



**Staff Meeting Bulletin
Hospitals of the » » »
University of Minnesota**

Roentgen Diagnosis

STAFF MEETING BULLETIN
HOSPITALS OF THE . . .
UNIVERSITY OF MINNESOTA

Volume XIX

Friday, January 16, 1948

Number 12

INDEX

	<u>PAGE</u>
I. CALENDAR OF EVENTS	220 - 222
II. THE POSSIBILITIES AND LIMITATIONS OF ROENTGEN DIAGNOSIS	
Leo G. Rigler, Professor and Chief, Department of Radiology and Physical Therapy	223 - 239

Published for the General Staff Meeting each week
during the school year, October to June, inclusive.

Address communications - -

Staff Bulletin
332-M University of Minnesota Hospitals
Minneapolis 14, Minnesota

UNIVERSITY OF MINNESOTA MEDICAL SCHOOL
CALENDAR OF EVENTS

January 19 - January 24, 1948

No. 186

Monday, January 19

- 9:00 - 9:50 Roentgenology-Medicine Conference; L. G. Rigler, C. J. Watson and Staff; Todd Amphitheater, U. H.
- 9:00 - 10:50 Obstetrics and Gynecology Conference; J. L. McKelvey and Staff; Interns' Quarters, U. H.
- 9:15 - Fracture Rounds; A. A. Zierold and Staff; Ward A, Minneapolis General Hospital.
- 10:00 - 12:00 Neurology Ward Rounds; A. B. Baker and Staff; Station 50, U. H.
- 11:00 - 11:50 Physical Medicine Conference; Subject to be announced; William Kubicek; E-101, U. H.
- 11:00 - 11:50 Roentgenology-Medicine Conference; Staff; Veterans' Hospital.
- 11:00 - 12:00 Cancer Clinic; K. Stenstrom and D. State; Eustis Amphitheater, U. H.
- 12:15 - 1:20 Pediatric Seminar; Analysis and Present Status of Tetralogy of Fallot; Georgia Perkins; 6th Floor Seminar Room, U. H.
- 12:15 - 1:20 Obstetrics and Gynecology Journal Club; M-435, U. H.
- 12:30 - 1:20 Pathology Seminar; Spontaneous Adrena. Tumors in Mice; Marcella Frantz; 104 I.A.
- 12:30 - 1:30 Physiology Seminar; The Acetylcholine Mechanism in Convulsive Activity; Jane Hyde; 214 M. H.
- 12:30 - 1:50 Surgery Grand Rounds; A. A. Zierold, Clarence Dennis and Staff; Minneapolis General Hospital.
- 1:30 - 2:30 Pediatric-Neurological Rounds; R. Jensen, A. B. Baker and Staff; U.H.
- 4:00 - 5:00 School of Public Health Seminar; Cardio-Vascular Research Program at the Laboratory of Physiological Hygiene; Ancel Keys; 113 MeS.

Tuesday, January 20

- 8:30 - 10:20 Surgery Seminar; Lyle Hay; Small Conference Room, Bldg. I, Veterans' Hospital.
- 9:00 - 9:50 Roentgenology Pediatrics Conference; L. G. Rigler, I. McQuarrie and Staff; Eustis Amphitheater, U. H.
- 10:30 - 11:50 Surgical Pathological Conference; Lyle Hay and Nathaniel Lufkin; Veterans' Hospital.
- 12:30 - 1:20 Pathology Conference; Autopsies; Pathology Staff; 102 I. A.

- 2:00 - 2:50 Dermatology and Syphilology Conference; H. E. Michelson and Staff; Bldg. III, Veterans' Hospital.
- 3:15 - 4:20 Gynecology Chart Conference; J. L. McKelvey and Staff; Station 54, U.H.
- 3:30 - 4:20 Clinical Pathological Conference; Staff; Veterans' Hospital.
- 4:00 - 5:30 Surgery-Physiology Conference; O. H. Wangensteen and M. L. Visscher; Eustis Amphitheater, U. H.
- 5:00 - 5:50 Roentgenology Diagnosis Conference; Leo G. Rigler and Staff of University Hospitals; M-515, U. H.

Wednesday, January 21

- 8:00 - 8:50 Surgery Journal Club; O. H. Wangensteen and Staff; M-515, U. H.
- 8:30 - 12:00 Neurology Rehabilitation and Case Conference; A. B. Baker and Joe R. Brown; Veterans' Hospital.
- 11:00 - 11:50 Pathology-Medicine-Surgery Conference; Metastatic Adeno Carcinoma from Resected Stomach; E. T. Bell, O. H. Wangensteen, C. J. Watson and Staff; Todd Amphitheater, U. H.
- 4:00 - 5:00 Infectious Disease Routes; Todd Amphitheater, General Hospital, Veterans' Hospital.

Thursday, January 22

- 8:15 - 9:00 Roentgenology-Surgical-Pathology Conference; Walter Walker and H. M. Stauffer; M-515, U. H.
- 8:30 - 10:20 Surgery Grand Rounds; Lyle Hay and Staff; Veterans' Hospital.
- 9:00 - 9:50 Medicine Case Presentation; C. J. Watson and Staff; Todd Amphitheater, U. H.
- 10:00 - 11:50 Medicine Ward Rounds; C. J. Watson and Staff; E-221, U. H.
- 10:30 - 11:50 Surgery-Radiology Conference; Daniel Fink and Lyle Hay; Veterans' Hospital.
- 11:00 - 12:00 Cancer Clinic; K. Stenstrom and D. State; Eustis Amphitheater, U. H.
- 12:00 - 12:50 Physiological Chemistry Seminar; On the Proteolytic Enzymes of Animal Tissues; Mary Jane Ochs; 214 M. H.
- 1:00 - 1:50 Fracture Conference; A. A. Zierold and Staff; Minneapolis General Hospital.
- 1:30 - 3:00 Pediatric Psychiatric Rounds; Reynold Jensen; 6th Floor West Wing, U. H.
- 4:00 - 4:50 Bacteriology Seminar; Rabbit Papillomas; Robert Fisher; 214 M. H.
- 4:30 - 5:20 Ophthalmology Ward Rounds; Erling W. Hansen and Staff; E-534, U. H.

- 5:00 - 5:50 Roentgenology Seminar. Radiology as Practiced in Palestine; Samuel Schar; M-515, U. H.
- 7:00 - 8:00 Urology-Roentgenology Conference; H. M. Stauffer and George Eaves; M-515, U. H.

Friday, January 23

- 8:30 - 10:00 Neurology Grand Rounds; A. B. Baker and Staff; Station 50, U. H.
- 9:00 - 10:30 Pediatric Grand Rounds; I. McQuarrie and Staff; Eustis Amphitheater, U. H.
- 9:00 - 9:50 Medicine Grand Rounds; C. J. Watson and Staff; Todd Amphitheater, U. H.
- 10:00 - 11:50 Medicine Ward Rounds; C. J. Watson and Staff; E-221, U. H.
- 10:30 - 11:20 Medicine Grand Rounds; Staff; Veterans' Hospital.
- 10:30 - 11:50 Otolaryngology Case Studies; L. R. Boies and Staff; Out-Patient Department, U. H.
- 11:00 - 12:00 Surgery-Pediatric Conference; C. Dennis, A. V. Stoesser and Staffs; Minneapolis General Hospital.
- 11:30 - 12:50 University of Minnesota Hospitals General Staff Meeting; Inguinal Dissections; Ivan Baronofsky; New Powell Hall Amphitheater.
- 1:00 - 1:50 Dermatology and Syphilology; Presentation of Selected Cases of the Week; H. E. Michelson and Staff; W-312, U. H.
- 1:00 - 2:50 Neurosurgery-Roentgenology Conference; W. T. Peyton, Harold O. Peterson and Staff; Todd Amphitheater, U. H.
- 3:00 - 3:50 Surgery Literature Conference; Clarence Dennis and Staff; Minneapolis General Hospital.
- 4:00 - 5:00 Pediatric-Surgery Conference; I. McQuarrie and O. H. Wangensteen and Staffs; 6th Floor, Child Psychiatry Clinic, U. H.

