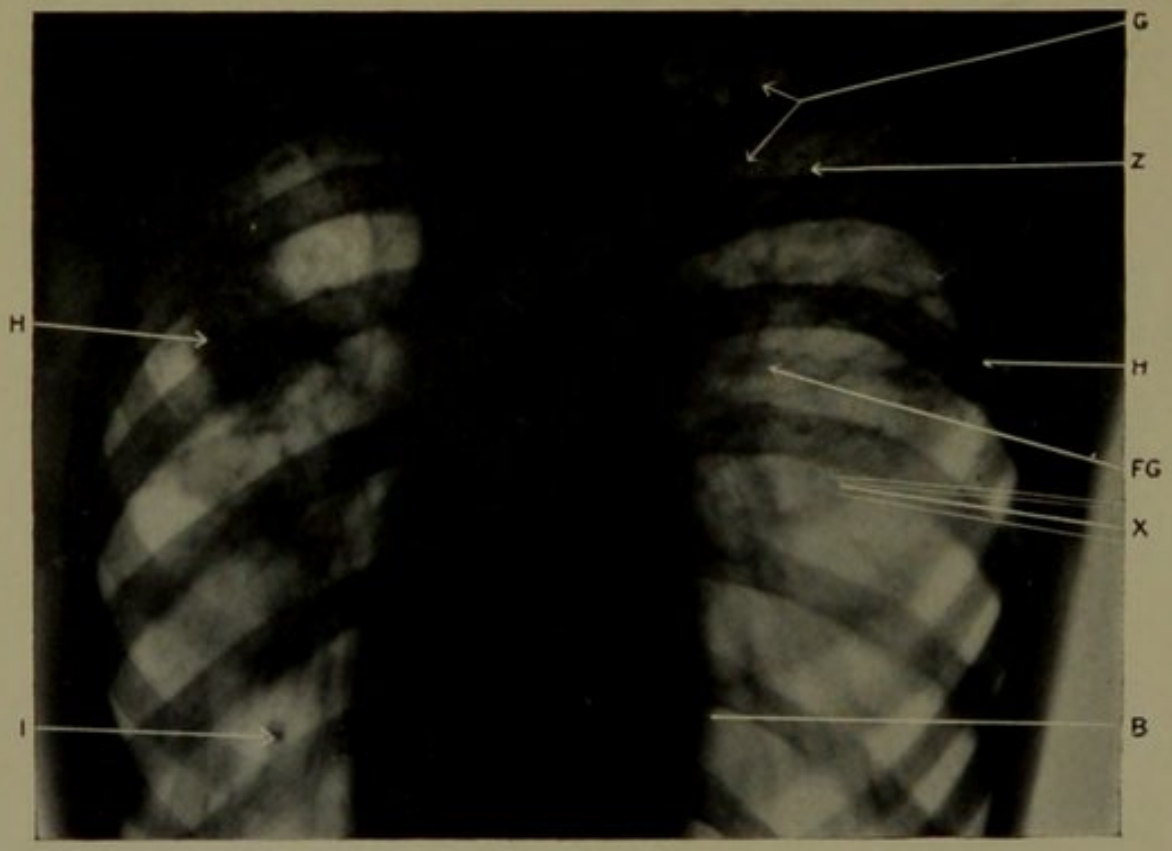


FIG. 7.—This case was radiographed to show an œsophageal stricture; although there were slight physical signs, they were not considered of importance. Radiographic findings: Diminished aëration of the entire right lung and left apex; *B*, heart is drawn into the vertical position—Hickey's symptom; *F G*, thickening around both roots; *G*, tuberculous infiltration of both lungs, more advanced on the right side, behind. The lesion in the right apex illustrates a typical subacute productive process as indicated by infiltration (*G*); *H*, small areas of consolidation in both lungs; *I*, isolated, calcified tubercles; *X*, isolated fibrous tubercles; *Z*, conglomerate tubercles.

The advantages of radiography are as follows: Radiograms may be made without risk to the operator or patient; one has a permanent record which he may study at leisure and compare with radiograms of similar cases, and save to compare with radiograms made at a later stage, to show whether the process is advancing, held in check, or resolving, and many of the cases do resolve. A radiogram may also be used to persuade a patient, who has few symptoms or physical signs, that radical treatment is necessary.

Dr. Minor says the radiogram gives such a wealth of detail that it is confusing and difficult of interpretation, and therefore, the fluoroscopic method is better. It seems just as rational to discard the

high power microscope because of the increased detail it gives. It is just the interpretation of this wealth of detail that enables one to make the diagnosis of tuberculosis by radiographic examination very much earlier than by fluoroscopic methods or physical diagnosis.

Rieder in Europe (Munich) and Hulst in America (Grand Rapids, Mich.) were the pioneer workers in rapid radiography of the chest, and much credit is due them; but both used the high vacuum method that does not combine the wealth of detail with the contrast that can be obtained with the low vacuum tube advocated by Leonard.

The following factors are important in the development of soft tissue radiography. (1) The perfecting of the apparatus that enables one to make radiograms of the chest while the patient holds the breath, or even during the diastole of the heart. (2) The improvement in technique, especially as regards the separation of the direct, indirect, and secondary or Sagnac rays.[3] (3) The selection of a tube suitable for the apparatus used and the seasoning of that tube so that it generates a large percentage of direct rays and enables one to make radiograms that show distinctly the muscle, fat, connective tissue, and even the blood in the veins at the anastomosis of the knee and elbow. This seemed to open up the field of soft tissue radiography, and the lungs offered the most fertile field for its application.

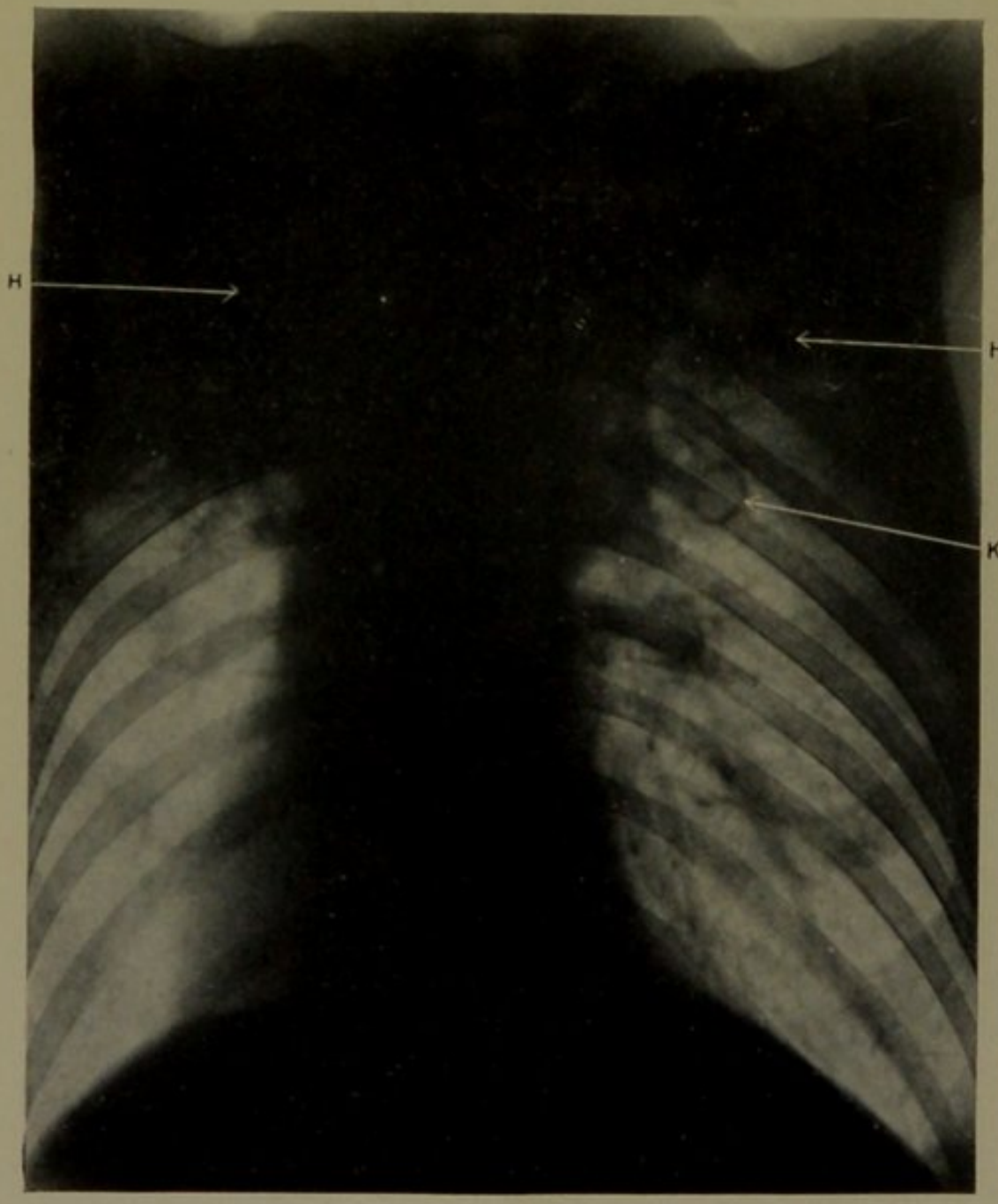
During the winter of 1904–05 I made about one hundred radiograms of incipient or early cases of tuberculosis. Many of the patients were referred from the Vanderbilt clinic after a careful physical examination had been made and recorded by Dr. Austin Riggs and at least one or two other members of the medical staff. If they all agreed as to the physical signs, the case was only radiographed to show the more advanced lesions; if they disagreed either on the character or location of the signs, the patients were radiographed and later the radiographic findings were compared with the physical signs.

