

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



**Bronchial Obstruction**

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

Volume XV

Friday, December 10, 1943

Number 10

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William A. O'Brien, M.D.

I. UNIVERSITY OF MINNESOTA MEDICAL SCHOOL  
 CALENDAR OF EVENTS  
 Week ending December 18, 1943  
 Visitors Welcome

Monday, December 13

- 8:00 - 9:00 Surgery Journal Club: O. H. Wangensteen and Staff, Main 515, U.H.
- 9:00 - 10:00 Roentgenology-Medicine Conference; L. G. Rigler, C. J. Watson and Staff, Todd Amphitheater, U. H.
- 9:00 - 11:00 Obstetrics and Gynecology Conference: J. L. McKelvey and Staff, Interns Quarters, U. H.
- 12:30 - 1:30 Pediatric Seminar; Pediatric Office, U. H., Staff.
- 1:00 - 2:00 Dermatology and Syphilology Clinics; C. W. Laymon, West 312 U.H.
- 2:00 - 3:00 Dermatology and Syphilology, Cases, J. F. Madden, West 306 U.H.

Tuesday, December 14

- 9:00 - 10:00 Roentgenology-Pediatrics Conference: L. G. Rigler, I. McQuarrie and Staff, Eustis Amphitheater, U. H.
- 9:00 - 10:00 Dermatology and Syphilology; Treatment Problems in Syphilis, F. W. Lynch, Main 436, U. H.
- 11:00 - 12:00 Urology Conference; C. D. Creevy and Staff, Main 515, U. H.
- 12:30 - 1:30 Pathology Conference: Autopsies, Pathology Staff, 102 I.A.
- 2:00 - 3:00 Dermatology and Syphilology, Selected Cases, J. F. Madden, West 306 U.H.
- 3:30 - 4:30 Treatment of Gonorrhoea; P. S. Pelouze, Todd Amphitheater, U. H.
- 4:00 - 5:00 Pediatrics; Grand Rounds, Pediatric Office, I. McQuarrie.
- 4:30 - 5:30 Obstetrics and Gynecology Conference; J. L. McKelvey and Staff, Station 54, U.H.
- 5:00 - 6:00 Roentgen Diagnosis Conference; K. W. Stenstrom, L. C. Bixler, Main 515, U.H.
- 8:00 - Minnesota Pathological Society; Some Observations on the Pathological Physiology of the Hydronephrotic Kidney, Harry A. Wilmer; The Pathology of Malaria (Case Report), E. M. James; A Case of Uremia due to Sulfathiazole, H. D. Nester; Medical Science Amphitheater.

## Wednesday, December 15

- 11:00 - 12:00 Pathology-Medicine Surgery Conference; E. T. Bell, C. J. Watson, O. H. Wangensteen and Staff, Todd Amphitheater, U. H.
- 1:00 - 2:00 Dermatology and Syphilology; Clinics, C. W. Laymon, West 312, U.H.
- 2:00 - 3:00 Dermatology and Syphilology; Allergic Dermatoses (Demonstration of Technique, E. M. Rusten, West 306 U.H.

## Thursday, December 16

- 9:00 - 10:00 Medicine Case Presentation: C. J. Watson and Staff, Todd Amphitheater, U.H.
- 10:00 - 12:00 Medicine Rounds: C. J. Watson and Staff, East 214 U.H.
- 1:00 - 2:00 Dermatology and Syphilology; General Problems in Syphilis, F. W. Lynch, West 312 U.H.
- 2:00 - 2:30 Dermatology and Syphilology: Selected Cases, F. W. Lynch, West 312, U.H.

## Friday, December 17

- 8:30 - 10:00 Grand Rounds; Pediatric Office, I. McQuarrie and Staff
- 9:00 - 10:00 Medicine Grand Rounds: C. J. Watson and Staff, Todd Amphitheater, U.H.
- 10:00 - 12:00 Medicine Ward Rounds; C. J. Watson and Staff, East 214 U.H.
- 1:00 - 2:00 Dermatology and Syphilology, Clinics, C. W. Laymon, West 312 U.H.
- 1:00 - 2:00 Medicine Case Presentation: C. J. Watson and Staff, Main 515, U.H.
- 1:00 - 2:30 Dermatology and Syphilology; Selected Cases of the Week, H. E. Michelson, West 306, U.H.
- 1:30 - 3:00 Roentgenology-Neurosurgery Conference; H. O. Peterson, W. T. Peyton, and Staff, Todd Amphitheater, U.H.

## Saturday, December 18

- 9:00 - 11:30 Surgery-Roentgenology Conference; O. H. Wangensteen, L. G. Rigler, and Staff, Todd Amphitheater, U.H.
- 9:00 - 10:00 Medicine Case Presentation; C. J. Watson and Staff, Main 515, U.H.
- 10:00 - 12:00 Medicine Ward Rounds; C. J. Watson and Staff, East 214, U.H.

U.H. - University Hospitals  
I.A. - Institute of Anatomy

## II. BRONCHIAL OBSTRUCTION: ROENTGENOLOGIC OBSERVATIONS

Leo G. Rigler

Occlusion of the bronchi is one of the common factors in both acute and chronic diseases of the lung. An understanding of the mechanism of this process and of its eventual effects will clarify greatly the concepts of pulmonary disease which we now have. It is of particular interest at this time to review the subject of bronchial occlusion because roentgen examination, using all the various methods which are now available, makes possible a detailed study of the effects of this process.

The causes of bronchial occlusion are of course numerous. They may be classified, first of all, into extrinsic and intrinsic factors. The extrinsic are relatively less frequent and are limited to the group of compressions of the bronchus, such as occur with aneurysm of the aorta, enlargement of the left atrium from heart disease, and tumors of the mediastinum. Obviously, one might in a broad way include in this group the compressions of the lung which follow pneumothorax, but these are not really true occlusions of the bronchi but merely compressions of the parenchyma of the lung around the bronchi.

The intrinsic causes are likewise numerous and are of far greater importance. First in order of frequency are the foreign bodies, which may occur either in the trachea, in the larger bronchi, or anywhere in the course of the tracheobronchial tree. Within the group of foreign bodies there should be included the relatively uncommon broncholiths, which are foreign bodies within the bronchi but occur as an extension from the peribronchial lymph nodes or from the lungs into the bronchi. Similar in their effects and manifestations are the tumors of the bronchi, including the benign adenomas, rarer types of tumors, and the carcinomas of the lung. A third cause of bronchial obstruction is an inflammatory constriction of the bronchus, such as occurs following lung abscess or in association with various types of pneumonia or other inflammatory stenoses

of the bronchus. Such an obstruction may occur from scar formation around a bronchus producing constriction, or it may occur as a result of a stenosing bronchitis. The latter is best illustrated in the case of tuberculous stenosis of the bronchus but may also occur as a result of other inflammatory processes. Granulation tissue, scar tissue, or purulent material may obstruct the bronchus. A fourth cause of obstruction of the bronchi is the excessive accumulation of mucus. Such accumulations usually occur in the smaller branches and are most commonly associated with asthma, although they occur as a result of chronic bronchial disease as well. The fifth factor is respiratory depressions, which include postoperative massive atelectasis, the effects of drugs such as morphine, anesthetics, and so on. In this instance we have also the accumulation of mucus within the bronchi, which however is not expired or coughed up as is commonly the case, and therefore produces plugging. Such obstructions usually occur in the smaller bronchi but may involve the larger ones also. Finally there is the bronchial obstruction associated with pneumonia and which likewise probably involves the smaller bronchi. For the purposes of this discussion, only the intrinsic bronchial obstructions will be considered.

The effects of bronchial obstruction are multiform. Paradoxical as it may seem, bronchial obstruction may produce both emphysema and atelectasis. It may produce bronchial constriction and bronchiectasis. The character of the obstruction, the nature of the obstructing process, the location of the obstruction--whether in a large or smaller bronchus, the degree of the obstruction, the rapidity with which it occurs, and the accidental incidence of secondary infection, all modify very markedly the results of bronchial occlusion. It is evident from this that an unusual multiplicity of effects may occur. These effects may be briefly outlined as follows: First, emphysema, which may be (a) local, (b) lobar, (c) unilateral, and (d) bilateral. The latter of course occurs only in cases of obstruction in

the trachea or diffuse obstruction of the smaller bronchi. Second, atelectasis, which again may be local, lobar, or may involve one entire lung. Third, the "drowned" lung phenomenon, in which an atelectatic lung retains large quantities of fluid and accumulates larger quantities of blood, giving a soggy, fluid-filled lung, which is airless as well. Fourth, bronchiectasis. Fifth, massive lung inflammation with multiple abscess formation as a secondary infection occurring in the obstructed lung. This usually eventuates in carnification of the lung or chronic lung fibrosis.

In order to delineate these various findings satisfactorily and to determine, whenever possible, the nature of the obstructing mechanism, its exact location in the bronchus, and the complete story of the effects which it produces, it is necessary to make rather elaborate x-ray examinations. The detailed study of the effects of bronchial obstruction is particularly important at this time because of the possibilities of surgical intervention in many of these cases. As a result I desire to emphasize the importance of the detailed x-ray examination of the lungs when bronchial obstruction is suspected.

The first procedure, which might be considered a sort of scouting expedition, is the fluoroscopic study of the chest. Here examination may be made in inspiration and expiration, and many of the conclusions as to the exact nature of the obstruction and of the effects that it produces, may well be delineated on this first fluoroscopic study. The patient can be examined in a number of oblique and lateral positions, as well as in the true postero-anterior and anteroposterior, and the determination of emphysematous, atelectatic, or bronchiectatic areas brought out.