Saturday, January 24

- 7:45 - 8:50 Orthopedics Conference; Wallace H. Cole and Staff; Station 21, U. H.
- 8:00 - 9:30 Psychiatry and Neurology Grand Rounds; Staff; University Hospitals.
- 9:00 - 9:50 Surgery-Roentgenology Conference; O. H. Wangensteen, L. G. Rigler, and Staff; Todd Amphitheater, U. H.
- 9:00 - 9:50 Medicine Case Presentation; C. J. Watson and Staff; M-515, U. H.
- 10:00 - 11:50 Medicine Ward Rounds; C. J. Watson and Staff; M-515, U. H.
- 10:00 - 12:50 Obstetrics and Gynecology Grand Rounds; J. L. McKelvey and Staff; Station 44, U. H.
- 11:00 - 12:20 Anatomy Seminar; The bronchial circulation; E. A. Boyden: Congenital right diaphragmatic hernia in the rat; L. J. Wells; 226 I. A.

II. THE POSSIBILITIES AND LIMITATIONS OF ROENTGEN DIAGNOSIS

Leo G. Rigler

Roentgen diagnosis having come of age, it is time to critically examine both the possibilities and limitations of a method which, because of its objectivity, because it appeals to the visual sense in which we all have the greatest faith, has a certain attractiveness for physicians and for the lay public, inspires a certain confidence, not always completely justified by its accomplishments. The widespread use of this method makes it scarcely necessary any longer to urge the application of the procedure for diagnosis. It is necessary, however, to attempt to indicate the fact that the reliance which is placed on roentgen study often goes far beyond the merits of the method. The contrary, of course, is often true and in many instances the findings are not given sufficient credence. Some definition of both the maximal and minimal possibilities, that is, the broad limitations of the method should be attempted.

That there are situations in which disease processes are present without any roentgen evidences of abnormality whatsoever is well known. Likewise, the fact that positive roentgen findings may become apparent at a stage in the development of an abnormal process when symptoms, physical signs or other evidences whatsoever are completely lacking is also known. Despite this there is relatively little written on this specific subject either in textbooks or in current periodicals. It is difficult to find any adequate discussion concerning the real significance of the negative roentgenogram in various diseases or material concerning the latent period before the appearance of roentgenologic signs. While the details of such structures as the lungs or the skeleton appear to be faithfully reproduced in the roentgenogram, a correlation of anatomical and roentgen findings reveals that many lesions which are microscopically apparent give no x-ray evidence whatever. It is evident that lesions must attain a sufficient size or produce sufficient

changes before they have enough contrast density to be visible.

Brailsford has pointed to the most obvious example, pregnancy, in which the process must be present for at least nine or ten weeks before there is any chance of x-ray diagnosis. Another example which is known to all and has been fully described in most textbooks is acute osteomyelitis. Here the absence of x-ray signs for as long as two weeks after the onset of symptoms -- if antibiotic or chemotherapy has been given the period may be even longer -- is a notable feature of the disease. Conversely, by means of roentgen examination of the stomach we have been able to demonstrate tumors as small as 5 mm. in diameter and as large as 7 cm. in diameter in patients who have no symptoms whatever. The following discussion concerns itself essentially with the matter of the detection of an abnormal process, not its identification. The latter involves an entirely different set of ideas, procedures and data. In the following pages I propose to review a limited number of disease processes in the thorax in which we have been able to collect fairly accurate data bearing on this problem.

There are three points of reference which one might use in determining the value of the roentgen method in the detection of an abnormal state at its earliest beginnings. The first would be the time of the actual onset of the disease whether it be the day or hour of exposure in the case of an infectious process or the time of implantation of the tumor in the case of a neoplasm. In the former there is some possibility of determining this point of reference particularly in such diseases as tuberculosis in which a specific exposure can often be clearly ascertained. In the case of neoplasms in humans it is impossible to state with any degree of certainty the exact time of inception. When such information is not available, as is the case in many other lesions as well as in neoplasms, another point of reference must be used; namely, the onset of symptoms. The third method of judgment rests in a quantitative determination of the size of the lesion neces-

sary to be demonstrable by roentgen study.

As stated above the best studied example is acute osteomyelitis. The following case illustrates well the latent period between the onset of symptoms and the development of roentgen signs. The exact inception of such a lesion is difficult to state although very likely it actually begins within a relatively short period of time before the onset of the symptoms.

Case No. 1

A male child of ten years came in with a history of a fall on December 12, 1945. He wrenched his right knee. Twenty-four hours later stiffness and aching pain in that knee developed. This became progressive and shortly thereafter a fairly high fever developed. Three days after the injury the temperature was 104°, a diagnosis of poliomyelitis was made but spinal puncture was negative. He was admitted to the University Hospitals four days after the fall and three days after the onset of severe pain and fever. No abnormality could be made out about the knee on roentgen examination at this time. Three days later re-examination was made and likewise appeared to be entirely negative. On December 24, 12 days after the onset of injury and 11 days after the onset of the severe pain and temperature, some very questionable findings are apparent in the upper end of the tibia but these are so doubtful that without the history they would probably be considered to be within normal limits. The next film was made 18 days after the onset of symptoms and shows a very characteristic picture of acute osteomyelitis. It should be noted that this patient had penicillin in rather large doses beginning on the 3rd day after the onset of symptoms and this may possibly have delayed the development of x-ray findings to some degree. Eventually a characteristic osteomyelitis of the tibia was observed and the patient was treated in the usual fashion.

Comment

At least 11 days after the onset of

fairly characteristic symptoms and signs with local evidences of swelling and tenderness the x-ray appearance of the bone was practically normal. This is quite typical of acute osteomyelitis as commonly observed.

A similar and well known situation, fully described experimentally and clinically by Snure and others, is the presence of extensive bony metastases without any evidences of roentgen changes whatever; especially is this true if the metastasis involves the spine or pelvis or is widespread throughout the bone marrow but produces no local distinctive areas of destruction. A similar situation occasionally occurs in multiple myeloma. These are, fortunately, the exception, not the rule but they illustrate the important point that there are conditions in which extensive symptoms, physical signs and laboratory findings are present while the roentgen examination, regardless of the technical care with which it is done, will be entirely negative.

Case No. 2

A 53 year old male was admitted to the Hospitals 2-26-47 complaining of persistent malaise, low abdominal pain, anorexia and vomiting following an upper respiratory infection. There was a slight loss of weight and four weeks prior to admission he noted the onset of black, tarry stools. On physical examination evidences of bone pain over the sternum and dorsal spine were obtained. The alkaline phosphatase was distinctly elevated but the acid phosphatase was normal. There were no other remarkable laboratory findings. Roentgen examination of the pelvis, lumbar spine, and urinary tract were made and showed no evidence of pathology. Further studies of the blood gave a leukemoid blood picture. The patient was in no condition to permit a gastrointestinal x-ray examination, but it was felt from the evidence that he probably had a carcinoma of the stomach. Bone marrow biopsy was done and showed the picture of extensive metastatic carcinoma of the bone marrow. Roentgen

examination of the pelvis and lumbar spine was negative. The patient expired two weeks after admission and autopsy was done. Carcinoma of the stomach with metastasis to the liver and lymph nodes were found. Small hemorrhagic areas in the bodies of the vertebrae were found fairly characteristic of tumor. On microscopic section it was seen that the whole marrow was replaced by cords and masses of tumor cells similar to those found in the stomach. The tumor infiltration was diffuse and there was very little destruction of bone trabeculae. The ribs show similar findings.