In every case in which the physical signs were present a well-defined lesion was found in the radiogram, and in many cases there were lesions in the opposite lung that gave no physical signs. This occurred in so many cases that I hesitated to make a diagnosis of tuberculosis, and decided to make radiograms of lungs post mortem. Specimens were selected that had been removed from the thorax without tearing the pleura, they were drained of as much of the œdematous fluid as possible, inflated to about the extent of normal inspiration, and radiographed. These radiograms, one of which is shown in Fig. 1, showed just about the same detail that it is possible to obtain in a favorable living subject (Fig. 2), and shadows similar to those seen in the cases from the Vanderbilt clinic were found in all these lungs.

[3] Archives of the Röntgen Ray and Allied Phenomena, May, 1905. Archives of Physiological Therapy, December, 1906.

The specimens were then sectioned and compared with the radiograms; in most of the cases the lesions were readily found and identified as tuberculous.

FIG. 8

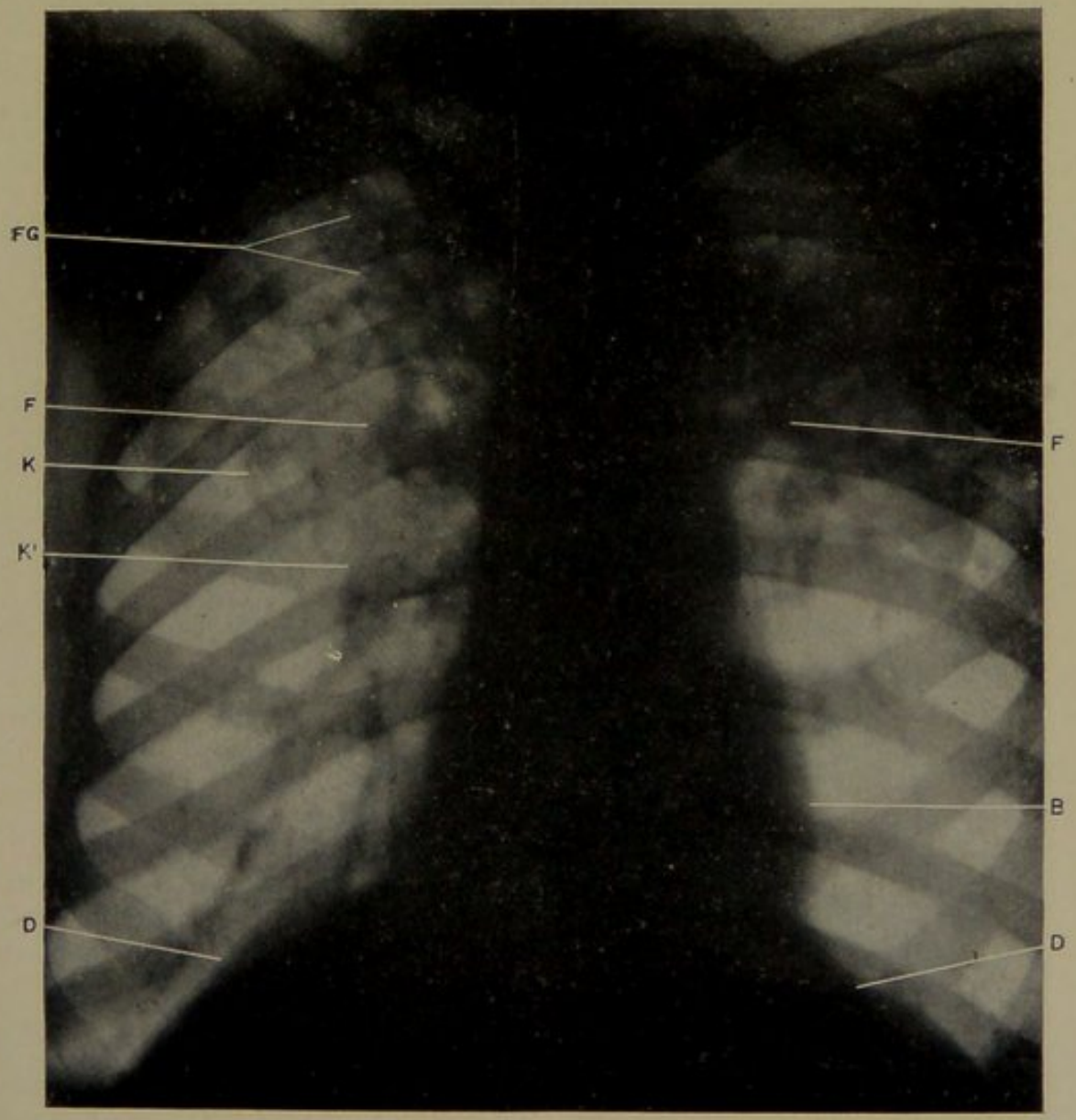


FIGS. 8 and 9.—This is a test case to compare the relative value of radiography and physical who found signs of consolidation at the left apex, but made a negative diagnosis of any more marked on the left than on the right; *B*, heart drawn into the vertical position *H*, consolidation of the left apex, more marked behind; *FG*, infiltration of the right upper with exudate; *K*, bronchiectasis, empty. It would hardly seem possible for a tuberculous but Fig. 10 is a similar case which escaped detection by one of the keenest diagnosticians

But some of the shadows, that resembled isolated tubercles scattered through the lung, were caused by one small bronchus or bloodvessel crossing the other, as seen on end section. One specimen of a child's lung appeared normal on external exami-

nation, but the radiogram showed several distinct old calcified lesions. On careful cross section these were not found, and the lungs were reported normal by the pathologist. Fortunately the

FIG. 9



signs. The physical examination was made and recorded by a very competent diagnostician. involvement of the right side. Radiographic findings: Diminished aëration of both apices, (Hickey's sign of tuberculosis); *D*, diaphragm retracted ; *F*, thickening around both roots; lobe, small area of consolidation; K^1, dilatation of the right descending bronchus filled process to reach the stage that is shown in the right lung without giving physical signs, in this city.

sections were saved, and when these spots were localized by sticking hat pins in at different angles and making more radiograms, they were readily located; and when they were examined microscopically, thev were reported as being tuberculous.

To the ultra scientific man this examination was unsatisfactory because the lungs had been removed from the thorax. I therefore tried to radiograph corpses at the morgue, just before autopsy, and other cases were radiographed immediately before and after death; but all these radiograms had the same appearance, and did not

FIG. 10.—Illustrates how extensive a tuberculous process may exist without one of the keenest physical diagnosticians being able to detect it. A process had been detected at the right apex, and the patient was radiographed to determine whether there was a cavity. Physical signs of a cavity at the right apex. Equivocal signs above the clavicle on the left side, no physical signs below. Radiographic findings: Diminished aëration over both lobes, more marked on the right side; *B*, heart small; *D*, diaphragm normal; *F*, typical tuberculous infiltration around both roots; *G*, infiltration of the entire right lobe; *K*, ill-defined cavity at the right apex.

resemble the lung in the living subject as closely as did the inflated lung. It is largely on this series of radiograms of postmortem specimens that the interpretation of the accompanying plates is based.

Radiographically the following varieties of lesions may be recognized, but how accurately these coincide with the pathological classifications can only be proved by further pathological radiography.

CLASSIFICATION I.

- **Acute and subacute.**
  - **1. Exudative.**
    1. Isolated tubercules, large and soft (Fig. 3, *X*).
    2. Conglomerate tubercules (Fig. 3, *Z*, and Fig. 6, *Z*).
    3. Consolidation: large areas of consolidation surrounded by soft tubercles (Fig. 4, *H*).
  - **2. Productive.**
    1. Small isolated tubercles with clear-cut, well-defined edges (Fig. 7, *X*).
    2. Union of three or four tubercules to form a conglomerate tubercule (Fig. 7, *Z*).
    3. Small areas of consolidation (Fig. 7, *H*).
    4. Fibrous appearance extending from the root and connecting areas of consolidation (Fig. 7, *F*, *G*, and Fig. 9, *F*, *G*).
    5. Complete consolidation (Fig. 8, *H*).
  - **3. Necrotic Cavity.**
    - Single (Fig. 5, *K*).
    - Multiple (Fig. 11, *K*.)
    - Full of exudate (Fig. 11, *K*).
    - Empty (Fig. 5, *K*).
    - Without thickened walls (Fig. 11, *K*).
    - With thickened, calcified walls (Fig. 5, *K*).
- **Chronic.**
  - **Miliary.** Small, clear-cut, well-defined isolated tubercules involving the greater part of both lungs without consolidation (Fig. 12).
  - **Fibroid.** Fibrous consolidation with retraction of the ribs and diaphragm and displacement of the heart (Fig. 13).
  - **Calcareous.** Few, scattered, calcified tubercles at the right apex (Fig. 21, *I*). Group of calcified tubercles around the root causing hemoptysis (Fig. 20, *Z*).

