The Duration of Carcinoma of the Lung*

LEO G. RIGLER, M.D., F.C.C.P., BERNARD J. O’LOUGHLIN, M.D. and RICHARD C. TUCKER, M.D.

Minneapolis, Minnesota

Considered a rare disease 30 years ago, carcinoma of the lung is today recognized as one of the common causes of death in individuals after the age of 40. It has been estimated that 10 per cent of all cancers occur in the tracheobronchial tree; by some authorities the respiratory tract is considered to be the third most common location for a fatal tumor.

Because of its protean nature cancer of the lung must be treated as an aggregate, rather than as an individual problem, if statistical validity is to be attained. In 1912, Adler3 had an international collection of 374 known cases of carcinoma of the lung. Today series of thousands of cases are reportable and, in March of 1951, 624 lung cancers studied by the joint efforts of the Consultation Clinic of the Brompton and Royal Cancer Hospital in the five years from 1944 to 1948 were reported.5 One year later, Ochsner, DeCamp, DeBakey and Ray22 were able to report the details of 948 patients with bronchogenic carcinoma which they had personally observed. Today “cancer of the lung is the most frequent visceral cancer of the male patient,” (Wynder and Graham, 195033). Overholt predicts that present practicing physicians alone will contribute 3,500 lung cancers to this rapidly growing list.23 A recent report from England and Wales shows that there were 15 times as many deaths reported from bronchogenic carcinoma in 1947 as in 1922.5

It is a natural reaction to question not only the reasons for this increase in international prominence but also its actual existence. Many authorities have suggested that the rising incidence was more apparent than real, or that it was a relative increase associated with the aging of our population. It is true that more people are reaching the visceral cancer age, but some other reason must be found to explain the elevation of lung cancer in men from eighth to first or second place.13 It would be heretical to suggest that the master pathologists of the last century failed to recognize this tumor and it would be a derogation to suggest that our pathologists today recognize it only because of the notoriety brought to it by the radiologists and surgeons. The increase would seem to be real. The correlation of the increase in bronchogenic carcinoma with the increase in the use of tobacco as indicated by Wynder and Graham,33 Ochsner, et al.22 and others may or may not be valid but the increase in incidence is certainly true.

Bronchogenic carcinoma works stealthily for a portion of its life but

*From the Department of Radiology, University of Minnesota Medical School, and Veterans Administration Hospital, Minneapolis, Minnesota.
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DURATION OF CARCINOMA OF THE LUNG

Once it announces its presence it proceeds with great rapidity toward the destruction of its host. That it works quietly is shown by the fact that 73 to 91 per cent "dig in" so firmly and extensively that they cannot be surgically attacked.\textsuperscript{19,31} That it works efficiently is demonstrated by an average survival of the host given as 8.3 months in England,\textsuperscript{3} and 2.4 to five months\textsuperscript{1} in the United States. The brief time available for surgical rescue is emphasized by Overholt in his Monograph, "Cancer of the Lung,"\textsuperscript{24} in which he shows how the sands of life run silently out of time's hourglass while the cancer becomes more and more firmly entrenched. Overholt and Schmidt\textsuperscript{25} and subsequently Overholt\textsuperscript{23} have emphasized the "silent phase" of bronchogenic carcinoma.

It is not surprising that the volume of writing about the pathology, histology, incidence, clinical findings and surgical treatment of carcinoma of the lung should be immense. It is a disease whose manifestations are very wide. It touches upon the pathological physiology of the bronchi and lungs; it exhibits every variety of pulmonary pathology; it imitates and is imitated by practically all the abnormalities to which the lung is heir. It is surprising, however, that so little is known of the mode of onset, the development, the life history, what we please to call the biography of the disease. In the case of tumors it is usually impossible to determine the exact time of onset, when the abnormal cell appeared, when it began to multiply. It is important, however, to know how rapidly such lesions grow, how long after the onset will they cause the death of the host.

The answer to such a question cannot be obtained from the history given by the patient for the onset of symptoms is often a poor criterion of the onset of a disease. The surgical specimen is an end result, the autopsy findings are even more remote. If we were able to procure repeated biopsies through the bronchoscope or make numerous repeated examinations of the sputum for cancer cells, in apparently healthy individuals, we might get some answers as to the time of onset, but this is obviously impossible. Furthermore, in most cases, once the diagnosis becomes apparent, some form of therapy is instituted which interferes with the ordinary development of the disease. However, there are some cases in which an opportunity for study is afforded as a result of an error in the interpretation of the first roentgen examination, a failure to appreciate the importance of early symptoms, or the refusal of any therapy by the patient. As a result, repeated roentgen studies may be made over a period of time thus affording a visual demonstration of the course of the disease.

For many years we have been interested in the past history of patients with carcinoma of the lung with a view toward the elucidation of five important points:

1) What is the duration of the disease from its onset until surgical intervention or the death of the host?

