THE EFFECT OF BRONCHOSTENOSIS UPON THE ROENTGEN-RAY SHADOWS IN CARCINOMA OF THE BRONCHUS*

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THE problem of the diagnosis of primary neoplasm of the lung seems at the present time to be attracting considerable attention, if one may judge by the frequency with which the subject is discussed at medical meetings. Indeed, this problem, which is occasionally relatively easy as clinical problems go, is often very difficult to solve, and unfortunately seems to be presenting itself more and more often for solution.

Ewing[1] states that primary carcinoma of the lung may arise from three different types of cells: (1) from the bronchial epithelium, (2) from the mucous glands, and (3) from the alveolar epithelium.

It is not possible to discuss satisfactorily at this time the diagnosis of primary carcinoma of the lung and to illustrate with cases showing the numerous different manifestations of this disease. Consequently the present discussion will be limited to one rather narrow phase of the question. Its object is merely to point out the remarkable changes in the shadows on the roentgenogram which may take place as the disease progresses and to indicate the rôle which bronchostenosis plays in the production of these changes.

It seems advisable first briefly to trace the events which accompany the development of bronchial carcinoma. As the tumor grows it does two things locally; (1) it invades the surrounding tissues, and (2) it gradually fills up the lumen of the bronchus causing more and more obstruction and in some cases finally obliterating it completely. Occasionally the disease is terminated by hemorrhage or some other accident before bronchostenosis occurs, but this in our experience has been uncommon.

An interesting discussion of the effects of closure of a bronchus is given by MacCallum.[2] When complete occlusion occurs, as Manges[3] has shown in his foreign body cases, there is collapse (atelectasis) of the corresponding part of the lung because the air remaining in the alveoli is quickly absorbed by the circulating blood. When the obstruction is incomplete, the bronchi distal to it become dilated. Hence in the gradually developing stenosis of a bronchial carcinoma the condition is first that of incomplete obstruction, and bronchiectasis follows with infection in its train. As the occlusion becomes more marked, atelectasis with its ensuing fibrous changes complicates the picture, although apparently it does not take place as suddenly as it does in a normal lobe, the bronchus to which is suddenly occluded as by a foreign body. As a result of the atelectasis or of the infection or of both, there is a marked thickening of the pleura. This is sometimes accompanied or followed by

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an effusion which may be limited by the pleural adhesions.

With the development of bronchostenosis definite changes may take place in the clinical picture as well as on the roentgenogram. The patient's condition becomes worse and he develops striking signs upon physical examination of the chest which are apt to change in a peculiar manner from day to day or even hour to hour. The changes on the roentgenogram depend upon the bronchus involved, and

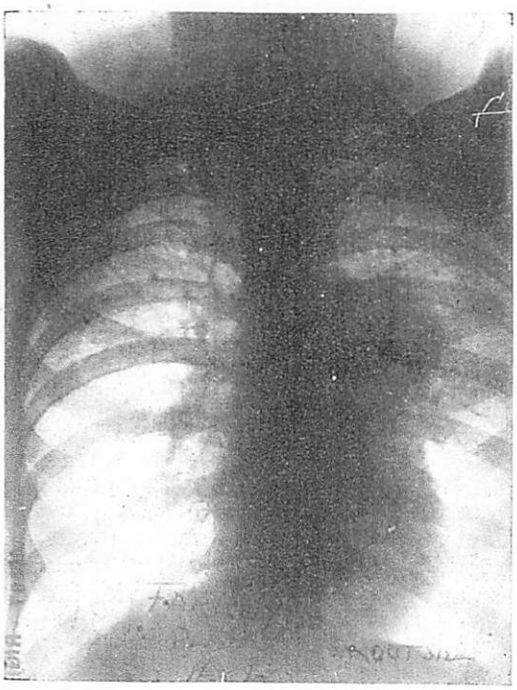

FIG. 1. Case I. Mesothelioma of pleura which invaded the bronchus and caused bronchostenosis. Jan. 10, 1921. A rounded shadow with ill-defined margins projects from the mediastinum into the left lung field.

it is to these that our attention will be confined.

Therefore, as far as its physical effects are concerned, it seems well to consider bronchial carcinoma as developing in two stages: 1. Stage of invasion; 2. Stage of bronchostenosis: Characterized by (1) bronchiectasis; (2) infection; (3) atelectasis; and (4) thickening and adhesion of the pleura, with or without fluid.

A study of our cases seems to show that the order in which these changes are listed here is probably the order in which they take place. Whether infection precedes, follows, or accompanies bronchiectasis is a debatable point. These two processes, however, in some cases at least, precede atelectasis, as for example, in Case IV.

Of the 5 cases from the Medical Service of the Presbyterian Hospital, New York City, illustrative of these changes, 4 have been proven by necropsy and by bronchoscopy. The clinical side will be touched upon as briefly as possible.

Case I (No. 48869). Although this discussion deals primarily with bronchial carcinoma, the first case is a mesothelioma of the pleura which invaded the lung and bronchus and caused bronchostenosis with its attendant results, and hence is of interest in the study of changes due to bronchial obstruction.

The patient was a man aged thirty-seven, who was admitted Jan. 27, 1921, complaining of cough and pain in the left chest of three weeks' duration. At the onset he consulted his physician who had a roentgen-ray examination made of the chest.