The pure type of each of these varieties may readily be differentiated from one another, but when the exudative and productive processes are each present to about the same extent, it is difficult to state which is which. Necrosis may occur in either exudative or productive processes, and the calcareous deposits represent old healed lesions of either type. The acute or subacute exudative tuberculosis process is recognized radiographically in its early stage by large, soft, isolated tubercules (Fig. 3, *X*), the edges of which are not clear cut and well defined. It has a great tendency, even in the early stage, to the formation of conglomerate tubercles (Fig. 3, *Z*) or small areas of consolidation. These go on rapidly to the typical form indicated by small areas of consolidation (Fig. 4, *H*) surrounded by large, soft, individual, or conglomerate tubercles. This variety of lesion may reach the stage of almost complete consolidation before the keenest ear detects the physical signs. Note the history under Fig. 3.

The subacute productive process is most typical in the early stage. The tubercles (Fig. 7, *X*) are small, dense, more isolated, and their edges are clear cut and well defined; and where several unite to form a conglomerate tubercle (Fig. 7, *Z*) they do not lose their identity. It does not go on rapidly to the stage of consolidation (Fig. 7, *H*), and the areas where it does occur are small and circumscribed; it can readily be traced back to the extension from the root

by the fibrous appearance (Fig. 7, *FG*) that radiates from the root and connects the areas of consolidation.

The productive process may reach the stage of infiltration, or even consolidation (Fig. 8, *H*), or with cavities (Fig. 8, *K*), before physical signs develop, as is illustrated in Figs. 8, 9, and 10; in these cases the most careful physical examinations were made.

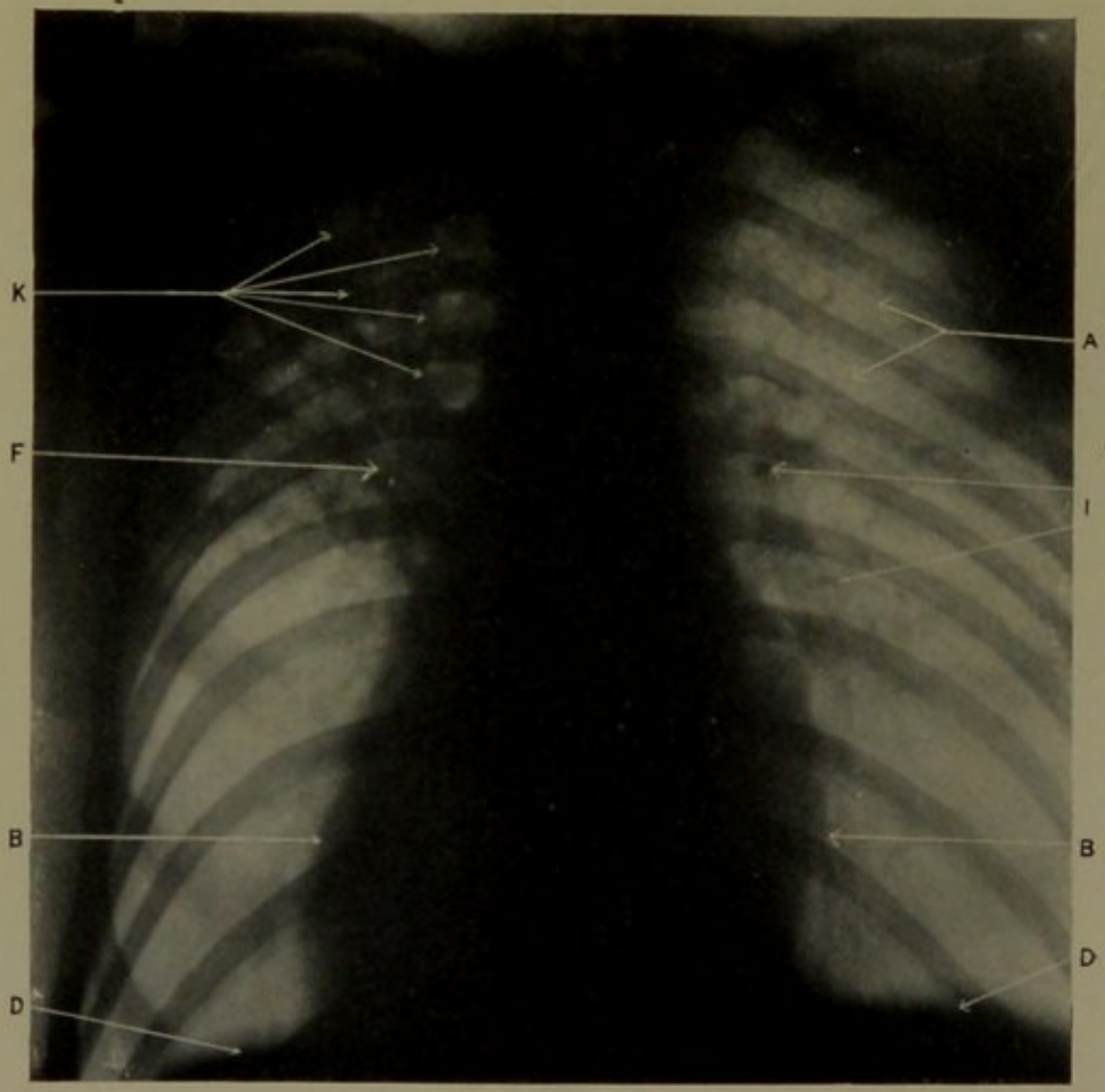


FIG. 11.—The history was typical of mixed infection with high temperature, sweats, cough, and expectoration; and physical signs of consolidation and cavity formation. This figure is to illustrate the necrotic type of infection. Posterior view: Diminished aëration at both apices, more marked on the left; *A*, normal markings; *B*, heart normal in size and shape and drawn somewhat into the vertical position; *D*, diaphragm normal; *F*, thickening around both roots, more marked on the left; *K*, multiple cavities without thickened walls and filled with exudate; *I*, calcified tubercles.

Necrosis may occur in either the exudative or productive process, and the necrotic areas may be full of exudate and hard to differentiate (Fig. 11, *K*) from the surrounding consolidation, or they may be empty and the cavity show distinctly (Fig. 5, *K*). There may be multiple cavities (Fig. 11, *K*) in a consolidated area, with little or no attempt at walling off; or there may be a large cavity with a dense wall, probably infiltrated with calcareous deposits (Fig. 5, *K*).

Chronic miliary tuberculosis is recognized by the extremely small, clear-cut, well-defined tubercles (Fig. 12, *X* and *Z*). In the most typical case that I have seen both lungs were equally effected, the process showed no tendency to consolidation, and there was not the fibrous appearance usually presented in the chronic fibroid consolidation.