2) What are the earliest manifestations of the tumor?

3) At what point in the history of the disease process is it possible to obtain roentgen evidences of abnormality?
4) What is the relationship between the onset of symptoms and the first appearance of positive roentgen findings?

5) What are the roentgen findings which characterize the early, pre-symptomatic stages of the disease?

In order to gain some insight into these questions, we have tried to obtain information as to the past roentgenologic history of patients with known carcinoma of the lung. For a number of years one of us has been tracing down and obtaining for comparison roentgenograms of the chest of such patients, made upon earlier occasions. In most cases such roentgenograms have been made as a part of an industrial or public health survey of apparently healthy individuals, or as a part of the treatment of some other disease. With the widespread use of roentgen examination for the discovery of pulmonary tuberculosis and the frequent use of the roentgenogram whenever any type of pulmonary disease is suspected, it is not surprising that many patients should have had roentgen studies of the lungs on occasions prior to the onset of a presently existing illness. In some of these there were found clear-cut roentgen evidences of a disease process—later proved to be carcinoma—many months and, in some cases, many years prior to the onset of symptoms. After observing cases with positive roentgen findings seven and one-half, five, four and three years before the patient presented himself with the symptoms of the disease, we decided to investigate this biography more systematically. Accordingly, we set about to discover as many early roentgenograms of the chest as possible amongst a group of 264 proved cases of carcinoma of the lung.

Letters were written to patients, wives, relatives, family doctors, surgeons, hospitals and Public Health agencies begging for information. Of 142 such letters, 75 were answered, and of these 29 produced material of use or interest. Frustrating factors were many. Vagrancy made continued observation impossible in some cases. With the death of the patient the wife usually moved, often without leaving a forwarding address, and sometimes she kept moving, living first with one of her children, then another. Some of the wives had died, while others had difficulty with senescent memories. The family doctor often had no x-ray films or had sent them to a surgeon or a hospital. Surgeons and hospitals often returned their films and records to their point of origin so that some seemed forever in transit. Some large clinics destroyed their roentgenograms. Perhaps the greatest disappointment came from the Public Health and mobile chest survey organizations who sometimes destroyed, but more often lost the records, apparently through administrative difficulties.

At last from the 264 pulmonary cancer cases, we collected 50 histologically corroborated cases in which a roentgenogram accidentally antedated the advent of the identifying symptoms or signs. No other factor than this chance roentgen examination prior to the time the patient became ill was used in the selection of these cases. Amongst the 50, 34 are dead, three are still living but are dying of the disease, and 13 have been operated upon, thus interrupting the normal sequence of events. The first group
of 37 non-operated cases may be referred to hereafter as Group I. Group II
refers to the series of cases that have had surgical intervention. All of
these roentgenograms, viewed in retrospect, proved to have some evidence
of the disease on or before the date on which the carcinoma could be
clinically identified. In addition, we have some 15 other cases, collected
at random, exhibiting similar findings.

A careful study of the history was undertaken to determine the date of
the very earliest symptom. As can well be imagined, much difficulty was
encountered here. For example, a great many of the patients had a so-
called chronic cigarette cough for 10 to 20 years. The significance of this
complaint must be minimized else it becomes impossible to point to any
specific date as the beginning of the disease symptoms.

It should be noted that the interval of time from the beginning of
symptoms, as dated by the patient, until death can be determined with
fair accuracy, but this interval may frequently be greater than the actual
duration of the symptoms due to cancer. Such exaggeration is due to the
inability of the patient to distinguish between the co-incidental symptoms
of other unrelated conditions and those symptoms associated with lung
carcinoma.

The reverse is true of the roentgen signs. Mass survey and routine chest
x-ray examinations do not always survey asymptomatic cases and in some
of our patients, roentgenograms were not made before or even at the time
of the initial symptoms or even at the onset of characteristic identifying
symptoms. Symptoms can often be elicited post hoc, once a lung lesion is
discovered. Even when the chest is examined at the opportune time for
the discovery of asymptomatic carcinoma, the films may not be available
for inspection. Despite these factors which tend to magnify the importance
of symptoms and minimize the importance of roentgen signs, almost 75
per cent of a group, selected because x-ray examination had been made
prior to any suspicion of the presence of carcinoma of the lung, were
asymptomatic at the time the lesion was visible roentgenologically. The
average interval between the registration of the first roentgen sign and the
death of the patient must be much less than the true duration of the
disease. Since three of the patients in Group I (non-operated) are still
alive, the duration of the actual disease will be greater by an unpredictable
amount than the average presented here.

Tumors subjected to radical surgery are collected in Group II since their
course may be ended by the cure of the patient, or it may be prolonged
by palliation of the patient, or a whole new set of abnormalities may be
caused by the operation and speed the patient’s demise. Therefore, in
evaluation of evidence pointing to the length of tumor life, this group
must be considered separately.