The first film (Fig. 1), Jan. 10, shows a rounded shadow with ill-defined margins projecting from the mediastinum into the left lung. His pain grew worse, he became dyspneic, lost weight rapidly and began to raise bloody mucoid sputum.

The second film (Fig. 2), Jan. 28, the day after admission, shows a marked advance in the shadow in the left lung field and diminished radiability of the periphery of the left lower lobe. This together with the bloody sputum suggests that invasion and constriction of the bronchus had already begun. It was recorded clinically at this time that the heart seemed slightly displaced to the left. Unfortunately, the rotation to the left on this film is so great that it is impossible to be sure about the position of the heart.

The third film (Fig. 3), Feb. 15, shows an increase in the shadow at the left base and definite displacement of the heart into the affected side which is the characteristic result of atelectasis. About ten days before this was taken the patient developed the physical signs of fluid, and the first of a series of four aspirations was performed, removing 500 c.c. of fluid. At the other

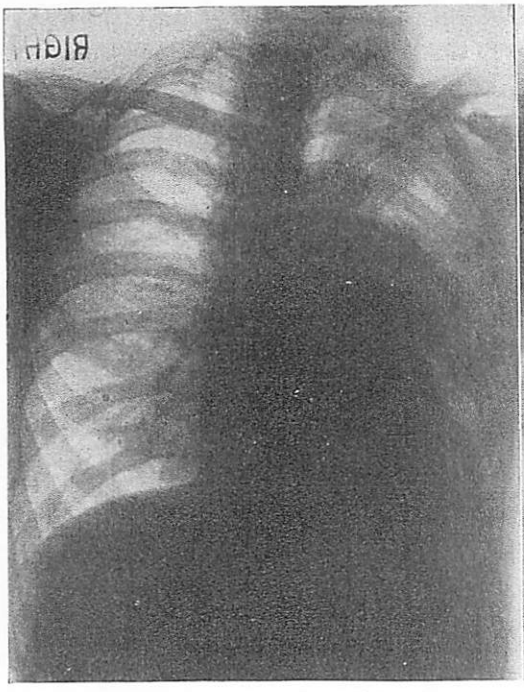

FIG. 2. Case 1. Jan. 28, 1921. A marked advance is evident in the shadow in the left lung field with diminished radiability of the periphery of the left lower lobe. This together with the appearance of bloody mucoid sputum suggests that invasion and constriction of the bronchus have begun.

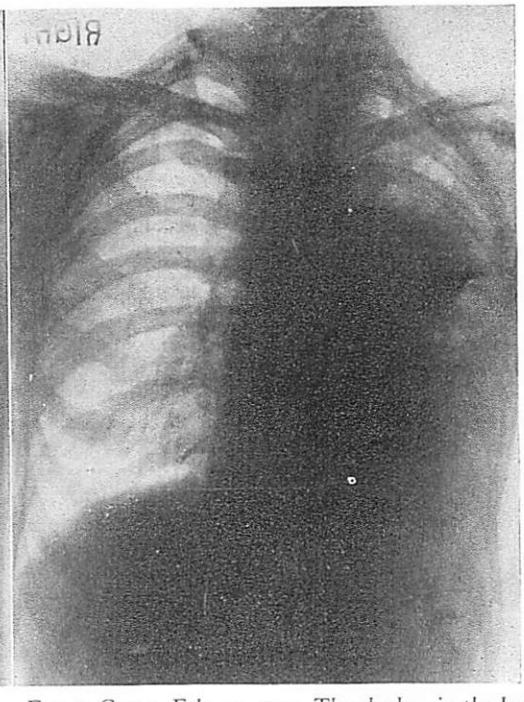

FIG. 3. Case 1. Feb. 15, 1921. The shadow in the lower part of the left lung is more dense and the heart is displaced to the left, the characteristic result of atelectasis. Shortly before this 500 c.c. of fluid were removed.

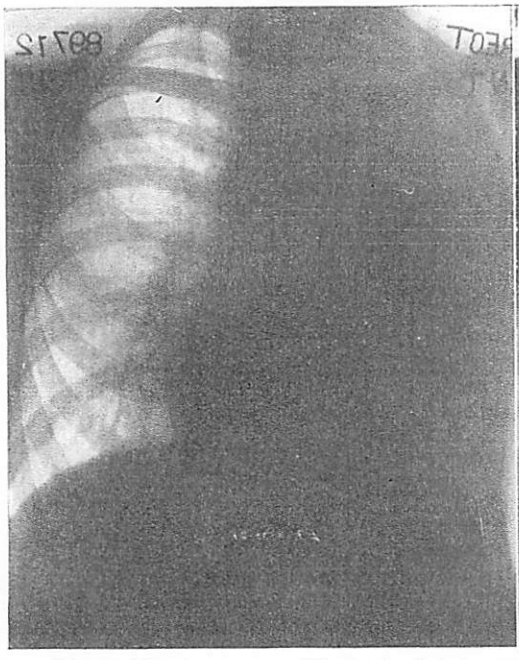

FIG. 4. Case 1. March 30, 1921. The entire left lung field is covered by a dense shadow. The heart is approximately in its normal position.

