A STUDY OF LOBAR PNEUMONIA AND ITS PULMONARY COMPLICATIONS BY SERIAL ROENTGENOGRAPHIC EXAMINATION*

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Among 272 cases of frank lobar pneumonia treated at the St. Louis City Hospital during the past two years, 152 were subjected to roentgenographic examination. Roentgenograms were made at from one- to three-day intervals during the course of the disease, and the findings were carefully correlated with clinical history and physical signs in many of the cases. This study of lobar pneumonia was undertaken with a view of determining the natural course of the disease, its complications and its sequelae.

From the pathological viewpoint, four different stages of the pulmonary lesion are recognized in pneumonia: (1) The stage of congestion and engorgement; (2) the stage of red hepatization; (3) the stage of grey hepatization, and (4) the stage of resolution. The stage of congestion is characterized by the engorgement of the blood-vessels and lymphatics and the production of an active edema in the air spaces, and, to some extent, in the interstitial tissue. At autopsy, particles of such material, although considerably denser than normal, will still float on water, showing that they are still air-containing to some extent. The increase in density of this material would hardly be sufficient to cast as dense a shadow in the roentgenogram as that produced by the stages of red and grey hepatization. This stage is so transitory, however, often lasting but a few hours, and the difference in density of the shadow in the roentgenogram so slight, that it is quite obvious that any differentiation of the active stage of consolidation would usually be impossible from the roentgenogram. After the crisis has occurred, however, in the stage of resolution, the irregularly resolving and absorbing exudate produces an uneven mottled appearance in the roentgenogram, which is quite distinctive of this stage of the disease. Since, from a practical standpoint, it is, therefore, impossible to determine definitely the active stage of the disease from the character of the shadow, let us consider the distribution of the consolidation and its bearing on the course, diagnosis and prognosis of the disease.

Roentgenographic Characteristics. The pathologist tells us that the process of consolidation is closely confined to one or more lobes, so that a definite knowledge is necessary of the position which these lobes occupy and the location of their interlobar septa. To illustrate with more accuracy the location of the interlobar septa, this case has been introduced (Fig. 1). The inflammatory reaction incident to a pulmonary abscess in the hilus region has resulted in the pronounced thickening of all of the interlobar septa. This case represents, then, a much more practical demonstration than any which could be obtained in the autopsy room or by inspection of dissecting-room material, and is excellently adapted for a study of the interlobar septa and the position of the various lobes of the lung. From this roentgenogram, taken in the lateral position, it will be seen that the upper lobe makes up a much greater part

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of the lung tissue than is generally supposed. When the tube is centered at the 5th dorsal vertebra at 28 in. distance, it will be noted that the central ray falls very closely along the interlobar fissure of the upper and middle lobes (Fig. 2A), so that the resulting shadow of upper lobe consolidation should be clear-cut and sharply outlined at its lower border, and the entire shadow should be very dense. Any slight variation in centering or tube distance

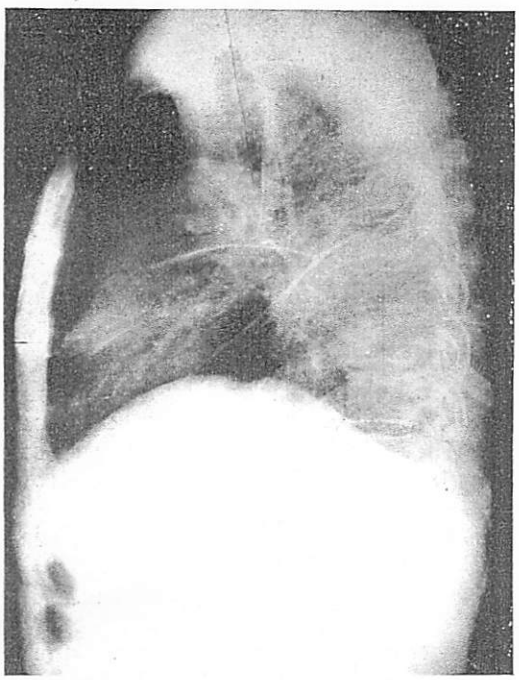

FIG. 1. Thickening of the interlobar pleura incident to a lung abscess in the hilus region. The marked thickening of the interlobar pleura serves to show the relationship of the various lobes. Note that the middle lobe does not touch the posterior chest wall at any point, but presents entirely at anterior wall.

should make little difference in the resulting shadow. Whereas middle lobe involvement (Fig. 2B) should present a similar sharpness of outline at its upper boundary and a hazy outline for its lower border, the entire shadow should not be as dense as the shadow of upper-lobe consolidation. Where the lower lobe is involved (Fig. 2C), the extreme lower portion of the lung will also be involved, and the upper border of the shadow should be more or less hazy in the ordinary position of the *x*-ray tube. When these essential points are borne in mind, a lobar consolidation involving one or more lobes can be readily differentiated and the roentgenographic characteristics easily explained.

Course of the Disease. Having analyzed the probable result of roentgenographic examination of consolidation of the various lobes, let us examine roentgenograms of various lobe consolidations, and pass to a

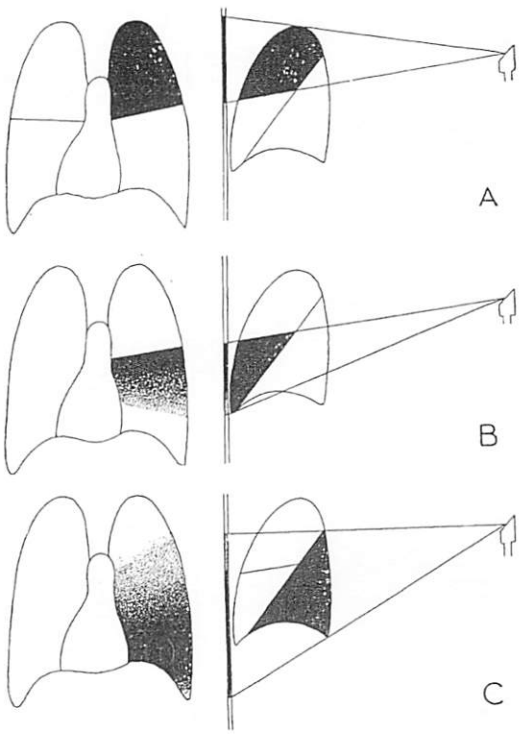

FIG. 2. Diagrams showing shadows produced by consolidation of various lobes, with the tube at 28 in. distance and centered at about the 5th dorsal vertebra. (A) Upper-lobe consolidation. The shadow is dense and the lower border is sharply defined. (B) Middle-lobe consolidation. In involvement of the middle lobe, the upper border of the consolidation is sharply defined, the lower portion is hazy. The extent of the shadow produced is relatively small compared to consolidation of other lobes. (C) Lower-lobe consolidation. The upper border of the shadow is hazy and the extent of the shadow produced is greater than any other lobe. The costophrenic angle often remains aerated during the acute stage of the disease.

consideration of the course of the disease. It will be seen that in practice the roentgenographic findings conform closely to those anticipated; atypical borders and anomalous lobes may occasionally be encountered (Fig. 3, A, B, C).