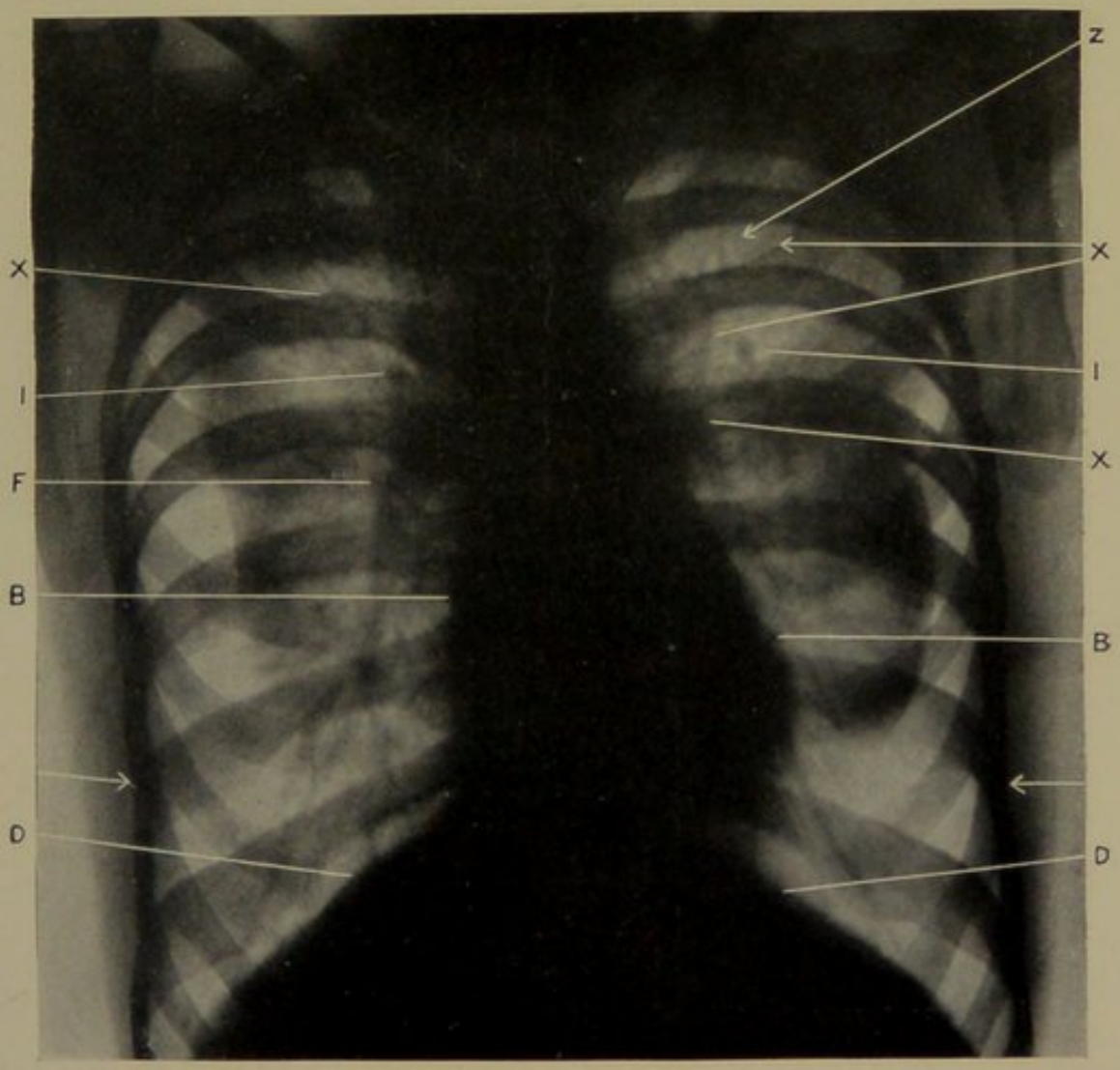


Fig. 12.—History of fifteen years of slight hacking cough, no expectoration, no tubercle bacilli in the sputum; slight physical signs; this is the most typical case of chronic miliary tuberculosis, involving the greater part of both lungs. Diminished aëration of both lungs. *B*, heart small and drawn into the vertical position; *D*, diaphragm arched up in the median line, thorax contracted; *F*, thickening around both roots; old calcified tubercles and fine mottled infiltration. Infiltration of both lungs, with extremely small, isolated (*X*) and conglomerate (*Z*) tubercles; *I*, calcified tubercles. The process shows no tendency to consolidation.

Chronic, fibroid consolidation is usually limited to one lung or part of one lung (Fig. 13). The consolidation may or may not be very dense and there is retraction of that side of the chest; frequently the ribs are drawn together, which gives a lateral curvature to the spine. The diaphragm is retracted and the heart is drawn to the affected side, or some say it is pushed over by the emphysematous lung on the opposite side.

Old calcified tubercles (Fig. 20, *I*) are most frequently seen at the root of the lung; they may be in the glands or in or around the walls of the bronchi, particularly the right descending bronchus and its branches (Fig. 17, *I*); they are usually the results of infection during childhood. When seen at the apex (Fig. 21, *I*) or at some other part of the lung, they are then the result of an old healed process probably of more recent origin, and are readily differentiated from the exudative or productive tubercule of an active or recently active lesion (Fig. 15, *X Z*).

Tuberculous infection may involve the lungs in the following ways:

CLASSIFICATION II.

Parenchymal involvement; may be exudative or productive, or a combination of both, and may have gone on to the stages of necrosis.	1. Limited to one or both apices (Fig. 3). 2. Limited to one lobe or the entire lung (Figs. 1 and 2). 3. Or it may involve part of both lungs (Figs. 8, 9, and 10).
Bronchial or peribronchial; may be exudative or productive, or both, but the productive process usually predominates.	1. Radiating in character from the root to the apex in adults (Fig. 1); to the base in children—old calcified (Fig. 17). 2. Bronchi alone may be involved (Fig. 14). 3. Bronchi and air cells supplied by bronchi may be involved (Fig. 15), with isolated (Fig. 15, *X*) or conglomerate tubercles (Fig. 15, *Z*). 4. Fibrous growth from the root without individual tubercles—not positively tuberculous (Fig. 14). 5. Bronchi may be normal in size with thickened walls, as in Fig. 15, *F G*; they may be dilated and filled with pus and exudate (Fig. 9, *K*), or empty—bronchiectasis (Fig. 9, *K*).
Root involvement may be glandular, bronchial, or peribronchial, either fibrous or calcareous.	1. Glandular may be circumscribed with clear cut edges (Fig. 16, *F*). 2. Groups of small glands connected by fibrous tissue which extends out along bronchi (Fig. 10, *F* and Fig. 17, *F*). 3. Bronchial or peribronchial thickening around the larger bronchi, without thickening of the root itself and without infiltration of the surrounding tissue (Fig. 18, *F*). 4. Or the walls of the larger bronchi may be thickened and seen on cross sections giving circles or the figure eight (Fig. 19, *F*). 5. This thickening may be shown in the active stage (Fig. 10, *F*), which is readily differentiated. 6. From the old calcified tubercules of a healed lesion (Fig. 20, *I*). Root (Fig. 20). Branch of descending bronchi (Fig. 17, *I*). Apex (Fig. 21).
Tuberculosis may be differentiated from	Dry pleurisy. Pleurisy with effusion. Empyema. Carcinoma. Aneurism.

The exudative, productive, or combination of both processes may involve the parenchyma of the lungs, and it may go on to the

stage of necrosis. It may be limited to one or both apices (Fig. 3), or one lobe (Figs. 5 and 6), or it may involve one entire lung (Fig. 13), or part of both (Figs. 8 and 9).

I have never seen a tuberculous lesion of the parenchyma without a typical tuberculous infiltration around the root. In some cases it is difficult to show the connection between the two processes, but with improved technique and more pathological radiography I

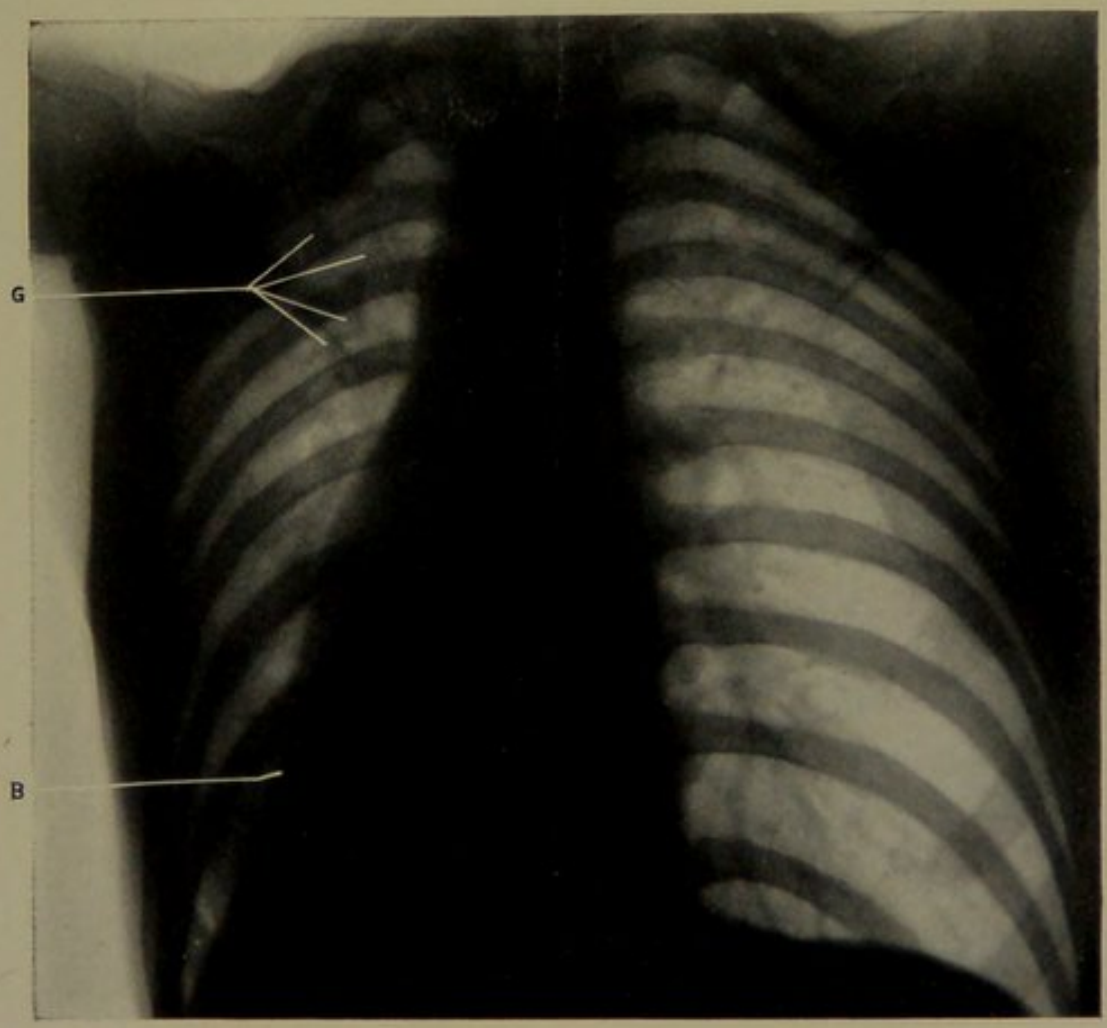


FIG. 13.—A case of chronic, fibroid tuberculosis, so-called fibroid phthisis. The left side of the chest is retracted. *B*, heart is drawn over to the left side, or some say pushed over by the compensatory emphysematous lung. In the upper lobe there is a typically mottled infiltration (*G*).

think that it will be established that all tuberculous lesions begin at the root and extend to the parenchyma.