In Table I are exhibited the data on the 37 non-operated cases desig-
nated as Group I.

It should be noted that three patients give a “cold” as the first symptom.
If this rather nondescript symptom were not considered, the average dura-
tion of symptoms would be appreciably shortened. It is also to be noted
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that in this advanced, generally inoperable group there was only one case, discovered purely by roentgen examination, in which the patient had no symptoms whatever, even at the time the tumor was finally identified.

In Table II are exhibited the data on the 13 patients who were treated surgically.

As might be expected, the nature of the cases, which appeared to be operable, is markedly different. There are five cases in this group without any apparent symptom even at the time of surgical exploration. Despite this, the average duration is much longer both as to symptoms and roentgen signs. This finding suggests that the type of lung carcinoma which is susceptible to surgical treatment is likely to be a slow growing, relatively benign tumor.

Physical examination, the usual keystone of diagnosis, is of no value here, since tumors large enough to give physical signs are no longer in an early stage and are usually unresectable. Symptoms also are too little and too late. In many cases the first symptoms are those of distant metastases. The cigarette cough which plagues nearly all of these patients has already been discussed. It sometimes does happen that a second or third order bronchus is occluded, giving symptoms of dyspnea, often called "asthma." In these instances "trapped air" may be identified by percussion and auscultation, but the subsequent small patch of atelectasis usually eludes the best of clinicians.

It is worth noting that if we eliminate the symptom "a cold" as being significant, 20 per cent of our cases, including both groups, were discovered to have serious disease by reason of a routine roentgen examination. This represents a significant difference between our series and others previously reported. The Brompton Hospital of London Series, for example, contained only 0.6 per cent of cases discovered by routine roentgen examination. In the series of 948 cases reported by Ochsner, et al., there were 332 cases in which resection was possible and only three of these were asymptomatic—less than 1 per cent.

The eliciting of symptoms is often difficult. But once the patient learns that he has a serious disease it is often possible to obtain a history of symptoms not previously given. Thus, nine patients who had no complaints at the time of the roentgen examination were found, in retrospect, to have had significant symptoms prior to the x-ray study. Of the 39 patients who were asymptomatic at the time of the first roentgen examination, 31 developed symptoms before the diagnosis was made or during hospitalization, while seven remained asymptomatic throughout the course to this date. In one instance, symptoms appeared coincidentally with the appearance of roentgen signs.

In reviewing the data it is observed that the longest duration of symptoms in Group I was 34 months. The longest duration of roentgen signs was 51 months. In Group II, the longest duration of symptoms occurred in a case with cough for 108 months. The significance of this might well be doubted except for the fact that there were roentgen evidences of localized emphysema, in the segment of lung later proved to be tumorous, present for an
even longer period. It is notable that in one case a peripheral nodule, easily observed, had been present for at least 53 months before the final diagnosis was established. Of the whole series, 12.6 per cent (including "a cold" as a significant symptom) were symptomless throughout the course of the disease until it was identified.

The average total duration of symptoms in the group of cases which were not interfered with surgically was 12.7 months. This corresponds closely with some reported series where comparable studies were made. Lindskog's patients, on the average, had symptoms for 6.7 months before diagnosis and lived five months longer, if untreated, a total of 11.7 months. Churchill gives one year as the duration of life from the discovery of the disease. Other data previously collected, as mentioned above, suggest that the duration of life after the inception of carcinoma of the lung is relatively short.

Roentgen signs of disease preceded the first symptoms by 7.8 months (average) in the patients in Group I. It is true that these signs were usually discovered in retrospect, but there can be no doubt about their presence. In Group II this discrepancy lengthened to 17.0 months between the average first detectable x-ray evidence of tumor and its clinical manifestations. Thus, in those patients selected for surgery the disease was either silent longer, or was more favorable to early x-ray detection, or both, by an interval of 9.2 months. It should be reemphasized here that the roentgen signs might well have been present for a much longer period of time since the first films were made fortuitously.

The duration of x-ray signs in the first group average 20.9 months. This is a longer cancer life than has ever been previously estimated. But all previous estimates were based upon the date of onset of the initial symptoms as the criterion for the presence of the tumor; the roentgen method has not been used previously in this manner. In the second group, the average duration of the disease as measured by roentgen signs was 36.4 months.

If one tries to estimate the duration of the disease using both symptoms and signs, and choosing the earliest evidences to appear, Group I average tumor life is stretched to 22.5 months. Save for isolated cases these are the longest average lung tumor life durations recorded.