Fluoroscopic examination in almost every case should be followed by roentgenograms, which will give greater detail and greater opportunity for study of the nature of the involved process. Roentgenographic examination should consist of postero-anterior films made in inspiration and in expiration. The utility of the

latter film is insufficiently appreciated and is probably too little employed. Although we have been fully aware of its importance for a good many years, we still fail to employ it routinely, largely because of the need for economy. Obviously, in patients suspected of a foreign body in the lung the expiration film is always made, but it is also extremely valuable, as will be shown in illustrative cases later, in tumors of the bronchi, bronchial asthma, or any type of bronchial occlusion. It should be understood that at any point during the course of these roentgen procedures, the diagnosis may be arrived at with considerable accuracy and no further examination need be done. On the other hand in many instances one must proceed through the entire gamut of roentgen procedures to determine the final nature of the process. Examinations in the various oblique views and often in the anteroposterior view, especially in the supine position, can then be made in order to bring out in greater detail the exact outline of atelectatic or bronchiectatic lobes and their exact position. In occasional cases roentgenograms made in the lordotic position are very helpful.

Following this procedure, the process having been localized to one or another of the lobes, body section roentgenography should be undertaken in order to bring out, if possible, the more exact location of the bronchial obstruction and its nature. It is frequently possible by this means to determine the exact bronchus which is obstructed and often, although not always, to exhibit the nature of the obstructive process.

As a final procedure bronchography with iodized oil may be undertaken. In such instances this is done to give a more accurate determination of the outline of the bronchi, of their lumen, of their distortions and constrictions. A positive shadow of the bronchus is obtained in this fashion, and negative shadows due to occluding masses within the bronchi can be brought out; but what is more important, the presence or absence of involvement of associated bronchi is determined. The lung may thus be

mapped out clearly so that the bronchial obstruction or bronchial lesion may be determined in its fullest extent. This is, of course, of first importance in the determination of whether or not a surgical procedure is feasible in any particular instance.

There is a surprising unity in the roentgen manifestations of the effects of tracheobronchial obstruction regardless of the cause. A simple foreign body in the bronchus, bronchial asthma, or a tumor of the lung give almost identical findings. I shall attempt to review some of these pulmonary changes, giving case reports as illustrations of each type of abnormality.

### Obstructive Emphysema

In order to understand the effects of bronchial obstruction, it is well to bear in mind certain peculiarities in the structure of the tracheobronchial tree and something of its pathological physiology. The most important point is the changing size of the bronchial lumen, as first pointed out by Jackson and Manges and since demonstrated repeatedly by other workers. Dr. Clarence Truog, working in the Department of Radiology, demonstrated both experimentally in animals and clinically in humans that the bronchi expand and contract during the course of inspiration and expiration. As a result, the lumen of the bronchus is distinctly narrower during the period of expiration. The same is true to a lesser degree of the trachea. Furthermore, the act of inspiration is a somewhat active one, whereas the act of expiration is much more passive. As a result of these factors, it is possible for a foreign body to enter into the trachea or into the bronchus and lie somewhat loosely within it. In consequence, air may be permitted to pass around the foreign body into the lung during inspiration, but the egress of air is obstructed to a considerable degree during expiration. A check valve is thus produced, with air continuing to enter freely but being exhaled with great difficulty. Obstructive emphysema results from such a process. Once the foreign body or tumor has become large enough to completely occlude the

inspiratory lumen of the trachea or bronchus or the mucosa has swollen sufficiently to clasp the obstructing mass firmly or there has been a sufficient collection of debris around the mass to completely occlude the bronchus, there is a complete change in the picture. Air can no longer enter but it will continue to be absorbed by the intact circulation. The alveoli will soon begin to collapse, and the conversion from obstructive emphysema to obstructive atelectasis occurs. Jackson has illustrated this process graphically in his book on Foreign Bodies in the Air Passages, and the figure is reproduced here in modified form (Fig. 1).

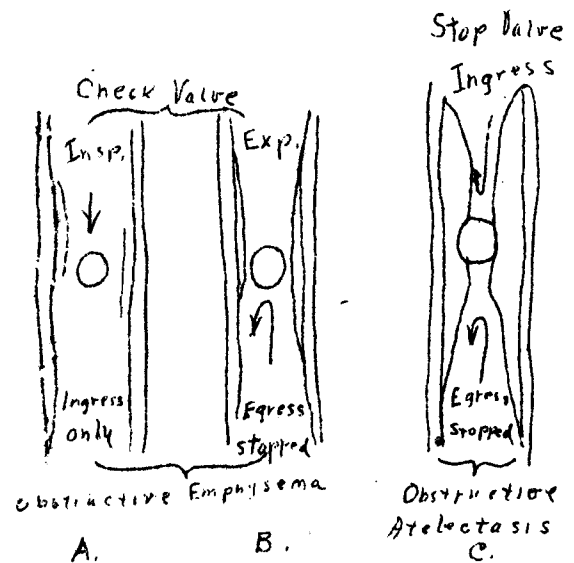


Fig. 1. Diagram adapted from Jackson, illustrating the effect of a mass in the bronchus.

The mechanism of production of obstructive emphysema, owing to the difference in diameter of the bronchus in inspiration and expiration, is shown in A and B; while complete obstruction of the bronchus, which occurs under other conditions, producing obstructive atelectasis, is shown in C.

Emphysema of both lungs occurs as a result of obstruction of the trachea when that obstruction is partial. Obviously complete obstruction of the trachea is not a clinical problem as it is followed by immediate death. Incom-

plete obstruction, however, is not rare as a result of foreign bodies or occasionally of tumors of the trachea. The result is a diffuse emphysema of both lungs, which in turn produces a striking roentgenologic picture. The heart instead of becoming somewhat wider and apparently slightly larger in expiration than in inspiration, as is normally the case, seems to become distinctly smaller, a paradoxical change in the size of the heart occurring. This is quite typical of foreign body obstruction. Interestingly enough, an almost similar appearance is produced in other types of emphysema in which the obstruction is not in the trachea but rather in many of the smaller bronchi. This is most classically illustrated in the case of bronchial asthma after it has been present for some period of time. A bilateral emphysema of rather marked degree may be present as a result of partial obstruction of many of the small bronchi by the excessive mucus which is so characteristic of allergic asthma. Truog and I have already presented the experimental and clinical evidence which substantiates this hypothesis. The typical roentgen evidences of generalized bilateral pulmonary emphysema are usually seen in cases of bronchial asthma. The paradoxical change in heart size as described above will also occur.

Unilateral obstructive emphysema is a common finding in foreign body obstruction of the bronchus. (See Case 1). As stated above, it is due to inability of the lung to expire its air because of the partial obstruction produced by the foreign body. This is not a ball valve mechanism but rather a check valve, as Jackson has described it. Films made in such a case during inspiration (Fig. 2A) may appear to be normal but the roentgenogram made expiration (Fig. 2B) reveals the normal expiratory elevation of the diaphragm on the normal side, while on the abnormal side the diaphragm remains in the same position in expiration as in inspiration. Likewise the lung on the abnormal side remains extremely radiable during expiration, while on the normal side the lung

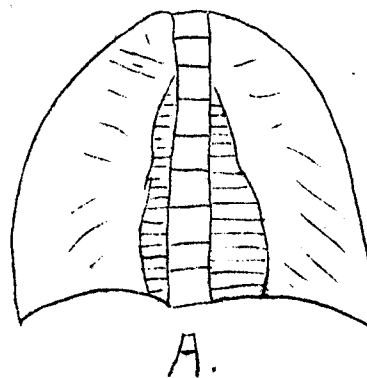


Fig. 2. Obstructive Emphysema from foreign body in left main bronchus.

A. Postero-anterior roentgenogram in inspiratory phase giving normal appearance of both lungs.

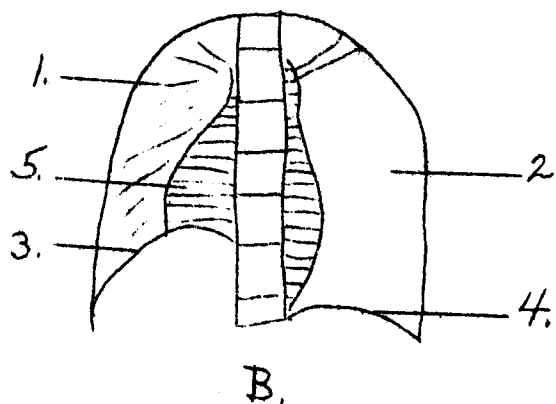


Fig. 2. Obstructive Emphysema

B. Postero-anterior roentgenogram in expiratory phase showing obstructive emphysema, left lung.

1. Normal density, right lung, in expiration,
2. Emphysematous left lung.
3. Normal elevation, right diaphragm,
4. Low left diaphragm.
5. Heart displaced to right.



loses its radiability and becomes much denser, which is the normal reaction in expiration. The heart likewise shifts in position, being displaced to the normal side during expiration and back to the midline during inspiration. (Figs. 2 and 3).

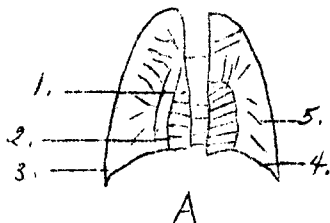


Fig. 3. Case 1, foreign body, left bronchus.

A. Case 1. Postero-anterior roentgenogram in inspiration, 24 hours after aspiration of peanuts, showing fairly normal situation.

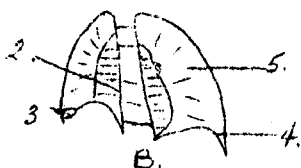


Fig. 3. Case 1.

B. Postero-anterior roentgenogram in expiration showing normal elevation of the right diaphragm, normal increase of density of right lung, and displacement of mediastinum to the right. The left lung is fully aerated and the left diaphragm is not elevated, indicating an obstructive emphysema of the left lung.