Radiographic examination of incipient cases indicates that in a very large percentage of cases the lesion at the root is more extensive than the parenchymal lesion; and so frequently radiograms show a distinct lesion at the root with no parenchymal involvement that it is reasonable to assume that it extends from the root to the parenchyma. Radiating from the root to the apex in adults (Fig. 14), and

to the base in children, may be seen infiltration in and around the walls of the bronchi, giving the appearance of the rough bark on the branches of a tree (Fig. 15, *F*, *G*); the air cells supplied by these bronchi are infiltrated with isolated (Fig. 15, *X*) or conglomerate (Fig. 15, *Z*) tubercles. The process has the appearance of a tree

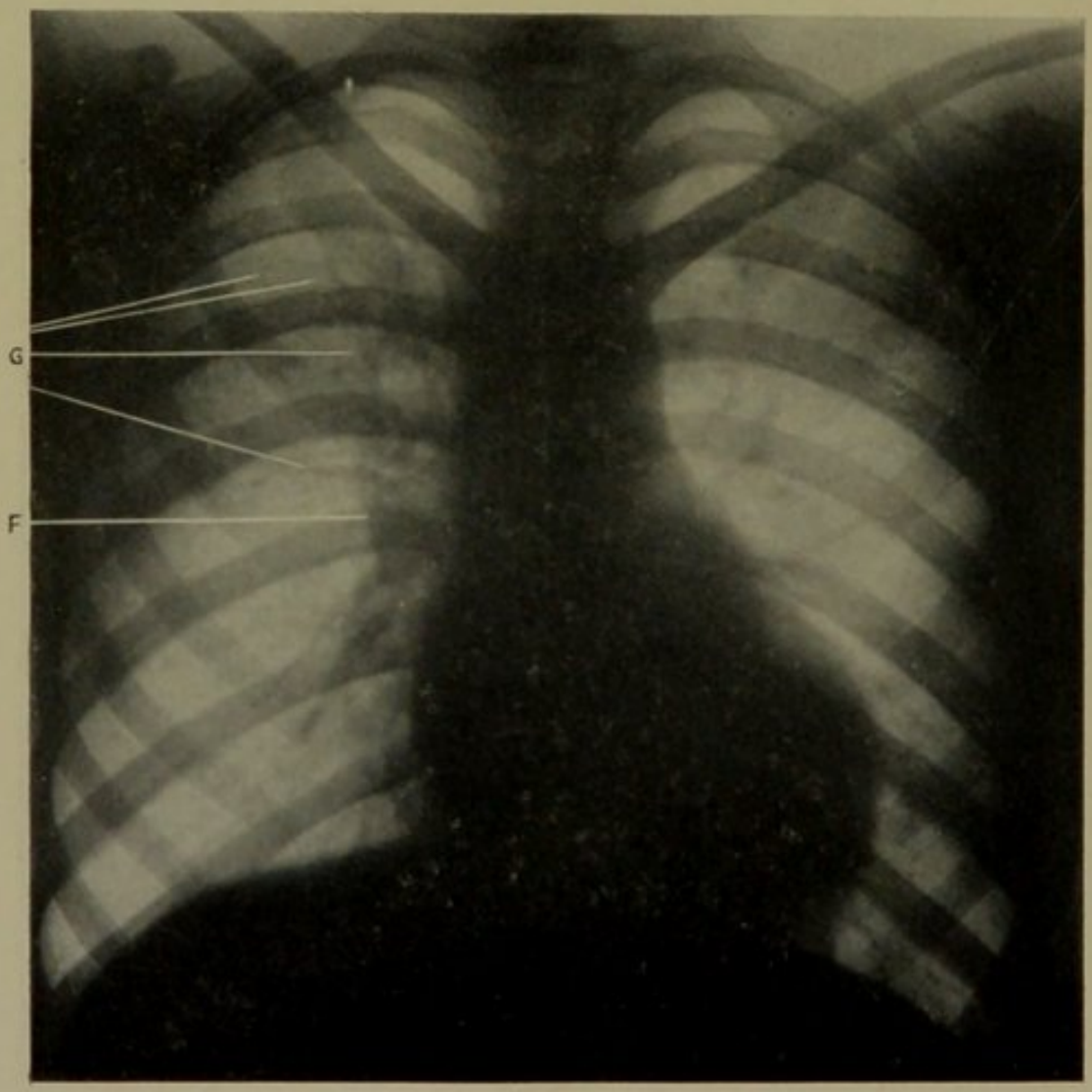


FIG. 14.—Illustrates the bronchial or peribronchial type of infiltration radiating from the roots of the lung. History equivocal. Physical signs: Few rales at the right apex, just below the clavicle, no dulness, or change of voice or breathing. Radiographic findings: Diminished aëration of both upper lobes, more marked on the right side; heart normal in size, shape, and position; diaphragm normal; *F*, typical thickening around the right root; *G*, radiating from both roots to the apices, more marked on the right side, are thickened bronchi without infiltration of the air cells supplied by them. This radiogram is especially interesting when compared with the following one (Fig. 15), where the process has extended and where there is an infiltration of the air cells.

budding in the springtime. There may be a diffuse fibrous growth extending from the root, without individual or conglomerate tubercles, giving the appearance of a general fibrous thickening and lack of aëration (Fig. 14, *G*). I am very cautious about making a diagnosis of tuberculosis in those cases in which the typical tubercles are absent. The bronchi may be normal in size (Fig. 15, *F*, *G*),

or they may be dilated and full of exudate (Fig. 9, *K*), or empty (Fig. 9, *K*). Tuberculous infection around the root of the lung may involve the glands (Fig. 16), the bronchi, or it may be peribronchial in character.

Glandular enlargement may be circumscribed with clear-cut edges (Fig. 16, *F*), but more frequently there is a group of small

