

BRONCHIAL & BRONCHIOLAR CARCINOMA

Experiences in diagnosis

A thesis for the Degree of Doctor of Medicine

by

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I would like to express my sincere thanks to the numerous people who have assisted me in various ways. Especially would I like to thank Dr. Whately Davidson who taught me the fundamentals of chest radiodiagnosis, for his interest and encouragement; Mr. George Mason, who allowed me full access to all operations and patients' records at Shotley Bridge; Mr. S.G. Griffin, Mr. W.C. Barnsley and numerous surgical registrars who patiently showed me their operative and bronchoscopic findings; Miss S. Winskill, for her enormous help in providing, at various times, the x-rays and hospital records of nearly 2,000 cases; and my wife, for her typing of the manuscript and her constant enthusiasm.

I am also particularly indebted to pathologists in Newcastle - Drs. I. Rannie, R.O.K. Schade and B.E. Tomlinson; in Edinburgh - Drs. Edith K. Dawson and T.W. Lees; and in Dundee - Dr. Helen Duguid, for their careful reviewing of the histology in the cases of bronchiolar carcinoma and to Mr. T. King, Queen's College, Dundee and Mr. E. Foster, Royal Victoria Infirmary, Newcastle for their help with the photographic reproductions.

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SUMMARY

This study was made in an attempt to assemble ideas, to confirm or refute the views of other writers and to suggest uncomplicated investigations which are of diagnostic value in suspected cases of bronchial carcinoma. Comparisons are made with bronchial adenoma and a group of bronchiolar carcinomata is reviewed.

A special study was made of the effects of bronchial carcinoma on the movements (28 cases) and contour (200 cases) of the barium-filled oesophagus and 500 cases of bronchial carcinoma which came to operation are reviewed.

The main conclusions are:

(1) There is a surprisingly small proportion of females (1:13) in a group of bronchial carcinomata subjected to thoracotomy.

(2) Bronchial adenoma is 10-20 times less common than is often suggested.

(3) In spite of the right lung being larger than the left, an operative series of cases of bronchial carcinoma contains more tumours on the left than on the right side. Highest operability rates occur in tumours of the left lower lobe and lingula.

(4) Epidermoid carcinoma accounts for two-thirds of cases which come to operation and three-quarters of those which are resected.

(5) Very few cases of bronchial carcinoma were truly asymptomatic.

(6) Haemoptysis requires careful investigation but considerable numbers of cases are seen in which no cause can be found. This symptom suggests that a peripheral "coin" lesion in the lung is most likely to be malignant.

(7) The presence or absence of pain bears no constant relation to the extent of mediastinal spread from bronchial carcinoma.

(8) Finger-clubbing occurred in 20% of cases of bronchial carci-

noma. Epidermoid carcinoma was 4 times as common as anaplastic tumour in these cases and accordingly operability rates were slightly higher in cases with clubbing than in those without it.

(9) Asymptomatic hypertrophic pulmonary osteoarthropathy was not found in any of 100 cases of finger-clubbing due to bronchial carcinoma.

(10) Bronchoscopic biopsy provided a positive diagnosis in 57% of cases of bronchial carcinoma and in 87% of bronchial adenomata. In carcinoma, the highest incidence of positive findings at bronchoscopy occurred in the right lower lobe (79%) and the lowest in the middle lobe (31%).

(11) Lateral oesophageal shift with respiration is an easily elicited sign of lower lobe or main bronchial stenosis.

(12) More than 1 out of every 4 cases of bronchial carcinoma referred to a surgical clinic showed varying degrees of extrinsic pressure on the oesophagus, most frequently seen in the P.A. and L.A.O. positions. This is a highly reliable sign of inoperability and may be of considerable diagnostic value when bronchoscopy is negative. In 68% of cases showing oesophageal deformity the primary tumour was on the right side and in the same proportion the histology of the lesion was anaplastic carcinoma.

(13) Fifteen out of 24 bronchial carcinoma M.M.R. pick-ups were inoperable. Only 4 were asymptomatic and 1 of these was inoperable.

(14) Common errors in x-ray interpretation are reviewed and suggested remedies are: careful study of operative specimens, the collection and continual review of all known radiological errors, and the use of a series of test films to detect the "blind spots" of different radiologists.

(15) Obstructive emphysema, unaccompanied by other radiological abnormalities, is a rare sign of bronchial carcinoma and apparently a very rare sign of early carcinoma.

(16) 11% of cases of bronchial carcinoma were of peripheral type; 76% of these were operable. Lobulation of outline, frequently visible on plain films, was common but valueless in differential diagnosis.

(17) Cavitation in a peripheral carcinoma occurred in 6.2% of cases; 74% of these were in the left lung and none occurred in a female. Operability rates were lower than in solid peripheral tumours. Different mechanisms probably operate to produce cyst-like cavities in different cases; only 3 out of 500 carcinomata showed this appearance.

(18) Unilateral engorgement of interlobular septa in a case of bronchial carcinoma indicates inoperability.

(19) Carcinoma arose in the middle lobe in 3.8% and in the lingula in 5% of cases; the latter were more frequently diagnosed by bronchoscopy than the former. Middle lobe carcinoma is less common than would be expected from the size of the lobe itself but by no means as rare as has been suggested by some writers. Bronchoscopy is frequently negative in middle lobe carcinoma and evidence of oesophageal deformity at barium swallow may suggest the correct diagnosis. No case of the "middle lobe syndrome" was seen over the age of 35.

(20) 75% of 12 cases in which a benign lesion was misdiagnosed as carcinoma occurred in the right upper lobe. Benign inflammatory conditions not infrequently take several months to resolve. Full radiological and clinical records of all cases wrongly diagnosed as carcinoma should be kept for ready reference at any time. Knowledge of the common sources of error should help to reduce misdiagnoses.

(21) Thin, watery sputum occurred in only 1 out of 7 cases of bronchiolar carcinoma in which a satisfactory history was available. This symptom may also occur in cases of metastatic disease which can resemble bronchiolar carcinoma clinically, radiologically and even histologically. A correct diagnosis of bronchiolar carcinoma cannot be made from the radiological appearances when the lung lesion is

solitary; it may be possible when lung shadows are multiple and full regard is given to the clinical picture. Bilateral disease is associated with an extremely poor prognosis but if a lesion is unilateral, resection may result in survival for several years.

and in the description of illustrations:

- L.A.O. - left anterior oblique
- P.A. - postero-anterior
- R.A.O. - right anterior oblique
- R.P.O. - right posterior oblique

- L.L.B. - left lower lobe
- L.M.B. - left main bronchus
- L.U.B. - left upper lobe
- R.L. - right lobe
- R.L.B. - right lower lobe
- R.U.B. - right upper lobe

Fig. 2 - Film (shown anterior) secondary to with.

Fig. 1 - 47 (shown anterior) refer to illustrations of and of space.

ABBREVIATIONS

The following abbreviations have been used, mainly in tables and in the description of illustrations:

L.A.O.	-	left anterior oblique	} positions
P.A.	-	postero-anterior	
R.A.O.	-	right anterior oblique	
R.P.O.	-	right posterior oblique	

L.L.L. - left lower lobe

L.M.Br. - left main bronchus

L.U.L. - left upper lobe

M.L. - middle lobe

R.L.L. - right lower lobe

R.U.L. - right upper lobe

Figs. I - VIII (Roman numerals) accompany the text.

Figs. 1 - 89 (Arabic numerals) refer to illustrations at end of thesis.

## INTRODUCTION

Bronchial carcinoma, one of the commonest and most lethal of malignant tumours, has received much medical and lay publicity on account of its apparent increased incidence in recent years. The latter is, in part, related to greater awareness of the condition by doctors, improved and more widely used diagnostic methods and the modern pathological view which classifies what were formerly regarded as sarcomata of the mediastinum or, in fewer cases, lung metastases, as primary bronchial carcinomata.

There is now an overwhelming, widely scattered volume of literature on carcinoma of the bronchus but, until recently, remarkably little of it has been concerned with the practical problems of diagnosis, especially in the earlier stages of the disease. Thus Fried (1948), in spite of quoting over 700 references, provided a minimum of useful guidance on diagnostic difficulties and their solution.