Comment

An extensive metastasis to the bone marrow is present but gives no x-ray findings probably because the bone trabeculae are not much changed and it is only the marrow tissue itself which is replaced by the tumor tissue. Nevertheless, the patient had symptoms of bone pain and was suffering from blood changes incident to the extensive involvement of the bone marrow. A similar situation is encountered not uncommonly in carcinoma of the breast.

To illustrate the converse of this I should like to review one other bone case before going on to the major portion of my thesis. It is difficult, of course, to determine when bone sarcomas or other primary tumors of bone have their actual onset. The symptoms of the patient give no clue as to this point. In almost all cases, if symptoms due to a primary bone tumor are present, the roentgen findings will be clearly apparent. Through a fortunate succession of events, I have been able to observe in the following case the roentgen evidences of abnormality some two months prior to the first onset of symptoms.

Case No. 3

A 12 year old girl had been admitted to the University Hospitals some 16 times with a history of multiple infections and a severe anemia. Throughout the years repeated studies were made and a diagnosis of aplastic anemia of undetermined origin was finally made. She was

given repeated blood transfusions for this condition. Amongst the numerous examinations, films of the skeleton were made on various occasions to determine whether there was any specific process which might give some clue as to the nature of the anemia. The femur appeared to be entirely normal except for some decalcification and some lines of growth arrest. This was in 1939. In 1940 another examination was made purely as a routine procedure. It should be emphasized that she had no symptoms whatever related to the bones at this time except for the anemia which had been present all these years. This child was very intelligent, she had been in the hospital on many occasions, and her history is very reliable as is that of her parents. Upon review of this film, although the observation was not made at the time, it is perfectly obvious that there is an area of sclerosis in the distal end of the femur which was not present on the previous films which had been made on various occasions. Three months after this examination pain developed in the knee. This was of minor character and really occasioned little concern on the part of the child's parents although they were very watchful of her health. It progressed, however. Eight months later a roentgenogram of the femur showed a classical sclerosing sarcoma the diagnosis of which was definitely established by biopsy. Treatment was undertaken but the patient succumbed to the disease. At autopsy a chondrosarcoma with sclerosis was found.

Comment

The evidences of a sclerosing lesion of the femur were apparent for a period of at least 3 months before the onset of any symptoms whatever. It is unusual that examinations of the bones are available prior to the onset of symptoms in cases of bone sarcoma but here is an illustration of the fact that roentgen examination may reveal changes even in malignant bone tumors before any onset of symptoms.

To illustrate a method of procedure which should lead to a better under-

standing of the possibilities and limitations of roentgen diagnosis, I wish to present some data which we have collected concerning diseases of the thorax, data derived from experimentation, from case studies, and from what might be called the past roentgen history. I am selecting some special situations since we have been unable, obviously, to review all types of pathology with these points of view in mind. I hope to discuss briefly pulmonary edema, pleural effusion, pneumonia, chronic tuberculosis, acute miliary tuberculosis, metastases to the lungs and, finally, bronchogenic carcinoma from these points of view.

The rationale of this approach is based somewhat on the following experiences which I believe any roentgenologist is likely to encounter. A student discovers that the sputum of a patient he has examined is loaded with tubercle bacilli. Characteristically, he promptly appears in the X-ray Department to have a roentgen examination of his chest and he wants to know at once whether or not he has become infected with tuberculosis. What answer should be given if his roentgenogram is negative? A patient comes into the hospital with a high fever, leukocytosis and all the symptoms of pneumonia. There are no physical signs. A roentgenogram is made and appears to be negative. The question immediately arises as to the significance of this negative roentgenogram. Does the patient have pneumonia even though the roentgenogram is negative? Shall the apparent negative roentgen findings be ignored and treatment be instituted just as if the patient had pneumonia? A patient comes in with very acute fever of perhaps a week's duration. He has cyanosis and tachypnea; the diagnosis of acute miliary tuberculosis is entertained because of his symptoms. Roentgen examination is made and the film appears to be entirely negative. What shall we say as to the diagnosis at this time or what criteria do we have for establishing the reliability of the roentgen study under such circumstances?

In any consideration of the early diagnosis of pulmonary diseases in an early stage the technique of the examination must be borne in mind. Obviously, faulty technique may militate strongly

against the possibilities of diagnosis. This is particularly true of small lesions. In the discussion it should be assumed that the best possible technical procedures for the particular condition under consideration are being used. There are, obviously, many obstructions to good technique which are often difficult or impossible to overcome such as the condition of the patient, his inability to hold his breath, necessity for making films at the bedside, etc. Nevertheless full consideration should be given to the assumption that the technique is reasonably good.

Pulmonary lesions may in general be divided into two groups; that is, those that are interstitial in character and those which are intra-alveolar in character. It is important to remember that in general the interstitial lesions are much less clearly delineated in the roentgenogram than the intra-alveolar lesions and usually at a later stage in the course of the disease.

A simple process in the lung such as pulmonary edema lends itself well to a discussion of this kind. In general, pulmonary edema is an intra-alveolar process and it is manifested in the roentgenogram at an extremely early stage of the disease regardless of the etiology of the process. We have had occasion to study large numbers of patients developing pulmonary edema, either postoperatively as a result of overloading of the circulation during a period in which the myocardial capacity is somewhat impaired, or in the usual medical conditions such as cardiac failure, hypoproteinemia, and nephritis. It is evident from our experience that pulmonary edema can be demonstrated quite effectively in the roentgenogram at a time when the symptoms are minor or difficult to interpret and the physical findings are either absent or minimal. The following cases illustrate this point.

Case No. 4

A patient with glomerulonephritis had had a period of hypoproteinemia

accompanied by generalized anasarca, extensive pulmonary edema and pleural effusion. She had recovered completely from this attack, the roentgenogram of the lungs was entirely clear; there were no physical findings whatsoever and the peripheral edema had disappeared completely. She was about to be discharged from the hospital when the intern came in to see her and she complained that she didn't feel quite as well as she had the day before. There was a slight increase in her respiratory rate but little else was obvious. She had been seen early that morning and appeared quite normal. The physical findings were entirely negative. Within two hours of the first onset of this slight dyspnea a roentgenogram of the chest was made and showed definite edema in the lungs as manifested by the usual mottling and increased density along the vascular trunks.

Within another 6 hours the edema was far more prominent and the full blown picture of typical pulmonary edema appeared.

An even more striking illustration of the roentgen demonstration of edema is illustrated by the following case report.