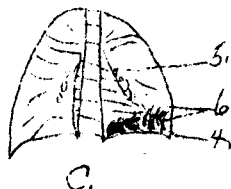


Fig. 3. Case 1.

C. Postero-anterior roentgenogram in same case, three months later, show-

ing atelectasis and "drowned" lung, left lower, from additional foreign body in a smaller bronchus. The heart is displaced slightly to the left, the diaphragm is elevated and there is a marked area of density at the base of the left lung overlapping the cardiac shadow.

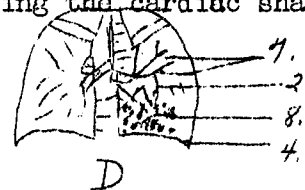


Fig. 3. Case 1.

D. Same case, one year later, with bronchography. Extensive saccular and cylindrical bronchiectasis of the left lower lobe bronchus is shown, filled with iodized oil.

1. Normal right lung
2. Heart
3. Right diaphragm
4. Left diaphragm
5. Emphysematous left lung
6. Atelectasis and "drowned" lung, left lower
7. Normal bronchi filled with iodized oil
8. Bronchiectatic cavities of involved lower lobe.

The findings are characteristic and have been well known since the original description by Manges many years ago. It is not so well known, however, that a similar phenomenon may occur in bronchial asthma and also in the early stages of bronchial tumors. Westermarck has emphasized the importance of this finding as an early sign of the presence of a bronchial tumor. Unfortunately, we are unable to make films routinely in expiration as well as inspiration, and it is possible that some bronchial tumors in an early stage may be overlooked as a result. Routine fluoroscopic examination of the chest with particular attention to the expiratory phase and routine roentgenograms made during expiration (Fig. 4) in individuals of the cancer age might result in the occasional early detection of a carcinoma of the bronchus in its

incipiency. (See Case 2.)

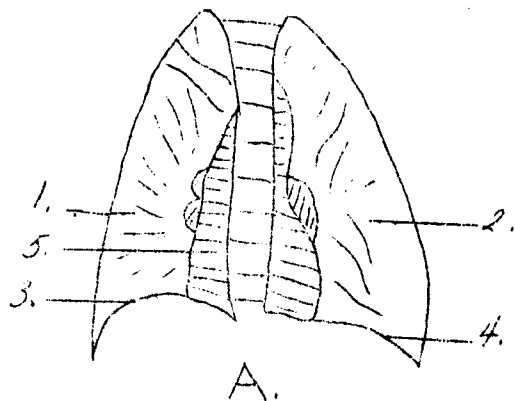


Fig. 4. Case 2, Obstructive Emphysema in a case of carcinoma of the bronchus.

A. Postero-anterior roentgenograms made in expiration, showing displacement of mediastinum to the right, abnormally increased radiability of left lung, low position of left diaphragm, and normal elevation of right diaphragm. Obstructive emphysema of the left lung from a carcinoma of the left main bronchus is present.

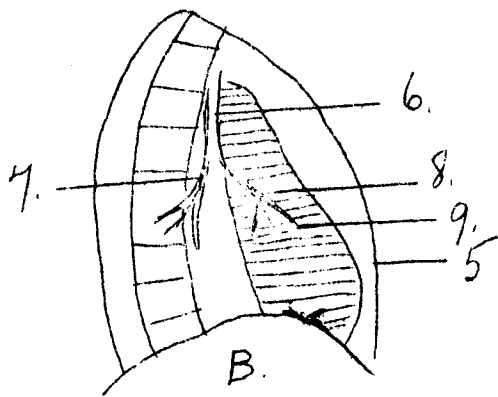


Fig. 4. Case 2.

B. Bronchogram in left oblique position showing carcinoma of left main bronchus only partially obstructing it.

1. Normal density of right lung in expiration
2. Emphysematous left lung in expiration

3. Normal elevation, right diaphragm, in expiration
4. Abnormally low left diaphragm
5. Heart displaced to right
6. Trachea filled with iodized oil
7. Normal right bronchi
8. Carcinomatous obstruction of left main bronchus, partial
9. Normal left lower bronchi.

- - -

In bronchial asthma also, in occasional cases, films made in expiration may demonstrate a distinct difference in the degree of emphysema of the two lungs, which indicates that the partial bronchial obstruction which is so common in this disease, may be more severe on the one side than on the other or may have extended more proximally on the one side than on the other, so that the larger bronchi are involved. We have seen several illustrations of unilateral obstructive emphysema in bronchial asthma. (Fig. 5). (See Case 3).

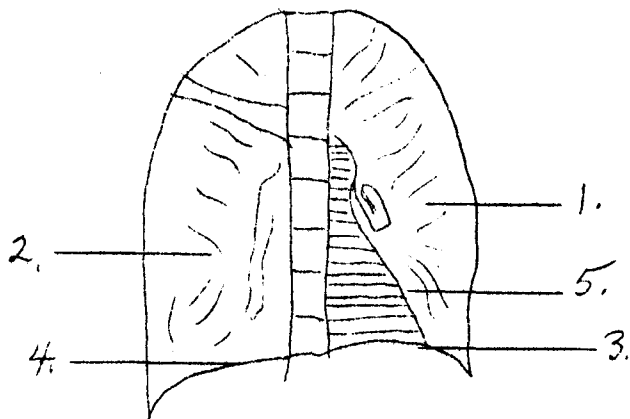


Fig. 5. Case 3, Obstructive Emphysema in a case of bronchial asthma. Postero-anterior roentgenogram made in expiration, showing displacement of the mediastinum to the left, greater radiability of right lung than left, and low position of right diaphragm, indicating obstructive emphysema of right lung. Patient had emphysema of both lungs to a moderate degree as well.

1. Normal density of left lung in expiration
2. Emphysematous right lung

3. Normal elevation of left diaphragm
  4. Abnormally low right diaphragm
  5. Heart displaced to left.
- - -

Local areas of emphysema have also been emphasized by Westernmark in the early stages of bronchial tumors, a zone of increased radiability being present well out to the periphery of the lung, distal to the tumor itself. If carefully studied, this may be an important sign in the early diagnosis of bronchial tumors.

#### Obstructive Atelectasis

The transition from obstructive emphysema to obstructive atelectasis may be very rapid, particularly in the case of foreign bodies in children. The same lesion, therefore, may produce these apparently opposite phenomena. Once the foreign body has become coated with granulation tissue and purulent material or the stenosis of the bronchus itself has become much more extreme, obstruction to both inspiration and expiration takes place. When this occurs, the gas from the lung will be absorbed by the circulation, and, no further gas entering into it through the obstructed bronchus, atelectasis supervenes. (Fig. 3). (See Case 1.)

The phenomenon of atelectasis is of interest in itself as it varies widely in its manifestations. Thus one may observe cases of massive atelectasis of an entire lobe or even of most of one lung without any remarkable increase in the density of that lung. The other manifestations of atelectasis, namely flattening of the thoracic wall, decrease in the size of the interspaces, displacement of the mediastinum toward the side of the lesion, elevation of the diaphragm on that side may all be present. On the other hand, in many cases of massive atelectasis either from obstruction of the main bronchus or from the smaller bronchi, the density of the lung is greatly increased. This is in sharp contrast to the

compressive atelectasis of the lung which occurs as a result, for example, of pneumothorax, in which an entire lung collapsed down to one fourth of its size may show only a minor degree of increased density as compared to the normal opposite side. The reason for this, of course, is obvious when one examines the phenomenon of atelectasis. With the disappearance of air from the lung, diminished pressure occurs which causes an increase in the amount of blood within the vessels in this area of the lung. The proportion therefore, of fluid to air is greatly increased. Added to this is the retention of secretions in the bronchi, which likewise may add to the density of the lung. There may in addition be some exudation of serum from the vessels into the alveoli after the removal of the air, which in turn would increase the lung density. In the case of compressive atelectasis, the blood as well as the gas is expressed from the lung so that there is relatively little increase in the x-ray density.

The appearance of a portion of the lung which has become atelectatic will depend largely on the degree of collapse and upon its extent. Thus collapse of marked degree of the right lower lobe produces a basal triangular shadow, paravertebral in position, sometimes almost lost within the shadows of the spine and diaphragm. (Fig. 8).

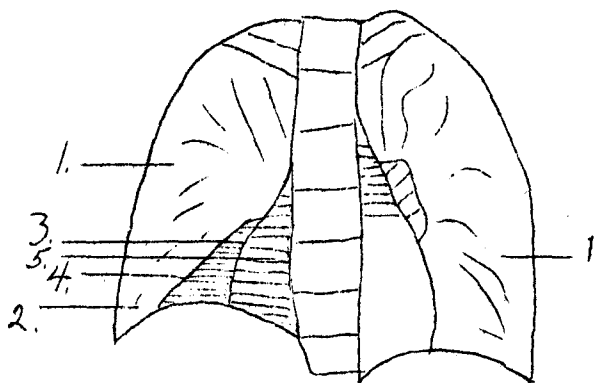


Fig. 8. Atelectasis, right lower lobe, in a case of pneumonia.

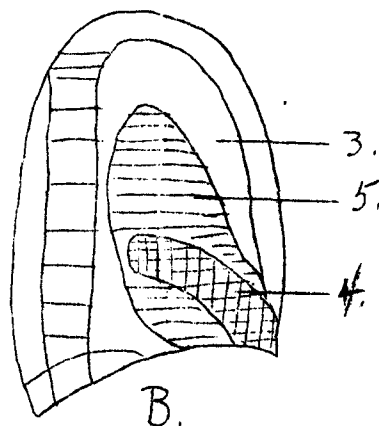
Postero-anterior roentgenogram.

Note displacement of the heart,

elevation of diaphragm, and typical paravertebral triangle formed by the atelectatic lower lobe.