The present study has been made in an attempt to assemble ideas, to confirm or refute the views of other writers and to suggest uncomplicated investigations which are of diagnostic value.

A special study has been made of the effects of bronchial carcinoma on the movements and contour of the barium-filled oesophagus. Attention has also been directed to certain aspects of cases of bronchial carcinoma which come to operation, especially the problems of early detection and errors in diagnosis. Bronchial carcinoma and adenoma are compared and a small group of bronchiolar carcinomata is reviewed. No attempt has been made to cover every diagnostic aspect of these tumours and such valuable techniques as bronchography and cytological examination of bronchial secretions are not discussed.

## MATERIAL AND METHODS

Unless otherwise stated, all cases were seen at the Northern Regional Centre of Thoracic Surgery, Shotley Bridge.

The material under review consists of:

- (1) 500 consecutive cases of histologically proved bronchial carcinoma which came to operation during a period of 4 years, 9 months from January 1950 to September 1954. Approximately 250 were seen by me personally, the relevant information in the remainder being obtained from case records and x-ray films.
- (2) 23 cases of bronchial adenoma which occurred during a 10-year period starting in January 1945. Personal experience covered only 7 of these. A detailed study of this group has not been made but, where appropriate, the findings have been compared with those in the carcinoma series.
- (3) 72 cases presenting with haemoptysis but without evidence of neoplasm or other recent lung pathology seen during the 7-years 1946-1952. Information on these cases was obtained from the hospital records.
- (4) Films of the hands, wrists and forearms in 100 consecutive cases of bronchial carcinoma associated with finger-clubbing but without clinical evidence of hypertrophic pulmonary osteoarthropathy.
- (5) Study of oesophageal movements on respiration in 23 cases with an enlarged hilar shadow subsequently proved to be due to bronchial carcinoma.
- (6) Barium swallow examinations on 200 consecutive histologically proved cases of bronchial carcinoma.
- (7) 12 cases in which pneumonectomy was performed on account of a mistaken diagnosis of malignancy.
- (8) 10 cases of bronchiolar or alveolar cell carcinoma. 4 were seen at Shotley Bridge, 4 in Newcastle and 2 in Dundee. 7 were observed by me personally, the other 3 being found on searching hospital records in Newcastle.

A single card was devoted to each patient - except those in groups (3) and (4) - and on it were recorded the desired clinical, radiological, pathological and operative details. The relevant information was abstracted from these and the original x-rays reviewed when necessary. In groups (3) and (4) the results obtained by studying case records and films were transferred directly to tables which included all the cases in each group.

Frequent reference is made to operable as opposed to inoperable tumours and, although precise definition of these terms is difficult, they afford a useful means of comparing two different groups of cases. Surgeons differ in their interpretation of operability in bronchial carcinoma and there may be considerable variation in the extent of lymph node dissection carried out in different cases; resectability and operability are not synonymous. It may be helpful to sketch briefly the surgical background of the cases under consideration. Five hundred operations were done (245 resections), the vast majority by surgeons of wide experience. Lobectomy was performed in 31 cases but standard pneumonectomy was the operation used in most cases requiring resection; dissection pneumonectomy was carried out in 21, "palliative" pneumonectomy - in the presence of obvious mediastinal glandular metastases - in 17, intrapericardial dissection in 6 and pleuro-pneumonectomy in 4. No rib or chest wall resections were performed. Histological evidence of malignant invasion of glands was frequently present when naked-eye inspection revealed no abnormality, thus, inevitably, many more "palliative" resections were carried out than those which were designed as such. By far the commonest cause of inoperability was extension of neoplastic tissue round the pulmonary vessels at the hilum. Many cases showed multiple feature of inoperability such as extensive involvement of mediastinal glands, great vessels, heart, oesophagus, diaphragm or chest wall.

SEX AND AGE INCIDENCE

Bronchial carcinoma is much commoner in males than in females. Most published figures in recent years show ratios which vary from 2:1 to 5:1 (Anderson, 1957). The highest preponderance I have been able to find in the literature was 9:1 which occurred in 1,457 cases reviewed by Ochsner, Ray and Acree (1954).

Personal findings.

(1) 464 out of 500 cases of bronchial carcinoma which came to operation occurred in males, a ratio of 13:1. These were, however, selected cases in that they were all regarded as fit for thoracotomy. A possible explanation for the considerably higher proportion of males than in other recorded series is that bronchial carcinoma may be correctly diagnosed at a later stage in women because of its lower incidence and consequently being less readily considered as a first possibility in diagnosis; hence the lower proportion of females in a group coming to surgery. Alternatively, the disease may have a worse prognosis in women so that relatively few cases are fit for operation by the time the diagnosis is made. This might be the result of undetermined factors or a higher incidence in females of the more malignant types of tumour. There were 36 females in the series of 500 and the histology of the tumour in these cases was:

Epidermoid	in 17 (47%)
Anaplastic	in 15 (42%)
Adenocarcinoma	in 4 (11%)

The proportion of anaplastic and particularly the adenocarcinomatous tumours is increased and that of the epidermoid type decreased compared with the figures for the entire group (c.f. Table 2, p. 12). Nevertheless, 21 (58%) of the 36 female cases were operable, a higher proportion than in the whole group of 500 where the operability rate was

490. If there were a still smaller proportion of epidermoid tumors -



Fig. I - Age and sex distribution in 500 cases of bronchogenic carcinoma subjected to thoracotomy.

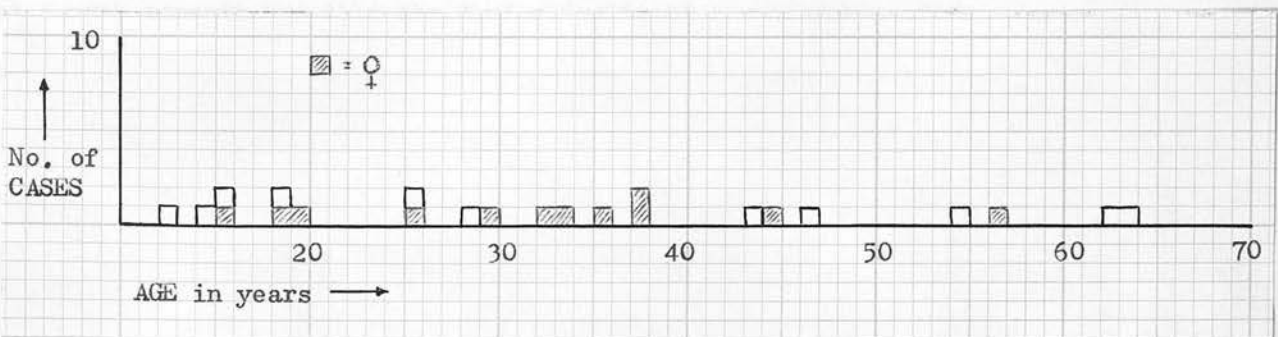


Fig. II - Age and sex distribution in 23 cases of bronchial adenoma.

49%. If there were a still smaller proportion of epidermoid tumours - and larger numbers of the more malignant types - among women considered unfit for surgical exploration, this could also contribute to the surprisingly few females subjected to thoracotomy in the present series.

(2) A sex ratio of 1:1 was found in 23 cases of bronchial adenoma. This conforms with the known much higher incidence of the benign tumour in females. Foster-Carter (1941) found that 62% of 71 cases he reviewed from the literature occurred in women.

(3) The youngest patient with a carcinoma was 24 and the oldest 70 (Fig. I). 367 (73%) occurred during the 15 years between 45 and 59 years of age. Fifty-five (11%) occurred under the age of 40 as compared with a figure of 69½% (of 23 cases) for this age group in bronchial adenoma (Fig. II). In carcinoma symptoms are usually present for a few weeks or months prior to diagnosis so that the age of onset of symptoms, judged in years, corresponds with the age distribution figures. In adenoma, on the other hand, a long history is common (McBurney, Clagett and McDonald, 1952) and the average duration of symptoms in 85 cases recorded by Moersch and McDonald (1956) was 2½ years. The onset of symptoms in 19 (82½%) of my 23 cases occurred under the age of 40 and in 15 (65%) under the age of 30 (Table 1) - at a much younger age than the vast majority of carcinomata. Only 1½% of 500 cases of bronchial carcinoma were under 30 years of age.