Case No. 5

A patient with Addison's disease was being studied by Dr. Gerald Evans and his associates concerning the effects of the administration of doca and high salt intake upon the size of the heart. Roentgenograms of the chest were being made at frequent intervals with a view to determining the relative changes in cardiac size. During the course of these examinations this patient showed in addition to the tuberculosis of the adrenals that there was an actual tuberculosis of the lung. The heart was very small, the lungs were dry and anemic looking during the periods of Addisonian crisis. There were several periods of treatment during which salt and doca were given and then withdrawn. On one of these occasions when the patient was sent up for examination of the heart, at a time when there were no symptoms nor physical signs

whatever to suggest any abnormality in the lungs, clear evidences of pulmonary edema in the bases of the lungs were apparent. The findings were so suggestive that the attention of the clinicians was directed to it at once. Even after looking at the roentgenograms and being given the opinion that pulmonary edema was present they re-examined her lungs with negative results. There were, likewise, no evidences whatever of subcutaneous edema. A review of the careful studies of the blood volume, which were being made daily, indicated that on this day a striking dilution of the blood with retention of chlorides was present so much so that pulmonary edema might readily have resulted.

Comment

Both of these cases demonstrate how sensitive the roentgen examination is as an indicator of the presence of pulmonary edema.

Another illustration of the sensitivity of the roentgenogram to the development of edema is given by the patients who are having surgery on the thorax. In such instances the patient is not infrequently put in a position in which the circulation to a portion of the lung is greatly hampered. Under such circumstances an edema of one lobe or one lung may readily develop. Roentgen studies have been made on the operating table in a number of such cases in which, because of the behaviour of the patient, some suspicion appeared in the mind of the surgeon that edema or atelectasis might be taking place. We have been able to demonstrate the findings of edema in a dependent lobe within a very few minutes after it had occurred.

The usefulness of the roentgen method for the demonstration of fluid in the thoracic cavity is well exhibited in patients with pleural effusion. In the case of transudation the point of reference must be quantitative rather than one of time since it is impossible to determine in most instances either from symptoms or from other

evidences as to exactly when the transudate began to accumulate. In the case of exudates there are usually symptoms which give a point of reference. Experiments with monkeys were performed a good many years ago in connection with some of our work on pleural effusions. Various fluids were introduced into the pleural cavity in known amounts. The quantities have been recalculated on the basis of the relative volume of the thorax of the animals under consideration and that of the average adult. As a result of this it appears probable that a minimum of 100 cc. of fluid in one hemithorax of the average adult is required for demonstration by roentgen study and then can only be seen if the lateral decubitus position is used.

By using the lateral decubitus position in clinical cases we have been able to demonstrate very small quantities of fluid repeatedly when physical findings were absent. On the other hand, if reliance is placed only upon the usual upright film, made in deep inspiration, fluid may not be apparent in the roentgen study when there are already some physical findings. Under such circumstances the quantity of fluid must reach 300 to 400 cc. in the adult thorax before there are definite roentgen changes. Another indication of the presence of small quantities of fluid lies in the appearance of the shadow of the interlobar fissure when the position of the patient is changed from upright to supine or prone. This is, of course, particularly true on the right side. By the use of many positions, we have repeatedly been able to demonstrate exceedingly small quantities of fluid, both transudates and exudates, in patients in whom symptoms were minimal and the physical findings entirely absent.

In the case of pneumonia it is rather difficult, of course, to establish the exact time when the infection occurred, at least in terms of hours. We can, however, in a few cases, get a point of reference from the symptoms of the patient. This is, of course, particularly true of the bacterial pneumonias, the so-called lobar pneumonias, in which, not uncommonly, the onset is sudden and sharp. We have had some success in obtaining

roentgenograms on patients very shortly after their first complaint particularly through the Students' Health Service. In other cases, because of a special combination of events, we have been fortunate in securing films on patients with pneumonia at a far earlier stage in the course of the disease than is commonly the case.

It should be noted at this point that the demonstration of consolidation in the lungs is attended by many sources of error. Lateral views are often necessary and particularly is it important to observe the density of the cardiac shadow. The reports from the literature reflecting on the absence of roentgen findings when pneumonia is actually present often are the result of poor observation, especially the failure to take the density of the cardiac shadow into consideration. To illustrate the possibilities of roentgen diagnosis in bacterial pneumonia the following cases will serve.

Case No. 6

A man with a clear-cut history was observed. He said he was perfectly well until a sudden onset of chills and fever and pain in the chest brought him to the hospital. The onset was very sharp and his history appeared to be very reliable. An x-ray examination was made one and a half hours after the first symptoms and already a triangular shadow of increased density, streaked in appearance and very characteristic of the very early stage of so-called lobar or bacterial pneumonia is apparent in the right upper lobe. Twenty-four hours later the process became extremely dense, went on to involve the entire lobe in perfectly characteristic fashion and the more typical appearance of lobar pneumonia was found. This was a pneumococcus type pneumonia.

Case No. 7

A child was coming to our outpatient clinic for another condition. He was seen late in the afternoon, his temperature was taken, and various other

examinations were done and at that time was apparently perfectly normal. He had to remain over for further examination the next day so he went to a motion picture theater that evening where he suddenly was taken with severe pain in the side, began to cough, and felt very uncomfortable. This persisted so that he had to leave the theater and finally reported to our admissions department. A roentgen examination was made at once just two and a half hours from the very first symptom. Here again, in the lateral view at least, the triangle of streaked density which is so typical of early lobar pneumonia was found.

Thus we see that in two cases of bacterial pneumonia an hour and a half and two and a half hours after the first onset of symptoms, diagnostic roentgenograms were apparent. We have studied some 20 fairly well controlled cases of similar character and it is our impression that practically all cases of bacterial pneumonia of the ordinary type will give positive roentgen signs within 12 hours and in the majority of cases within six hours after the first onset of symptoms.

In the case of the atypical or virus pneumonias the situation is completely different and it is interesting to note that these are really interstitial processes at the beginning whereas the bacterial pneumonias start with an intra-alveolar exudation. The difference in the pathology likewise produces a sharp change in the time of development of x-ray findings. In atypical pneumonia 24 and even 48 hours may elapse before one can make a definite determination of an abnormal process in the roentgenogram, although the patient's symptoms are outstanding. The physical findings are even more dilatory in their appearance and the roentgen findings almost always precede the physical signs. There are, of course, cases in which the roentgen findings are readily apparent although the patient has very few symptoms. But when the time of onset is known it will be usually found that a fairly long period has elapsed before the x-ray findings appear.

Case No. 8

A white male aged 24 was admitted to the Hospitals one week after the onset of symptoms. The illness began with a chill and there had been daily temperature deviations as high as 102°. Persistent cough with expectoration of mucopurulent sputum was present. There were a few crackling rales over the right lower lobe. The white blood count was 11,000 with 81 per cent neutrophils. The sputum showed only micrococci and staphylococci. Later studies of the sputum, the reaction to therapy and the temperature curve all suggested a fairly characteristic picture of atypical pneumonia. On x-ray examination, however, only a very few faint changes were made out in the lower lobes which were rather difficult to interpret. They may well represent interstitial infiltrations but are not at all characteristic.

Comment

This is an example of an atypical pneumonia present for almost a week yet giving x-ray findings which might well be considered essentially negative.

A negative roentgenogram, therefore, 12 hours after the onset of symptoms suggesting lobar pneumonia is of great significance. In patients with symptoms of atypical pneumonia, however, 48 hours must elapse before negative findings can be considered at all conclusive.

Many years ago McPhedran and Opie directed attention to the latent period which usually elapses between the appearance of the roentgen signs of pulmonary tuberculosis and the development of symptoms. In 1934 I used the term "latent period" to designate the delay between the exposure to the tuberculous infection and the development of roentgen findings. I reported a series of five cases of pulmonary tuberculosis in young adults whom I had opportunity to observe frequently and whose history of exposure and tuberculin skin test was known. Recently there appeared an editorial in a paper by Brailsford in which he likewise directs attention to this latent period between

the beginnings of a disease and the development of roentgen signs. Brailsford also emphasizes tuberculosis since it is of considerable importance to know the significance of negative roentgen findings in relationship to the time exposure due to tuberculosis. That some delay must occur is evident. Such an interval may account in part, at least, for the failure to sift out all cases of tuberculosis in induction centers, for example, or in tuberculosis surveys.