FIG. 5. Case 1. April 18, 1921. The dense shadow covers the entire left side and the heart is again displaced to the left. Between this examination and the one preceding only 600 c.c. of fluid had been removed.

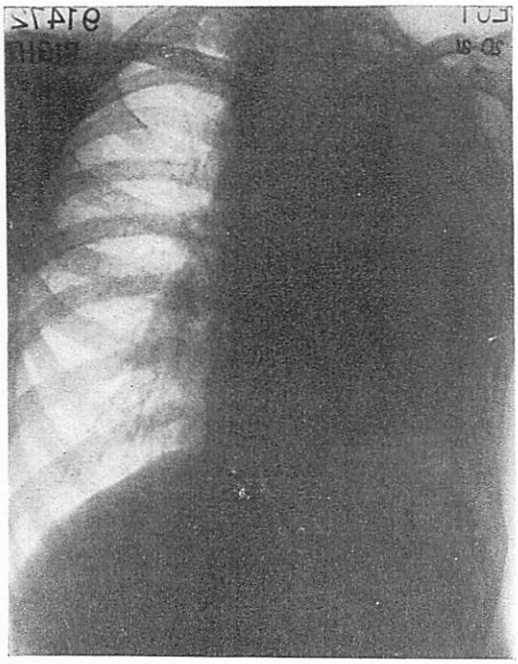

FIG. 6. Case I. May 20, 1921. The left lung field is opaque and the heart is displaced into the shadow as at the preceding examination.

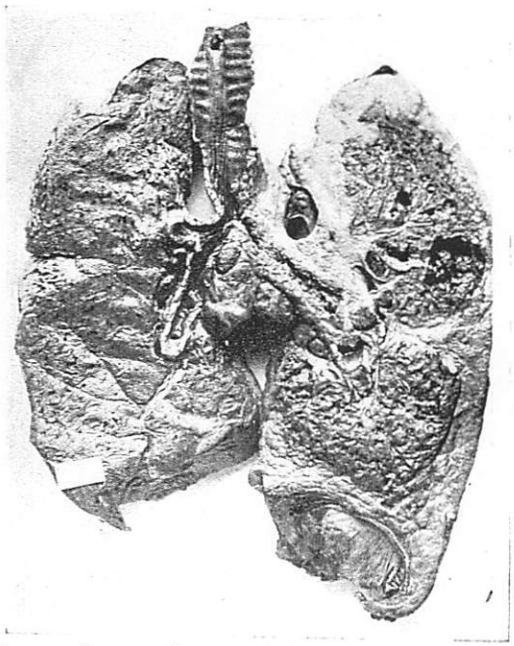

FIG. 7. Case I. Necropsy July 7, 1921, disclosed a mesothelioma of the pleura which completely occluded the left primary bronchus, filled the mediastinum and covered most of the left lung. All of the bronchi of the lower lobe were dilated and filled with pus. In the upper lobe were two cavities.

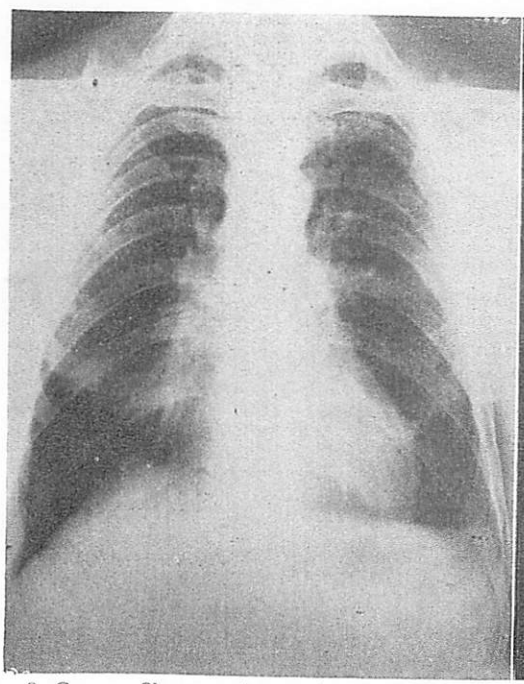

FIG. 8. Case II. Slow-growing carcinoma of the right descending bronchus Dec. 29, 1920. A hazy ill-defined shadow is present in the region of the right descending bronchus. The inner third of the right side of the diaphragm is held up. The pleural adhesions at the left base are the result of pneumonia and empyema twenty-five years before this illness.

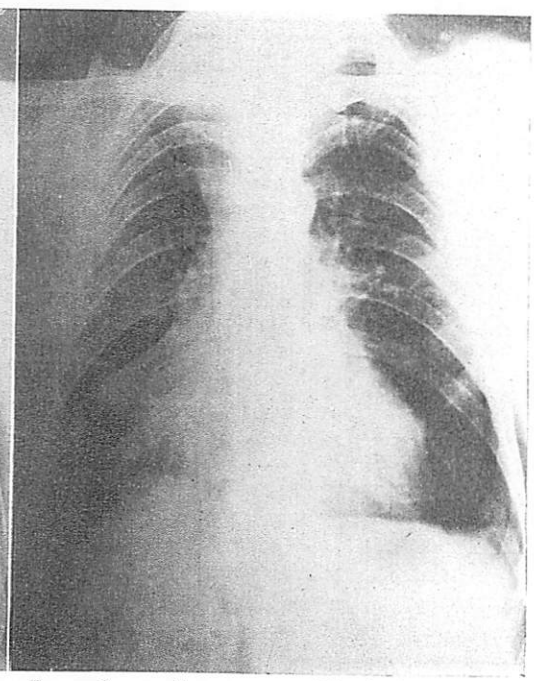

FIG. 9. Case II. Sept. 15, 1921. The shadow in the region of the right descending bronchus seen on the preceding film taken nine months earlier has increased in size. (This print was made from a rather poor contact reproduction and does not do justice to the original film.)

aspirations likewise only small amounts of fluid were obtained.