(4) The frequency of bronchial adenoma has been variously estimated as 10% (Schinz, Baensch, Friedl and Uehlinger, 1953), 6% (Foster-Carter, 1941) and 5% (Willis, 1953) of all primary bronchial tumours and Saphir (1958) described it as "not rare". The incidence at Shotley Bridge was very much lower than this and bronchial adenoma constituted only 0.75% of approximately 3,000 cases of primary bronchial tumour seen over a 10-year period up to December 1954. In the Newcastle

TABLE 1 - AGE OF ONSET AND DURATION OF SYMPTOMS PRIOR TO ESTABLISHMENT OF CORRECT DIAGNOSIS IN 23 CASES OF BRONCHIAL ADENOMA

Approx. AGE of ONSET of SYMPTOMS (years)	TIME INTERVAL until DIAGNOSED	
	YEARS	MONTHS
3	9	
11	3	
13	2	
14	-	10
17	2	
17(?)	45(?)	
18	-	1
18	-	9
18	10	
25	-	2
25	-	8
25	12	
25	18	
28	4	
29	-	4
31	2	
33	2	
34	10	
37	-	5
42 Asymptomatic	-	-
45	18	
54	-	3
55	1	

region very many cases of bronchial carcinoma obviously unfit for surgery are not referred to the thoracic surgery unit whereas all cases in which a diagnosis of bronchial adenoma is made are likely to be seen there.

This suggests that the true incidence of bronchial adenoma may be considerably lower than 0.75% of all primary tumours of the bronchus and that many of the figures in the literature give the erroneous impression that this tumour is 10-20 times commoner than it really is.

CONCLUSIONS.

BRONCHIAL ADENOMA AND CARCINOMA

(1) The small proportion of females (1:13) in a series of cases of bronchial carcinoma coming to operation may be the result of greater delay in diagnosis or the occurrence in the female of a tumour with a worse prognosis than that which occurs in the male.

(2) Bronchial adenoma shows an approximately equal sex incidence.

(3) The onset of symptoms occurs under the age of 30 in 65% of adenomata and in 1 1/2% of carcinomata.

(4) Bronchial adenoma appears to be 10-20 times less common than is often stated.

Small carcinomas prior to thoracotomy are often the type primarily affected is concerned - no distinction is made between central and peripheral tumours. Localization in the most majority of cases is that reported from 1100, bronchography and operative findings. When bronchography is negative and thoracotomy shows an inoperable mass round the lung root it may be difficult to determine accurately the site of origin of the tumour.

It would be expected from the relative sizes of the two lungs, primary carcinoma is slightly commoner on the right side than the left (Hillis, 1933). This position was reversed in the present series and 22 out of 244 cases occurred in the left lung. A reasonable explanation is that tumours on the left side are liable to the distribution here partly due to those on the right side or maximum a higher proportion of cases reported as 1:1 for exploratory surgery.

(5) The character of the right main bronchus and its proximity to the main arterial and pulmonary (and hence systemic) lymphatics account for the absence of any case with a collapsed right lung in contrast with 20 cases showing a collapse of the left lung.

(6) Fisher, Johnson and Murray (1931) considered the radiologically low incidence of all histological types of tumour in the left lower lobe

### ANATOMICAL DISTRIBUTION & OPERABILITY

It is unsatisfactory to attempt classification of the different x-ray appearances which may occur in bronchial carcinoma. Nor would it be helpful because oversimplification tends to obscure the essential principle that the radiological picture is a constantly changing one and may alter rapidly over a short interval of time (Kerley, 1951), even from one day to the next.

#### Personal findings.

(1) Fig. III shows diagrammatically the radiological presentation in 500 cases of bronchial carcinoma prior to thoracotomy as far as the lobe primarily affected is concerned - no distinction is made between central and peripheral tumours. Localization in the vast majority of cases is that apparent from films, bronchoscopy and operative findings. When bronchoscopy is negative and thoracotomy shows an inoperable mass round the lung root it may be difficult to determine accurately the site of origin of the tumour.

As would be expected from the relative sizes of the two lungs, primary carcinoma is slightly commoner on the right side than the left (Willis, 1953). This position was reversed in the present series and 262 out of 500 cases occurred in the left lung. A reasonable explanation is that tumours on the left side metastasize to the mediastinum less rapidly than do those on the right and so constitute a higher proportion of cases regarded as fit for exploratory surgery.

(2) The shortness of the right main bronchus and its proximity to the main carina and mediastinum (and hence earlier inoperability) account for the absence of any case with a collapsed right lung in contrast with 10 cases showing a collapse of the left lung.

(3) Patton, McDonald and Moersch (1951) remarked on the strikingly low incidence of all histological types of tumour in the left lower lobe

500  
238 in R. LUNG      262 in L. LUNG

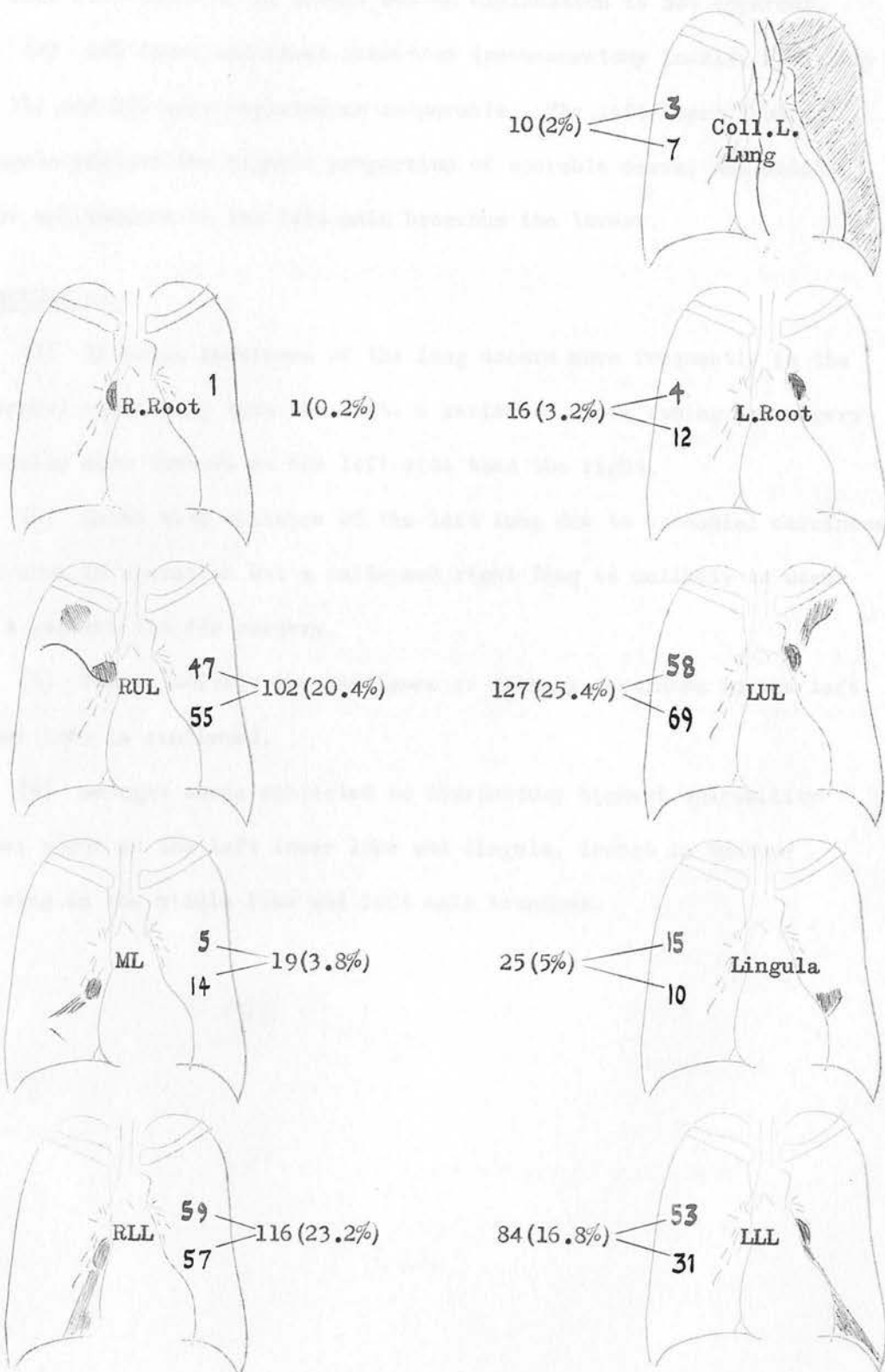


Fig. III - Anatomical distribution (diagramatic representation) of radio-logical changes in 500 cases of bronchial carcinoma which came to thoracotomy. Red figures indicate number which were operable, black figures below these the number which were inoperable.

in 849 cases of bronchogenic carcinoma seen at the Mayo Clinic. This is also noticeable in my series but an explanation is not apparent.