We have now collected 13 cases in which we have been able to ascertain similar data to those previously reported. In these patients negative skin tuberculin tests and negative roentgenograms are on record on repeated occasions. The time of exposure to a known tuberculosis is fairly clear. From three to five weeks after the exposure there is a conversion of the tuberculin test from negative to positive. In some cases we have films made four, five and six weeks after the tuberculous exposure with negative results. Then at ten to twenty weeks positive roentgen findings appear and further study for a number of years confirms the diagnosis of tuberculosis.

It should be noted that these cases are of a particular character since they are young adults apparently tuberculosis free before exposure, yet the roentgen findings suggest what is usually designated as reinfection tuberculosis. I should emphasize that none of these patients had symptoms at the time of the discovery of the lesion although they developed symptoms later. An illustrative case of this type is described below.

Case No. 9

A nurse aged 19 had been examined several times. Her tuberculin skin test was negative and the roentgenograms of the chest were negative. She was exposed to tuberculosis in a group of patients. Five weeks later her tuberculin skin test was found to be positive. At the same time the roentgen examination was negative. Ten weeks after exposure a small area of infiltration measuring about 10 mm. in diameter appeared in the left subclavian area. There was some evidence of exudation about it. There were

no clinical symptoms nor physical signs. Five months later the lesion showed some diminution in size and appeared denser and more fibrotic. The shadow remained about the same thereafter.

It is interesting to note that Malmros and Hedvall, in a monograph on the development of tuberculosis, published in 1938, were able to collect a series of somewhat similar cases and in their group they undoubtedly have been able to demonstrate, in a few cases at least, x-ray findings eight weeks after the first exposure to tuberculosis. The latent period, here described, is no doubt, dependent upon the size of the lesion and it is significant that there is a close correlation with the experimental work on tuberculosis in animals. It takes about 6 weeks after the usual type of induction of experimental chronic tuberculosis in animals for tubercles to coalesce in characteristic fashion. Obviously some further time has to elapse before these microscopic tubercles enlarge sufficiently to arrive at a size of nodule which is demonstrable in the roentgenogram.

McPhedran, Opie, Dale and a great many others have done many experiments in an effort to demonstrate what size a single lesion must attain to be visible in the roentgenogram of the adult chest. McPhedran showed that lesions of 1.5 to 2 mm. in diameter could be demonstrated in the inflated lung removed from the thorax. Experiments which Dr. Joseph Jorgens has been conducting on living individuals under favorable technical conditions and also with the use of a phantom have up to this time indicated our inability to satisfactorily demonstrate a single lesion in the living individual less than three millimeters in diameter. In the phantom 2 mm. appears to be the minimum. Further experiments are being carried on in this direction.

In connection with this the matter of acute miliary tuberculosis is of great importance. I believe every experienced roentgenologist and pthysiologist would agree that, with only very minor exceptions, individuals who have symptoms

which are the result of chronic parenchymal pulmonary tuberculosis will exhibit demonstrable roentgen signs. Patients with symptoms usually have sufficient exudation so that the roentgen examination is positive. There are some exceptions, of course, to this rule. In most cases the exceptions, I believe, will be found to be, not the usual parenchymal tuberculosis, but rather bronchial tuberculosis in the early stages before there is appreciable parenchymal extension or bronchostenosis. In such situations, i.e., a pure bronchial tuberculosis, symptoms such as hemoptysis may be present, the sputum may contain tubercle bacilli without distinctive roentgen findings being exhibited. This might well be expected from the anatomy of the process.

In the acute pulmonary tuberculous processes, particularly acute miliary tuberculosis, the dictum that x-ray findings precede symptoms does not hold. In a large percentage of the cases of acute miliary tuberculosis the roentgen findings are completely absent at the first onset of symptoms and often for a long period of time thereafter. So far as we can determine from correlated studies of autopsies and roentgen examinations the difference lies largely in the number and size of the tubercles which are present. When one considers that the usual miliary tubercle is less than one millimeter in diameter it becomes evident at once that some other factor must be present in order to give the striking picture which acute miliary tuberculosis frequently exhibits. This additional factor has been the subject of a good deal of discussion but it seems to me it has been fairly well established that it is largely a matter of superimposition. If a sufficient number of these small half millimeter or millimeter sized tubercles are lined up a sufficient density will be produced to give the shadow which is seen in the roentgenogram and until such time the roentgenogram may appear to be completely negative.

In some cases striking and characteristic findings will appear within a week or ten days after the onset of symptoms. In many, however, as long as six or eight

weeks may elapse. The following case demonstrates the latter finding.

Case No. 10

A patient who had a mass in the mediastinum, which was thought to be a dermoid cyst, was admitted to the hospital and was operated upon. The cyst was found but owing to inflammatory adhesions could not be entirely removed, so was drained. Shortly afterward she developed a fever which rapidly became severe, dyspnea developed and seven weeks later she died. Roentgen examinations of the chest were made on several occasions, the last being six days before death and the appearance was normal except for the tube draining the mediastinum. At autopsy, numerous miliary tubercles measuring from one half to one millimeter and a few 2 mm. in size were found. These were largely on the pleura and were rather widely, but thinly, distributed. There were some in the lungs as well. The number was much less than is usually the case and I am inclined to believe that this is the explanation for the failure to observe any changes in the film.

Comment

Six weeks after the first onset of symptoms of miliary tuberculosis, a good roentgenogram of the chest failed to reveal any evidences of the disease. We have seen many other cases of the same type. A negative roentgenogram, therefore, even six weeks after the onset of severe symptoms, does not exclude acute miliary tuberculosis. Roentgen findings may be present but frequently are not.

That very small lesions in the lungs can be demonstrated effectively by roentgenography is best shown in the case of metastatic processes particularly such as occur from sarcoma, from Ewing's tumor and also, in all probability, from carcinoma. We have been able to observe a number of such cases and to have the opportunity to demonstrate the difficulties and the advantages of roentgen examination in this situation. Here we have a condition in which the roentgen findings invariably precede the symptoms

and the physical signs; they certainly appear at a very early stage in the development of the lesion. It is, of course, impossible to say when the lesion actually began. Brailsford has said that he could demonstrate metastases from sarcomas within two weeks of their dissemination but he has made the assumption that the dissemination occurred on the day of the amputation, an assumption which is scarcely valid. We have studied a number of such cases intensively and I should like to report one of these to illustrate our observations.

Case No. 11

A male of 15 developed a Ewing's sarcoma of the tibia; amputation was done and it was followed by irradiation. His lungs were being examined at semi-annual intervals with a view to finding metastasis. The roentgenograms appeared entirely normal until about three years after amputation when the first change was observed; that is, an extremely small nodule measuring about 3 mm. in diameter in the roentgenogram was seen. It was clearly visible because of its situation well out at the periphery of the lung where the contrast with the surroundings was striking. This being the only lesion in the lungs we were in some doubt, naturally, as to the exact diagnosis although it was felt that a metastasis was likely present. Six months were allowed to intervene before a re-examination was done and at the end of that time the lesion appeared to have grown in size so that now it measured about 7 mm. in diameter. At this time it was suggested that a segmental pneumonectomy be performed and this was done by Drs. John Paine and Richard Varco. The specimen showed a typical metastatic nodule actually measuring about 6 mm. The patient recovered promptly and without incident. He was re-examined again about 7 months later. The lesion on the right was entirely absent and there were no residual evidences of the surgery but now a similar nodule became apparent on the opposite side. It was not clearly recognized at this time but on re-examination six months later it was observed. At this time a segmental pneumonectomy was performed on the left and a similar tumor removed. There was already another

metastasis on the right but it was so small that it was not observed. Six months later several metastases became clearly evident. The distinction of such small lesions from vascular shadows is difficult to make but might be accomplished by making films in different phases of respiration, by rotation, or by timing the exposures in the cardiac cycle as described by McPhedran and Weyl.