On March 8 the patient was bronchoscoped. The opening of the left main bronchus could not be found. The right appeared normal. The growth had also invaded the esophagus causing considerable obstruction. On March 15 a film showed the entire left lung field to be obscured.

The fourth film (Fig. 4), March 30, shows the entire left chest covered with this dense shadow with the heart approximately in its normal position. It is difficult to explain this shift in the position of the heart, as the fluid seemed to be present only in small quantities. About five days after this film was taken, approximately 600 c.c. of fluid were removed.

The fifth film (Fig. 5), April 18, shows the heart displaced to the left again, although only the above mentioned 600 c.c. of fluid had been removed.

The last film (Fig. 6), May 20, shows the same displacement of the heart into the shadow covering the left lung field.

Necropsy on July 7 disclosed a large firm mass filling up the mediastinum, continuous with a layer of the same tissue covering most of the left lung and binding it to the chest wall (Fig. 7). The left primary bronchus was entirely surrounded and completely occluded by the tumor. The left lung contained no air. The main bronchus to the lower lobe was dilated and its surface ulcerated. The cut surface of the lung was bathed in purulent fluid. All of the bronchi of the lower lobe were dilated and filled with pus. In the upper lobe were two cavities.

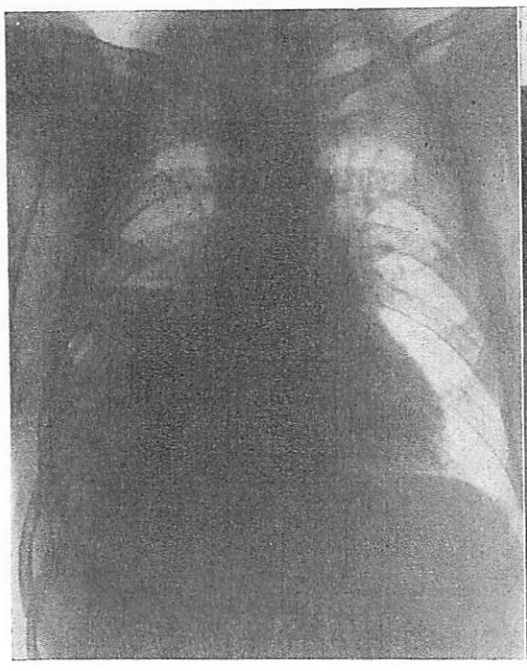

FIG. 10. Case II. March 4, 1922. The shadow at the right base is increased in size and is more dense toward the mediastinum than toward the periphery. A study of the case suggests that the changes associated with bronchostenosis were probably taking place. The band-like shadow across the middle of the right lung field is puzzling. It might be the rather small middle lobe in process of becoming atelectatic. Shortly after this 300 c.c. of fluid were removed.

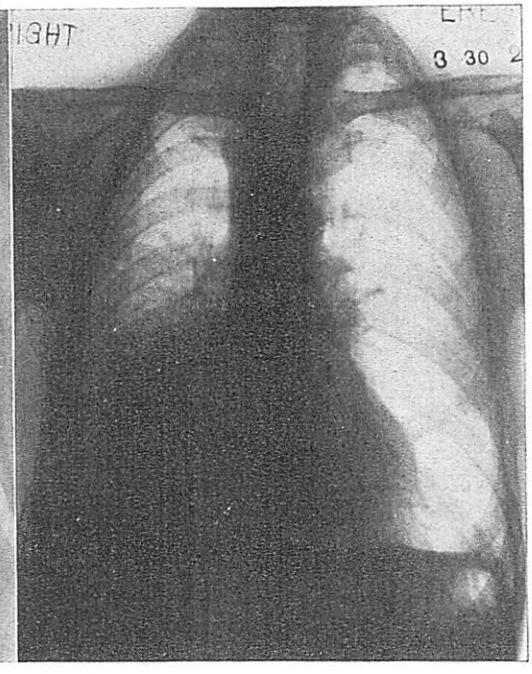

FIG. 11. Case II. March 30, 1922. The shadow at the right base has become homogeneously dense. It is higher at the mediastinum than at the periphery. The upper part of the upper lobe is obscured and the pleura along the right margin of the mediastinum seems thickened.

CASE II (No. 53513). The second case is one of a slow-growing carcinoma of the right descending bronchus. I am indebted to Dr. L. G. Cole of New York City for the first two films and to Dr. R. D. Duck-

worth of White Plains, N. Y., for the third.

The patient was a man aged fifty-one, whose symptoms began with cough, dyspnea on exertion and what was described as "inspiratory asthma" during the fall of 1920.