(4) 245 cases underwent resection (pneumonectomy in 214, lobectomy in 31) and 255 were regarded as inoperable. The left lower lobe and lingula yielded the highest proportion of operable cases, the middle lobe and tumours in the left main bronchus the lowest.

CONCLUSIONS.

(1) Although carcinoma of the lung occurs more frequently in the (larger) right lung than the left, a series of cases coming to surgery contains more tumours on the left side than the right.

(2) Cases with collapse of the left lung due to bronchial carcinoma may come to operation but a collapsed right lung is unlikely to occur in a patient fit for surgery.

(3) The relatively low incidence of primary carcinoma in the left lower lobe is confirmed.

(4) Amongst cases subjected to thoracotomy highest operability rates occur in the left lower lobe and lingula, lowest in tumours arising in the middle lobe and left main bronchus.

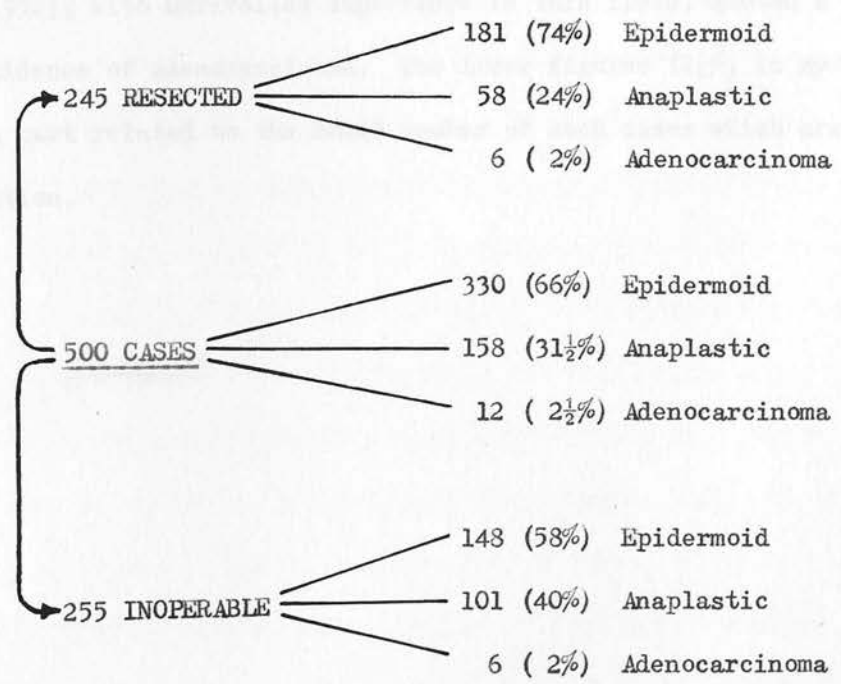
HISTOLOGICAL TYPE

Satisfactory histological classification of bronchial neoplasm is often difficult since more than one appearance may occur in different parts of the same tumour (Kennaway, 1955), metastases may have a histological appearance differing from that of the primary tumour and the distinction between less differentiated epidermoid and anaplastic tumours is extremely arbitrary. Bronchoscopic biopsy is frequently taken from an ulcerated or infected surface of the tumour and cell patterns are affected by superimposed inflammatory lesions (Patton, McDonald and Moersch, 1951). Nevertheless, a satisfactory over-all picture of a series of cases may be obtained by reviewing the incidence of the various histological types of tumour.

Personal findings and conclusions.

Histological examination of tissues obtained at bronchoscopy, thoracotomy or from resected specimens was carried out in all 500 cases by the Department of Pathology, University of Edinburgh (Table 2).

TABLE 2 - INCIDENCE OF HISTOLOGICAL TYPES IN 500 CASES OF BRONCHOGENIC CARCINOMA WHICH CAME TO OPERATION



The material is highly selected in that all cases showed no detectable extrathoracic metastases at the time of operation. Consequently the incidence of tumours which tend to metastasize early is relatively low. Koletsky (1938), in an autopsy series, found extrathoracic metastases in 35% of epidermoid, 86% of adenocarcinomatous and 89% of anaplastic tumours.

Epidermoid carcinoma accounted for 66% of 500 cases submitted to operation, 31½% were anaplastic and 2½% adenocarcinoma. The distribution amongst resectable tumours was 74% epidermoid, 24% anaplastic and 2% adenocarcinoma. In contrast, 58% epidermoid and 40% anaplastic tumours constituted the inoperable group. Epidermoid carcinoma thus accounts for a high proportion (two-thirds) of cases which came to operation and an even higher one (three-quarters) of those which are operable.

181 out of 330 (55%) of epidermoid tumours and 58 out of 158 (36%) of the anaplastic type were resectable.

There were 12 adenocarcinomata: 6 were peripheral lesions, 3 of these being 8-10 cm. in diameter. Four occurred in females, a male:female sex ratio of 3:1 as compared with 13:1 in the whole series. Liebow (1952), with unrivalled experience in this field, quoted a 9-12% incidence of adenocarcinoma. The lower figures (2½%) in my series may be in part related to the small number of such cases which are fit for operation.

### PREVIOUS HISTORY

Many patients have been x-rayed previously, often in other hospitals or clinics, either routinely or because of chest trouble in the past. The time factor is of prime importance in chest radiodiagnosis and comparison of present radiographs with those taken at an earlier date, be they full-size or miniature films, is one of the most helpful and most often overlooked single steps in the investigation of doubtful chest lesions. A shadow which, in itself, is not characteristic of any particular disease may take on new significance when the changes which have occurred in a known interval of the time become apparent. Minor - but significant - alterations from the normal appearance may be difficult to detect unless an earlier film is available for comparison (Fig. 39). It is important that a patient's earlier films should actually be seen and much reliance cannot be placed on a previous (especially mass miniature x-ray) report which may have been misquoted or, in retrospect, wrong. Now that mass radiography is so widely employed, many patients have been x-rayed in this way within a few months or years of their recent complaint.

A carefully taken previous history is helpful, not so much in the diagnosis of carcinoma, but in order to distinguish other conditions from it. Previous accidents or injuries are occasionally significant. A collapsed lower lobe in which bronchial biopsy is persistently negative may conceal a foreign body inhaled, unknown to the patient, months or years previously. A lung haematoma may develop after non-penetrating chest injuries with multiple rib fractures and show on the x-ray as a circular or ovoid opacity; Salyer, Blake and Forsee (1953) reported 3 such cases, all of whom, however, were less than 25 years of age.

A previous operation for removal of a tumour in another part of the body is of importance when a patient presents with a round, well-

defined shadow in the lung or, much less frequently, with an endobronchial tumour of unusual histology. The operation may have been many years ago since some metastases grow very slowly (D'Abreu, 1953).

Lipoid pneumonia may closely resemble carcinoma and a history of oil ingestion could be helpful in suggesting the true diagnosis. It is noteworthy that inquiry into this aspect of the history in most cases is only made after the histological appearances of the diseased lung are known. A history of oil ingestion was obtained in 5 out of 6 cases of lipoid pneumonia reported by Davis, Hampton, Bickham and Winship (1954) and in 33 out of 35 cases (Hampton, Bickham and Winship, 1955).

The previous history may suggest the correct diagnosis in such conditions as hydatid cyst, amoebic abscess or aortic aneurysm, all of which can, at times, resemble bronchial carcinoma.