In a great many of our cases there was complete consolidation of an entire lobe

at the first examination, even when the first roentgenogram was made within twenty-four to forty-eight hours after the onset. It is quite evident, therefore, that in many cases, probably the greater majority, complete consolidation occurs within a very short time. In a certain number of instances, however, the pathological process does not progress so rapidly. In some of these patients, on first examination, a definite consolidation was seen at the hilus region, which, on successive examinations, progressed rapidly outward, rarely requiring more than twenty-four to forty-eight hours to reach the periphery (Fig. 4). Whether of the slower, progres-

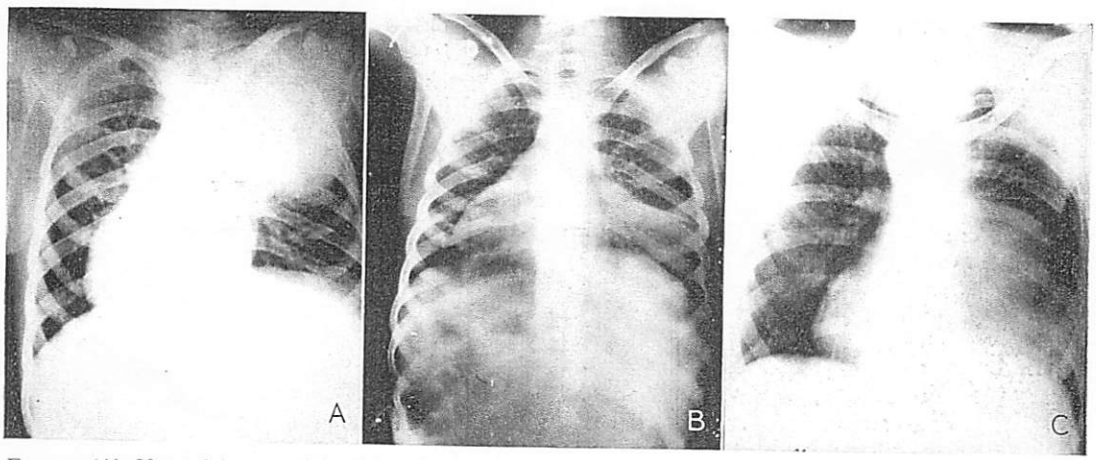

FIG. 3. (A) Upper-lobe consolidation. Note sharply defined lower border. (B) Middle-lobe consolidation. Note sharply defined upper border, hazy lower portion and small extent of involvement. (C) Lower-lobe consoldiation. Note hazy upper border, and large amount of involvement. Lower-lobe consolidation extends higher than middle-lobe consolidation. The costophrenic angle is aerated.

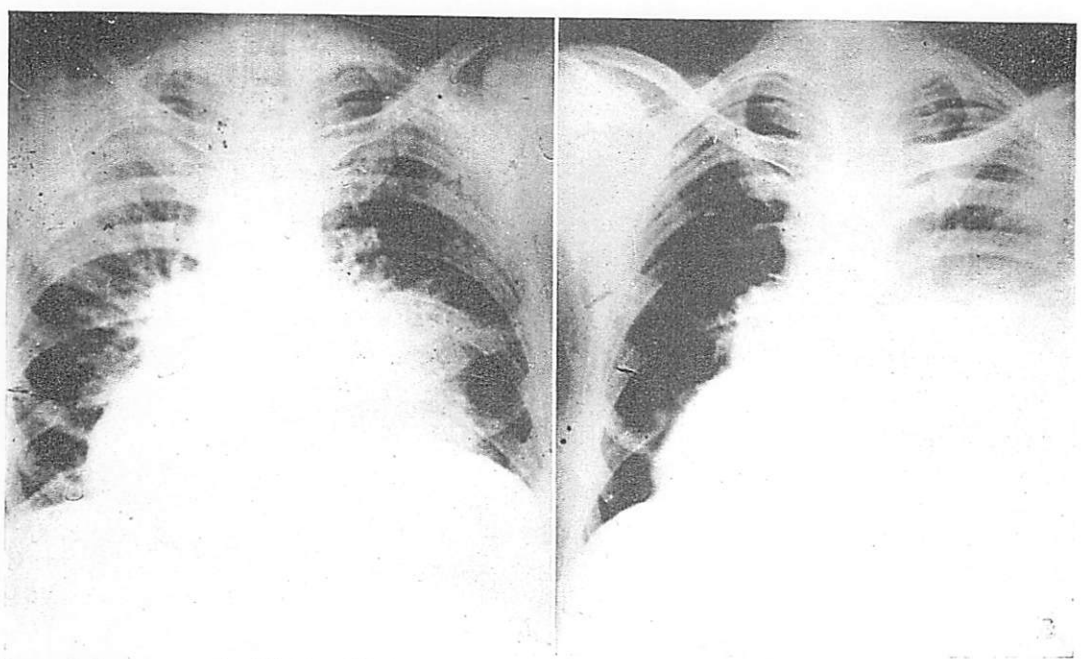

FIG. 4. Lobar pneumonia. (A) Consolidation commencing in the hilus region. (B) Plate made twenty-four hours later, showing extension to the periphery and involvement of the entire lower lobe.

sive type, or the rapidly consolidating form, the shadow produced is of a homogeneous character, presenting an even density throughout, showing only dense peribronchial markings, which, at the onset of the process, are usually seen through the consolidation shadow. The zone of advance of the process is feathery and uneven, and shades off into the normal tissue. The edge of the advancing shadow

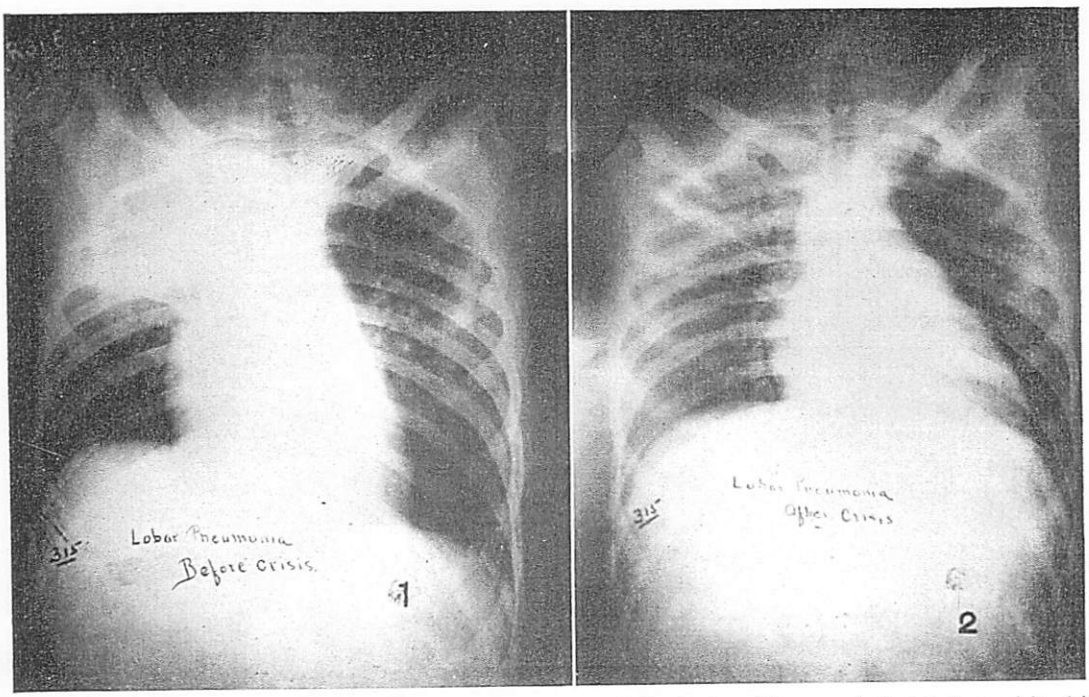

FIG. 5. (1) Upper right lobar pneumonia showing characteristic shadow. Plate made just before crisis. (2) Showing almost complete resolution in three days after crisis.

is composed of the radiating extension of accentuated peribronchial markings. This is probably due to the fact that the process, commencing in the hilus area, has progressed more fully to dense consolidation than that in the periphery, which is involved in the later stage, and also because the amount of consolidated tissue obstructing the ray is greater in the inner than in the outer zone of the lung. As the disease progresses, and consolidation becomes more dense, the peribronchial markings become obliterated, and the entire shadow may be of homogeneous density. In the natural course of the disease, little change is seen in the shadow from the time complete consolidation is reached until the time of the crisis. Shortly after the crisis, resolution begins, and the shadow changes rapidly from the homogeneous type to that of an uneven mottled appearance. Very soon the accentuated peribronchial markings again become apparent, and the uneven mottled area gives place to groups of soft isolated infiltrations. The entire area may be overshadowed by a pleural haze if the pleura has become thickened during the course of the disease. Resolution is very rapid, however, and all evidence of infiltration and consolidation may have completely disappeared within three days after the crisis (Fig. 5). Ordinarily, however, complete resolution requires a somewhat longer time—from seven to ten days; persistence of consolidation for fourteen days after the crisis should be viewed as distinctly pathological. It is, therefore, quite evident that the consolidation in lobar pneumonia, at least in many instances, starts at the hilus and extends peripherally.