1. Normal lung
2. Elevated right diaphragm
3. Heart displaced to the right
4. Triangular shadow of atelectatic lobe
5. Increased density of the cardiac shadow from overlapping atelectatic lobe.

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B.

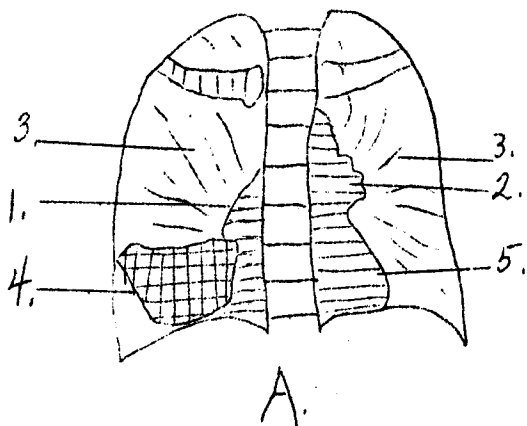
Fig. 6. Isolated atelectasis.

B. Lateral view, showing outline of middle lobe which is contracted both above and below, being shrunk down to a considerably smaller size than is normal, and increased in density.

1. Vascular shadow, right lung
2. Vascular shadow, left lung
3. Vascular marking of lungs
4. Atelectatic middle lobe
5. Heart shadow.

---

The remaining lobes compensate for the decreased size of the collapsed lobe by emphysematous expansion so that there may not be as marked an elevation of the diaphragm or displacement of the heart as occurs in the more acute types. The collapse of one lobe and expansion of the others may be detected by the increased radiability of the emphysematous lobes as compared to the opposite side and the diminution in the size of the vascular shadow at the root of the lung. Atelectasis of the middle lobe (Fig. 6) is best made out in the lateral view, the inward curving borders and greatly diminished size of the lobar contours being characteristic.



A.

Fig. 6. Isolated atelectasis of the right middle lobe from obstruction of the middle lobe bronchus.

A. Postero-anterior view showing diffuse shadow of increased density with slight displacement of the mediastinum and elevation of the diaphragm.

Collapse of the upper lobe (Fig. 7) is identified by the elevation of the horizontal interlobar fissure and its convex lower surface.

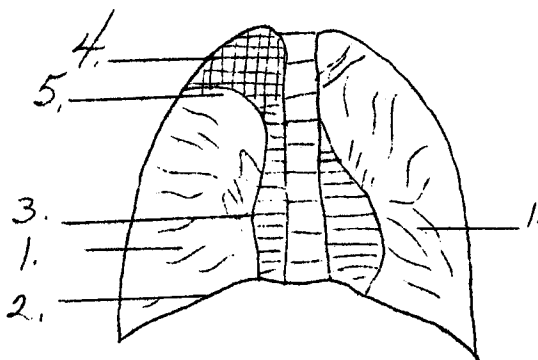


Fig. 7. Atelectasis, right upper lobe, in a case of bronchial asthma.

Postero-anterior roentgenogram.

Note the dense shadow of the right

upper lobe and the upward curve of its lower border, which is typical of atelectasis. There is displacement of the heart to the right and moderate elevation of the right diaphragm. Both lungs are emphysematous aside from the atelectatic area.

1. Emphysematous lungs
2. Slightly elevated right diaphragm
3. Heart displaced to the right
4. Atelectatic upper lobe, very dense
5. Upward displacement of interlobar fissure with typical convex border.

- - -

When the left lower lobe becomes atelectatic, it too shrinks into a basal paravertebral triangle, but its shadow must be seen through that of the heart behind which it lies (Fig. 9).

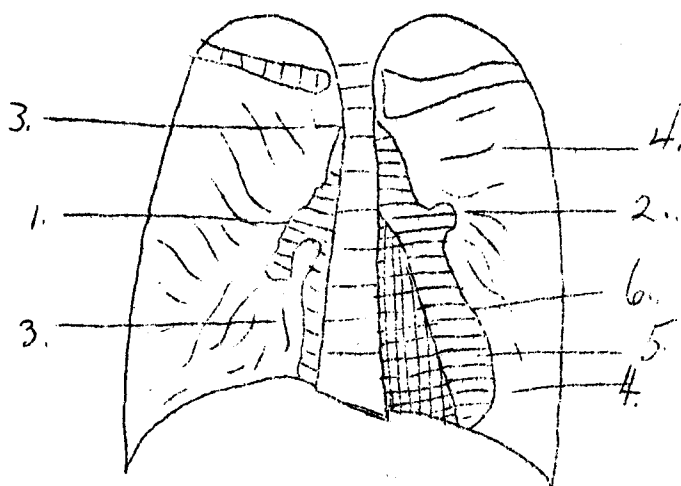


Fig. 9. Atelectasis of left lower lobe in a case of bronchiectasis without obstruction.

Note the typical basal triangular shadow behind the heart.

No obstruction of the main bronchus could be made out; this apparently began as an atelectasis from some process in the parenchyma of the lung and was followed by bronchiectasis.

1. Normal vascular shadow, right lung

2. Very small vascular shadow, left lung, indicating that upper lobe only is expanded.
3. Normal right lung
4. Emphysematous left lung owing to expansion of upper lobe.
5. Basal paravertebral shadow representing atelectatic left lower lobe
6. Heart shadow.

- - -

The occurrence of atelectasis in bronchial asthma (Figs. 7 and 10) illustrates the fact that an airless lung may result from obstruction of the smaller as well as the larger bronchi. In asthma, partial obstruction of many of the smaller bronchi by mucous plugs produces emphysema. The occasional acute exacerbations which asthmatics suffer, which are often thought to be pneumonia, are in fact most commonly episodes of lobar or unilateral pulmonary atelectasis. These result from increase in the size of the plugs which go on to complete obstruction of the bronchi. Truog and I have observed five cases of bronchial asthma in which the characteristic roentgen phenomena of atelectasis were observed during acute febrile episodes. (See case 5, Fig. 10). At autopsy one may occasionally observe as a cause of death in bronchial asthma, extensive atelectasis of one or both lungs from complete plugging of many small bronchi.

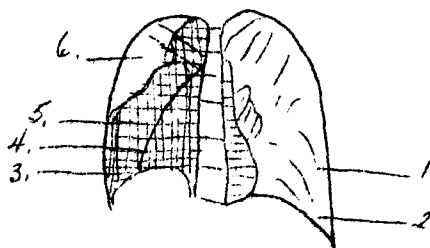


Fig. 10. Case 4. Massive atelectasis in a case of bronchial asthma

Postero-anterior roentgenogram, shows marked density of most of the right lung, extreme displacement of the heart to the right, and elevation of the right diaphragm. Note the increased densit;

of the right side of the heart because of the superimposed atelectasis.

1. Normal left lung.
2. Normal position of the left diaphragm
3. Elevated right diaphragm
4. Heart displaced to the right
5. Density of atelectatic lung
6. Remaining portion of upper lobe, which is still aerated.

Atelectasis is the most prominent roentgenologic feature of lung tumors, both of the benign and malignant varieties. It occurs more slowly in this situation than in the case of foreign bodies, but in other respects it may not differ radically. The characteristic density of the lung, retraction of the heart and mediastinum to the side of the lesion, elevation of the diaphragm, and flattening of the thoracic wall are present (Fig. 11). There is a difference between the behavior of benign and malignant tumors in this respect, in that a benign tumor is likely to be of much longer standing and to produce an incomplete obstruction. This may produce emphysema at the outset but later may become sufficiently severe so that a low-grade atelectasis of more chronic variety is produced. In the case of carcinoma the obstruction no doubt becomes high grade very quickly, and the rapidity of its occurrence produces a somewhat different picture (See case 5).

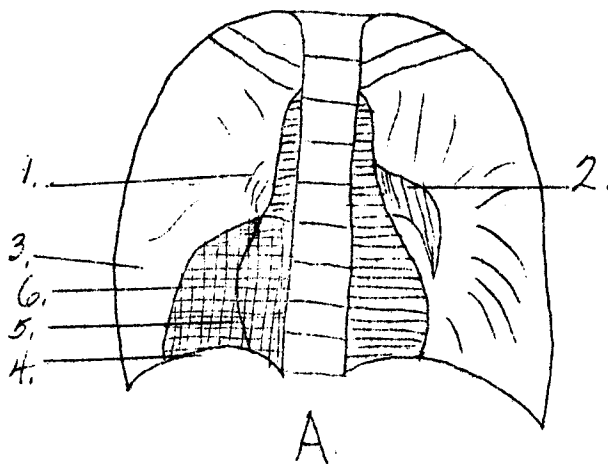


Fig. 11. Case 5. Bronchial adenoma, right lower, with "drowned" lung, atelectasis and bronchiec-

tasis.

- A. Postero-anterior roentgenogram showing peculiar contour of "drowned" lung, with only moderate displacement of right diaphragm and heart.

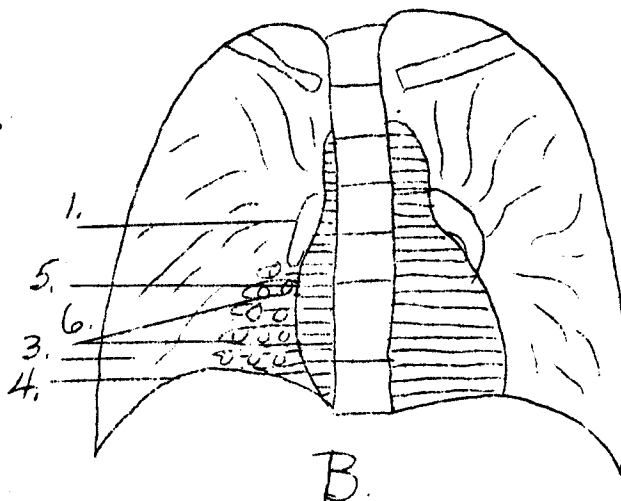


Fig. 11, Case 5.