Exceptional risks of developing bronchial carcinoma have been recognized in several unrelated industries. Except for the mining of radio-active materials, the highest incidence has occurred in chromate, asbestos and sheep-dip workers. In the U.S.A. Machle and Gregorius (1948) found that workers over the age of 50 employed at chromate plants showed a mortality rate from bronchogenic carcinoma about 40 times that occurring in other industrial groups. Wyers (1949) found cancer of the lung in 14.8% of 115 necropsies on patients with asbestosis and Doll (1955) reported an excessive number of deaths from bronchogenic carcinoma - amounting to 10 times that expected in the general population - among 113 asbestos workers, each of whom had been exposed for not less than 20 years. Hull and Fanning (1948) found that employees engaged in sheep-dip manufacture suffered a mortality from cancer of the skin and bronchus double that of the neighbouring population.

From the diagnostic point of view, a more important aspect of the occupational history is that some occupational diseases may closely

resemble bronchogenic carcinoma. A well-defined mass in one lung may be due to complicated pneumoconiosis (Fig. 73) and a collapsed or consolidated middle lobe may be the result of silicosis (Giuntoli, 1953). Sometimes a very short exposure to dust, such as 1 or 2 years, many years ago (e.g. 30) is associated with a massive silicotic shadow closely resembling carcinoma (Kergin, 1952). A history of contact with flour, grain or other dust may suggest aspergillosis which can be associated with extensive consolidation and atelectasis and closely resemble carcinoma (Hinson, Moon and Plummer, 1952).

Over-diagnosis of malignancy may result if a history of heavy smoking is allowed to weigh too heavily in favour of carcinoma when a chest lesion of undetermined nature is being investigated (Figs. 69, 74, 75).

## S Y M P T O M S

"There are no characteristic signs and symptoms of primary carcinoma of the lung" (Rienhoff, 1944). Most patients complain of symptoms too late for treatment to be successful.

### ASYMPTOMATIC CASES

Now that "early detection" is a prominent feature of modern medical practice, it has become customary to regard a considerable number of cases as asymptomatic. Aird (1949) quoted a figure of 20%.

#### Personal findings.

In only 6 cases out of 500 (1.2%) could the lesion have been described as truly asymptomatic; 3 of these were mass x-ray "pick-ups". Many patients reply in the negative when questioned as to any complaints at the present time, but on direct questioning admit to one or more of the commoner symptoms of bronchial carcinoma, especially a previous haemoptysis or recent infective chest illness. This fairly large group of cases with recent symptoms, temporarily in abeyance, can hardly be classified as asymptomatic since a previous chest infection is one of the commoner modes of presentation of the operable carcinoma.

Only 1 out of 23 cases of bronchial adenoma was truly asymptomatic and 4 others were temporarily symptom-free at the time of admission to hospital.

These findings correspond with the results seen in mass x-ray campaigns where surprisingly few cases of carcinoma are really symptom-free. Boucott and Sokoloff (1954) found less than 10% of 77 "pick-ups" were truly asymptomatic.

### SINGLE SYMPTOMS

Cough, often unproductive, is the commonest symptom in bronchial

carcinoma but it, and to a lesser extent dyspnoea, is relatively common in the age-group of carcinoma; it is a change in, rather than the presence of such symptoms which may be most important.

Cough, haemoptysis, dyspnoea or pain frequently occur together but appreciable numbers of patients fit for surgery present with only one of these complaints.

#### Personal findings.

In 34 cases (7%) only one local symptom was present; 13 had haemoptysis, 8 had cough (with or without sputum), 7 had pain and 4 complained only of dyspnoea. One of these symptoms plus weight loss as the sole complaints occurred in 16 cases (3%). Clubbing of the fingers plus weight loss were the only presenting features in 5 cases (1%).

#### HAEMOPTYSIS

Haemoptysis may be denied by the patient unless he is closely questioned, particularly as it has not infrequently occurred a few weeks or months previously. It nearly always takes the form of a few streaks of blood in the sputum and if, as occasionally happens, it is profuse, this is most likely the result of erosion of a vessel by a cavitating growth.

Blood seldom accumulates in sufficient quantity in the alveoli to produce a shadow on the x-ray such as may occur when bleeding is more profuse (Hastings-James, 1952).

Moersch (1951), reviewing 670 bronchoscopies, 200 of which were performed because of haemoptysis, found that the commonest cause of this symptom was a malignant tumour of the bronchus, lung or trachea and that it occurred in 48 out of 91 cases of bronchogenic carcinoma. The bleeding was usually of short duration. Douglas and Carr (1952) followed up 75 patients who had been investigated for haemoptysis with

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negative results (plain x-rays, bronchoscopy and bronchography in each case) and were able to trace 55; there was one death from a bronchogenic carcinoma a year later and 50 were alive and well 5 years later. MacHale (1953) found that 4 out of 71 cases of haemoptysis with a normal x-ray had a bronchogenic carcinoma and Davidson (1954) advised bronchoscopy in all cases of haemoptysis with a normal chest x-ray.

The bronchus is seldom eroded by metastatic tumours in the hilar glands but this possibility should be borne in mind and King and Castleman (1943) reported 20 cases in which this had occurred and bronchogenic carcinoma had been simulated; 4 presented with blood-streaked sputum.

Small haemoptyses are fairly frequent in chronic bronchitis (Anderson, 1953) and according to Wilson and Kilpatrick (1955) haemoptysis is as common as black sputum in cases of complicated pneumoconiosis.

#### Personal findings.

It is important to investigate cases of haemoptysis with no obvious cause since it is a common symptom in bronchial carcinoma and may be the only one, as occurred in 13 of my 500 cases. On the other hand, patients are seen in whom, despite complete investigation (including bronchoscopy and bronchography), no definite cause for haemoptysis can be found. Seventy-two such cases in which no evidence of carcinoma appeared at a 6 months follow-up were seen at Shotley Bridge during the 7 year period 1946-1952, the majority being labelled - for lack of a more convincing diagnosis in some cases - chronic bronchitis, bronchiectasis or hypertension. This group emphasizes that haemoptysis, although a potentially serious symptom, is not necessarily associated with malignancy and helps to keep this symptom in its correct perspective.

The question arises as to whether bronchoscopy is desirable as the initial investigation of a small haemoptysis when the chest x-ray is genuinely normal. Cases of this sort do occur but are uncommon,

especially if a previous chest x-ray can be compared with the recent one, since films which might be passed as "normal" can then be seen to show slight hilar enlargement or other minimal changes.

In the present series of 500 cases which came to operation there were no completely normal chest x-rays (P.A. and lateral) but only slight abnormalities were not unusual and if these cases had been bronchoscoped a week or two earlier they would obviously have fallen into the x-ray negative, bronchoscopy positive group. It seems reasonable to bronchoscope a patient with a normal chest x-ray and undoubted haemoptysis for which there is no obvious explanation, provided he would be fit for operation should a neoplasm be discovered. Bronchoscopy should certainly be carried out if haemoptysis is repeated. In all other cases a further P.A. and lateral film in 2-3 weeks time should suffice, especially if there is chronic bronchitis, which apparently is a not uncommon cause of haemoptysis in association with a normal chest x-ray.

#### DYSPNOEA

According to Tudor Edwards (1946) definite dyspnoea is a late symptom and is due not so much to the amount of lung put out of action by disease but probably to mediastinal fixation with loss of vertical movements of the lung root on respiration.

#### Personal findings.

An analysis of 116 cases of right lower lobe carcinoma which came to operation showed that 40 out of 59 operable and 41 out of 57 inoperable cases complained of dyspnoea on exertion. Variations in severity of dyspnoea are not taken into account but the incidence of the symptom in the two groups is practically identical. It seems doubtful if mediastinal involvement was the main cause of dyspnoea in these cases.

PAIN

Pain occurs frequently in other chest diseases which may resemble carcinoma. Pneumoconiosis is often associated with a transient, aching pain of obscure causation (Wilson and Kilpatrick, 1955) and chronic inflammatory lesions in the upper lobes may produce considerable pain in the chest, shoulder and upper arm (Ashe, McDonald and Clagett, 1951). A vague tightness or discomfort in part of the chest - rather than true pain - is commonly present in carcinoma.