Review of Literature and Discussion. A review of literature, however, seems to show this at variance with the observa-

tions of some men. Mason[1] described the roentgenographic appearance of pneumonia in children as a triangular shadow with the base at the periphery and the apex at the hilus of the lung. He further stated that the consolidation commences in the periphery and gradually progresses to involve the hilus. He quotes the conclusion of Weill and Mouriquand[2] from the consideration of 350 pneumonia cases studied by *x*-rays, that the early shadow is usually triangular in shape, with its base usually conical and generally axillary. They have never seen a shadow which could be considered entirely central. Mason himself describes this consolidation and illustrates two cases, both of right upper-lobe involvement, which, in the roentgenograms, suggest a more intense consolidation at the periphery. He emphasizes the observation that the process of consolidation always begins in the part nearest the pleura and thus, during the beginning of the process, at any rate, is separated from the root of the lung by normal aerated lung tissue, and that central pneumonia, therefore, does not exist. On the basis of roentgenograms taken in cases in which physical signs of consolidation did not exist, where there was apparently an aerated zone of normal lung tissue beneath the surface consolidation, he concludes that in these instances the lack of physical signs is due to the failure of transmission of the breath sounds from the hilus through the aerated lung tissue to the surface. In December of the same year, Stewart,[3] in a publication on the differential diagnosis of lobar pneumonia and empyema in children, comments on Mason's theory as follows: "While I am not prepared at the present time to accept in its entirety the explanation given by Dr. Howard Mason of New York for the frequent lack of positive physical signs in some cases of pneumonia, I do believe that his theory holds good in many cases showing late physical signs. As many cases of pneumonia are believed to start at the root and spread toward the cortex, this explanation would seem to apply only to those commencing at the pleural surface." In the same publication he describes a root or hilus pneumonia in children, and shows illustrations of this type of consolidation beginning in the hilus region of the lung, spreading fanshaped into all the lobes and usually remaining confined to this region. In spite of this demonstration of root pneumonia, Barjon,[4] in his book on Pleuro-Pulmonary Affections, says: "These proofs do away with the idea of central pneumonia which would explain the late appearance of physical signs. Indeed, the shadow of the pneumonic triangle begins at this base, and this base is always cortical, since it develops in the axilla. Finally, the radioscope never shows in any case a primary central focus without some relation to the cortical portion of the lung. In short, central pneumonia does not exist, but everything progresses as if it did." In a recent publication the writer[5] reported 12 cases of hilus pneumonia occurring among 276 cases of pneumonia examined. Eleven of these were of the distinctly inflammatory type, 1 occurring in a child, and 10 in adults. In a previous publication,[6] the existence of hilus pneumonia in the adult in connection with the influenza epidemic was pointed out.

It is quite probable that many cases of pneumonia in children do follow the course indicated by Mason in his essay on pneumonia: beginning at the periphery and progressing inward to the hilus. Among the cases included in this series several instances are present where the consolidations occurring in children followed this course (Fig. 6). To say that this is the only course followed in children is manifestly wrong, in view of the many existing cases of hilus pneumonia previously cited in the literature. It is also unmistakably true that many cases do occur in adults in which the consolidation starts in the hilus region and spreads toward the periphery. While it is possible that in adults, certain cases may exist in which consolidation starts in the periphery, we have never encountered one in which this relationship could be established. Mason's explanation of the failure to elicit certain physical signs is probably quite correct in certain instances. It is also true that a similar obscurity in physical signs can occur when the consolidation is confined to the hilus region, in so-called hilus or root pneumonia, and it is

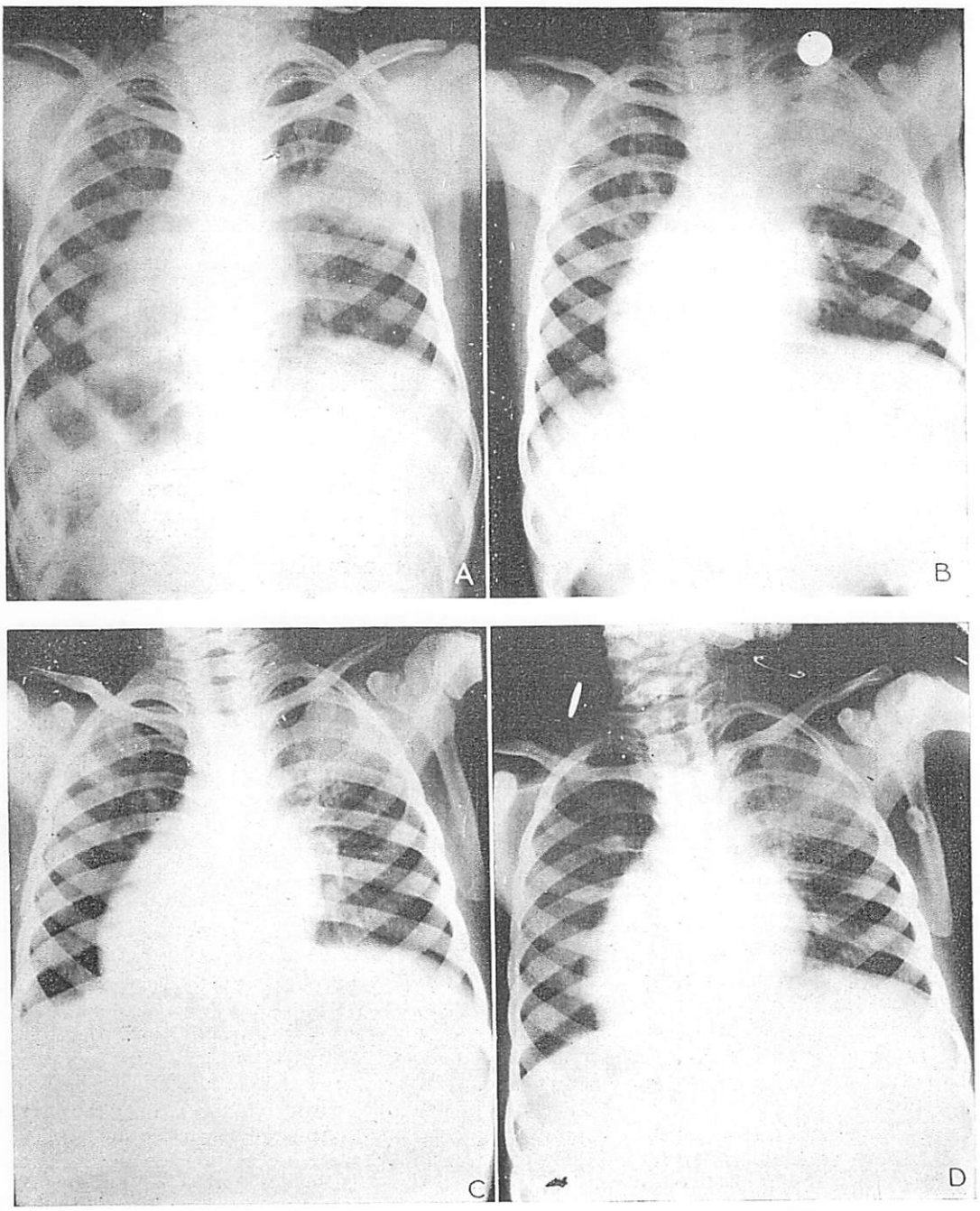

FIG. 6. Lobar pneumonia right upper lobe. Type referred to by Mason as starting in the periphery and advancing to hilus. (A) Note the consolidation of lower and outer portion of the right upper lobe. The sharply-defined lower border establishes the identity of the lesion as upper rather than middle lobe consolidation. (B) Within forty-eight hours there was advancement of the process to involve the entire upper lobe. (C) Shortly after the crisis resolution begins. (D) Continued favorable resolution of the process.

probable that the same explanation holds in these cases. Furthermore, from the plates which have been shown of lobar pneumonia in adults, it is evident that, in the greater number of instances, lobar pneumonia starts as a central consolidation in the hilus region and spreads peripherally. It would seem, therefore, that, at least in the majority of instances, our old conception of lobar pneumonia was the correct one; the obscurity in physical signs in certain instances being due to a centrally located consolidation which had not yet reached the surface.