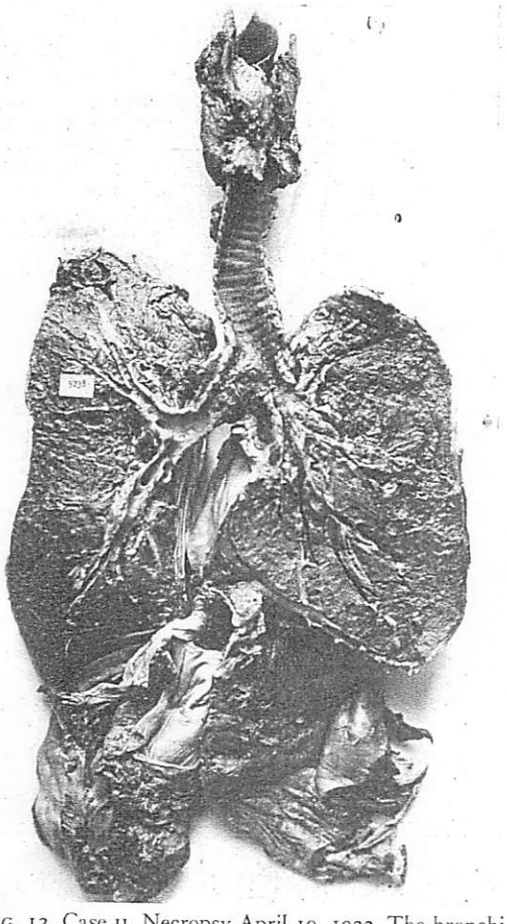

FIG. 12. Case II. Necropsy April 19, 1922. The bronchi to all the lobes were markedly constricted by carcinoma of bronchial origin which contained masses of calcium. The middle and lower lobes were firm and inelastic and contained multiple abscesses. The lung was covered with thickened pleura except at the apex.

The first roentgenogram of the chest was made Dec. 29, 1920 (Fig. 8). There is a rather hazy ill-defined shadow in the region of the right descending bronchus and a holding up of the inner third of the right diaphragm. The old pleurisy on the left is due to a pneumonia and empyema twenty-five years before.

The second film (Fig. 9), September 15, 1921, approximately nine months later, shows essentially the same shadow somewhat increased in size. In February, 1922, he had an acute illness followed by a fever with considerable watery sputum.

The third film (Fig. 10), March 4, 1922, shows considerable increase in the shadow at the right base which appears rather irregular in density, being more dense toward the mediastinum than toward the periphery. Just below the level of the fourth rib there is a band-like shadow of medium density and with fairly sharply defined margins which is rather puzzling. A study of the pathological specimen and of the succeeding roentgenogram suggests that this shadow may be the rather small middle lobe, in process of becoming atelectatic. Shortly after this the chest was aspirated and a small amount of fluid, about 300 c.c., removed.

The patient was admitted to the hospital March 29. The last film (Fig. 11), March 30, 1922, shows a dense shadow at the right base, higher at the mediastinum than at the periphery. The upper part of the upper lobe is obscured by a hazy shadow, and the pleura along the right margin of the mediastinum seems thickened.

Hoping to find an abscess which could be drained a thorocotomy was done. A small amount of slightly turbid fluid was found. The lung did not collapse. Aspiration of the lung itself yielded pus.

Necropsy April 19 (Fig. 12) disclosed a carcinoma of bronchial origin which contained masses of calcium, leading the pathologist to say that it had probably been very slow growing. (The duration of this case was at least a year and a half.) The lung was covered with thickened pleura except at the apex. The openings of the bronchi to all three lobes were markedly constricted and when they were opened pus came from them, especially from the lower lobe. Behind the constrictions the bronchi were dilated. The middle and lower lobes were firm and inelastic and contained multiple abscesses, many of which could be seen to connect with small bronchi.

CASE III (No. 58201). The third case is one of carcinoma of the right upper lobe

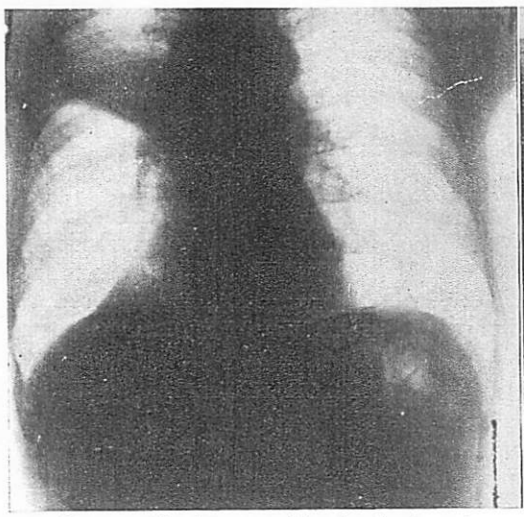

FIG. 13. Case III. Carcinoma arising in the bronchus to the right upper lobe. Aug. 19, 1923. Extending across the right lung field is a shadow, the lower margin of which is sharply defined at about the level of the interlobar septum. It fades off into the air-containing upper lobe which is distinctly less radiable than the corresponding portion of the left lung. It would seem that atelectasis had begun to take place. The inner third of the right diaphragm is pulled up.