Simon (1953) said that deep-seated substernal pain in cases of bronchogenic carcinoma is an indication of mediastinal involvement. Klassen, Morton and Curtis (1951) reported 7 cases of inoperable bronchogenic carcinoma in which they transected the vagi above the pulmonary plexus and immediately below the origin of the laryngeal nerve; this resulted in abolition of the cough reflex and almost complete abolition of pain on the affected side. They suggested that when cough and pain diminish considerably in a patient with a bronchogenic carcinoma, this may be due to spread of the disease to involve the vagus.

Personal findings.

(1) It was possible to assess reliably the presence or absence of pain in 462 out of 500 cases which came to operation. 119 out of 237 inoperable cases had no pain, inoperability in nearly all of these being due to the presence of mediastinal spread. This means that mediastinal involvement can be present in very many cases without producing pain and the latter cannot be taken as a sign of the extent of the disease.

Pain of various types was present in 89 out of 225 operable cases - a smaller proportion than in the inoperable group but again illustrating the unreliability of this symptom in distinguishing between early and late cases.

(2) Excluding those who had or probably had had a previous pleural

effusion there were 19 out of 225 operable and 28 out of 237 inoperable cases in whom pain had been present and subsequently disappeared. The disappearance of pain is evidently not a reliable sign of mediastinal involvement either.

(3) 100 consecutive cases judged unfit for operation (for a large variety of reasons) were also reviewed with regard to the presence or absence of pain. 53 were found to have pain, 47 no pain. The variability of this symptom in all groups of cases is striking and little significance can be attached to it. Its main importance is that it may result in the patient's seeking medical advice in the first instance and - in the absence of any other obvious cause for it - should warn the radiologist to examine each hilar shadow with particular care. Appearances like those in Figs. 33 and 36 should, ideally, not be missed but it is negligent to disregard such changes in the presence of known pain in the chest.

#### WEIGHT LOSS

The general symptoms of bronchogenic carcinoma such as loss of weight, loss of energy and loss of appetite do not differ significantly from those of neoplasm in other parts of the body but Davidson (1954) stated that weight loss is much less common in bronchogenic than in other carcinomata.

#### Personal findings.

31 out of 245 operable (12½%) and 41 out of 255 inoperable cases (16%) had lost more than 1 stone in weight (Table 3). Larger numbers had lost smaller amounts of weight but these more variable figures form a less reliable means of comparison between the two groups.

20 out of 84 cases of left lower lobe carcinoma had lost more than 1 stone in weight. This was a higher incidence of considerable

TABLE 3 - INCIDENCE OF WEIGHT LOSS IN 500 CASES OF BRONCHOGENIC CARCINOMA WHICH CAME TO OPERATION. RED FIGURES INDICATE THOSE IN WHICH LOSS EXCEEDED 1 STONE.

No. of cases	SITE of Tumour	No. with WEIGHT LOSS	
		OPERABLE	INOPERABLE
102	RUL	18 (4)	25 (10)
19	ML	1 (1)	2 (1)
116	RLL	21 (11)	20 (8)
127	LUL	13 (5)	32 (8)
25	Lingula	8 (2)	3 (1)
84	LLL	22 (8)	20 (12)
27	Main Bronchus	1 -	9 (1)
500		84 (31)	111 (41)

weight loss than in other lobes and is the more surprising since operability rates were higher in this lobe than in all other sites (Fig. III, p.10). The reason for this is not apparent; it may have been fortuitous.

#### GASTRIC SYMPTOMS

Wenzl (1950) recorded a high incidence of gastric symptoms (anorexia, discomfort, flatulence or nausea) in patients with bronchogenic carcinoma and suggested that they might be due to vagal involvement by tumour. Kerley (1951) commented on the large number of cases which were found at barium meal examination, their leading symptoms being weight loss and dyspepsia.

#### Personal findings.

Six out of 500 cases (1.2%) were detected at barium examinations; 5 at barium meal and 1 at barium enema. All were right-sided growths, 1 in the right upper lobe, 1 in the middle lobe and 4 in the right lower lobe; all were operable except the middle lobe lesion. In only one case had a gastro-intestinal abnormality been detected - a simple gastric ulcer from

which the patient died as a result of perforation 4 days after pneumonectomy. Experience in general hospitals in Newcastle suggests that the majority of bronchial carcinomata detected at barium meal examinations are unfit for surgery. This would account for the small number in the 500 cases which came to operation.

### CONCLUSIONS

- (1) Very few cases of bronchial carcinoma coming to operation are truly asymptomatic.
- (2) A single symptom (haemoptysis, cough, pain or dyspnoea) occurred in 7% of cases of bronchial carcinoma coming to surgery.
- (3) Unexplained haemoptysis in the cancer age group requires immediate investigation but this symptom is not uncommonly due to benign causes.
- (4) Mediastinal involvement does not appear to be the main factor in producing dyspnoea in bronchial carcinoma.
- (5) Pain may cause the patient to seek medical advice in the first instance and this symptom should alert the radiologist to study the hilar shadows with care. The presence, absence or disappearance of pain appear to give no reliable indication of the extent of tumour spread.
- (6) Loss of more than 1 stone in weight amongst patients coming to operation is only slightly more common in the inoperable than in the operable cases.
- (7) Few operable cases of bronchial carcinoma are initially detected at barium meal examinations.

FINGER CLUBBING

Rapid onset of finger clubbing in a patient of the cancer age group and with an abnormal hilar or lung shadow is one of the few useful clinical signs in the diagnosis of bronchial carcinoma at a reasonably early stage. When the chest abnormality is a localized mass in the pleura, hypertrophic pulmonary osteoarthropathy associated with benign pleural tumour is an important possibility to consider (Clagett, McDonald and Schmidt, 1952; Price-Thomas and Drew, 1953).

Personal findings.

(1) Table 4 records the incidence of finger clubbing in 500 cases of bronchial carcinoma which came to thoracotomy; comparison is made with the operability rates and histology in those who had no clubbing. When finger changes were doubtful such cases were included in the "without clubbing" group.

TABLE 4 - RELATIONSHIP OF OPERABILITY AND HISTOLOGY TO FINGER-CLUBBING IN 500 CASES OF BRONCHOGENIC CARCINOMA WHICH CAME TO THORACOTOMY

	500 cases of Bronchogenic Carcinoma	HISTOLOGICAL types		
		Epidermoid	Anaplastic	Adeno-
Number WITHOUT clubbing	395	248	137	10
Number of these OPERABLE	184 (46%)	131 (53%)	48 (35%)	5 (50%)
Number WITH clubbing	105	82	21	2
Number of these OPERABLE	61 (58%)	50 (61%)	10 (48%)	1 (50%)

Clubbing was present in 105 (21%) and histology showed epidermoid tumours in 82 (50 were resected), anaplastic neoplasm in 21 (10 were resected) and adenocarcinoma in 2. Only 2 showed hypertrophic pulmonary osteoarthropathy and both had epidermoid tumours; one was in the lingula and underwent pneumonectomy and the other an inoperable tumour in the left

upper lobe.

Epidermoid tumours were thus about 4 times commoner than anaplastic in patients with finger clubbing, whereas in the whole group of 500 cases the ratio of epidermoid to anaplastic growths was more nearly 2:1 (66% epidermoid:31½% anaplastic - Table 2, p.12). Semple and McCluskie (1955) found a similar predominance of epidermoid tumours in 17 out of 21 cases of hypertrophic pulmonary osteoarthropathy due to bronchogenic carcinoma.

The occurrence of finger clubbing in one of every five cases in this series is likely to be the result of the high proportion of epidermoid tumours in a group which comes to operation.

(2) Operability rates were slightly higher in cases with finger clubbing than in those without it; that this is not entirely due to the commoner epidermoid tumour being more often associated with clubbing than is the anaplastic neoplasm is shown in Table 4.

Out of 500 cases of bronchogenic carcinoma which came to operation, 58% of those with clubbing and 46% of those without it were resectable. When these were broken down into histological types an operable tumour was found in the epidermoid group in 61% of those with clubbing and 53% of those without it; in the anaplastic group 48% of those with clubbing and 35% of those without it were operable.

The presence of finger clubbing, therefore, does not imply a poor prognosis. If anything, the reverse is true of cases which are subjected to thoracotomy.