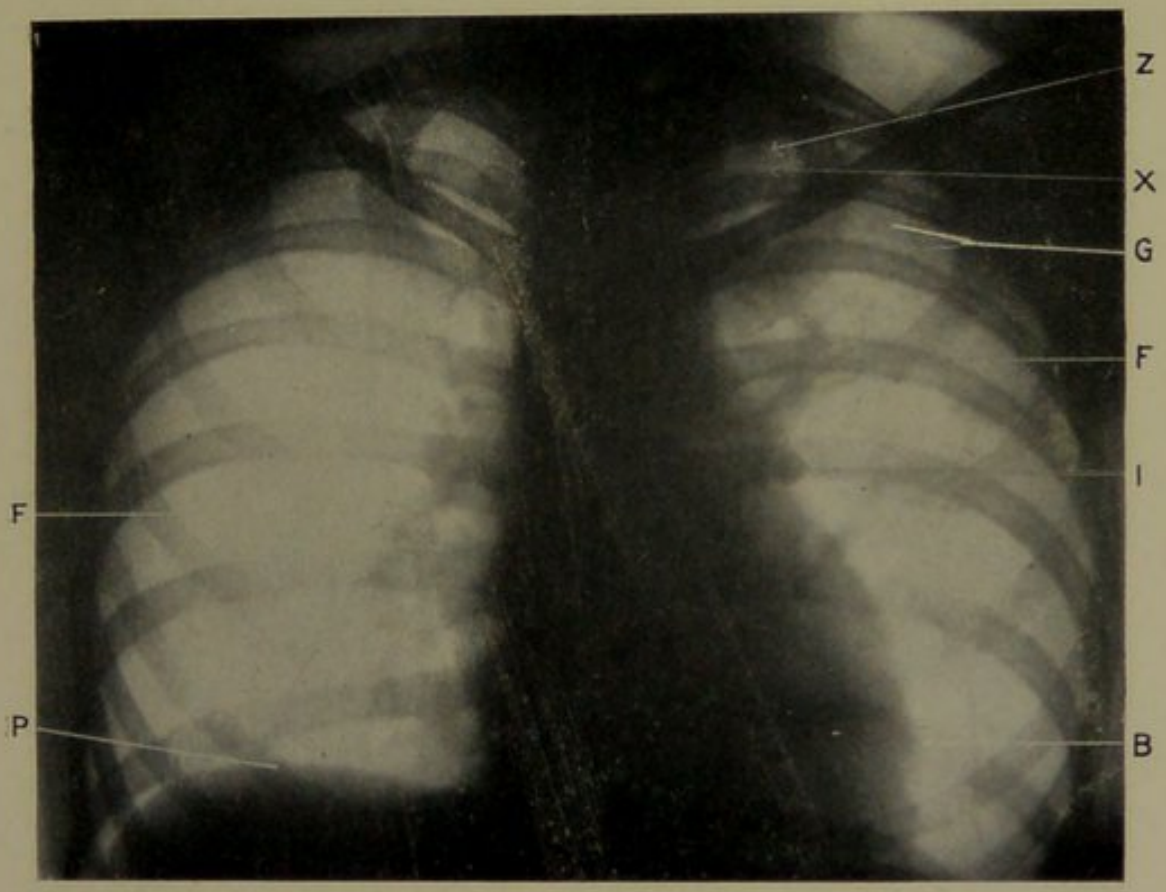


FIG 15.—This is one of the most classical plates of early tuberculous infiltration that I have made, but unfortunately is it very difficult to reproduce for publication. The original plate shows the following detail very distinctly: Diminished aëration of the left upper lobe; *B*, heart normal in size, shape, and position; *F*, thickening around both roots, more typically tuberculous where it extends out along the bronchus on the left side, having the appearance of the rough bark of a tree. The air cells supplied by this bronchus, and only these air cells, are infiltrated with miliary (*X*) and conglomerate (*Z*) tubercles giving the mottled appearance so typical of tuberculous infiltration of the lung (*G*). Family history: Father and mother died of tuberculosis. History: No cough, expectoration, or physical signs; loss of five pounds in weight and loss of sleep in the month of May, neither of which would ordinarily cause a patient to consult a physician for tuberculosis. The diagnosis of this case was made solely on the radiographic examination; the patient was treated accordingly, and the last I heard was perfectly well.

glands connected by fibrous tissue which extends out along the bronchi and bloodvessels (Figs. 10, *F*, and 17, *F*). There may be infiltration in or around the larger bronchi without thickening at the root and without parenchymal involvement (Fig. 18, *FG*)

The walls of the larger bronchi may be infiltrated, and when seen on cross section give the appearance of circles or figure "8" (Fig. 19, *F*), and may be surrounded by a few isolated tubercules (Fig.

19, *X*), which would indicate activity. The infiltration of the root may be shown in the active stage (Fig. 10, *F*), when it has a soft diffuse appearance, which is readily differentiated from the old healed calcified lesion (Fig. 20, *I*), which is usually the result of infection during childhood.

Healed tuberculous processes vary in their appearance according to the variety and extent of the lesions and the time that has elapsed since they were active. The exudative process when checked shows

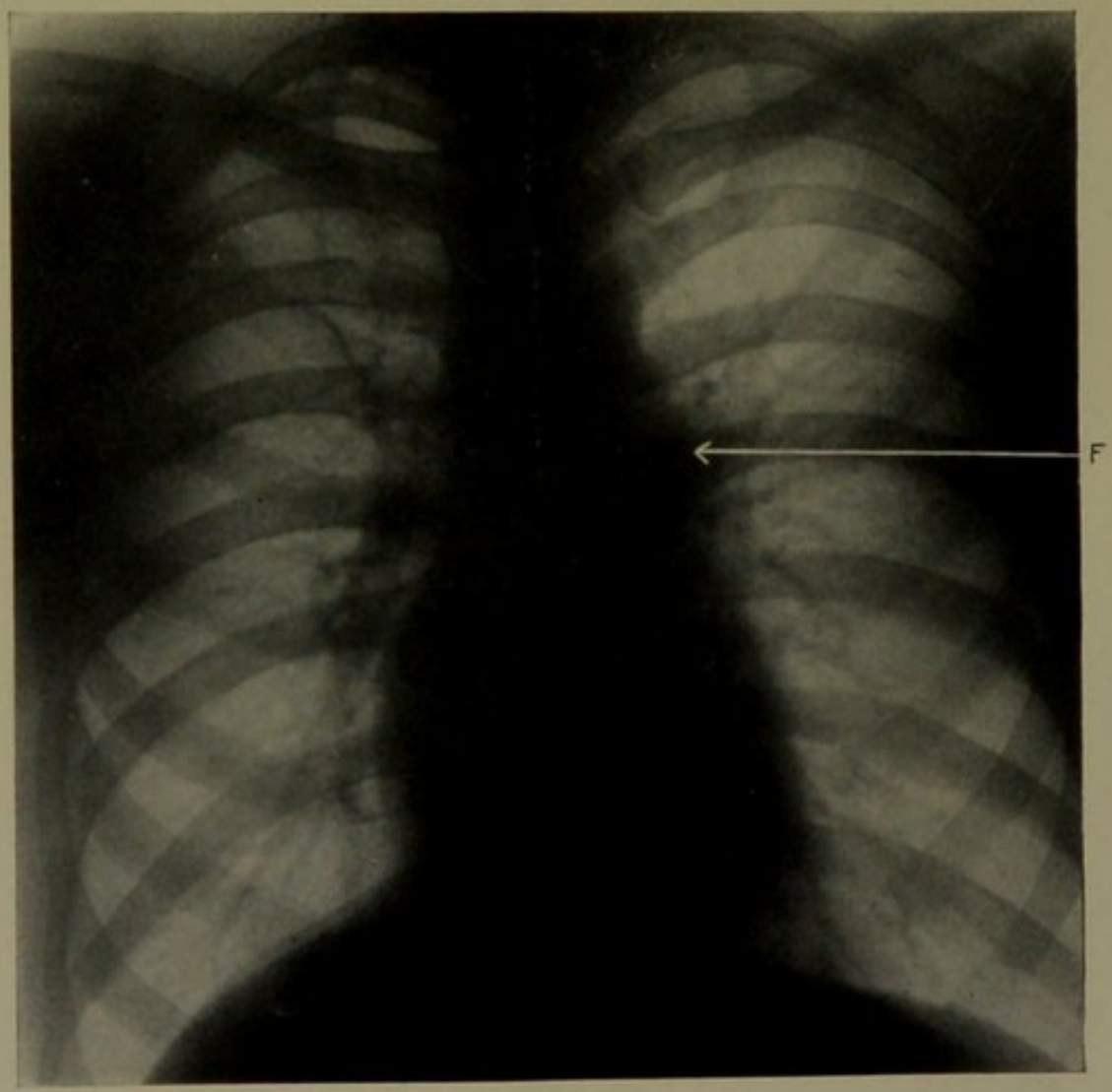


Fig. 16.—Shows a circumscribed gland (*F*) on the left side, opposite the tip of the third rib.

a much greater tendency to resolve than is generally supposed, and all that may remain of quite an extensive exudative process is a few scattered calcified tubercules (Fig. 21, *I*).

The productive process tends to a fibrous thickening that sometimes seems to resolve or at least diminish in density. This is probably a mixed process; and the exudate resolves and the fibrous process contracts. The old calcified lesions are found most frequently around the root (Fig. 20, *I*) and the right descending bronchus

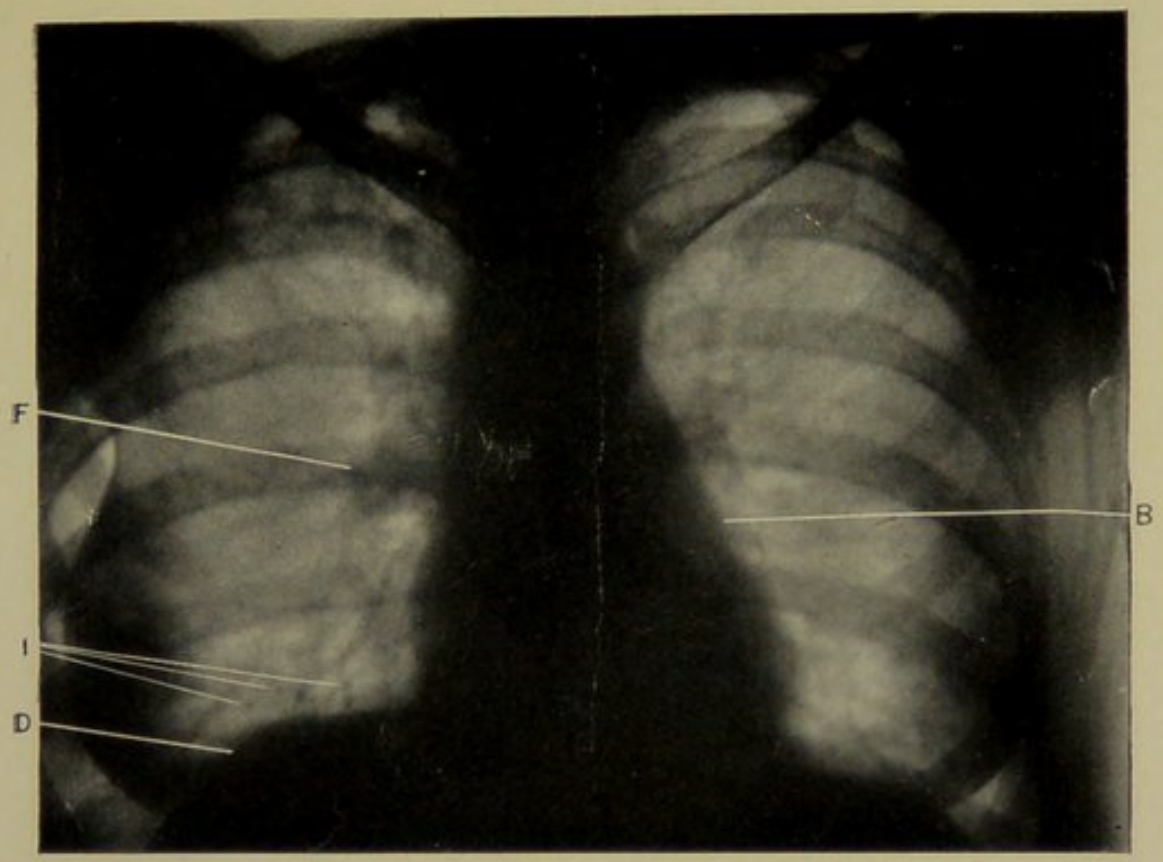


FIG. 17.—Illustrates typical acute infiltration around the root and old calcified tubercules (*I*) around the right descending bronchus, with localized retraction of the diaphragm (*D*); *B*, heart normal; *F*, acute infiltration around the root; *D*, diaphragm, localized retraction in the area of old calcified tubercles (*I*)