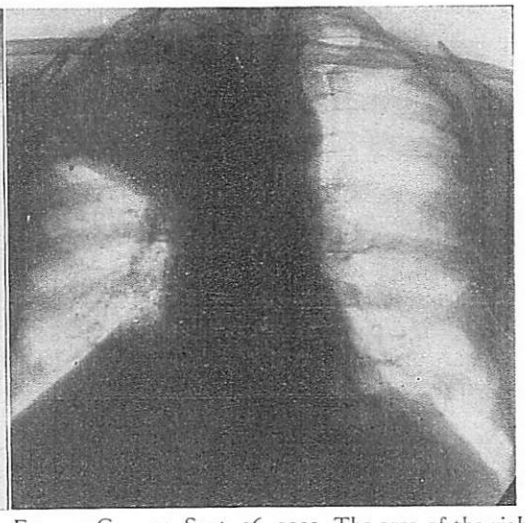

FIG. 14. Case III. Sept. 26, 1923. The area of the right upper lobe is occupied by a dense shadow with a sharply defined concave lower margin. The upper lobe has become atelectatic.

bronchus. I am indebted to Dr. I. Seth Hirsch of New York City for the first and last films. The patient was a man aged sixty-two. His first symptom which appeared in the spring of 1923 was apparently swelling of the face and neck. He was admitted to Bellevue Hospital, August 15, 1923.

The first film (Fig. 13), Aug. 19, shows a shadow in the upper part of the right lung field with a sharply defined lower margin extending from the mediastinum to the lateral chest wall at about the level of the interlobar septum. It fades off above into the air-containing remainder of the upper lobe which is less radiable than the corresponding portion of the left lung. It would seem that atelectasis had begun to take place. The inner third of the right side of the diaphragm is pulled up. This change in the diaphragm has been present in 3 cases of carcinoma of the bronchus to the right upper lobe. Examination of the pathological specimens and consultation with the pathologists has failed to produce an explanation of its mechanism.

The patient left Bellevue Hospital against advice Sept. 2 and about three weeks later came to the Out-Patient Department of the Presbyterian Hospital. He then complained of unproductive cough shortness of breath and loss of weight.

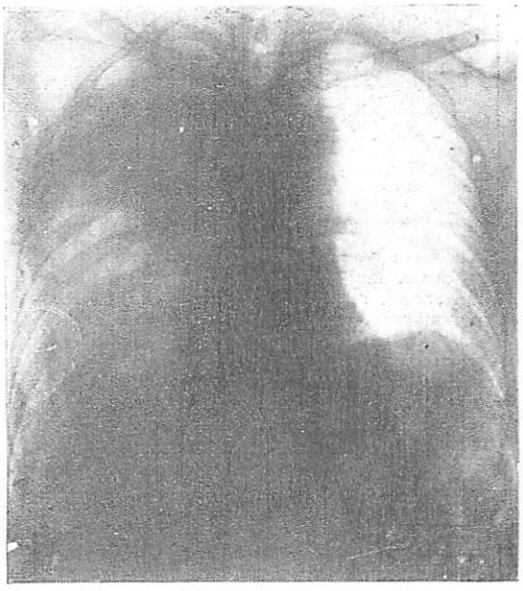

FIG. 15. Case III. Nov. 25, 1923. The shadow in the region of the right upper lobe is unchanged. The shadow of medium, rather irregular density which occupies the lower part of the right lung field was found to be due to bronchopneumonia. At necropsy the carcinoma involved only the upper lobe bronchus. The upper lobe was covered with thickened pleura and contained small bronchiectatic cavities.

The next film (Fig. 14), Sept. 26, shows the area of the right upper lobe to be

occupied by a dense shadow with a sharply defined concave lower margin. He was admitted to the hospital Oct. 13.

A film Oct. 15, and another Oct. 29, showed no essential change except that the lower margin of the shadow in the right lung field bulged downward and became convex instead of concave. Roentgenoscopic examination in various positions showed that the lower margin of this shadow slanted from behind downward and forward, indicating that it occupied exactly the position of the upper lobe.

Bronchoscopic examination disclosed firm-walled tumor nodules involving the lung field is obscured by a shadow of medium, rather irregular density, due to bronchopneumonia.

Necropsy Dec. 7, disclosed a hard nodular mass in the mediastinum surrounding the great vessels, trachea and right bronchus. There were dense adhesions over the right upper lobe. On section of the lung, the bronchus to the right upper lobe was practically obliterated by the growth and tumor nodules were scattered along the right primary bronchus to the posterior wall of the trachea.The growth had invaded the lobe for a short distance as a tongue-like projection along the interlobar septum.