(3) Clubbing of the fingers was found with all varieties of radiological picture; the only appearance which occurred with striking frequency was the breaking down peripheral neoplasm. Table 5 shows the incidence of finger clubbing in cavitating and solid peripheral neoplasms: 19 out of 31 cavitating tumours (61%) were associated with finger clubbing

whereas only 7 out of 54 solid tumours (13%) showed this change. Seventeen of the cavitating tumours associated with clubbing were epidermoid and 2 anaplastic in type, conforming with the known tendency of peripheral epidermoid tumours to form a breaking-down neoplastic abscess.

(4) It has been said (Mendlowitz, 1942) that hypertrophic pulmonary osteoarthropathy may be symptomless. Accordingly A.P. radiographs of both hands, wrists and forearms were obtained in 100 consecutive cases of bronchial carcinoma with definite finger clubbing but without clinical evidence of hypertrophic pulmonary osteoarthropathy; many had marked soft tissue deformity of the fingers and toes. (No operation was performed in 53, thoracotomy in 26, pneumonectomy in 17 and lobectomy in 4.)

In no case was a subperiosteal lacework of new bone seen in the metacarpals, forearm bones or phalanges.

TABLE 5 - INCIDENCE OF FINGER CLUBBING IN PERIPHERAL CARCINOMA OF THE LUNG

SITE	CAVITATING		NON-CAVITATING	
	No. of cases	No. with CLUBBING	No. of cases	No. with CLUBBING
RUL	6	4	10	1
ML & RLL	3	0	17	1
LUL & Lingula	15	10	14	2
LLL	7	5	13	3
	31	19	54	7

CONCLUSIONS.

(1) Operability rates are slightly higher in cases of bronchial carcinoma which show finger clubbing (commonest in epidermoid tumours) than in those which do not.

(2) Finger clubbing is particularly associated with the breaking-down

peripheral epidermoid carcinoma.

(3) Asymptomatic hypertrophic pulmonary osteoarthropathy was not found in any of 100 cases of finger clubbing due to bronchial carcinoma.

collagen resulting from about two to four days in cases with asymptomatic hypertrophic pulmonary osteoarthropathy and other conditions associated with clubbing is present.

None of the individuals tested with the polymerization technique for it is often impossible to say from the quantitative appearance whether the abnormality seen is a symptom or one of the less common causes such as tuberculosis, and chronic granulomatous disease or even epidermoid carcinoma of the lung (Guttmann, 1957; Garcia, 1959). In any case, the histology of the condition may important prognostic and therapeutic implications. A possible source of error which may occur in the study of the histology of the condition may be the degree of clubbing and interpreting the histology as being primarily inflammatory in nature whereas the changes, in fact, are secondary to an underlying carcinoma.

When a carcinoma involves a main or lobar bronchus, an early bronchial tumor may be regarded as visible. Tubercles, usually submucosal in type, sometimes occur submucosally and obliterate the normal longitudinal folds of the bronchial wall, producing the so-called "beaded" appearance of granulation tissue. In other conditions the appearance of granulation tissue is similar to that of carcinoma but the changes of malignancy are not sufficient to cause a marked clubbing of the fingers.

We wish to emphasize that the primary clubbing of the fingers is not a symptom of the carcinoma but a primary clubbing of the fingers. It is important to emphasize that the primary clubbing of the fingers is not a symptom of the carcinoma but a primary clubbing of the fingers. It is important to emphasize that the primary clubbing of the fingers is not a symptom of the carcinoma but a primary clubbing of the fingers.

### BRONCHOSCOPY

Bronchoscopy is indicated in any patient beyond childhood with a short history of chest symptoms and whose x-rays show lobar (or lung) collapse persisting for more than a few days, in cases with suspicious x-ray appearances and when recurrent and otherwise unexplained haemoptysis is present.

Biopsy of any endobronchial lesion which is producing collapse is desirable for it is often impossible to say from the bronchoscopic appearances whether the abnormality seen is a neoplasm or one of the less common causes such as tuberculosis, non-specific granulation tissue or even amyloid deposits in the bronchi (Whitwell, 1953; Gordon, 1955). In any case, the histology of the neoplasm has important prognostic and therapeutic implications. A possible source of error which may occur at bronchoscopy is the finding of granulation tissue in the biopsy material and interpreting the lesion as being primarily inflammatory in nature whereas the changes, in fact, are secondary to an underlying carcinoma.

When a carcinoma involves a main or lobar bronchus, an endobronchial tumour may or may not be visible. Tumours, usually epidermoid in type, sometimes spread submucosally and obliterate the normal longitudinal furrows of the bronchial mucous membrane, producing the roughened appearance of granulation tissue. On other occasions the only evidence of neoplasm may be broadening of a carina or an impression of fixity or distortion of a lobar orifice due to pressure from enlarged glands or a tumour mass.

The vast majority of endobronchial tumours are primary but Willis (1948) emphasized the importance of the bronchoscopist's and pathologist's being aware that secondary carcinoma in the lung occasionally involves the bronchial wall and simulates a primary carcinoma. He had observed similar spread in lymphadenoma and lymphosarcoma affecting the hilar

glands. King and Castleman (1943) commented on the rarity of the condition but were able to report 20 cases of secondary carcinoma in hilar glands which had spread to involve the bronchus, resembling a primary carcinoma; 4 presented with blood-streaked sputum. Fried (1948) recorded 3 similar cases - a granulosa cell tumour of the ovary, a teratoma of the testis and a hypernephroma of the kidney which occurred 8 years after nephrectomy. The latter was described as the tumour which, above all others, "chooses" the bronchial wall as a metastatic site. Bronchial biopsy was positive in 4 out of 10 such cases reported from the Mayo Clinic (Seiler, Clagett and McDonald, 1950).

Protrusion of a malignant tumour into the bronchus is, then, insufficient evidence for the diagnosis of bronchial carcinoma but the history may be helpful and suggest the true origin of the neoplasm. Even in the presence of a known primary tumour (past or present) elsewhere, an endobronchial neoplasm is still very much more likely to be a separate primary than the result of invasion by a metastasis.

#### Personal findings.

Table 6 shows an analysis of the results of bronchoscopy in 473 cases of bronchial carcinoma of lobar distribution which were all fit for surgical exploration. The remaining 27 cases in the series of 500 are not included in this group since they had tumours in the main bronchi above the upper lobe orifices; a positive bronchoscopic biopsy was obtained in each one. Cytological examination of material aspirated at bronchoscopy was not carried out in any of the cases; if it had been, more positive diagnoses of carcinoma would obviously have been obtained.

Bronchoscopy gave a positive diagnosis of carcinoma in 272 cases (57%), was equivocal in 65 (14%) and showed no abnormality in 138 (29%). The total number of operable cases was 237 and in these bronchoscopy provided a definite diagnosis of carcinoma in 133 (56%)

TABLE 6 - RESULTS OF BRONCHOSCOPY IN 473 CONSECUTIVE CASES OF BRONCHIAL CARCINOMA OF LOBAR DISTRIBUTION WHICH CAME TO THORACOTOMY

LOBE	No. of CASES	RESULTS of BRONCHOSCOPY *			
		+	N.A.D.	±	
R.U.L.	102	47 RESECTIONS	→ 26	17	5
		55 INOPERABLE	→ 25	20	9
			51 (50%)	37 (36%)	14 (14%)
M.L.	19	5 RESECTIONS	→ 0	5	0
		14 INOPERABLE	→ 6	5	3
			6 (31%)	10 (53%)	3 (16%)
R.L.L.	118	60 RESECTIONS	→ 45	9	6
		58 INOPERABLE	→ 49	6	3
			94 (79%)	15 (13%)	9 (8%)
L.U.L. (excluding lingula)	127	57 RESECTIONS	→ 22	29	6
		70 INOPERABLE	→ 31	21	18
			53 (42%)	50 (39%)	24 (19%)
LINGULA	25	15 RESECTIONS	→ 7	7	1
		10 INOPERABLE	→ 6	2	2
			13 (52%)	9 (36%)	3 (12%)
L.L.L.	84	53 RESECTIONS	→ 33	14	6
		31 INOPERABLE	→ 22	3	6
			55 (65%)	17 (21%)	12 (14%)
Overall results ----->			57%	29%	14%

- + = Biopsy showed carcinoma
- \* N.A.D. = (1) No abnormality shown or (2) Pus as the only abnormality.
- ± = (1) Possible tumour seen but biopsy negative or showing only squamous metaplasia suggestive of carcinoma, or
- (2) No tumour seen but some abnormality such as narrowing, rigidity or distortion of a bronchus or broadening of a carina.