Admitting the premise that carcinoma of the lung may be present without symptoms, and we can cite many advanced cases to prove it, it is evident that some new information about the life of this tumor has been found. In our two groups we have 39 patients who were asymptomatic at the time of the first roentgen evidence of the tumor. Traditionally, and in medical literature, the duration of the disease has been described as averaging between five and 11 months. But we find on the basis of our Group I cases a life history of 22.5 months. A new 10 months of life is offered, not to the patient, but to the radiologists, surgeons, and possibly the roentgen therapists in which to recognize and treat this lesion. It is entirely possible that the earlier treatment thus made available may preclude many of the metastases and much of the cachexia, may prolong
life, and decrease the morbidity from pulmonary carcinoma. But this
cannot be achieved without more labor. Recognition and treatment of the
disease in those 10 early months will require an increased alertness, sus-
picion, boldness and skill in order to see the tiny lesion, suspect its nature,
remove it, and still not jeopardize the procedure. Over-diagnosis and over-
treatment can bring even a sound approach into disrepute.

A consideration of the earliest roentgen signs and the changes observed
in serial roentgenograms of the chest made on patients with carcinoma
of the lung gives some information as to the earliest manifestations of the
tumor, the possibilities of roentgen detection at an early stage, and the
significance of certain changes in the roentgenogram. The earliest changes
observed in the group of patients discussed above are as follows:

1) A nodular density in the lung periphery.
2) A solitary cavity or abscess in the lung parenchyma.
3) An area of infiltration along the vascular trunks.
4) Unilateral enlargement of the hilum shadow.
5) Segmental or lobar or even unilateral whole lung emphysema.
6) Minimal areas of atelectasis, usually linear in type.

From observation of serial roentgenograms made at semi-annual inter-
vals of patients with non-pulmonary primary malignant tumors we have
found that metastatic nodular lesions in the periphery of the lung are
usually detectable when three millimeters in diameter, rarely so when only
two millimeters in size. Similarly, the peripheral nodular lesion of primary
carcinoma can be detected at an early stage. We have observed one case
of squamous cell carcinoma in which a lesion three millimeters in diam-
eter was visible. There were no symptoms. The lesion was overlooked but
three and one-half years later another routine examination of the chest
was made while the patient was still free of any symptoms. At this time
the lesion was two centimeters in diameter and perfectly obvious. In
another case, a lesion one centimeter in diameter was observed but thought
to be a tuberculoma. Seven and one-half years later the patient first
developed symptoms suggestive of the disease. At this time the lesion was
large and typical of carcinoma. Obviously, there are occasional tumors,
particularly those which prove to be of the undifferentiated variety, in
which the growth is very rapid. An example of this type occurred in a
patient admitted because of prostatic enlargement. There were no pul-
monary symptoms but the routine film made on admission revealed a
nodule 1.5 centimeters in diameter. Because of an error nothing was done
about this and the patient was discharged after his prostatectomy. Nine
months later he developed cough and hemoptysis which resulted in another
roentgenogram of the chest. At this time the lesion already had filled
most of the right upper lobe. As might be expected this tumor proved, on
microscopic examination, to be a highly undifferentiated carcinoma.

From the cases observed we have found that the lesions which arise in
the periphery of the lung gradually enlarge in concentric fashion (Figure 1)
tend to extend toward the root of the lung (Figure 2), and finally produce
lymph node enlargement. While the detection of such tumors is relatively
FIGURE 1 Case 1: Carcinoma lung arising as peripheral nodule. (A) Nodule in left lung, poorly defined, peripheral position, found six months earlier during chest survey. (B) Extension of mass peripherally and centrally. Symptoms now present, 15 months after original X-ray finding. Pneumonectomy shows squamous cell carcinoma, lingular segment of left upper lobe.
easy their identification is particularly difficult. They are not likely to
shed cells which can be detected by microscopic examination of the
sputum. They cannot be reached by the bronchoscope. Body section roent-
genography is helpful since it may permit the determination of the
presence or absence of calcium within the lesion. If calcium is found it
strongly suggests either hamartoma or tuberculoma. Every peripheral
nodular density which does not contain calcium, especially if found in an
individual over 50 years of age, should be considered a primary carcinoma
until proved otherwise. Frequently local biopsy through the medium of a
segmental resection of the lung or exploratory thoracotomy must be
undertaken. Such lesions are readily detected by roentgen examination in
their earliest stages. Many are now being found as a result of the routine
examination of the chest of symptomless individuals. In the series here
reported, 38 per cent were peripheral nodules.

The following two cases are presented as illustrations of the duration
and progress of a nodular lesion.

CASE 1: A 50-year old male had an x-ray examination during a chest survey in
January 1947. A “spot” on the left lung was found. He was symptomless at that
time. The “spot” was considered of no significance by his physician; reexamina-
tion on June 18, 1947 (Figure 1A), revealed a nodule of fair size in the periphery
of the left lung which was not sharply demarcated. Such a shadow in a 50-year
old male is certainly an indication for exploratory thoracotomy but nothing was
done. About a month later, some seven months after the nodule was first observed
in the roentgenogram, he began to lose some weight. There were no other symp-
toms. In April 1948, 15 months after the original examination, cough, hemoptysis
and chest pain first appeared. He came in for treatment one month later and a
roentgenogram made on May 3, 1948 (Figure 1B), shows the nodule to have en-
larged markedly in a concentric fashion, both peripherally and centrally. Pneu-
monectomy done at that time revealed a squamous cell carcinoma of the lingula
of the left upper lobe. Patient is still alive and well.