- B. Postero-anterior roentgenogram after removal of adenoma, showing diminished size of atelectatic lung, displacement of heart and diaphragm, and bronchiectatic cavities within atelectatic lobe.

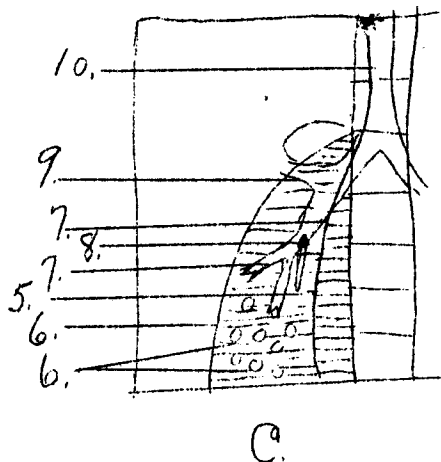


Fig. 11, Case 5.

- C. Body section roentgenogram showing air in trachea and bronchi and tumor in right lower lobe bronchus. Bronchiectatic cavities are also shown.

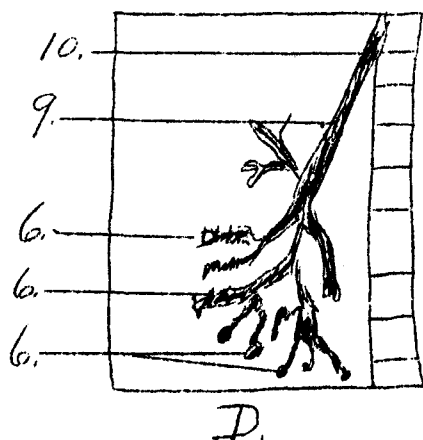


Fig. 11, Case 5.

D. Bronchogram of right side only, showing characteristic dilated bronchi of right lower lobe due to long-standing obstruction of bronchus from tumor.

1. Small vascular shadow of right lung.
2. Normal vascular shadow of left lung.
3. Emphysema of remaining portions of right lung.
4. Elevated right diaphragm.
5. Heart displaced to right.
6. The "dornwed" lung and bronchiectasis.
7. Lower lobe bronchi.
8. Bronchial adenoma within air-filled bronchus.
9. Upper lobe bronchus.
10. Trachea.

Atelectasis is an outstanding manifestation of respiratory depression, and in this situation it is probably largely related to obstruction of the smaller bronchi from the accumulated secretions which are neither exhaled nor coughed up because of the depression of the respiration. This is the situation in post-operative massive atelectasis with which we are so familiar. It may also occur, however, as a result of excessive doses of morphine or other respiratory depres-

sants during periods when the lung is held largely at rest so that expiration of accumulations of secretions cannot occur. It has also been noted, particularly by Fleischner, that after chest injuries local areas of atelectasis may occur, and he has adduced considerable evidence to indicate that such areas of atelectasis may eventuate in bronchiectasis. After an injury to the chest there is a tendency to hold the thoracic wall rigid because of the pain. There is consequently a depression of respiration and of cough with the result that these patchy or plate-like areas of atelectasis occur. In fact, Fleischner believes this is so important that he advocated the use of local anesthetics to relieve pain after chest injury in order that the patient may breathe freely and thus keep the lungs well drained.

The occurrence of atelectasis in association with pneumonia (Fig. 8) is likewise related to obstruction of the smaller bronchi, although here too an occasional case is seen in which a larger bronchus appears to be obstructed. Some investigators, notably Coryllos and Birnbaum, have asserted that lobar pneumonia is simply an infected atelectasis. While this is probably not true, atelectasis may occur either synchronously with pneumonia or as a complication. In the atypical group of pneumonias, particularly atelectasis of minor degree is not infrequent, and in children it is common. In all probability the atelectasis may occur as a result of the inability of the patient to evacuate secretions properly by exhalation or by cough, so that they tend to obstruct the bronchi.

Atelectasis, in addition, occurs as a result of constrictions of the larger bronchi which eventuate from pneumonia, lung abscess, fungus infection, or more particularly tuberculosis of the bronchus itself. In such instances the obstruction may be due to accumulation of pus, granulation tissue, or to an actual scar forming stenosis. As the bronchus closes down, atelectasis will supervene. This phenomenon is strikingly shown in the case of tuberculosis in which the gradual

collapse of a lobe which was originally fully inflated may be observed during the progression of a tuberculous lesion. (See Case 6, Fig. 12). As has been well demonstrated by Cohen, Higgins, and others, bronchostenosis may be an extremely important factor in the persistence of a tuberculous lesion. Inflammatory bronchostenosis may also occur from external scar formation around the bronchus such as follows a lung abscess or certain pneumonias.

ly the smaller vascular shadow on this side.

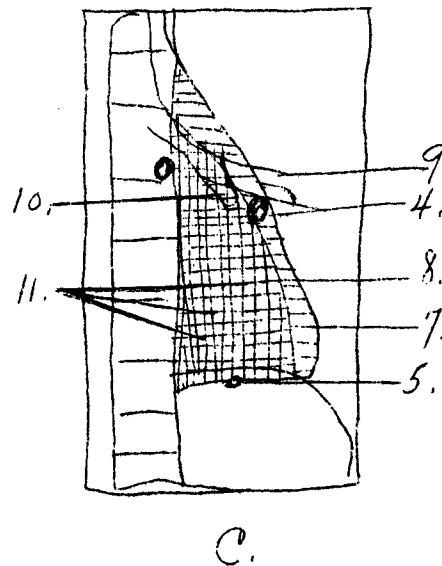
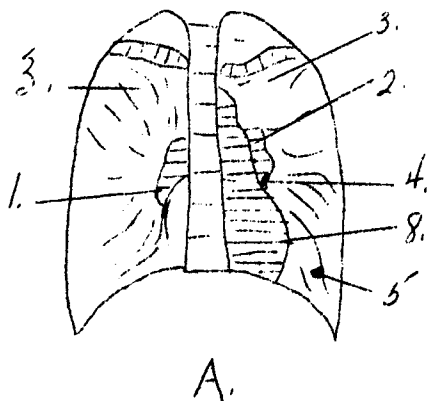


Fig. 12, Case 6. Atelectasis and bronchiectasis, left lower lobe, from tuberculous bronchostenosis.

Fig. 12, Case 6.

C. Body section roentgenograms showing basal triangular shadow of atelectic lobe, Ghon tubercle displaced towards the spine, and calcified interbronchial and peribronchial lymph nodes. Note the obstructed column of air in the right lower bronchus.

A. Postero-anterior view (Oct. 1940) showing calcified tuberculous focus and peribronchial lymph nodes before the development of atelectasis.

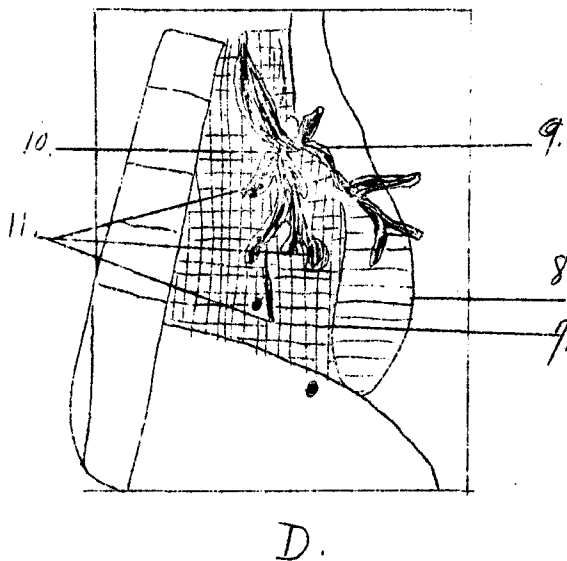
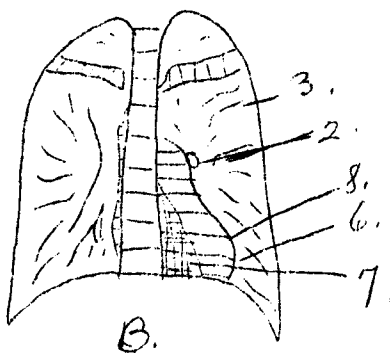


Fig. 12, Case 6.

Fig. 12, Case 6.

B. Same case, one year later, showing basal triangular shadow, with apparent disappearance of calcified tuberculous focus. Note the apparent emphysema of the left lung due to the expansion of the upper lobe, especial-

D. Bronchogram showing partial obstruction of the left lower bronchus and cylindrical dilatation of the bronchi distal to it.



- D.--
1. Normal vascular shadow, right.
  2. Vascular shadow, left.  
Note reduction in size in B.
  3. Vascular markings of lungs.
  4. Calcified peribronchial lymph nodes.
  5. Calcified tuberculous focus.
  6. Emphysematous left upper lobe.
  7. Atelectatic left lower lobe.
  8. Heart shadow.
  9. Left upper lobe bronchus.
  10. Constricted and bronchiectatic left lower lobe bronchus.
  11. Bronchiectatic cavities.
- - -

The end-results will be identical. (See Case 7, Fig. 13).

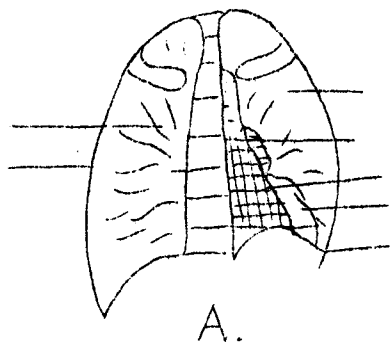


Fig. 13, Case 7. Atelectasis and bronchiectasis from nonspecific inflammatory stenosis of the left bronchus.