Prognosis. Pneumonia, uncomplicated by other pulmonary lesions, may itself prove fatal. Neither the location of the consolidation, its extent nor the density of the consolidation is a determining sign in the prognosis. The most extensive involvement of lung tissue may end in recovery: the smallest areas of involvement may result fatally. The process in one lobe may resolve only to be followed by consolidation in another, possibly adjacent to the primary involved lobe, possibly remote. All the lung tissue on one side may be involved in a massive consolidation. As a general rule, however, involvement of a single lobe gives much the best prognosis, especially where the shadow shows the characteristic changes described as natural for the course of the disease. Usually, lobar pneumonia resolves very rapidly: three days after the crises may be sufficient for complete resolution; seven to ten days, however, is the average time. If fourteen days elapse after the crisis without signs of progressive favorable resolution, or if no crisis occurs within this period, the condition is abnormal, and it can be depended upon that some complication of pneumonia is present. Persistence of the shadow over this period did not occur in a single instance, unless there was some complicating pathology.

Pulmonary Complications. The most frequent pulmonary complications of lobar pneumonia are:

1. Dry pleurisy with thickening of pleura.
2. Pleural effusions, serous or purulent; either general or localized.
3. Plastic serofibrinous pleurisy.
4. Chronic interstitial pneumonia or fibrosis.
5. Lung abscess.

Dry pleurisy, resulting in a thickening of the pleura, both at the periphery and in the interlobe, is so frequent an attendant with pneumonia that it is probably best considered as a part of the pathological process. The presence of a pronounced pleural reaction is, in itself, almost pathognomonic of a recent inflammatory lesion. Roentgenographically, the linear shadow

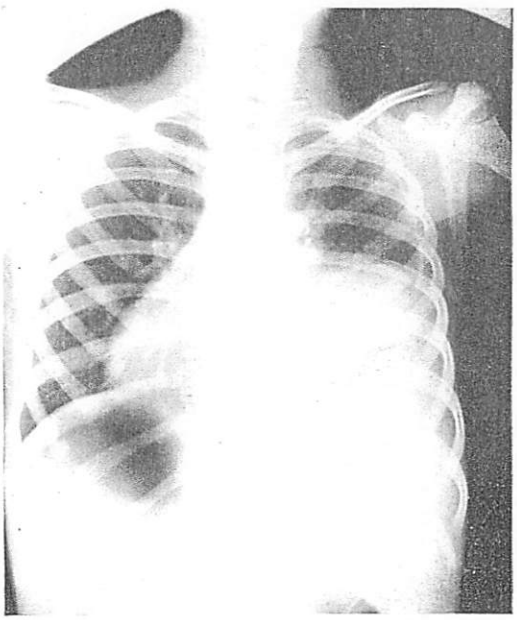

FIG. 7. Very frequently a small amount of fluid forms in the pleural cavity during the course of the disease. Note the ribbon-like shadow running along the parietal wall. The rounded appearance of the upper portion of the consolidated area is suggestive of a small collection of interlobar effusion.

running upward along the parietal wall of the chest and the dense linear shadow extending across the chest from the hilus to the periphery when the interlobar pleura is involved, are familiar to all roentgenologists. After the disease has progressed to involve the pleura, a small amount of serous fluid may collect (Fig. 7). This obscures the costophrenic angle and produces a ribbon-like shadow along the parietal chest wall, not unlike pleural thickening, and at times almost indistinguishable from it. This occurs so frequently during the course of the disease that it

seems quite probable that it is a provision of nature to keep the inflamed pleural surfaces apart, and prevent adhesions. Its presence is of little significance, merely adding to the difficulty of differential diagnosis between lower-lobe pneumonia and pleural effusion. Larger collections of fluid may occur in the free pleural cavity during the course of a pneumonia, and these have the same characteristics of fluid encountered under ordinary conditions in the chest. Where the pneumonic consolidation is in the upper portion of the chest, any additional shadow forming in the lower chest from the accumulation of fluid can be readily detected. The costophrenic angle, being the most dependent portion of the chest, is first to be obscured, and the shadow extends across the lower portion of the chest running up along the axillary border. The upper border of the effusion is hazy and concave, extending higher up toward the axillary side. The heart and mediastinal structures are usually displaced somewhat to the opposite side, due to the weight of the fluid. This is not an infallible sign, however, and has not been observed on certain occasions with moderately large effusions. Where a primary consolidation in the lower lobe is complicated by a pleural effusion, the diagnosis becomes more difficult, and it is often very hard to decide just how much of the shadow is due to consolidation and how much to fluid. Pleural effusions encountered as a complication of pneumonia may be either serous, serofibrinous or purulent. Since it is impossible to tell from the density of the shadow the character of the fluid, it is impossible to differentiate between serous effusion and empyema. The clinical picture may give some indication, but aspiration is the only reliable test. Pleural effusion may not only be general, involving the entire chest cavity as previously described, but may also be localized by adhesions between the two pleural layers at any point at which the pleural layers come in contact with each other (Fig. 8). This may be between lobes of the lung, when an interlobar effusion results. Such effusions usually present a clear-cut shadow extending across the entire half of the chest from the hilus to the periphery.

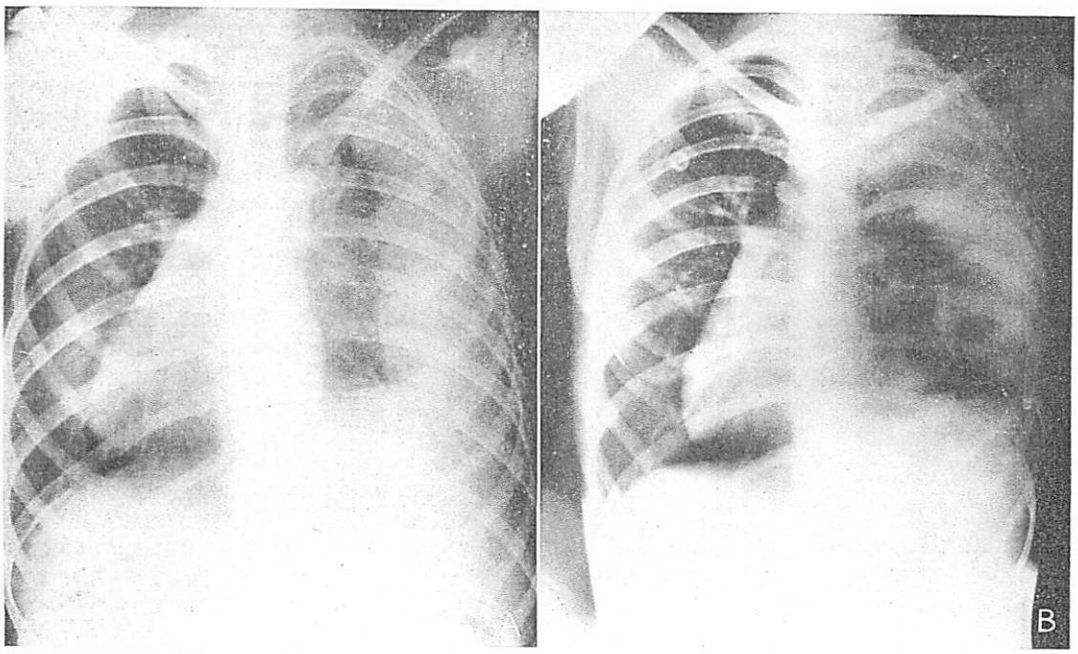

FIG. 8. Localized fluid entrapped between the two pleural layers. Localized collections of fluid, unassociated with plastic serofibrinous pleurisy, are sharply outlined. Being between the layers of pleura, the shadow is peripheral in location. (A) Localized fluid without pocketing. (B) Localized fluid showing a tendency to pocket formation.