Discussion: Such nodules as indicated above should never be ignored, but
the fact that it could remain in the lung for a period of over 16 months
before any procedure was undertaken and that the development of real
pulmonary symptoms occurred 15 months after the first roentgen signs
indicates the long duration of some lung tumors. At the time of surgery it
appeared to be a thoroughly operable lesion and the fact that the patient
is still alive four years thereafter indicates the relatively favorable char-
acter of the lesion despite the length of time during which we know it was
present in the lung.

CASE 2: A 72-year old male was first found to have a “spot” in the right lung
on a chest survey on July 22, 1949 (Figure 2A). It was apparently not considered
of serious moment by his physician although the lesion was large and poorly de-
defined. It was clearly a peripheral lesion and at the time when the first examina-
tion was made there were no symptoms and no evidences in the roentgenogram
of obstruction of a major bronchus. The first symptom of weight loss appeared in
March 1951, 20 months after the first roentgen finding (which was then already
far advanced). The first roentgenogram when the patient appeared for definitive
treatment was made April 16, 1951 (Figure 2B), and shows the characteristic
atelectasis, retraction, and increased density of the right upper lobe which are so
FIGURE 2 (Case 2): Carcinoma lung arising peripherally and extending into major bronchus. — (A) Mass in right upper lobe with poorly defined borders, peripheral origin, found during chest survey, no symptoms. — (B) Atelectasis right upper lobe from obstruction of bronchus. Symptoms began only one month before, 20 months after the first x-ray finding. The appearance here is characteristic of tumors arising in a major bronchus, yet the earlier film (A) indicates a peripheral origin.
common with obstructive bronchogenic carcinoma. Despite the minimal pulmonary symptoms, the patient already had metastases and operation was not done. He died June 4, 1951, and at autopsy an adenocarcinoma obstructing the right upper lobe bronchus was found. There were many metastases in various portions of the body.

Discussion: Such a case demonstrates clearly that a tumor arising in the periphery may extend centrally so that by the time of the autopsy it gives the impression of a tumor which arose primarily in the right upper lobe bronchus. This false impression of the origin of bronchogenic tumors has no doubt occurred many times because the only evidence available was that in the terminal stages of the tumor; it seems probable that many apparently peripheral lesions grow centrally and eventually produce obstruction, as was the case here. It is notable that the relatively minor symptoms did not appear until 20 months after the first lesion was seen in the roentgenogram.

A second finding, a rounded area of lesser density in the lung surrounded by a dense, ring-like shadow represents the necrotic abscess of a tumor. In contrast to the abscesses which appear in the atelectatic lung which results from bronchial obstruction, the cavity which results directly from tumor necrosis and ulceration usually stands alone, surrounded by normal lung. In its early stages the peripheral zone of density may be fairly thin but frequently at one point in this ring there will be found a small nodule or thickening producing an eccentric appearance. This is the most important identifying clue. Nevertheless any lung abscess in an individual of the cancer age, especially if there is no other good explanation for its presence, should be considered carcinomatous until proved otherwise. Fortunately these lesions commonly shed cells and the identification of the tumor may be made by means of microscopic examination of the sputum. As the lesion progresses many changes take place. The outer wall becomes thicker, more irregularities of nodular character can be seen along it, and dense masses appear within the gas-filled cavity itself. Such lesions are not observed for the long periods of time cited above since they are more malignant, spread more rapidly, and the diagnosis is more readily established so that some treatment is applied. Six per cent of the group showed an abscess as the first roentgen sign.

A third type of manifestation consists of an accentuation of the vascular trunks to such a degree as to suggest an interstitial infiltration. The appearance closely simulates fibroid tuberculosis but is more regular in its appearance. Patchy areas of a minimal degree of density appear. In addition, a few, small, nodular densities can be made out along the course of these apparently thickened vessel markings. While suggestive of an abnormal process, such changes are difficult to identify. As time goes on, the area of infiltration becomes large enough to present an appearance of consolidation; i.e., a more diffuse, homogeneous density appears. The lesions tend to radiate toward the hilum and the latter may enlarge at an early stage. Such tumors are usually thought to be inflammatory processes, in
FIGURE 3 (Case 3): Carcinoma of lung producing enlargement of hilum shadow. — (A) First examination for cardiac symptoms. Note minor but definite enlargement left hilum (arrow). No pulmonary symptoms. — (B) Roentgenogram three months after onset of symptoms. Marked lobulated enlargement of hilum (arrows). Note sharp increase in size. (C) Lateral view demonstrates central position of shadow (arrows) indicating mass is in or around hilum.
their early stages, but the diagnosis of carcinoma should always be considered. The beginning enlargement of the root of the lung should identify their true nature. Only a very small number of such cases were found in our series.