Comment

It is evident that exceedingly small lesions may be seen before there are any symptoms or physical signs in the case of the metastasis.

There is, however, even here, another side of the coin not commonly pointed out and that is the case of miliary metastases in which the lesions are less than one millimeter in size. If one follows patients to autopsy consistently it is astonishing occasionally to find a patient whose pleural surfaces appear to be studded with tiny metastases yet the roentgenogram appeared to be entirely negative. A characteristic example is reported below.

Case No. 12

A patient with carcinoma of the esophagus was operated upon by Dr. Richard Varco. During the course of the exploration of the mediastinum he also explored the left lung and found numerous, exceedingly small, miliary nodules over its surface. These were confirmed first by biopsy and later at autopsy as metastases from carcinoma. Yet a roentgen examination had been made the day before operation and nothing but a few tiny shadows were seen; they were indistinguishable from the vascular trunks. Even knowing the findings it is impossible by magnification or otherwise to demonstrate any abnormal shadows.

Comment

It is clear that metastases of 3 mm. or over may often, although not always, be exhibited in the roentgenogram. Miliary metastases like miliary tubercles may readily escape detection.

Finally, with this same point of view in mind, I should like to explore one more field of roentgen diagnostic endeavor; that is, primary carcinoma of the lung. Here again we have no means for determining the time of onset but we do have evidence with regard to the first symptoms of the patient. The problem of whether or not we can determine the presence of a primary tumor in the lung by means of roentgen examination prior to the onset of symptoms is of considerable importance. The widespread trend toward mass surveys of the chest may well lead us in the direction of an attempt to diagnose such tumors in symptomless individuals, more frequently than heretofore.

Because roentgenograms of the chest are made so commonly we have been successful in tracing down earlier films made in various institutions other than our own on a considerable number of patients in whom we have suspected or have demonstrated the presence of a bronchogenic tumor. We have thus obtained a sort of past roentgenologic history that has permitted us to get some idea as to whether or not carcinoma of the bronchus may be present with symptoms and without apparent x-ray findings or conversely whether the roentgen findings may appear in many cases before the onset of any symptoms whatever. Our experience in a number of cases indicates: (1) that with adequate examination the roentgen findings may well be evident in many cases at a time when the patient is apparently well; (2) that the roentgenologic findings are almost always present if the patient has symptoms; (3) that, in the cases in which physical signs and symptoms are present, while there appears to be an absence of roentgen findings, adequate examination, particularly in different phases of respiration, will almost invariably produce roentgen evidences of abnormality.

In order that abnormal changes be observed in the early stages which we are considering it is necessary to pay close attention to relatively minor changes in the normal lung pattern. Particularly is it necessary to determine differences in the degree of inflation of the lungs during the phases of respiration. I do not wish to go into the details of

the roentgenologic findings in primary tumors of the lung. I would only point out three important signs which are exhibited in this series of films and to which perhaps more attention should be given. Let me emphasize that none of the things that I shall speak of are necessarily pathognomonic of bronchogenic carcinoma. They represent, however, clues which should lead us to further investigation and thereby the establishment of the diagnosis in more unequivocal fashion.

The first sign is enlargement of one of the root shadows of the lung. We all appreciate the great variation which exists in the size of the root shadows and the numerous lesions which may produce enlargement of one or both of the root shadows leaving it as a residual but without present clinical significance. Nevertheless, in view of the increasing frequency with which carcinoma of the lung is seen and the extreme importance of the problem from the standpoint of the salvage of many individuals it is incumbent upon us to give more attention to such minor changes.

Case No. 13

A patient came in with pain in the fibula which proved to be due to a destructive tumor. On biopsy examination this was shown to be a metastatic adenocarcinoma. Routine examination of the chest was then made and an enlarged root shadow on the right side was ascertained. On the lateral view this was clearly in the center of the lung around the bronchi. Further studies with bronchography and planigraphy revealed constriction of the right lower lobe bronchus characteristic of carcinoma. The lesion might well have been completely overlooked were it not for the metastatic process which was already present. The patient had no particular pulmonary symptoms.

Comment

Such a finding of a unilateral enlargement of the hilum shadow in a symptomless individual might well be observed during the course of a mass survey. Such cases should certainly be

singled out for intensive study.

The second sign is an area of density in the periphery of the lung which may be round and sharply defined or irregular and poorly defined. In themselves such isolated shadows are difficult to distinguish from a variety of other processes such as tuberculoma, atypical pneumonia, benign tumors, localized abscesses, fluid filled lung cysts. Nevertheless such a shadow may be the first clue to the presence of a peripheral or infiltrating carcinoma of the lung and may often be found accidentally. The following three cases illustrate that minimal findings in the periphery of the lung, representing the first stages of carcinoma, may be detectable in the roentgenogram before the onset of symptoms or may readily be overlooked even after the development of symptoms.

Case No. 14

A 59 year old male consulted a physician in July, 1945, when he began to complain of respiratory symptoms. There was a cough productive of a whitish to yellow sputum and a low grade pain in the chest localized over the sternum accompanied by weakness, fatigability and listlessness. Roentgenograms of the chest were made elsewhere on August 28, 1945, and were considered to be negative. On re-examination, however, they do show a very small density in the right superior mediastinum with slight enlargement of the hilum shadow. Because of the negative diagnosis nothing was done; the pain continued and became somewhat more severe. He was admitted to another hospital September 29 where he developed chills and fever and a diagnosis of atypical pneumonia was made. Roentgenograms made October 1 showed a definite infiltration of considerable degree in the right upper lobe extending out from the mass which was originally present in the films of August 28.

He was first seen here October 21, 1945, at which time he was seriously ill and a mass had developed overlying the sternum between the third and fourth interspaces on the right side. There were no physical findings insofar as the lungs themselves were concerned except for

some dullness over the area of the mass. Bronchography was undertaken and no obstruction to the major bronchi could be made out. It was impossible to fill out the anterior branches of the right upper lobe bronchus, however. Further examination showed destruction of the sternum and a mass extending to the left side.

The patient expired November 7. In the right upper lobe numerous nodules varying in size from 1 mm. to 5x4 mm. in diameter were found. In addition there was a large lobulated lymph node measuring 8x5 cm. to the right and superior to the bifurcation of the trachea. In the microscopic section these appeared to be typical of small cell carcinoma characteristic of a primary lung tumor. Metastatic lesions were also found in the sternum, spleen, kidney and in the brain.

Comment

Here we see a lesion, present in the films made after the onset of symptoms, but unrecognized because of its extremely small size. When it became large enough to give a more distinctive shadow metastases had already occurred. It is evident that primary carcinoma of the lung may, in some cases, give respiratory symptoms even when the tumor is of small size and difficult to detect in the roentgenogram; yet the demonstration of the nodule in the original films bears out the dictum that roentgen findings will be visible if symptoms are present.