The outer margin is often rounded and the lower border sharply defined, in these respects differing from consolidation of the middle lobe (Fig. 9). Collections of fluid, localized by adhesions of the parietal and visceral pleura, may occur in any portion of the pleural cavity. They are most frequent in the lower portion of the chest, in the axillary border and in the posterior cul-de-sac. Occasionally they are observed in the upper portion. Regardless of position, localized pleural effusions are nearly always sharply outlined unless they occur in connection with plastic serofibrinous pleurisy. In determining the location of such localized effusions, the lateral view is most helpful. Such effusions may be either serous or purulent in character. That small collections of pus, either in the lung or entrapped between the pleural layers, frequently escape detection, is evidenced by this case (Fig. 10, A, B, C, D). In this instance two drams of thick pus were aspirated from the lower chest during the height of the consolidation. Resolution progressed favorably and complete restoration to normal resulted. Pneumothorax is a very rare complication of pneumonia, and usually occurs in connection with post-pneumonic empyema.

Another condition which sometimes complicates pneumonia is plastic serofibrinous pleurisy. This complication, although not so frequently met with, is apt to be more serious than the other complications previously mentioned. Presenting no features akin to an effusion, it must necessarily be considered as a separate entity from the roentgenologic standpoint. The pneumonic process may run a natural course ending by crisis, the temperature may fall to normal and remain so for a short time, only to be followed by a post-critical rise and a persistent septic temperature, or a definite crisis may never occur, the temperature gradually assuming this septic character. Roentgenographically, the consolidated area does not resolve in the customary manner (Fig. 11). Large blotchy areas of increased density remain usually most pronounced at the periphery, the central portion of the shadow showing indication of normal resolution. The pleura is extremely thick and presents a stringy appearance, due to the fibrinous exudate. At autopsy the pleural surface is shaggy, with heavy strands of fibrinous exudate enmeshing small abscesses. These abscesses may attain considerable size, and may even represent localized areas of effusion. The pus content is usually very thick and creamy, due to the high fibrin content. The process may invade the lung, resulting in multiple small abscesses and interstitial fibrosis. Such involvement may be small in extent and may completely resolve, even

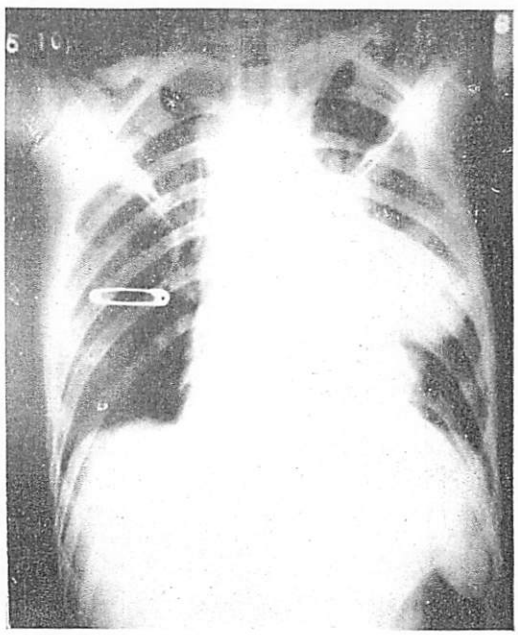

FIG. 9. Interlobar collection of fluid. Note the dense homogeneous shadow extending from the hilus to the periphery; note also the rounded appearance of the outer margin.

where pus is present, leaving only a small pleural adhesion. Resolution of such a process usually requires six to eight weeks, however. Repeated roentgenographic examinations will indicate the progress of resolution, and will aid in determining the prognosis. Where the condition is very extensive, however, the outlook for ultimate complete restoration to normal is not so good. Where any considerable amount of pus is present, or where it is evident from repeated roentgenographic examinations that the condition is not progressing favorably, surgical intervention and evacuation of the pus may aid materially in the

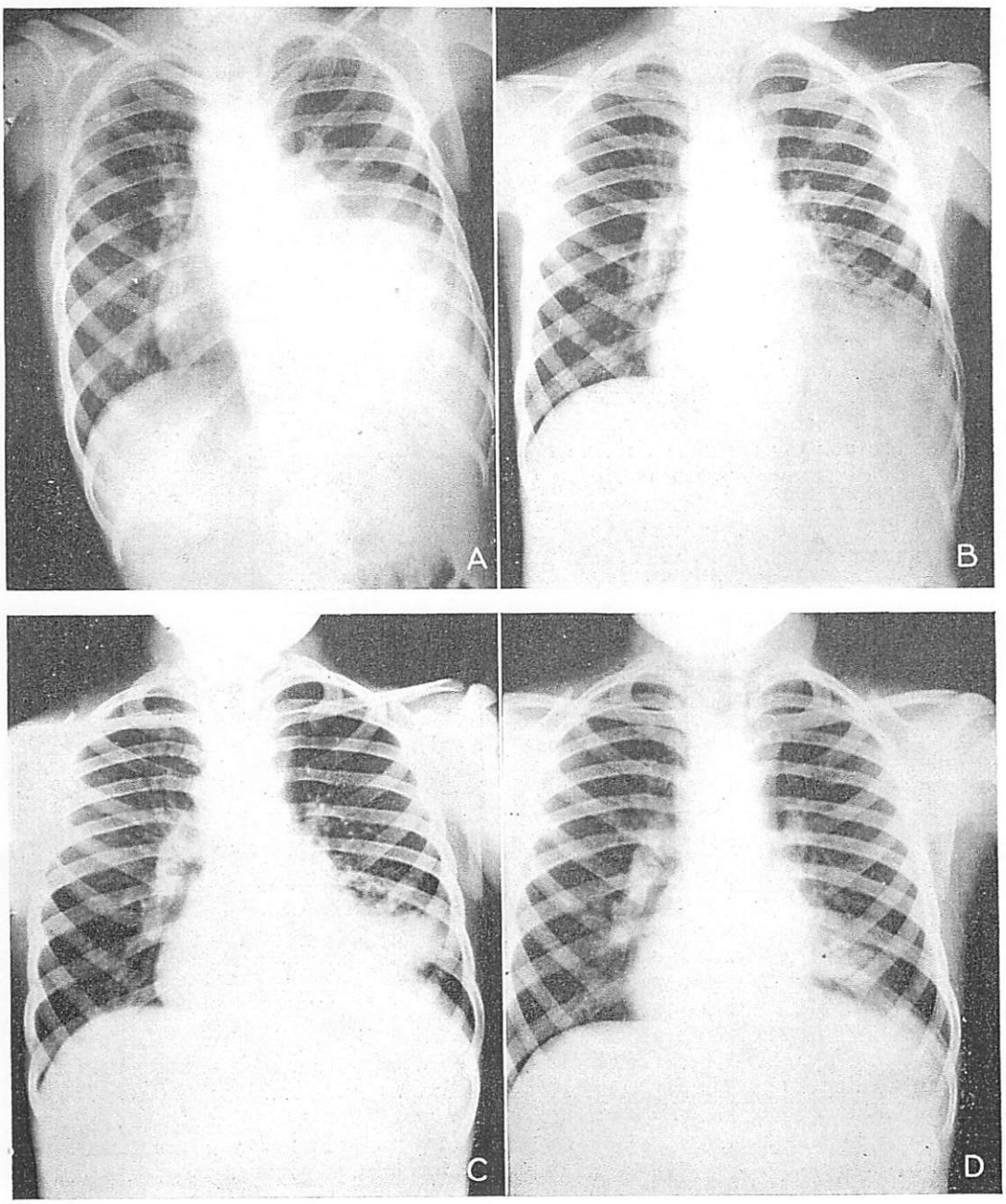

FIG. 10. That small collections of pus, either in the lung or entrapped between the layers of pleura, often escape detection, is evidenced by this case. (A) Lower right-lobe pneumonia just after crisis. At this time a needle was inserted and two drams of pus aspirated from somewhere within the involved area. (B) Plate made three days after aspiration of pus. Note the network appearance of upper border and marked recession of the process. (C) Plate made three weeks later, showing continued favorable but very slow resolution. (D) Plate two weeks later showing continued favorable resolution. Almost complete restoration to normal. Clinically the child had fully recovered.