Most important of all the roentgen signs found in this early stage of development is an enlargement of the hilum shadow of one lung (Figures 3 and 4). Forty-eight per cent of the cases were in this category. Furthermore, it is the most commonly overlooked sign. The shadow results from the extension of a tumor of a large bronchus into the peribronchial tissues or to the involvement of peribronchial lymph nodes. Nevertheless it may be a very early sign. An irregular enlargement of the hilum, particularly if it exhibits radiating linear areas of density around it, is extremely significant. Unfortunately there are marked variations in the normal hilum shadows. Furthermore, many non-tumorous lung lesions produce changes in the hilum. When the hilum appears abnormal, lateral, oblique and planigraphic examinations are very helpful. In this group particularly, comparison of films made at intervals, if they are available, is very helpful (Figure 3). Such tumors are commonly accompanied by evidences of bronchial obstruction but not necessarily so in their earliest stages. In any case, films should be made in both phases of respiration in order to accentuate any signs of bronchial obstruction which may be present. As time goes on the evidences of obstructive emphysema, followed by atelectasis, and then by the late inflammatory processes, which commonly result from bronchial obstruction, will be observed. In this group, as well, we have seen patients with clear roentgen evidences of the tumor as long as three years before symptoms appeared. In many cases, not until atelectasis supervened did the patient complain. Without doubt the unilateral enlargement of the root of the lung is the most important, the most frequent, and the most commonly overlooked early roentgen sign of pulmonary carcinoma.

Bronchial obstruction may be an early sign of tumors of the bronchus. Westerman reports that 96 per cent of 100 cases of proved carcinoma of the bronchus showed obstruction of some degree. Our experience does not bear out so high a figure but certainly bronchial occlusion is common and frequently is the very first evidence of the presence of a tumor. This is particularly true of the group of cases which show enlargement of the root shadow, in addition, but the evidences of obstruction may be present alone.

Occlusion of the bronchus from a tumor may result in a number of findings similar to those occurring with foreign bodies. Obstructive emphysema may be an early sign, as previously reported, and was present in approximately six per cent of this small series (Figure 4A). It may be segmental, lobar, or may involve the entire lung. While often visible in ordinary postero-anterior roentgenograms made during inspiration it is best demonstrated in the expiratory phase, in some cases, only in films made during expiration.

The transition from emphysema to atelectasis (Figure 4) may be extremely rapid. We have been able to observe this in several cases in which
FIGURE 4 (Case 4): Carcinoma of lung manifested by enlarged hilum and segmental emphysema. (A) Roentgenogram made because of chronic cough. Evidences of chronic bronchitis in both lower lobes. Minor but definite enlargement of the left hilum (arrows). There is also a marked emphysema in a segment of the left upper lobe. (B) Reexamination 22 months later shows mass in left upper lobe, abscess cavity and further enlargement of the left hilum. Symptoms had been present for nine months prior to this time.
the diagnosis was not clearly determined and the patient was watched for a period of time. In one case about four months intervened from the first observation of emphysema until a complete atelectasis supervened in the same lobe. It is impossible, of course, to determine how long this period will last since cases are rarely recognized without some procedure being undertaken which prevents the development of the atelectasis.

Atelectasis is usually a late sign of bronchogenic carcinoma but in occasional cases occurs in a pre-symptomatic stage. Usually it is segmental and may be observed as a band-like or linear area of density in the roentgenogram. In studying such cases over a period of time, the contraction of a segment from a band-like or triangular shadow to a linear one is observed. As time goes on the tumor mass is seen and still later the usual lobar or unilateral density or a more extensive atelectasis.

The following two cases are reported to indicate the importance of minor degrees of enlargement of the hilum shadow and of the presence of emphysema as an early sign of carcinomatous obstruction of the bronchus.

CASE 3: A 65-year old, obese male, was first seen on October 21, 1948, with symptoms and signs of coronary disease. There were no definite pulmonary symptoms other than dyspnea and no physical signs in the lungs. A roentgenogram (Figure 3A) showed an enlarged heart. The left hilum was also enlarged but this was overlooked. In June 1949, an ulcerative lesion on the lower lip was biopsied and proved to be a squamous cell carcinoma. This was irradiated and later a neck dissection was done, two positive nodes being found. Reexamination of the chest was made on March 14, 1950, and showed further enlargement of the left hilum shadow. Again it was overlooked.