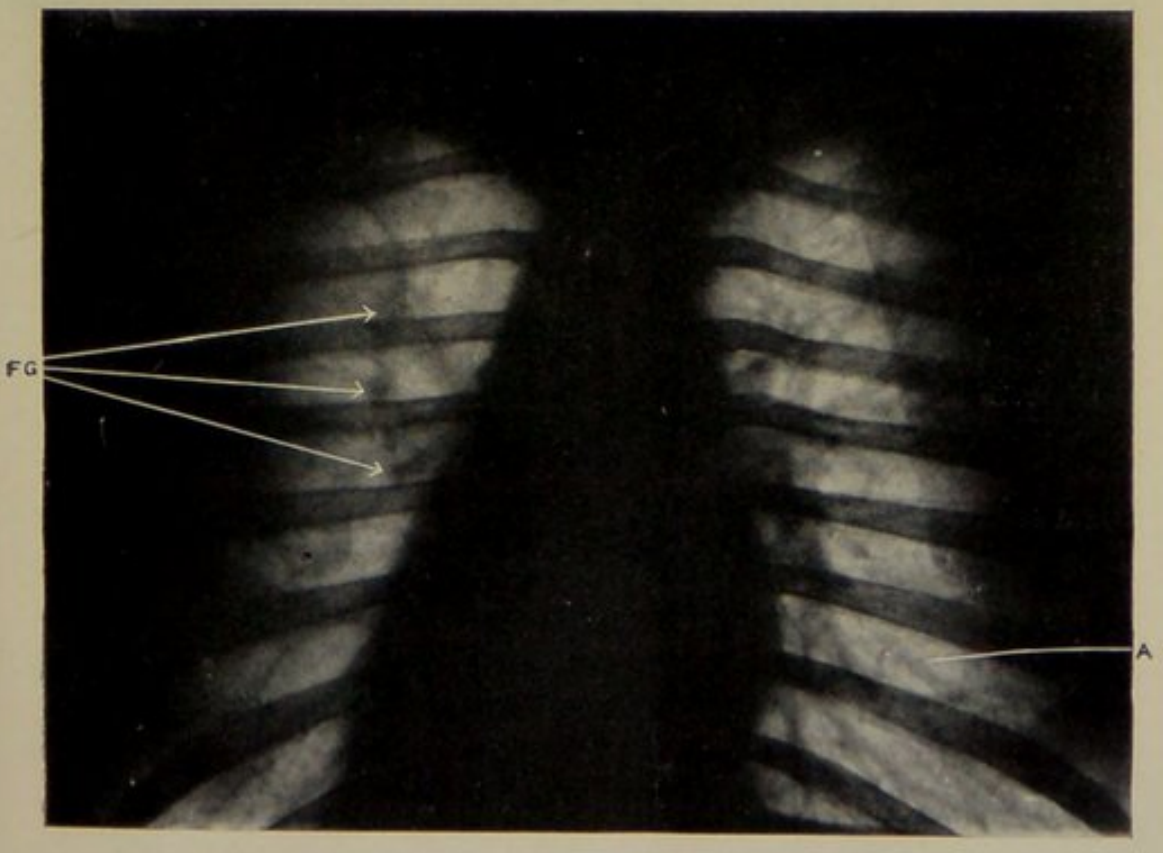


FIG. 18.—Illustrates infiltration around medium size bronchi like a fan, without infiltration around the root. Posterior view: *A*, normal markings of the lungs show distinctly; *FG*, bronchial or peribronchial infiltration of medium size bronchi spreading out like a fan.

(Fig. 17, *I*), and are the result of infection during childhood. These are present in a very large percentage of cases, thus corroborating the cutaneous reaction made by von Pirquet, referred to early in this paper.

The differentiation of tuberculosis from other pulmonary lesions may be definitely made solely by the radiographic examination. Dry thickened pleura may be differentiated from tuberculous infiltration by the smooth, homogeneous appearance and the normal markings of the lung showing through. Pleurisy with effusion

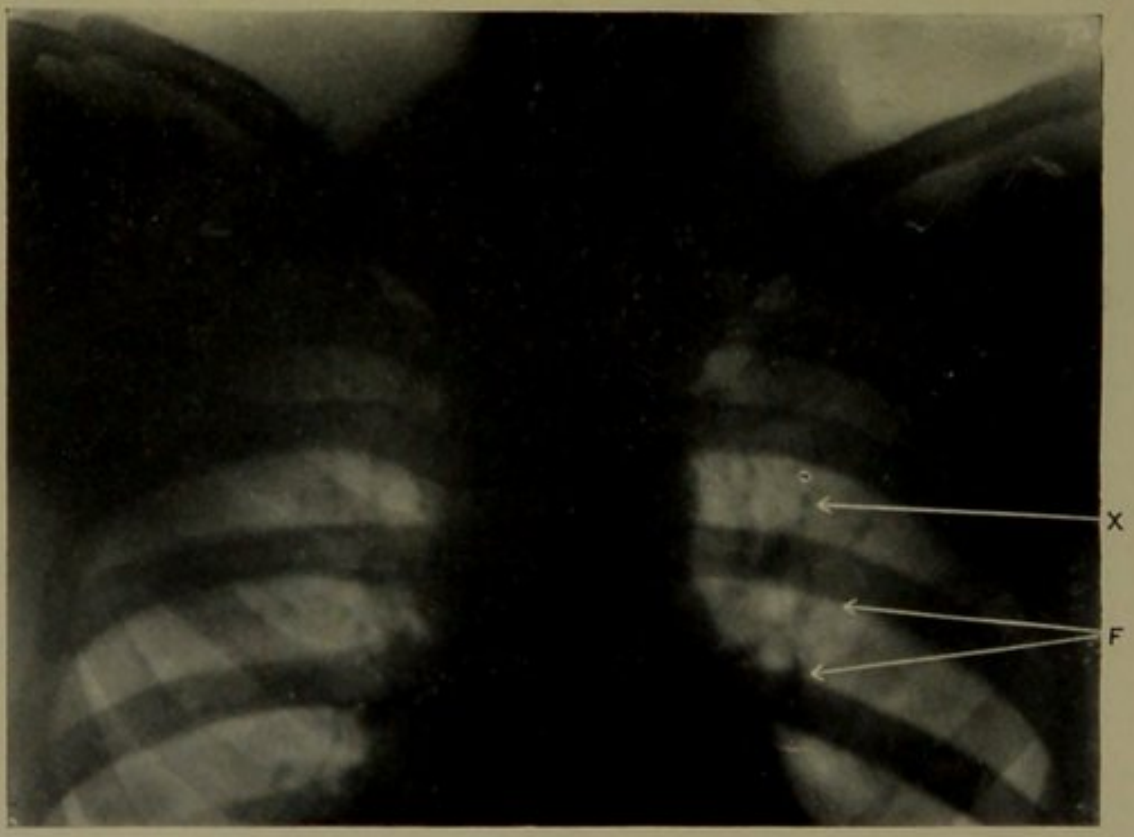


FIG. 19.—The only symptom was hemoptysis. The physical signs were absolutely negative. This was a test case examined for admission to the Saranac Sanatorium, and there were absolutely no physical signs of tuberculous infection. Repeated radiographic examinations showed a typical figure-of-8 thickening (*F*) around the root, surrounded by scattered tubercles (*X*). The patient was sent to Saranac solely on the radiographic findings; reacted to tuberculin injections, and later developed physical signs over this area, but recovered rapidly.

has a smooth, homogeneous appearance shading off gradually to the density of the lung at the upper surface of the fluid. Empyema, especially if encapsulation, is of equal density throughout, with clear-cut edges, and it does not have the mottled appearance of tuberculous infection. Carcinoma has an appearance similar to the fibrous consolidation, but it has more of a nodular appearance, and unless complicated by tuberculosis no individual or conglomerate tubercles are present. Aneurysm has to be differentiated only from mediastinal glandular involvement, and this is sometimes difficult unless a

fluoroscopic examination is made to see whether the tumor pulsates.