ultimate recovery. By reason of the enmeshed character of the pus and its very viscid consistency, it often happens that surgical intervention or any other method of treatment is of little avail, and the process goes on to ultimate fibrosis (Fig. 12). The pleura, both parietal and visceral, becomes enormously thickened, obliterating the pleural cavity. The small abscesses entrapped between the layers of pleura throughout the fibrinous exudate become absorbed and are replaced by fibrous tissue.

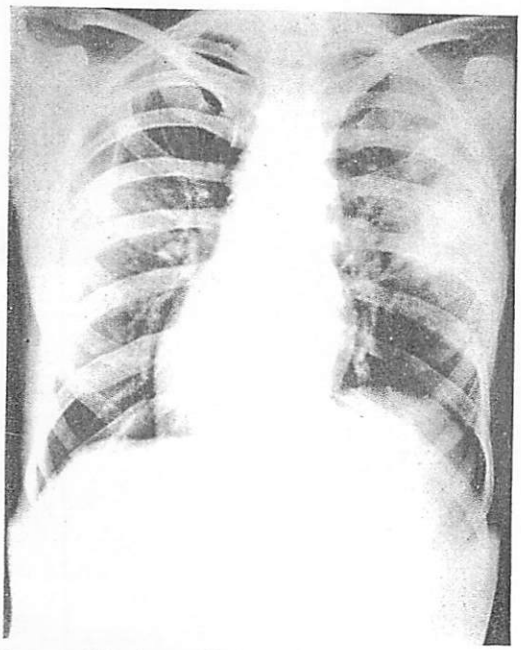

FIG. 11. Plastic serofibrinous pleurisy with localized collection of fluid. Note the peripheral location of the shadow, and that when associated with plastic pleurisy, localized collections of fluid are not sharply outlined.

Organization takes place, and finally scar tissue is formed. The lung tissue may become involved and an interstitial fibrosis, similar in character, may result, either from an extension of the process, or as a result of functionless condition produced in the lung. The ultimate stage of the process is a contraction of the scar tissue. The heart and mediastinal structures are drawn over toward the affected side. The diaphragm is elevated and the intercostal spaces are narrowed. The entire side of the chest becomes more shallow than the normal side, a condition which is even more apparent since compensatory emphysema of the normal lung usually results. The entire lung is practically replaced by fibrous tissue showing a dense irregular shadow. The condition produced is known pathologically as chronic interstitial pneumonia. Some modification of this process is probably what has been referred to as "unresolved pneumonia."

The last complication of pneumonia to which I desire to call attention is lung abscess. Persistence of the consolidated

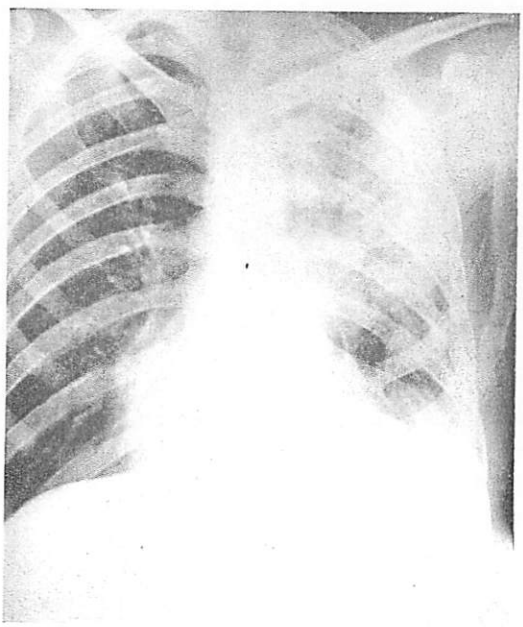

FIG. 12. Chronic interstitial pneumonia following organization of a plastic serofibrinous pleurisy. Note the narrowing of the interspaces, the elevation of the diaphragm and the displacement of the heart and mediastinal structures to the right.

area beyond the time normal for a lobar pneumonia, without favorable signs of resolution, is almost pathognomonic of abscess formation. Often, the diagnosis of a complicating abscess can be made by the roentgenographic appearance, fully five to seven days before the indications are present clinically.

Differential Diagnosis. During the early stage of lobar pneumonia, the consolidation may be confined to the hilus region and resemble, in all respects, hilus pneumonia. Within twenty-four hours, however, the hilus consolidation should spread toward

the periphery, confining itself to a single lobe, if the condition is due to lobar pneumonia. If the condition is due to hilus pneumonia, the shadow will remain constant and will not spread peripherally. As a general rule, when the consolidation is fully developed, there is little difficulty in the diagnosis of lobar pneumonia. Occasionally, however, even the acute shadow of lobar consolidation may be confused with other conditions. Caseous tuberculous pneumonia (Fig. 14) may cause a mas-

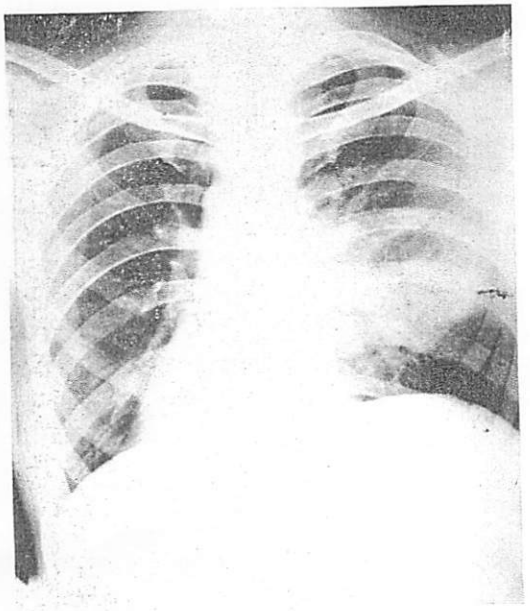

Fig. 13. Lung abscess following lobar pneumonia of the lower lobe.

sive homogeneous consolidation confined closely to one or more lobes, which may resemble in every detail the consolidation from lobar pneumonia. The symptoms and course of the disease readily differentiate the conditions. Caseous tuberculous pneumonia requires from three to four months for resolution, whereas lobar pneumonia may completely resolve in as many days. Caseous tuberculous pneumonia usually leaves behind definite cavity formation; lobar pneumonia resolves completely and leaves a perfectly normal appearance. It is undoubtedly true that caseous tuberculous pneumonia may occur in any of the lobes of the lung, but the upper lobes are undoubtedly the most frequent site; the right side being most frequently involved. Where the roentgenographic evidence alone is analyzed, the differential diagnosis may depend entirely upon the course of the disease. The clinical history, however, may serve at once as a determining factor. In the tuberculous type of pneumonic consolidation, the temperature is never so high and there are morning remissions even to normal, a condition not obtained in lobar pneumonia. There is not the pronounced leucocytosis obtained in lobar pneumonia. The patient does not feel exceptionally bad, and may even be up and about; in pneumonia, on the other hand, the patients are quite ill and confined to bed. In this connection may I say that in the opinion of the writer, positive diagnoses as to chest conditions without a previous consideration of the clinical history are very hazardous.