In October 1950, 24 months after the first x-ray evidences of an enlarged hilum, the first pulmonary symptoms, that is, a persistent "cold," cough, some sputum production and occasional hemoptysis, appeared. There was also some weight loss. The next roentgen examination was made on December 15, 1950 (Figure 3B), showing a massive enlargement of the left hilum. The enlargement had been very rapid in the past nine months. In the lateral view (Figure 3C) the shadow is seen to be actually in the hilum and not superimposed upon it from a lesion in the lung itself. Bronchography two weeks later showed a complete obstruction of characteristic type in the left upper lobe bronchus although on bronchoscopy the tumor could not be seen. The aspirated sputum was negative for tumor cells.

Pneumonectomy revealed a large squamous cell carcinoma of the left upper lobe bronchus, microscopically characteristic of a primary bronchogenic tumor. There were large lymph nodes in the hilum and invasion of the contiguous lung. The patient expired two days post-operative from coronary thrombosis.

Discussion: The progressive enlargement of one hilum shadow from a tumor is well illustrated here. Furthermore, the symptoms did not appear until several years after the first finding was observed. The course of events here was interrupted by surgery so that the period of 27 months is the minimum between the first x-ray evidences and the time of the fatal outcome of the lesion. It is notable that evidences of bronchial obstruction are not clearly apparent in the roentgenogram, even though by means of bronchography a fairly complete obstruction appears to be present. This is a common finding.

CASE 4: A 52-year old male was first seen on March 20, 1947, because of a cough of many years standing. The roentgenogram at this time (Figure 4A) revealed a distinct obstructive emphysema of the left upper lobe and a minor degree of en-
largement of the left hilum. There were also evidences of chronic bronchitis involving both lower lobes. For this reason the left upper lobe findings of emphysema were ignored and the enlargement of the hilum was thought to be of inflammatory nature. Six months later dyspnea began. Fourteen months after the first x-ray evidences, hemoptysis, cough and weight loss were first noted. Reexamination was made on July 3, 1948, and a marked density was noted in the region of the left upper lobe where emphysema had previously been present. The hilum shadow had increased somewhat in size. The density was thought to be due to pneumonia and nothing further was done. The thought that this was due to pneumonia was borne out by the fact that a month later the shadow in the left upper lobe seemed to decrease in size. This is a common error and is due to the fact that as the atelectasis increases, the compensatory emphysema of the other lobe increases as well so the shadow seems to diminish in size, for a time.

He was first admitted for treatment on November 30, 1948, complaining essentially of repeated attacks of influenza and pneumonia. At this time there was a large mass in the left upper lobe. A final film was made on January 11, 1949 (Figure 4B). This shows the extensive density involving the left upper lobe with a cavity within it. This no doubt represents both atelectasis and a very large lung abscess. The hilum shadow is covered to such a degree that it is difficult to observe its enlargement, but even so it appears to be distinctly larger than on the previous examination. The sputum showed characteristic cancer cells. He was considered inoperable and died on May 26, 1949, 26 months after the first evidences of the lesions observable in the roentgenogram.

Discussion: The changeover from emphysema to atelectasis is observed here and the final development of abscess formation in the atelectatic lung is also apparent. The first clue to this process was in the enlarged hilum and the emphysema accompanying it. In cases of this type in which there has been a chronic bronchitis with other changes in the lungs, the diagnosis becomes particularly difficult. Yet any enlargement of the hilum, especially if accompanied by evidences of obstructive emphysema or obstructive atelectasis, should be investigated to the fullest extent possible to exclude a carcinoma.

Obviously there are many other roentgen signs of carcinoma of the lung. We have discussed here only those found either in the pre-symptomatic stage of the disease or in roentgenograms taken a long time before the diagnosis became apparent.

It is evident from our experience that the routine or survey x-ray examination is the best and, in fact, the only applicable method for the early detection of pulmonary tumors. Roentgen evidence usually antedates symptoms, and in such cases periodic or routine chest films may exhibit lesions over two millimeters in diameter. The appearance of the lesion on the roentgenogram does not bring automatic recognition. It must be interpreted as an abnormal shadow, and someone must prod the asymptomatic patient into submitting to further, more definitive measures.

The human difficulties in interpretation of the roentgenogram can be decreased when control films of an earlier date are available for comparison of questionable shadows. Early tumors about the hilum are particularly hard to separate from normal root-shadow structures (Figures 3A and 4A). A firm knowledge of hilar anatomy and its normal variations becomes essential. This can be attained by planigraphy of the normal hilum, and
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by examining plain roentgenograms in retrospect after large tumors have become evident. It is possible that mensuration of the hila with comparison will be helpful in establishing whether or not enlargement is present. An appreciation of the urgency of the situation is more difficult to acquire. This factor must be more widespread before the cancer death rate can be expected to be reduced. That lesions were frequently overlooked is demonstrated by the fact that among the cases listed, 23 small hilar tumors went undetected until a later examination or the beginning of identifying symptoms. Three peripheral nodules were overlooked and four were misinterpreted as tuberculomas or chronic pneumonia. Localized emphysema was also overlooked. Small abscesses were likewise missed if medial in position, or misinterpreted if peripheral.