Case No. 15

A 42 year old white male came in because of occipital headaches, weight loss and difficulty in walking. He had had no respiratory symptoms whatsoever, the entire complaint being related to the headaches and some personality changes. There were no physical findings in the thorax. As a result of clinical studies it was thought that he might have a cerebral abscess. On roentgen examination a small nodule, fairly sharply defined was found in the right lung. While this was not entirely characteristic it was suggestive either of a

tumor of primary origin or possibly a metastasis such as might occur from a hypernephroma. No evidence of hypernephroma was found. By means of ventriculography symmetrical dilatation of the lateral ventricles and of the third ventricle were demonstrated. A frontal craniotomy and ventriculotomy was done with some improvement in his condition. Then a suboccipital craniotomy was performed and a brain abscess encountered. Although this was drained he went progressively downhill and expired. At autopsy the abscess in the brain was found to be due to a carcinomatous metastasis. The lesion in the right lung was found to be an abscess cavity within a carcinoma apparently of the peripheral type. The bronchial origin was not demonstrated.

Comment

A solitary nodule proved to be a peripheral carcinoma. It should be noted that here the roentgen evidences of the tumor were present before the onset of respiratory symptoms.

Case No. 16

A white male of 62 was first seen in this hospital October, 1938. He came in complaining of headaches and a maxillary sinusitis was found to account for this symptom. A routine film of the chest was made at that time and was reported to be negative. However, on re-examination, minor changes suggesting fibrosis and infiltration can definitely be made out in the right apex. There were no pulmonary symptoms at that time although the changes in the roentgenogram are quite definite. Three months later he began to have some pain in the chest, slight cough with some fever. In February of 1939 clubbing of the fingers was observed by his own physician. Two weeks later another roentgenogram of the chest was made and a definite mass could be made out in the right apex corresponding to the areas of infiltration shown in the film made 5 months earlier. Later the process increased and the patient finally succumbed to the lesion developing metastases to the liver.

Comment

The infiltrative process in the right apex was present some three months before the first symptoms of any pathology in the chest. The failure to report it was an error. It is very doubtful that it would have been considered a tumor in any case but it is probable that re-examination would have been made at an earlier date when the growth in size might have directed attention to this diagnosis.

The third sign consists of a minor change in the relative radiability of a portion of one lung, which is the result of obstructive emphysema. First reported by Westermarck in 1938, we now believe this to be an important early sign of bronchogenic carcinoma, particularly well brought out if films are made both in expiration and inspiration. The emphysema results from partial obstruction of a bronchus and is usually followed by atelectasis when the obstruction from the tumor becomes complete. In the second stage of bronchial obstruction as described by Westermarck a relative emphysema is present on the affected side. It can usually be observed well only in expiration. In the third stage a true emphysema develops so that the abnormal lung remains inflated even during inspiration. In the last stage the bronchus is completely obstructed, air cannot get into the lung, the remaining air is absorbed and atelectasis supervenes.

From our observation of a fairly large series of cases in which we have been fortunate enough to obtain films made at various intervals before the onset of symptoms, we feel that more careful observation of differences in radiability would lead to further examination, particularly films made during the phase of expiration, and closer investigation of the patency of the bronchi. As a result the diagnosis of carcinoma of the bronchus might well be made at an earlier stage. The following cases illustrate our observations of such findings.

Case No. 17

A male of 57 came in because of pain in the chest and cough. On the first roentgen examination there was observed an area of emphysema in the right upper lobe. In the inferior portion of the right upper lobe there could be seen a somewhat linear zone of density fairly characteristic of atelectasis. The whole right upper lobe was larger than normal and on expiration failed to contract down as did the remaining portions of the right lung and the left lung. Thus the combination of atelectasis and emphysema from obstruction of the right upper lobe bronchus was clearly observed in this case at this time. Planigraphic and bronchographic examinations revealed a characteristic carcinomatous obstruction of the right lobe bronchus which was later proved by bronchoscopic biopsy. At exploration the extent of the lesion was such as to make extirpation impossible.

Comment

The combination of atelectasis and emphysema produced simultaneously by a tumor of the bronchus is illustrated in this case. In most patients the emphysema comes first; the atelectasis is a late development. In this case the symptoms were already present at the time the roentgen findings were observed.

Case No. 18

A male, aged 58, was admitted to the University Hospitals February 5, 1940. His health had been good until four weeks prior to this time. At that time he began to cough and raised some blood-tinged sputum, as much as three ounces being raised daily. There was also some hoarseness during the first week of his illness. He gave a history of periodic elevated temperature ranging from 101 to 103°F. There was no pain and he was only moderately dyspneic but there had been a weight loss of 20 pounds.

Physical examination showed evidences of weight loss. Percussion of the chest showed hyper-resonance on the left but with complete absence of breath sounds--the typical signs of trapped air. A few musical rales were audible in most of the

left lung. There was a small node palpable deep in the suprasternal notch. The findings otherwise were essentially negative.

A roentgenogram of the chest made in deep inspiration appeared to be essentially negative but fluoroscopic examination of the chest made at this time showed a typical pendulum motion of the mediastinum which was in the mid-line during inspiration and moved distinctly to the right side on expiration. A roentgenogram was made in expiration and showed the normal elevation of the right diaphragm, the normal decrease in radiability of the right lung and a shift of the mediastinum to the right. The left lung retained its inspiratory radiability and the left diaphragm remained low. The appearance is characteristic of obstructive emphysema shown only in the expiratory phase. In addition, there was a little mottled density at the very base of the left lung behind the heart.

Bronchography was undertaken and an irregular, ragged obstructive process in the left main bronchus just beyond the carina was observed, the appearance being characteristic of bronchogenic carcinoma which was incompletely occluding the left main bronchus. Bronchoscopic examination showed the granular mass nearly completely obstructing the left main bronchus about 1 cm. below the carina. Biopsy was done and microscopic examination gave the typical findings of a bronchogenic carcinoma. Because of the supraclavicular lymph node and evidences of metastasis to the mediastinal lymph nodes pneumonectomy was not undertaken. Re-examination was done a month later and showed emphysema of the left lower lobe even during inspiration. The patient was treated with radium and x-ray therapy and eventually succumbed to the illness.

Comment

In this case the first signs were an obstructive emphysema of the left lower lobe. It is notable that there was very little evidence of a mass in this case and very slight evidences otherwise on roentgen examination to

indicate a carcinoma until the fluoroscopy and bronchography were undertaken. The small area of increased density at the left base very likely represents a beginning atelectasis associated with the emphysema. The roentgenograms illustrate the bronchial obstruction in the stage of expiratory emphysema at first. Later a permanent emphysema of the same lobe occurs so that it is clearly visible during inspiration as well.

In cases of this type it is conceivable that typical advanced symptoms and definite physical signs might be present with negative roentgen findings if a simple postero-anterior roentgenogram in deep inspiration were the only examination made. The addition of fluoroscopy or films made in expiration gives the positive roentgen evidence.

Case No. 19

A white male, aged 56, was in good health up to the latter part of 1943 when he began to have frequent colds. In February, 1944, he had an episode of pain in the abdomen with vomiting and was hospitalized elsewhere for a period of eight days. The cause of this illness was never definitely determined. He recovered apparently completely from this episode and returned to work. During his stay in the hospital a routine roentgenogram of the chest was made and was reported as negative. On close examination, however, there is shown a distinct enlargement of the left hilum shadow and a definite emphysema of the left upper lobe.