Considering the large percentage of cases in which tuberculosis is found at autopsy when only a few gross sections are made of the specimen, and the fact that the Germans say that 98 per cent. of all

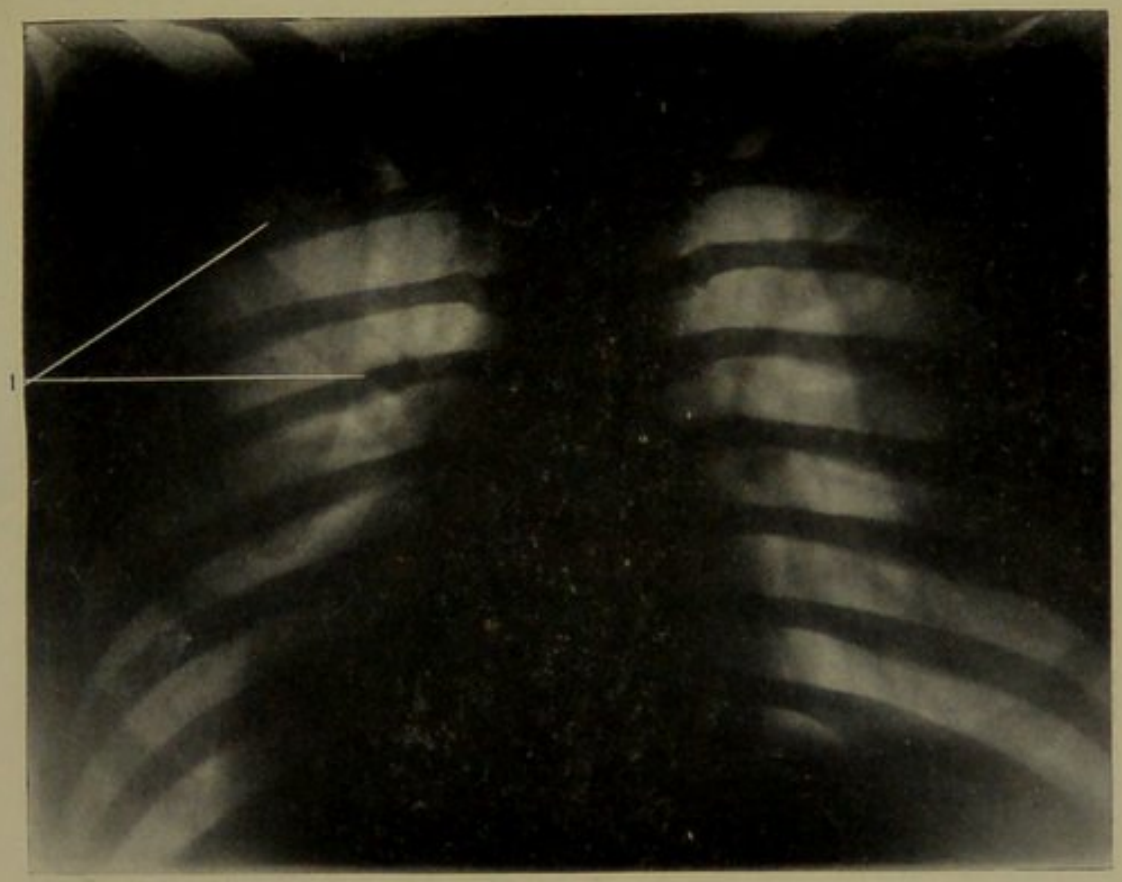


FIG. 20.—This radiogram illustrates a group of calcified tubercles in the walls of the large bronchi, causing hemorrhage on exertion. History: During or immediately after a game of basket-ball this girl, who had previously been perfectly healthy, had profuse hemoptysis without other symptoms, and with absolutely no physical signs to indicate a tuberculous process. The girl consulted a physician who has all doubtful cases of the chest radiographed, regardless of whether he gets physical signs of tuberculous infection or not. A series of these plates showed a group of calcified tubercles around the root of the right lung, in close proximity with the base of the heart, and I believe that, either from forced heart or respiratory action, these tubercles scratched through the membrane, and caused profuse hemoptysis. The physician who referred the patient to me made a positive diagnosis of tuberculosis, based entirely on the radiographic findings. The attending physician, in another vicinity, ridiculed the diagnosis, because of the absence of physical signs. Several months later physical signs developed and the diagnosis was confirmed. The girl went to Colorado, and the process was checked. This is only one of several cases in which there was hemoptysis on exertion, with no physical signs. Swimming and basket-ball are the exercises that have caused the hemoptysis in most of these cases.

adults have or have had a tuberculous lesion of the lung, and that 93 per cent. of children reacted to the cutaneous tuberculin test, it is not a question of who has tuberculosis, but what is the variety and extent of the lesion and is it active or inactive.

If pulmonary tuberculosis can be diagnosticated radiographically as early and accurately as now appears, and if one can state with a reasonable degree of certainty the variety of the lesion and whether

it is active or inactive, and can determine with absolute certainty whether the process is advancing, held in check, or resolving, it

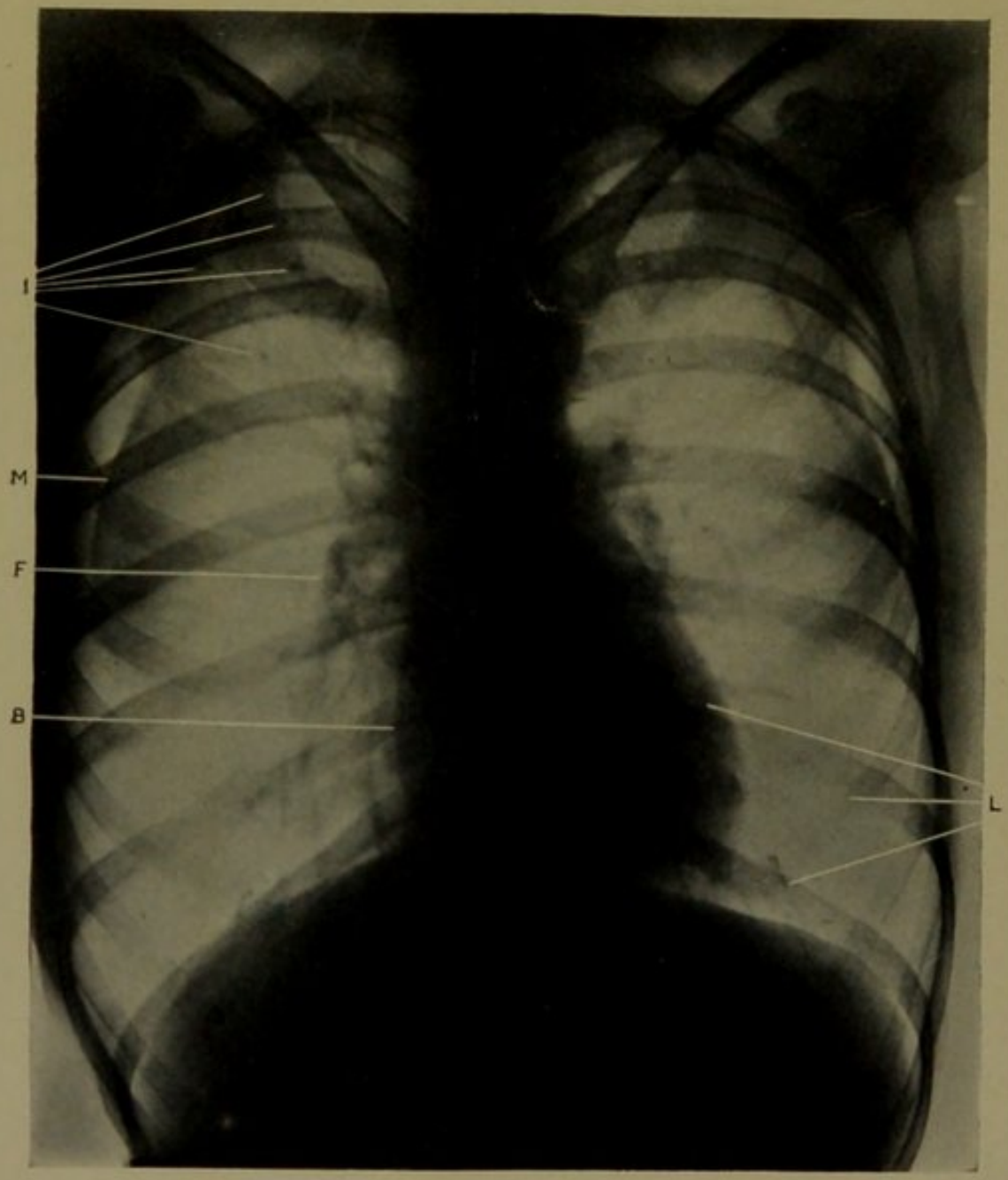


Fig. 21.—This illustrates a normal chest except a group of old calcified tubercles at the right apex, which are all that remain of quite an extensive process that was active nineteen years previously. No physical signs were apparent. Normal markings of the lungs show distinctly. *B*, heart normal in size, shape, and position, diaphragm normal; *F*, thickening around the root (old process); *M*, mammary gland should not be mistaken for consolidation; *L*, calcified costal cartilages should not be mistaken for calcified tubercles; *I*, old calcified tubercles at right apex.

seems that the question of the diagnosis of incipient pulmonary tuberculosis is solved.

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