- A. Diffuse increased density on left side with some areas of mottling suggesting bronchiectasis.

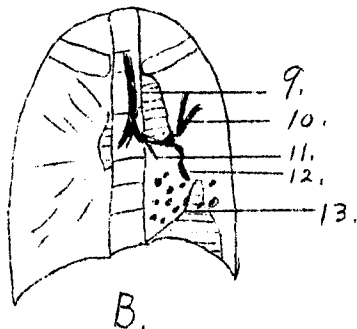


Fig. 13, Case 7.

- B. Bronchogram showing marked distortion and constriction of the left lower lobe bronchus with bronchiec-

tasis of the lower branches of the left upper lobe.

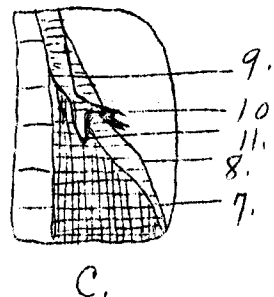


Fig. 13, Case 7.

- C. Body section roentgenogram showing obstructed left lower lobe bronchus.

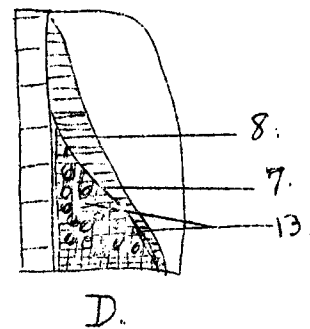


Fig. 13, Case 7.

- D. Body section roentgenogram showing bronchiectatic cavities and atelectasis of lower lobe.

1. Normal vascular shadow, right.
2. Small vascular shadow, left.
3. Vascular markings of lung.
4. Elevated left diaphragm.
7. Collapsed left lower lobe.
8. Heart displaced to left.
9. Trachea.
10. Left upper lobe bronchi, normal.
11. Constricted left lower lobe bronchus.
12. Lingula branch, left upper, with bronchiectasis.
13. Bronchiectatic cavities in left lower.

Atelectasis of long standing usually eventuates in bronchiectasis. Obviously the contrary is also true, and a long-standing bronchiectasis may produce atelectasis. In some cases it is difficult to determine definitely which is the originating process. In many instances, particularly in children, however, it is clear that the atelectasis precedes the bronchiectasis. In the case of tuberculosis and other specific inflammatory processes, in the case of foreign bodies, and in the case of tumors, the atelectasis no doubt is the primary process with the bronchiectasis supervening as a result of it. (See Cases 1, 5, 6, 7).

#### "Drowned" Lung

Another phenomenon which is occasionally seen as a result of bronchial occlusion has been designated by Roberts as the "drowned" lung, in which the atelectatic lung becomes filled with fluid. This is in large part due to the retention of secretions in the smaller bronchi but may also be due to excessive amounts of blood in the airless lung. Under those circumstances the obstructed lung does not shrink down to the same degree as in ordinary atelectasis, and the secondary effects of atelectasis are not so apparent. It is characterized roentgenologically by the peculiar shape of the area of density, the upper surface tending to be rather flat instead of forming a triangular area. (Fig. 3B, Fig. 11A). The whole area may be rectangular as a result. In some instances the interlobar fissure may show some actual external bulging from the pressure of the fluid retained within the lung. This occurs with foreign bodies, especially after they have been present for some period of time and some infection has supervened upon the atelectatic lung. It may also occur occasionally with tumors and with other types of obstruction. (See Case 5.)

#### Bronchiectasis

Bronchiectasis is another result of long-standing, slowly occurring obstruc-

tions. It is particularly likely to occur in relationship to obstructions of the major bronchi such as occur with foreign bodies, (Case 1, Fig. 3C), slowly progressing tumors, (Case 5, Fig. 11D), such as adenomas of the bronchus, and inflammatory constrictions which have progressed slowly. (Cases 6 and 7, Figs. 12 and 13). With the slowly occurring obstructive process in the larger bronchi there is produced a dilatation of the bronchi distal to the point of obstruction. This finding is an outstanding feature of primary tumors of the bronchus especially of the benign type. Observation of a localized bronchiectasis in one lobe (Fig. 11B) should lead to intensive investigation with a view to determining the source of the obstruction. The characteristic roentgen findings of bronchiectasis will be observed. The area of involvement will show increase in density, and often numerous small or larger areas of rarefaction will appear. The segment of lung may take on a "honey comb" appearance. Body section roentgenography will often reveal the outlines of a partially collapsed lobe and, in some instances at least, may demonstrate the positive shadow of a tumor or foreign body within the air-filled bronchus. (Case 5, Fig. 11C). If the bronchiectasis is due to some other type of stenosis, the constricted bronchus will be seen. (Fig. 13C). The abrupt cessation of the column of air is suggestive of bronchostenosis, although this finding may be deceptive if the bronchus deviates sharply in direction. Further study with bronchography may complete the demonstration of the presence of a tumor or determine definitely the point of stenosis. (Figs. 13C, 14). The tumor will appear as a defect within the dense shadow of the opaque medium or the constriction can be visualized directly by the narrowing of the bronchial lumen.

The observation of intermittent bronchiectasis alternating with atelectasis or with the "drowned" lung phenomenon should always lead to the thought of a benign or malignant bronchial tumor, as such obstructions frequently relent for short periods of time. The inflammatory constrictions and foreign body obstructions are usually more persistent.

Obviously any type of stenosis of the bronchus may result in bronchiectasis.

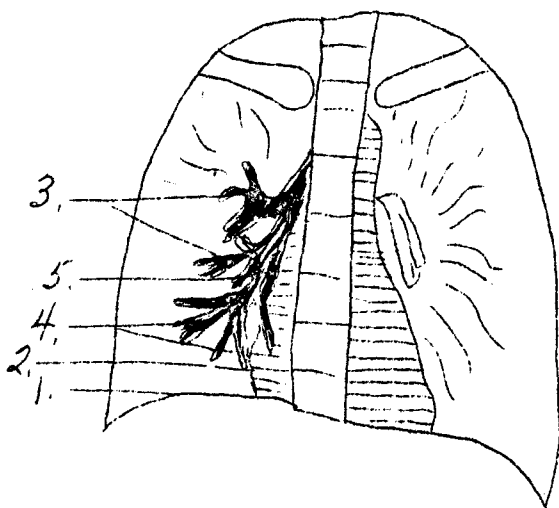


Fig. 14, Case 8. Case of broncho-stenosis, nonspecific, simulating carcinoma.

Bronchography showing smooth, uniform stenosis of right middle lobe bronchus, which proved to be a nonspecific inflammatory process, although it was somewhat suggestive of a carcinoma.

1. Elevated right diaphragm.
2. Heart displaced to right.
3. Normal upper lobe bronchi filled with iodized oil.
4. Normal lower lobe bronchi filled with iodized oil.
5. Completely stenosed right middle lobe bronchus.

- - -

It should be noted that cystic bronchiectasis may occur as a result of very long standing, slowly progressive bronchostenosis. (Case 7). The smaller bronchi may be involved, and because of their thin, elastic wall, extreme dilatation of these bronchi may occur, producing the appearance of multiple cysts. These are often confused with congenital cysts of the lung, but body section roentgenography or bronchography may often demonstrate that they originate from a stenosis of one of the major bronchi which occurred so slowly and over such a long period of time that opportunity was given for the smaller bronchi to dilate in this striking

fashion. Such a process may occur from a foreign body located in one of the smaller bronchi or from a partial constriction of the bronchus which develops slowly over a long period of time. (See Case 7.)

Finally, with infection supervening, obstruction of the major bronchi may result in abscess formation, (Case 3), carnification of the lung, or both. This is an end-stage and is rather nondescript as the character of the process tends to destroy all the normal markings and normal landmarks of the lung. Marked fibrosis may supervene with scar formation (See case 7), retraction of the mediastinum toward the side of the lesion, and elevation of the diaphragm. Within the massive density of the fibrotic lung, proper x-ray technique may make it possible to detect multiple small abscesses. Such changes in the lung are not an uncommon result of neglected foreign body obstruction but also occur with tumors, both of the benign and malignant variety, obstructing the bronchus. Lung fibrosis is also an end-result of other types of bronchostenosis.

Numerous errors may occur in the roentgen delineation of bronchial obstruction. The most common relates itself to the finding of a bronchostenosis which appears to be carcinomatous and eventually proves to be inflammatory or benign. Thus I have seen cases of tuberculous bronchostenosis, actinomycosis with bronchial obstruction, and simple nonspecific inflammatory constriction which simulated closely, both clinically and roentgenologically, carcinoma of the bronchus. (See Case 8, Fig. 14). Likewise benign tumors of the bronchi may be mistaken for carcinoma and vice versa. Obviously the bronchoscopic biopsy is the court of last resort in the determination of the diagnosis in such cases. Unfortunately, it is not always possible to obtain sections from the involved area of the bronchi which are diagnostic. In occasional cases an atelectatic lobe or one with bronchiectasis may be completely overlooked because its shadow is lost in that of the diaphragm, heart, or spine. The manifestations of bronchial obstruction may be so multiform

as to make interpretation difficult. The possibilities of error must be taken into consideration and judgment exercised as to the validity of the findings obtained.

It goes without saying that the roentgen examination is but one of the procedures which should be utilized in the careful study of such cases as are here discussed. In many instances the physical findings, the sputum examination, or the bronchoscopy will determine far more accurately the nature of the disease condition.