Two months later the patient had a sudden chill with a high temperature and was admitted to another hospital again. His temperature was high and oxygen was necessary. Sputum examination showed pneumococci Type 1. On roentgen examination of the chest there appeared to be a complete consolidation of the left lung. Under chemotherapy the patient recovered. Follow-up roentgen examination, however, showed some resolution of the pneumonic process in the lower lobe but an atelectasis of the left upper lobe was clearly apparent. There was also, at this time, evidence of an increased size of the left hilum.

Repeated examination three weeks later showed much the same findings and the mass in the left hilum was more apparent. A tentative diagnosis of bronchogenic carcinoma was made. Owing to the patient's condition bronchoscopic examination was postponed and it was not done until July 17. The diagnosis of bronchogenic carcinoma was then determined positively by means of biopsy and microscopic study.

The patient was admitted to the University Hospitals July 23 apparently in good health. Physical examination was entirely negative except for dullness on percussion of the entire left chest and hyperresonance of the right lung. The temperature was normal and there were no other significant findings. Roentgen examination showed an obvious atelectasis of the left upper lobe of severe grade with a mass in the left hilum.

On July 31, 1944, Dr. Owen Wangenstein did a total pneumonectomy of the left lung. A group of enlarged mediastinal lymph nodes were found and apparently all dissected out. The specimen showed a papillary tumor in the left main bronchus extending fully 2 cm. into the upper lobe bronchus but overriding the orifice of the lower lobe bronchus as well. The tumor extended through the wall of the bronchus into a mass of lymph nodes measuring 5 cm. in diameter. Microscopic study indicated that it was a squamous cell carcinoma of the bronchus with metastasis to the lymph nodes.

Comment

In the original films, made during the course of routine examination, a distinct difference in the radiability of the two upper lobes can be made out. This film was made in deep inspiration, despite which the emphysema of the left upper lobe is clearly apparent. At the same time there is seen a moderate enlargement of the left hilum. Observation of these two findings at that time might have led to a suspicion of the correct diagnosis two months before the onset of symptoms, and further investigation would have been carried on five months earlier than actually was the case.

The transition, in the left upper lobe, from emphysema to atelectasis is well shown in this instance. This transition occurred somewhere between February and April of that year. It appears to have been associated with a secondary infection since he actually had a pneumococcus Type 1 pneumonia involving the lower lobe as well as the atelectasis of the upper lobe.

Case No. 20

An iron miner was examined elsewhere on repeated occasions to detect early silicosis. He had some complaint of pain in the chest in 1944 and some cough prior to that time but this disappeared. He was seen January 29, 1945, at which time he had no complaints whatever. Routine examination of the chest was made because of the possibility of silicosis. In the roentgenogram, made at this time elsewhere, a local area of emphysema in the right upper lobe can be made out characteristic of the segmental obstructive emphysema described by Westermarck as the first sign of obstruction of the bronchus. It should be emphasized that there were no symptoms at this time. Several months later he began to have a cough and occasionally a little fever. Four months after this examination he developed a severe temperature and an acute process from which he recovered very slowly. He returned to work in July of 1945. He continued to have slight cough. A year later in July, 1946, routine examination of the chest was again made. At this time, however, he had a chronic cough and some physical findings such as diminished breath sounds and dullness below the right clavicle. Later examination in this hospital revealed a characteristic atelectasis of the same segment of lung which was seen to be emphysematous in the roentgenogram made 18 months earlier. Planigraphy and bronchography showed a characteristic carcinomatous obstruction of the right upper lobe bronchus which was later confirmed both by bronchoscopy and by exploration. The lesion could not be extirpated.

Comment

In this case then, a localized finding suggestive of carcinoma of the bronchus

was present approximately two months before the very first symptom and eighteen months before any physical findings or serious symptoms were apparent.

Finally, I should like to report one more case which was somewhat complicated but illustrates again the possibilities of early diagnosis of carcinoma of the lung prior to the onset of symptoms.

Case No. 21

A physician was known to have an enlarged right root shadow with calcification within it for many years. He was in the habit of having films of his chest made at yearly intervals because of this finding, although he had no specific symptoms. About two years before the development of any pulmonary symptoms he had a roentgen examination because he had a moderate hypertension and the determination of his heart size was desired. This examination was made at another hospital. A film was made in deep inspiration and because the technician thought that this was an error, since the diaphragms had been pulled down too far, another film was made in mid-respiration. It is interesting to observe the distinct difference between these two films at a time when this man had no symptoms whatever. There is clearly an obstructive emphysema of the right lung shown only in the expiratory film. He was re-examined approximately a year and a half later in deep inspiration only. At that time the first evidences, in addition to the obstructive emphysema, became apparent; that is, the root shadow had extended itself farther into the base of the lung and a nodule had appeared along its outer periphery. Unfortunately, because of the fact that the shadow had been large before and comparison was not made between this and the previous film these findings were not observed. Approximately six months later the first symptoms appeared. There was cough, pain in the chest, some malaise and loss of weight. At this time a characteristic nodular tumor in the right root became apparent. Unfortunately, even at this time the diagnosis was not fully appreciated because examination of his sputum on one occasion exhibited tubercle bacilli. A

further delay occurred. When we saw him for the first time six weeks later atelectasis and all the characteristic evidences of carcinoma obtained. Pneumonectomy was done but was of no avail as metastasis appeared shortly in the cervical lymph nodes.

Comment

Minor changes in the lung indicative of emphysema might have been observed about two years prior to the onset of symptoms. Definite enlargement of the root shadow was present on roentgen examination six months before the onset of symptoms. Such cases indicate unequivocally that in bronchogenic carcinoma positive roentgen signs may well be present before the first appearance of symptoms.

SUMMARY

There are definite limitations to the roentgen demonstration of abnormalities. Some of these may be clearly defined and may be expressed in terms of the relationship of the appearance of roentgen signs to the inception of the disease or to the onset of symptoms or in a quantitative way. The possibilities and limitations of roentgen diagnosis are particularly well illustrated in diseases of the thorax. The results of some of our studies in this field are summarized as follows:

1. Pulmonary edema can be detected before the onset of appreciable symptoms and in the very earliest stage of its development providing it is an intra-alveolar type of process.
2. Interstitial edema is poorly demonstrated by roentgen examination.
3. Pleural effusion in amounts of 100 cc. or more can be detected if positional change is utilized during the examination.
4. Bacterial pneumonias are demonstrable, in some cases, within a few hours after the first onset of symptoms and in practically all cases within twelve hours after the first onset.
5. Atypical or virus pneumonias do not give distinctive roentgen manifestations for 24 to 48 hours after the onset of the symptoms and the extent of the pathology is not well demonstrated.
6. Pulmonary tuberculosis of the ordinary chronic type is demonstrable in the roentgenogram in from ten to twenty weeks after the first exposure to the disease. In almost all cases of parenchymal tuberculosis of the chronic type the roentgen findings precede the symptoms.
7. Miliary tuberculosis gives symptomatic evidence of its presence before the roentgen findings are apparent and symptoms may be present for as long as seven weeks without any x-ray evidence whatever.
8. Nodular lesions such as metastasis are demonstrable when their size is 3 mm. or larger in diameter. Miliary metastases may not be seen until they are very numerous or large in size.
9. Bronchogenic carcinoma almost invariably gives positive roentgen signs, if thorough examination is done, when symptoms are present. In many cases of bronchogenic carcinoma, the x-ray findings will be present before the onset of any respiratory symptoms. Examination during expiration as well as inspiration will facilitate the early diagnosis.

Further studies of similar nature should be undertaken to determine the limitations of roentgen examination in the diagnosis of all disease processes.