Only under the rarest circumstances would the lobar distribution of a bronchopneumonia be confused with lobar pneumonia. The comparative rarity of the former condition, its occurrence in connection with septicemia or as a complication of influenza, its invasion by peribronchial infiltration and the blotchy, uneven appearance of the shadow will aid in the differential diagnosis of the two conditions.

Syphilis of the lung produces, at times, massive homogeneous consolidation, which may, at a single examination, resemble lobar pneumonia. While the consolidation from syphilis is usually more massive, a similar picture may be presented by lobar pneumonia, and again the determining factor must be sought in the clinical history. Whereas one would expect a patient with lobar pneumonia of this extent to be desperately ill, syphilis of this extent may have remarkably few symptoms. The Wassermann reaction and resolution of the consolidation after salvarsan are the deciding factors.

Tumors of the lung rarely produce any confusion. The only type of new growth which, in the writer's experience, has ever in any way simulated pneumonia, is the metastasis from a hypernephroma. Hypernephroma (Fig. 15) may be confined to the lower lobe of the lung produc-

ing a dense homogeneous consolidation which at times may simulate lobar pneumonia or fluid. Three such cases have come under the writer's observation, which were either confirmed by autopsy or microscopic sections from material obtained by lung puncture.

One of the most difficult differential diagnoses may be in the differentiation between lower-lobe pneumonia and fluid, or the simultaneous existence of both. The upper border of a pleural effusion extends from the hilus region upward and outward to the axilla, and may conform very closely to the upper border of a consolidation in the lower lobe. It is true that the costophrenic angle is obliterated in fluid and is usually well aerated during the acute stage of lower-lobe consolidation, but very often a somewhat later stage of the disease finds it obliterated, whether by extension of the consolidation to this remote portion of the lung, or by obliteration from a small collection of protective fluid, makes little difference in the difficulty of diagnosis. The heart and mediastinal structures are usually displaced in fluid, but, as has been said, that is not an infallible sign, for either no displacement at all may be present, or it may be so slight as to be indeterminate. Under certain conditions, therefore, the differential diagnosis between lower-lobe pneumonia and fluid becomes very difficult. A method which we have used occasionally, and have found most useful in the differentiation of the two conditions will be briefly outlined (Fig. 16). Since the upper bounding plane of the lower lobe is on a relatively straight line running from behind forward and downward, it follows that the image cast on a plate of consolidations of the lower lobe, if the ray is projected along the upper surface, will be a definite straight line, clear-cut at its margin and very dense. When made in the ordinary position, the beam of *x*-rays traverses the wedge-shaped upper portion of the lower lobe, causing a gradual shading off into the normal lung, and resulting in a hazy upper border which is not sharply outlined and not dense. Fluid, on the other hand,

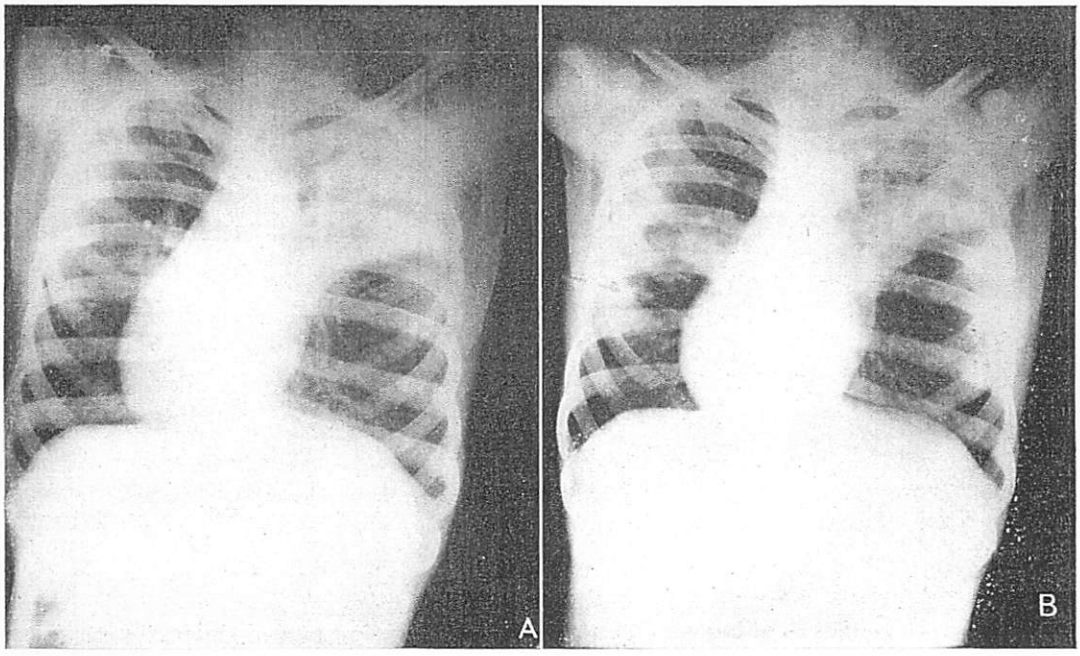

FIG. 14. (A) Acute caseous tuberculous pneumonia of the lobar type. This condition simulates very closely the consolidation from lobar pneumonia, and can only be differentiated at the onset by the lack of serious clinical symptoms, and later on by the protracted course of the disease. (B) Three months later. Same resolution has occurred with cavity formation.

when it has reached a stage confusing it with pneumonia, owing to the curved line which it produces, both from before backward and upward, and from within outward and upward, never casts a clear-cut upper border, no matter what the position of the tube. While roentgenograms made in the ordinary position may show a hazy, indefinite upper border, either in lower-lobe consolidation or in fluid, roentgenograms made with the tube centered high up will show a clear-cut upper border if the shadow is due to consolidation, but a persistently hazy outline if it be due to fluid.

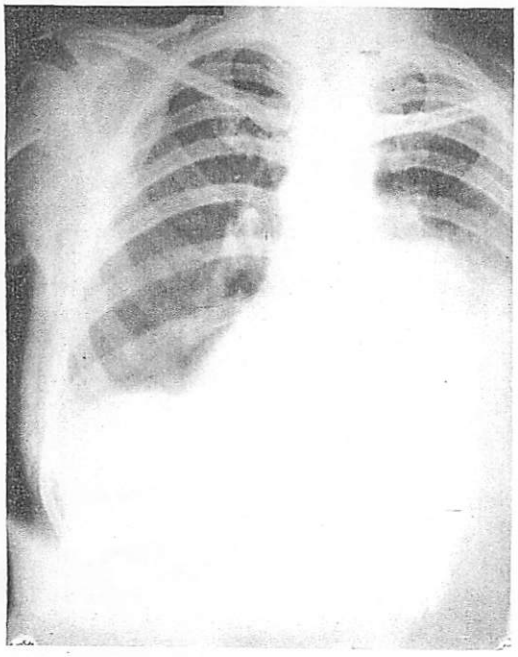

FIG. 15. Hypernephroma, metastatic in the chest, causing consolidation of the right lower portion of the chest simulating lobar pneumonia or fluid, and may be indistinguishable from these conditions without clinical history.

In the resolving stage, the most easily confused lesion is that of the infiltrative type of tuberculosis. This is especially the case where the pneumonia involves the upper lobe. Here, again, the clinical history may be the determining factor: a short duration and profound illness suggest an inflammatory process; a longer duration without serious illness labels the condition as more probably of tuberculous origin.

Localized pleural effusion will rarely be confused with tumors of the pleura, as the history and previous plates made during the course of the disease will differentiate. Localized pleural effusions are sharply outlined, and, being between the layers of the pleura, are seen at the periphery rather than at the midportion of the lung. In these respects they differ from lung abscess, which is not clearly outlined, being surrounded by an irregular zone of inflammatory infiltration; being in the lung substance, its shadow appears as a consolidation and usually does not extend to the periphery.