### Summary

1. Bronchial occlusion may occur as a result of the following intrinsic factors:
  - 1) Foreign bodies
    - a. aspirated
    - b. endogenous (broncholiths)
  - 2) Tumors
    - a. benign
    - b. malignant
  - 3) Inflammatory constrictions
    - a. tuberculous
    - b. fungus
    - c. nonspecific
  - 4) Bronchial asthma--mucous plugs in small bronchi
  - 4) Respiratory depressants--mucous in small or large bronchi
  - 5) Pneumonia
2. Bronchial occlusion may produce the following results:
  - 1) Obstructive emphysema
    - a. local
    - b. lobar
    - c. unilateral
    - d. bilateral
  - 2) Obstructive atelectasis
    - a. local
    - b. lobar
3. There is a unity in the manifestations of bronchial obstruction, regardless of the cause, so that similar roentgenologic findings may be observed in such widely divergent processes as foreign bodies, asthma, and lung tumors.
  - c. unilateral
  - d. bilateral
- 3) "Drowned" lung
- 4) Bronchiectasis
- 5) Abscess
- 6) Chronic lung fibrosis
4. The changing diameter of the lumen of the trachea and bronchi during inspiration and expiration results in the production of two apparently opposite phenomena, emphysema, and atelectasis, from the same obstructing mechanism.
5. A transition from obstructive emphysema to obstructive atelectasis to bronchiectasis or to lung abscess may occur as a result of any of these processes, depending upon the nature and location of the obstructing mechanism, the degree of the obstruction, the rapidity of its occurrence, and other more accidental factors.
6. Thoroughroentgen examination in patients suspected of bronchial obstruction should include the following procedures:
  - 1) Fluoroscopy of the chest in various positions.
  - 2) Roentgenograms made in inspiration and expiration in various positions.
  - 3) Body section roentgenography of the local area of the lung involved.
  - 4) Bronchography of the involved bronchus and of the remaining bronchi if necessary.

7. Exact localization and determination of the nature of the bronchostenosis is important in order to permit proper surgical approach. Careful roentgen examination when added to the various other procedures such as physical examination, bronchoscopy, and sputum examination will permit an exact delineation of the nature, location, extent, and effects of any type of bronchial obstruction.

to the left, and the left diaphragm was elevated.

Bronchography was undertaken and the typical picture of extensive cylindrical and saccular bronchiectasis of the left lower lobe was found (Fig. 3D).

Bronchoscopy was again done, and a second peanut was removed from the left lower bronchus. The patient improved rapidly but continued to have some cough and mucopurulent sputum.

### C A S E R E P O R T S

#### Case 1.

##### Foreign body in bronchus producing obstructive emphysema, atelectasis and bronchiectasis

, a boy of two years, was admitted with a history of having aspirated a mouthful of peanuts 24 hours before. The symptoms and physical signs were suggestive of a foreign body in the bronchus.

Fluoroscopic examination and roentgenograms in inspiration and expiration were made. The expiratory film showed the characteristic depression of the left diaphragm, displacement of the heart to the right and unchanged radiability of the left lung, indicating an obstructive emphysema of the entire left lung. (Fig. 3B).

A portion of a peanut was removed bronchoscopically from the left main bronchus. The emphysema seemed to clear up, but he did not make the usual rapid recovery. Cyanosis and labored respiration persisted for several days, and tracheotomy had to be performed. Some consolidation then appeared at the left base, but the patient left the hospital on 3-6-39. The density at the left base persisted, and repeated roentgen examinations revealed an atelectasis of the left lower lobe. (Fig. 3C).

The patient was lost sight of but returned in January, 1941 when roentgen examination was again made. At this time a marked density of the left lower lobe was present with numerous rarefactions within it. The heart was displaced

#### Comment:

The progression from obstructive emphysema to obstructive atelectasis and finally to bronchiectasis from the same obstructive mechanism is well illustrated in this case. The striking change in the roentgen findings is notable. During the emphysematous phase the heart and mediastinum are displaced away from the side of the lesion, the diaphragm downward. The radiability of the lung is increased. During the atelectatic phase the heart is displaced toward the side of the lesion, the diaphragm upward, and the radiability of the lung is decreased. The resultant bronchiectasis is best demonstrated by bronchography with iodized oil.

#### Case 2.

##### Carcinoma of bronchus with obstructive emphysema

, a male aged 58, came in complaining of dyspnea, weight loss, hoarseness, hemoptysis. His first symptoms began in January 1939, with an initial episode of hemoptysis. Later, weakness, dyspnea, and anorexia developed.

Routine fluoroscopy of the chest revealed an increased density at the left base of very small extent. During expiration some emphysema of the entire left lung was observed. Roentgenograms made in expiration (Fig. 4A) showed a shift of the mediastinum to the right, greater radiability of the left lung than the right and failure of the left diaphragm to move upward. The findings were char-

acteristic irregular filling defect in the left main bronchus was demonstrated (Fig. 4B). The appearance was typical of a bronchogenic carcinoma partially obstructing the left main bronchus.

Bronchoscopic examination revealed a typical bronchogenic carcinoma in the left main bronchus. Microscopic examination of the biopsy confirmed the diagnosis.

#### Comment

A case of obstructive emphysema resulting from a tumor of the bronchus in an early stage is here presented. The partial obstruction of the bronchus produced the unilateral emphysema in much the same manner as occurs with a foreign body. It is notable that the fluoroscopy and expiration films gave the first concrete evidence of the presence of the carcinoma.

#### Case 3.

##### Unilateral obstructive emphysema with bronchial asthma

a 41-year-old female, presented herself with a history of exertional dyspnea of three months duration and of asthma for many years. The dyspnea had become more marked recently. On physical examination, there was diminished breathing on the right side, and the motion of the right diaphragm was limited.

Fluoroscopic examination and roentgenograms in inspiration and expiration were made. There was clear evidence of emphysema of both lungs, as commonly found in asthma. In addition on expiration the heart moved to the left, the radiability of the right lung was not changed, and the diaphragm did not move upward (Fig. 5). The appearance was typical of obstructive emphysema of the right lung. Body section roentgenograms showed some distortion of the trachea but no evidence of tumor or foreign body in the bronchi.

Bronchoscopy was done but showed no particular evidence of abnormality in the

upper bronchi.

Obstructive emphysema of the right lung persisted for several months, and then recovery occurred, although the asthma and generalized emphysema persisted.

#### Comment:

Here we have an illustration of unilateral obstructive emphysema associated with asthma. The partial obstruction of many of the smaller bronchi, which is a common accompaniment of asthma, apparently became so much more severe on one side than the other that it produced the effect of a foreign body obstruction.

#### Case 4

##### Massive atelectasis with bronchial asthma

a female, aged eight years, had a long history of allergy and bronchial asthma. On 11-15-39 the child had a severe emotional scene. The following day she began to have respiratory difficulty and a dry, hacking cough. She had had similar attacks on previous occasions.

On physical examination at entrance there was mild cyanosis, the respirations were short and jerky, and the interspaces on the right side retracted on respiration. At this time the temperature was 103°. After two days it dropped rapidly to normal. There were 18,000 white cells.

Roentgen examination made several months earlier, when the child was reasonably well, had shown the typical uniform bilateral emphysema of bronchial asthma. Reexamination at this time showed the heart pulled over sharply to the right, the right diaphragm elevated, and almost the entire right hemithorax uniformly dense (Fig. 10). Within 48 hours the upper lobe had become roacrated completely, the heart was almost in normal position. The density of the lower lobe had the characteristic basal triangular form of atelectasis. Within

a week the lung was clear and the roentgenogram was identical with that observed several months before.

Bronchoscopy was done on 11-17-39, and the right bronchi were found to be markedly contracted, the mucosa edematous, and the lumen completely filled with thick, purulent secretion. This was removed by suction, and the right lung began to clear at once. The patient recovered from her attack of atelectasis completely, but the asthmatic seizures continued.

Comment:

This case illustrates abundantly the close relationship between emphysema and atelectasis. The mucous plugs partially obstructing the bronchi and thus producing emphysema suddenly enlarge either from excessive production of mucus or from the supervention of infection or from other causes. Complete obstruction of the bronchi then occurs, and the lung becomes airless in a relatively short time. This is not an uncommon event in asthmatics.

Case 5.

... , a male, aged 32, came in 8-4-41, with a history of continuous cough since March of 1940. At that time he had caught cold which lasted a month, but after the cold he kept on coughing on any exertion. The cough was productive and was blood tinged after August. In December of 1940 he became completely disabled from the cough. He had lost 25 pounds in weight but regained it before entrance. There was a history of repeated attacks of "pneumonia" beginning at the age of ten, the last one occurring in March 1941.

On physical examination some rales were heard at the base of the right lung, and there was dulness on percussion. Whispered voice and vocal fremitus were impaired. The sputum was foul and was negative for tubercle bacilli. The other findings were of no significance.

The tentative clinical diagnosis was

bronchiectasis. Roentgen examination 8-5-41 (Fig. 11A) revealed atelectasis and "drowned" lung of the right lower lobe. The diagnosis of bronchial occlusion from tumor, foreign body, or from an inflammatory stenosis was made.

Bronchoscopy done August 27 showed a tumor mass occupying the entire lumen of the right lower lobe bronchus. Most of it was removed and air was seen to enter into the right lower lobe immediately. The tumor mass was friable and bled easily. It was made up of columns and ill-defined clusters of dark cells supported by a vascular stroma. The diagnosis was bronchial adenoma.

Body section roentgenograms were made on September 6 (Fig. 11C), and the tumor was seen within the lumen of the right lower lobe bronchus. Bronchoscopy was again done on September 8, and the tumor was again made out. The right middle lobe bronchus was clear. The lower lobe was markedly obstructed. Tissue was again removed. The microscopic diagnosis was the same.