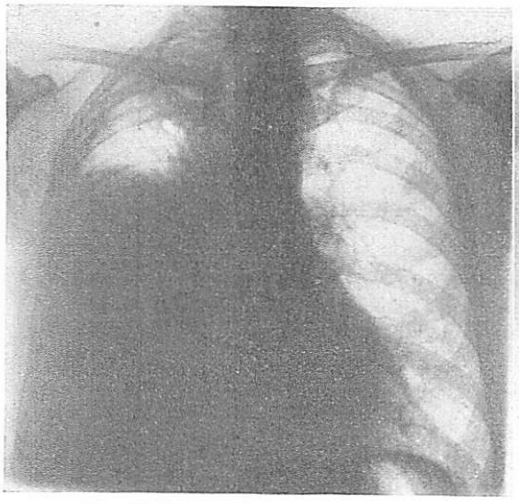

FIG. 16. Case IV. Carcinoma probably arising in the right descending bronchus. March 26, 1924. A dense homogeneous shadow with a well-defined rounded upper margin occupies the lower two-thirds of the right lung field. The right apex is clouded. In the right second interspace are some small rounded or oval shadows of diminished density characteristic of cavities. The trachea is displaced to the right. Four days later bronchoscopy disclosed a growth occluding the lower end of the right primary bronchus. Atelectasis is complete in the middle and lower lobes and is probably beginning in the upper.

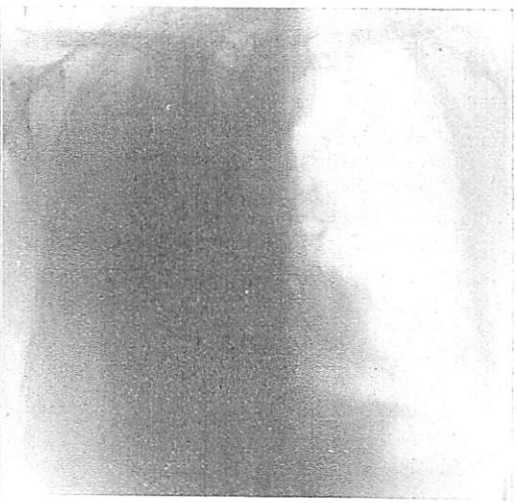

FIG. 17. Case IV. April 18, 1924. The entire right hemithorax is covered by a dense shadow. In the right second interspace the shadows of diminished density probably representing bronchiectatic cavities can be seen. The heart and trachea are displaced to the right. Atelectasis of the right lung is complete.

posterior wall of the trachea just above the bifurcation, the right main bronchus and to a less extent the left. The mouth of the bronchus to the right upper lobe was obstructed. The patient was discharged against advice Nov. 7.

About two weeks later he was admitted to the City Hospital, Welfare Island. The last film (Fig. 15), Nov. 23, shows the shadow in the region of the right upper lobe practically unchanged. Below it the

The bronchi of the upper lobe were dilated and small bronchiectatic cavities were present. There was a diffuse bronchopneumonia of the middle and lower lobes. About a liter of fluid was found in the right pleural cavity. I am indebted to the courtesy of Dr. L. H. Cornwall, pathologist to the City Hospital, New York, and to his associate Dr. J. R. Lisa for the opportunity to examine this specimen upon two occasions.

Case IV (No. 50502). The fourth case is one of carcinoma arising probably in the bronchus to the right lower lobe. The patient was a man aged sixty-six, who was admitted to the hospital March 25, 1924, complaining of pain in the right chest, cough and weakness of six months' duration. He had spit up blood upon one occasion at the onset.

The first film (Fig. 16), March 26, shows a dense homogeneous shadow with a rounded, fairly well-defined upper margin which occupies the lower two-thirds of the right lung field. The trachea is displaced to the right. In the right first interspace are several small rounded or oval shadows of diminished density which suggest multiple small cavities.

The patient was bronchoscoped March 30. The bifurcation of the trachea was displaced to the right. The right main bronchus was clear to about the site of the upper lobe bronchus which, however, could not be identified. Below this the lumen was blocked by a fungating vascular friable growth which looked like carcinoma. These bronchoscopic findings indicate that the mainstem bronchi to all three lobes were occluded.

The second film (Fig. 17), April 18, shows the entire right lung field covered by the shadow. On careful inspection of the right first interspace the small shadows of diminished density described on the preceding film can be seen. The trachea is markedly displaced to the right, as is the heart.

A third film on May 23 showed no change except a little difference in the size and arrangement of the cavities in the right upper lobe. The patient died shortly after this and permission to perform a necropsy could not be obtained.

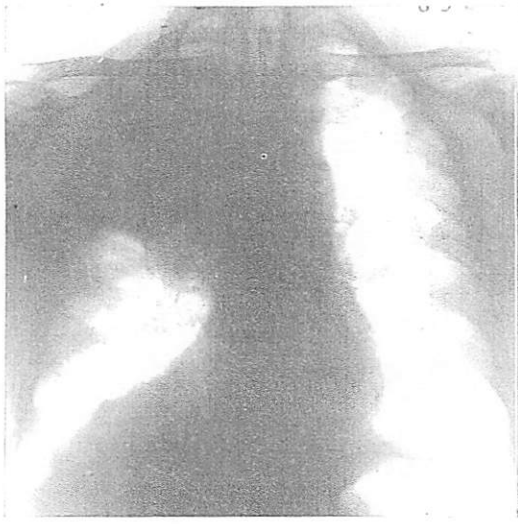

Fig. 18. Case v. Carcinoma of the bronchus to the right upper lobe. Aug. 8, 1923. The upper half of the right lung field is occupied by a dense shadow with a sharply defined lower border which is convex close to the mediastinum and concave toward the periphery. The inner third of the right diaphragm is pulled up.