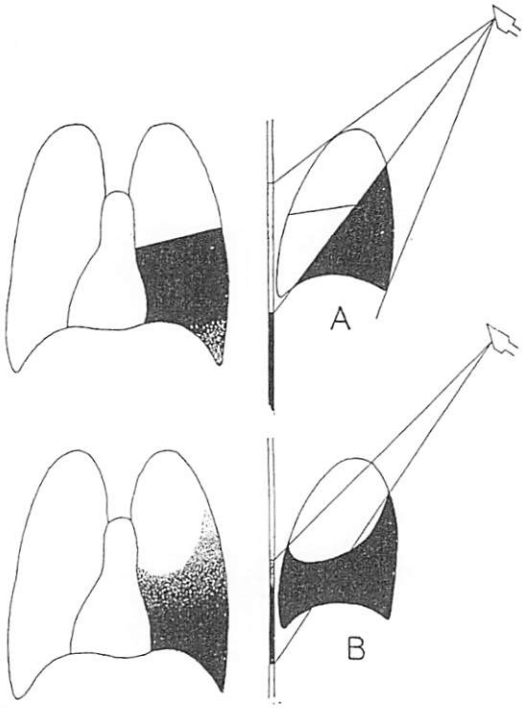

FIG. 16. Diagram showing character of shadows cast by lower-lobe consolidation and fluid with high position of tube. In this position the upper border of lower-lobe consolidation becomes sharply defined and the upper border of fluid remains hazy, no matter what the position of the tube.

Plastic pleurisy with localized collections of pus has the same peripheral location, differing thus from abscess of the lung, but is not sharply outlined and differs in this respect from an ordinary pleural collection.

The differentiation of organized pleurisy and interstitial pneumonia from large pleural effusions or massive pneumonic

consolidations lies in the manifestations of scar-tissue contraction—the pulling over of the mediastinal structures, the pulling up of the diaphragm, the narrowing of the intercostal spaces and decrease in size of the pleural cavity on that side.

SUMMARY

1. Owing to the similarity in appearance, differentiation between the stages of active consolidation in lobar pneumonia is impossible from the roentgenogram.

2. In the majority of cases, lobar pneumonia starts as a consolidation in the hilus region, rapidly spreading peripherally, and involving an entire lobe. In a few cases in children, the onset of consolidation is cortical and progresses toward the hilus.

3. The shadow produced is homogeneous and is usually confined to one or more lobes. The shadow produced by involvement of the various lobes is indicated by diagrams.

4. During the stage of resolution the shadow becomes mottled and irregular, complete resolution being effected often in a very short time—three days.

5. The average time for resolution is seven to ten days after the crisis. Persistence of shadow or failure of resolution after fourteen days is distinctly pathological, and suggests some complicating lesion.

6. The pulmonary complications most frequently encountered following pneumonia are:

(*a*) Dry pleurisy with thickening of the pleura.

(*b*) Pleural effusion, either serous or purulent, and either general or local.

(*c*) Plastic serofibrinous pleurisy.

(*d*) Chronic interstitial pneumonia or fibrosis.

(*e*) Lung abscess.

7. Their roentgenographic differentiation is indicated.

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DISCUSSION

Dr. Ullmann. Dr. Sante has covered the subject so thoroughly that I am rather at a loss what to say. At Santa Barbara we do not have very much pneumonia, although we have plenty of other things.

I would like to ask Dr. Sante if he has seen at any time what Dr. Billings spoke of in 1916 as pseudo-lobar pneumonia. I do not know whether there were any roentgen examinations made of these cases or not.

Dr. Sante did not speak of purulent bronchitis as a complication. I saw one child, twelve years old, who, after a pneumonia had cleared up, continued to run a temperature. The question of any empyema was seriously considered, although the physical signs were pretty well gone. Stereoscopic plates showed a cast of the entire bronchial tree which appeared as though it had been injected with an opaque medium. This condition entirely cleared up three or four days later.

I was glad to hear the statement made that any shadow remaining over two weeks was abnormal.

There was a condition seen during the war following gassing, especially after mustard gas, which I have never seen in civil life. I would like to ask if anyone else has seen it. During my service with the British Army I was fortunate enough to make stereoscopic plates of men dying with acute pneumonia following inhalation of mustard gas. These plates were made immediately after death and an autopsy held within a half-hour. I can best describe the appearance as a honeycomb. Bleeding into the pleural cavity was found at autopsy and the lungs were filled with patchy emphysematous areas in an edematous lung. These areas of emphysema and edema were apparently responsible for the honeycomb appearance in the roentgenograms. The hemorrhage and emphysema were probably due to the violent coughing which was such a marked feature of these cases.

I would like to ask Dr. Sante if there was any routine position for taking pneumonia cases. I take it that a portable outfit was used. I would like to know if he found it difficult to have the patients sit up for the examination.

DR. LEWALD. I was present at the time the paper referred to by Dr. Sante was read, and at that time made the statement that I had seen 2 cases of pneumonia starting at the root and extending to the periphery. This bears out what Dr. Sante has also observed, and I am sure that his observation is quite correct; that we do have pneumonia starting at the hilum and later extending out to the surface, although that may not be as common as pneumonia starting at the surface and extending to the root.

DR. SANTE (closing discussion). Referring to Dr. Ullman's statement as to psuedo-lobar pneumonia; one of the cases which I presented was such a case—so-called lobar distribution of brochopneumonia. Autopsy proved it to be bronchopneumonia following an influenza infection.

In the army service we were afforded opportunity to examine a great many influenza pneumonia cases at daily intervals, and were able to follow their development from clusters of peribronchial infiltration to the complete lobar lesion. Without serial radiographs the differentiation from lobar pneumonia would be very difficult.

I have had no personal experience with membranous bronchitis or recently gassed cases.

I was very glad indeed to hear of Dr. LeWald's observations and am quite sure that many here have had a similar experience. I feel, however, that the vast majority of lobar pneumonia cases start at the hilus and progress to the periphery. In a great number of instances this progress is very rapid, but many times a case will be encountered while the consolidation is still in the hilus region. In these patients serial radiographic examinations will show the progress of the lesion to the periphery.

PROGNOSIS IN TUBERCULOSIS OF THE LUNGS FROM EXAMINATION BY THE X-RAYS*

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WHEN a roentgenologist makes a diagnosis of pulmonary tuberculosis, it is seldom that he sees the patient after a lapse of six months, so that he can confirm his report. If he makes a mistake and gives a positive diagnosis and the patient is well after a year, no blame is attached to the roentgenologist and the physician in charge gets the credit of a cure. If, on the other hand, he makes a mistaken negative diagnosis and the patient goes from bad to worse, the patient naturally goes elsewhere for another *x*-ray report. It thus happens that our reports on pulmonary tuberculosis are not checked up as they are on fractures. We learn it very quickly if we make a mistaken diagnosis in stomach or bone work, but not if we give a mistaken diagnosis in a case of pulmonary tuberculosis.

In order to check up my own diagnoses of pulmonary tuberculosis I have analyzed my findings during three and a half years at a soldiers' hospital. This hospital has had the opportunity of following T. B. cases for three to four years, and during that time I examined 2,321 chest cases, making 2,574 stereoscopic plates. Of these, 141 were cases of T. B. of the lungs. Some of these cases reported once or twice a year for *x*-ray examination. All are now routinely examined by stereoscopic sets.

I selected the films of patients who had pulmonary tuberculosis and who were examined by *x*-rays year by year, and put these films up side by side. By this means I have been able to see the advance in the disease from year to year. From the excellent clinical notes which have been kept of these patients, I have confirmed the clinical findings with the *x*-ray plates and made a short summary to go with the plates. It is interesting to note that in general the *x*-ray findings of pulmonary tuberculous disease have been in advance of the clinical findings. I have also been struck by the fact that patients in whom the *x*-rays have shown no tuberculosis have been sent to a sanatorium and have returned after about a year with a report

* Read at the Twenty-third Annual Meeting of THE AMERICAN ROENTGEN RAY SOCIETY, Los Angeles, Calif., Sept. 12–16, 1922.
Discussion of this paper and the others in the same symposium will appear in a later number of the JOURNAL.