Silent carcinomas may be diagnosed by their appearance on the roentgenogram alone but frequently symptoms which seemed atypical or minimal are given greater significance when roentgen evidences become apparent. More advanced lesions may have their resectability as well as their identity betrayed by a chest film, but in the ordinary course of events this requires fluoroscopy to demonstrate functional changes, planigraphy to delineate the gross appearance and extent of the lesion, and bronchography to map its environs. Then, if histological confirmation is otherwise unavailable, and if no medical contraindication exists, thoracotomy to obtain a sample of the tumor for biopsy is indicated. If this be an "excision biopsy" so much the better.

SUMMARY

The study of the life history of cancer of the lung is best made by serial roentgenograms. The course of the disease as observed in this manner is herein described.

As a result of these studies certain facts emerge as follows:

1) Cancer of the lung has a greater duration from its inception until death than has hitherto been considered.

2) In a small series of inoperable cases the average minimum duration of life was 22.5 months.

3) In a series of operable cases the average minimum duration from the time of the first roentgen evidences until surgery was 36.4 months.

4) Roentgen findings are usually present in the pre-symptomatic stages of the disease and are almost invariably present after the onset of symptoms.

5) The earliest roentgen evidences of the disease have been recorded as long as nine years before the death of the patient and as long as four and one-half years before the onset of symptoms.

6) The extension of peripheral lesions centrally thus simulating an origin in a large bronchus is described.

7) The development of roentgen evidences of obstruction long after the appearance of an enlarged hilum shadow is traced.

8) The various roentgen signs which appear early are delineated. The most frequent and important of these is an enlargement and irregularity of one hilum shadow.
RESUMEN

La historia vital del cancer se hace mejor por la serie de roentgenogramas. El curso de la enfermedad así observado se describe.

Como resultado de este estudio ciertos hechos emergen como sigue:
1) El cancer del pulmón tiene una duración desde su iniciación hasta la muerte, mayor de lo que hasta aquí se habla considerado.
2) En una pequeña serie de casos inoperables el mínimo-medio de duración de la vida ha sido de 22.5 meses.
3) En una serie de casos operables la duración media-mínima desde el tiempo de las primeras evidencias hasta que se realizó la cirugía fue de 36.4 meses.
4) Los hallazgos radiológicos se encuentran ya en el periodo pre-sintomático de la enfermedad y son casi invariablemente presentes después del principio de los síntomas.
5) Las evidencias radiológicas más tempranas de la enfermedad se han podido encontrar hasta nueve años antes de la muerte del enfermo y hasta cuatro años y medio antes del principio de los síntomas.
6) La extensión de lesiones periféricas hacia el centro, simulando así un origen en los grandes bronquios se describe.
7) El desarrollo de evidencia radiológica de obstrucción mucho después de la aparición de un hilio crecido se describe.
8) Se describen los diversos signos radiológicos que aparecen temprano. El más frecuente y también el más importante es el crecimiento y la irregularidad de la sombra hiliar.

RESUME

La meilleure façon d'étudier l'histoire d'un cancer du poumon est de la lire sur des radiographies en série. Les auteurs décrivent l'évolution telle qu'elle a pu être observée par ces procédés. Certains faits semblent particulièrement importants:
1) La durée de l'évolution d'un cancer du poumon depuis son début jusqu'à la mort est plus longue qu'on l'a pensé jusqu'à présent.
2) Dans une petite quantité de cas inopérables, la durée minimum de vie fut de 22.5 mois.
3) Dans une série de cas opérables, le taux minimum de temps écoulé depuis le moment de la première constatation radiologique jusqu'à la chirurgie, fut de 36.4 mois.
4) Les constatations radiologiques sont habituellement relevées dès la phase présymptomatique de la maladie, et d'une façon à peu près constante. elles existent dès que les symptômes ont fait leur apparition.
5) Les premières constatations radiologiques de la maladie ont pu être faites jusqu'à neuf ans avant la mort du malade, et jusqu'à quatre ans et demi avant l'apparition des symptômes.
6) Les auteurs décrivent des lésions périphériques qui s'étendent vers la région centrale du thorax, simulant ainsi une tumeur dont le point de départ serait dans une grosse bronche.
7) Des signes radiologiques certains d'obstruction bronchique peuvent
apparaître longtemps après une image qui n’était caractérisée que par des ombres hilaires augmentant de volume.

8) Les auteurs précisent les différents éléments radiologiques qui permettent un diagnostic précoce. Le plus fréquent et le plus important en est l’augmentation de volume et l’irrégularité des ombres d’un des hiles.

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