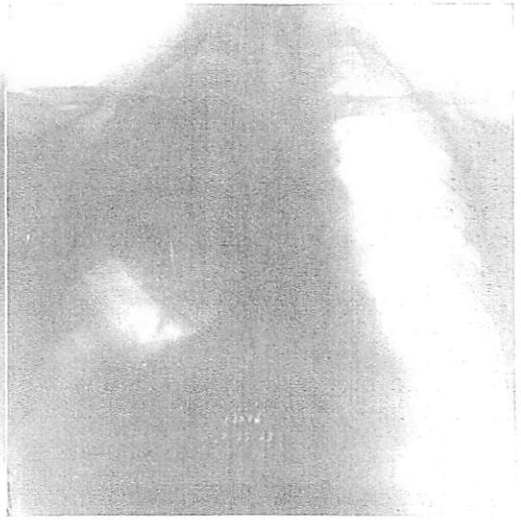

Fig. 19. Case v. Aug. 27, 1923. The lower margin of the shadow in the right lung bulges downward. The marked change in the appearance of this shadow was thought to be due to the retention of pus and secretion in the bronchi and bronchiectatic cavities, causing an actual increase in the size of the atelectatic upper lobe.

In this case, at the time of the first roentgen-ray examination atelectasis of the middle and lower lobes had taken place, and there is evident cavitation, presumably bronchiectatic, of the right upper lobe. At the second examination the right upper lobe had become atelectatic but the small cavities persisted.

Case V (No. 57814). The fifth case is one of carcinoma arising in the bronchus to the right upper lobe. The patient was a man aged fifty-one, who came to the Out-Patient Department complaining of swelling of the head. For three months he had had cough with bloody sputum at times,

and dyspnea on exertion. Six weeks prior to his appearance his face and neck became swollen.

The first film (Fig. 18), August 8, shows a dense homogeneous shadow, the lower border of which is convex medially and concave toward the periphery, occupying the upper half of the right lung field. The inner third of the right diaphragm is pulled up as noted in preceding cases.

He was admitted to the hospital August 25, 1923. The second film (Fig. 19), August 27, shows a marked increase in the downward bulge of the shadow.

Necropsy was performed September 12 and disclosed a carcinoma of the bronchus to the right upper lobe, the lumen of which was so narrow that only a small probe could be passed through it. Beyond the obstruction it was dilated and contained pus. The upper lobe was shrunken and its bronchi dilated and filled with pus. The pleura over the upper lobe was very thick and adherent. The bronchi to the middle and lower lobes were not obstructed.

There is no obvious explanation for this change in the size and contour of the shadow in the right lung field. As the middle lobe bronchus was uninvolved it could not be due to the development of atelectasis of a small middle lobe. The tumor itself extended only 4 cm. below the bifurcation and the same distance to the right of the trachea. The most probable explanation is the actual increase in the size of the upper lobe due to the accumulation of pus and secretion in the bronchiectatic cavities. This would also apply to the change described in the lower border of the shadow in Case III.

SUMMARY AND CONCLUSIONS

The object of this paper is to demonstrate the rather striking changes which may take place in the lung shadows during the course of primary bronchial carcinoma. These are of interest because the impression produced on the mind of the observer may be quite different at different times in the disease.

A study of our cases suggests that, as far as its physical effect is concerned, bronchial carcinoma may be considered as developing in two stages: (1) stage of invasion, and (2) stage of bronchostenosis which is characterized by bronchiectasis, infection, atelectasis, and pleural thickening, with or without fluid.

The hazy ill-defined shadow about the hilus during the stage of invasion may be replaced, as the effects of bronchostenosis begin to manifest themselves, by a dense homogeneous shadow covering the area of one or more lobes, sometimes accompanied by displacement of the heart and trachea to the affected side. Such massive shadows are due to atelectasis of the corresponding lobes with associated bronchial and pleural changes and not to the tumor itself. Hence it is evident that they are not characteristic of bronchial carcinoma but may be produced by any process which occludes a bronchus. Syphilitic stricture and pressure on a bronchus from an aneurysm or from tuberculous glands are other causes of bronchostenosis. During the past three years, however, we have had 7 instances of bronchostenosis due to pulmonary neoplasm, only 2 from syphilis and none from pressure of an aneurysm or tuberculous glands. It would seem from our experience that neoplastic bronchostenosis is distinctly more common.

It is obvious that a correlation of clinical and laboratory information is necessary in order to reach a definite conclusion in these somewhat confusing cases. But when these shadows occupying the position of one or more lobes present themselves for consideration, if the possibility of bronchostenosis due to neoplasm is mentioned, the diagnostic machine will at least be started on the right road.

I wish to thank Dr. Wm. C. Von Glahn for his kindness in placing his pathological material at my disposal. Cases I and II have been reported by him.*

BIBLIOGRAPHY

1. Ewing, James. Neoplastic Diseases. W. B. Saunders, Philadelphia, 1922, p. 809.
2. MacCallum, W. G. Textbook of Pathology. W. B. Saunders, Philadelphia, 1916, p. 414.
3. Manges, W. F. Roentgen-ray diagnosis of non-opaque foreign bodies in air passages. Am. J. Roentgenol., 1922, ix, 288.

*Von Glahn, Wm. C. Cases illustrating malignant tumors of lung and pleura. *Proc. N. York Path. Soc.*, 1923, xxiii, 113.