A bronchogram (Fig. 11D) was made September 17 after bronchoscopy. At this time the tumor defect and a typical cylindrical bronchiectasis could be made out. Bronchoscopy was again done September 21 and the tumor could again be made out; as much as possible was removed.

The patient was discharged and has been apparently entirely well ever since. Reexamination in March of 1942 (Fig. 11B) showed bronchiectasis still present, much the same as it was in September. The patient has had no symptoms since that time and is working every day. Bronchoscopy was performed again April 22. No tumor mass could be made out at this time and no evidence of growth.

He was seen again in October. He had gained five pounds; there was no cough, no sputum, no fever. Bronchography was again done October 22, 1942, and showed bronchiectasis still present.

Case 6.Tuberculous stenosis of bronchus  
with atelectasis and bronchiectasis

, a male aged 18, first reported to the Student Health Service in the routine course of events with a positive tuberculin skin test in October 1940. A simple postero-anterior roentgenogram of the chest showed a calcified Ghon tubercle at the left base and calcified peribronchial lymph nodes on this side (Fig. 12A). There was also a slight increase in density of the lower portion of the left upper lobe, the exact nature of which was not apparent. Apparently he was perfectly well at that time.

He returned to the Health Service for routine recheck on 10-9-41 and said he had been in perfect health. No effort was made to reexamine him at this time. November 27 he reported to the Health Service because of intermittent pain in the left side of the chest for the past month. He was referred to the X-ray Department, where a postero-anterior roentgenogram was made (Fig. 12B). Striking changes were found in the left lung. The left lower lobe was dense and retracted behind the heart. The latter was displaced to the left. The upper lobe showed increased radiability and some diminution in the size of its vascular shadow. The calcified tuberculous focus observed the year before and the calcified peribronchial lymph nodes could not be seen.

It was concluded that he had sustained a complete atelectasis of the left lower lobe. Body section roentgenography (Fig. 12C) confirmed this, showing a basal triangular dense shadow at the left base, containing rarefied areas characteristic of bronchiectatic cavities. The calcified parenchymal focus and the calcified peribronchial and interbronchial glands were also visible lying close to the spine and invisible in the ordinary roentgenogram because of the overlying shadows of the heart and the atelectatic lobe. The bronchial outlines were seen, and the left lower lobe appeared to be completely obstructed. Bronchography was done and a partial

obstructed left lower lobe bronchus was made out with typically dilated bronchi distal to it (Fig. 12D).

On bronchoscopy a tumor mass could be made out in the left lower lobe bronchus, which on microscopic examination of the biopsy specimen proved to be a tuberculoma. Meanwhile an area of disease in the right upper lobe had appeared, which increased somewhat in size. Acid-fast organisms were not found in the sputum but were found on gastric lavage. He was sent to Glen Lake Sanatorium.

Comment:

In this instance of tuberculous bronchostenosis the gross nature of the pathological process was clearly made out by means of various roentgen studies. The collapse of the lobe, the bronchial obstruction, and the bronchiectasis were all delineated. It was not until the bronchography and bronchoscopy that the inflammatory nature of the process could be defined.

Case 7.Inflammatory constriction of bronchus with atelectasis and bronchiectasis

a female of 24 years, was first seen here 9-4-41. She had had a cough as long as she could remember that became productive five years before. The quantity of sputum increased, so that she was raising about a cupful a day. The symptoms seemed to have started with an attack of whooping cough or measles at the age of four, but this was not entirely definite. There was no history of foreign body aspiration. For a number of years she had been treated by various physicians and had been in tuberculosis sanatoria because of the suspicion of tuberculosis. She had had repeated bouts of what was thought to be pneumonia. Three years ago she had had a marked hemoptysis. She now had clubbed fingers.

She was first seen in consultation



with Dr. Flancher of the Sandbeach Sanatorium, March 8, 1940, at which time bronchiectasis and collapse of the left lower lobe were made out roentgenologically and again in December 1940, at which time this same process was observed. It was thought she had a stenosis of the left lower lobe bronchus.

She was first admitted to the University Hospitals in February 1941 at which time roentgenograms of the chest and bronchograms were made. There was shown increased density at the left base with areas of rarefaction within it. The left diaphragm was markedly elevated and the heart and mediastinum drawn to the left side (Fig. 13A). Bronchography showed a stenosing process of the left lower lobe bronchus with bronchiectasis and involvement of the lingula branch of the left upper lobe (Fig. 13B). The process was readily recognized as an inflammatory rather than neoplastic constriction. There was some question of involvement of the remaining branches of the left upper lobe. In the bronchograms a distinct distortion and very marked narrowing of the left lower lobe bronchus were clearly apparent. Further lung mapping of the other bronchi was undertaken, and the process was found to be confined to the left bronchi with the chief involvement in the lower lobe but with some involvement of the upper as well. Body section roentgenography (Figs. 13C and 13D) revealed clearly the characteristic basal triangular shadow of a completely atelectatic left lower lobe. The multiple bronchiectatic and abscess cavities within it were clearly outlined, and the obstruction to the air-way of the left lower lobe bronchus was demonstrated. The presence of cavities in the lower portion of the left upper lobe was also noted.

Numerous bronchoscopies were done, all of which showed thick foul pus in the bronchi. The left main bronchus was found to be completely occluded by exudate. The opening into the left lower bronchus was markedly stenosed and poorly visualized. Numerous aspiration bronchoscopies were undertaken, and in each instance pus was removed.

At various times after her first visit here the patient had run a high fever, during which there was marked increase in the density of the left lung and evidences of recurrence of pneumonia and atelectasis within this lung.

As the bronchiectatic process had spread thoroughly into the upper lobe, pneumonectomy had to be undertaken. At operation there were numerous adhesions to the pleura. Marked retraction of the mediastinal content toward the left side was found. There was marked induration in the mediastinum. The left lung was removed in toto. There was a thin-walled cyst-like cavity in the apex of the left upper lobe. Many smooth-walled cavities were found throughout both the upper and lower lobes, but in the lower lobe there were numerous dilated bronchi, some being filled with pus. The lower lobe was markedly contracted, the whole parenchyma being airless. The upper lobe was still fairly well expanded. The findings indicated an inflammatory constrictive process in the left lower lobe bronchus with secondary bronchiectasis, atelectasis, fibrosis, and abscess formation.

The patient withstood the operation well and appeared to be recovering without any incident in the usual manner for patients with pneumonectomies.

#### Comment:

In this case the possibilities of roentgen examination are realized to their fullest extent. The atelectasis, bronchiectasis, and abscess formation which resulted from the bronchial obstruction were all delineated. The character of the obstruction, its inflammatory nature, its exact location, and the extent of the involvement of the bronchi were all brought out by roentgen examinations.

#### Case 8.

##### Inflammatory bronchostenosis simulating carcinoma of bronchus

, a male aged 44, developed a severe cold with a cough in the spring of 1943. He was in excellent health prior

to that time. His cough persisted, became productive in character, with a thick, tenacious, yellowish white sputum. In June 1943 he noted a dull persistent pain in the right chest anteriorly and medially which sometimes became sharp and shooting in character. In July he complained of malaise and generalized weakness. He had lost seven pounds in the last month. There had been no hemoptysis at any time. The temperature, pulse, respiration, and blood pressure were normal. Physical findings showed some dullness in the region of the right middle lobe, a slight decrease in breath sounds over this area, but no other evidences of abnormality. Laboratory findings were not significant. The sputum was consistently negative for organisms.

On roentgen examination, atelectasis and bronchiectasis of the right middle lobe were observed. Body section roentgenography and bronchography (Fig. 14) were done and showed a complete stenosis of the right middle lobe bronchus. The bronchus was funnel-shaped, narrowing down to a smooth point of obstruction. The appearance was not typical of carcinoma, but this diagnosis seemed the most likely one.

Bronchoscopy was done on three occasions, and complete obstruction of the right middle lobe bronchus was found. It appeared to be smooth and uniform, the appearance suggesting edema, but at one point its appearance gave the impression that a ligature had been tied around the bronchus. Attempts to dilate the stenotic area were unsuccessful. No tissue could be obtained for biopsy, and the appearance did not suggest especially a carcinoma.

Exploratory thoracotomy was done by Dr. Kinsella. The right pleural cavity was densely obliterated by fibrous vascular adhesions. The middle lobe was pinkish in color and soft but was not air containing and not expanded. A small lymph node was found which was removed but on section showed no evidence of pathology. There were dense fibrous adhesions between the middle and lower lobes, the fissure being obliterated.

Right middle lobectomy was done. The lobe weighed 17 grams. The contracted bronchus could be made out; it was 1.5 cm. in length, and its lumen had a diameter of only 1 mm. and was filled with necrotic material which grossly appeared caseous. The remainder of the lobe appeared entirely atelectatic. Sections from around the bronchus showed dense fibrous tissue infiltrated with lymphocytes and with some epithelization of the few remaining alveoli. The bronchi had no epithelium. In one bronchus there were numerous cholesterol crystals. No evidence of tuberculosis or other specific pathology could be made out. The appearance suggested most strongly a chronic interstitial pneumonia with scar formation and stenosis of the bronchus or chronic bronchitis and peribronchitis with obstruction of the bronchus of the right middle lobe. The laboratory findings were of no particular significance. Sputum examinations were consistently negative.

#### Comment:

Such a case illustrates the possibilities of error both in the roentgenologic and clinical interpretation of the results of bronchial obstruction. It was not at all difficult to demonstrate the bronchial obstruction, its exact location, and the nature of its effects upon the involved lobe. In the absence of positive bronchoscopic evidence, however, it was impossible to determine the exact nature of the obstructing mechanism. In this instance lobectomy was necessary regardless of the cause of the obstruction. Fortunately the exploration permitted the determination that the process was not malignant and pneumonectomy was avoided.