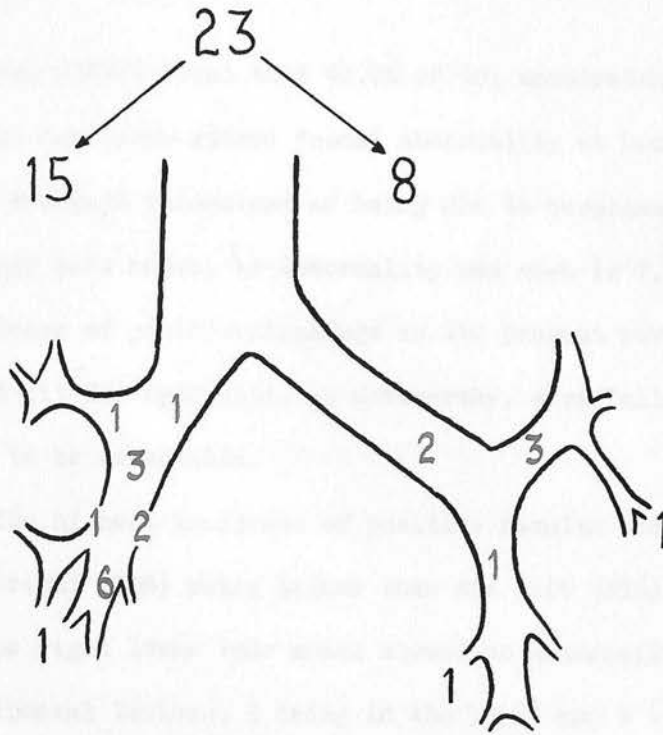


Fig. IV - Bronchoscopic findings in 23 cases of bronchial adenoma. RED figures in bronchial tree indicate POSITIVE biopsy; BLACK figures indicate NO abnormality seen.

and was entirely negative in 81 (34%).

By comparison, a positive bronchoscopic biopsy was obtained in 20 (87%) out of 23 cases of bronchial adenoma; the 3 cases in which no abnormality was seen were all circular, peripheral tumours (Fig. IV). While bronchoscopic biopsy yields positive results so frequently in bronchial adenoma, cytological examination of exfoliated cells in the sputum or bronchial secretions is evidently very rarely positive. According to McDonald (1955) the mucosa over an adenoma remains intact so exfoliative cytology does not produce positive results; this observation had been helpful in distinguishing adenoma from a small-cell undifferentiated carcinoma. Papanicolaou and Liebow (1956) regard the exfoliation in bronchial adenoma as less profuse than that which occurs in carcinoma, the cells lacking pathognomonic features but their grouping and appearance being similar to what is seen in sections of the tumour itself.

Lea (1952) found that 92.7% of 501 unselected, proved cases of bronchial carcinoma showed "some" abnormality at bronchoscopy although this was not always recognized as being due to neoplasm until the results of the biopsy were known; no abnormality was seen in 7.3%. The much lower incidence of positive findings in the present series, all judged as at least fit for operation, is noteworthy, especially in those which were found to be resectable.

The highest incidence of positive results occurred in the lower lobes, the right (79%) being higher than the left (65%). Of the 9 operable cases in the right lower lobe which showed no abnormality at bronchoscopy 7 were peripheral lesions, 2 being in the basal and 5 in the apical or subapical segments. Fourteen of the 53 operable cases in the left lower lobe showed no abnormality at bronchoscopy; 11 of these were well-defined peripheral lesions occurring in all segments of the lobe, one had produced a segmental collapse of the apical segment, one a lobe solid with carcinoma and one a small abscess in the lateral basal segment.

36% of the right upper lobe and 39% of the left upper lobe lesions showed no abnormality at bronchoscopy; 7 of the 29 operable left upper lobe cases which showed no abnormality were peripheral lesions.

It is noteworthy that the middle lobe gave the highest incidence of negative results (53%) and none of the 5 resectable cases of middle lobe carcinoma showed any abnormality at bronchoscopy. The next most difficult site in which to obtain a definite diagnosis was the left upper lobe where bronchoscopic examination was negative in 39% of 127 cases. It is important to appreciate the limitations of a negative bronchoscopic examination in different parts of the lung.

Tudor Edwards (1946) quoted Tuttle and Womack (1943) who showed that peripheral carcinomata tend to metastasize early and, out of 44 cases, those which were demonstrated at bronchoscopy had an average survival time

of 33.9 months as compared with 13.7 months in cases which showed no abnormality at bronchoscopy.

In the present series when the results of bronchoscopy were related to operability, it was found that the positive-bronchoscopy group had a resection rate of 49% as compared with 59% in the bronchoscopy-negative cases (Table 7). This is at variance with the findings of Tuttle and Womack as regards the presence of intrathoracic spread but does not, of course, take into account the later development of more distant metastases.

TABLE 7 - COMPARISON OF OPERABILITY RATES IN BRONCHOSCOPICALLY POSITIVE AND NEGATIVE CASES (extrapolated from Table 6)

Results of BRONCHOSCOPY	No. of cases	No. OPERABLE
Positive biopsy	272	133 (49%)
No abnormality	138	81 (59%)

Borrie and Griffin (1951) pointed out that endobronchial pulsation is not diagnostic of aneurysm since it may occur in cases of bronchial carcinoma. The finding of oesophageal deformity due to compression by enlarged subcarinal glands may be the only radiological method of distinguishing these two conditions prior to thoracotomy (p.49).

Bronchoscopy may be of great value when symptoms alter in a case of long-standing lung disease and recent changes are difficult to assess radiologically (Fig. 62).

#### CONCLUSIONS.

(1) Bronchoscopy was negative in 1 out of every 3 cases of operable bronchial carcinoma and in 1 out of 7 cases of bronchial adenoma. (Cytological examination of bronchial secretions was not performed.)

(2) Positive findings at bronchoscopy are least likely to occur in

the middle lobe (1 case in 2) and most likely in the right lower lobe (4 cases out of 5).

(3) A lower resection rate occurred in tumours visible at bronchoscopy than in those which showed no bronchoscopic abnormality.

The site of the abnormality under investigation here, with the exception of the peripheral lesions, lateral and anterior views are frequently more useful than the antero-posterior.

In a normally shaped chest the tracheal bifurcation lies 10-12 cm. behind the mid-sternal line. The anterior and posterior chest walls are 16 cm. behind and 14 cm. in front of the mid-sternal line. In a slightly oblique chest the tracheal bifurcation lies 11 cm. behind the mid-sternal line. In a slightly oblique chest the tracheal bifurcation lies 11 cm. behind the mid-sternal line.

The upper lobe bronchus and lower (1950) described a right posterior oblique position for viewing demonstration of the middle lobe bronchus. L.V. Campbell and associates in the demonstration of disease in the left lower lobe behind the heart and lateral chest wall in cases of lung carcinoma, a lateral oblique is considered the only method of obtaining satisfactory demonstration of a posteriorly placed lesion.

The peripheral nodes on a plain (lateral) film (Fig. 3). This view is also useful in differentiating left upper lobe carcinoma from certain squamous cell carcinoma which may be centrally placed in the upper lobe. The entire pulmonary artery is in cross-section with clarity (Fig. 2).

L.V. Campbell and associates in their study of the chest in lung carcinoma, they suggest that the course of the pulmonary arteries is clearly lateral and 1-2 cm. from the midline. The position of the hilum (Fig. 4). In a normally shaped chest the tracheal bifurcation lies 10-12 cm. behind the mid-sternal line. The anterior and posterior chest walls are 16 cm. behind and 14 cm. in front of the mid-sternal line. In a slightly oblique chest the tracheal bifurcation lies 11 cm. behind the mid-sternal line.

Particular points regarding the shape and distribution of these groups are discussed in the accompanying text.

### TOMOGRAPHY

Friman-Dahl (1946) considered tomography the most important radiological investigation in cases of bronchogenic carcinoma.

The positions used (A.P., lateral or oblique) depend on the site of the abnormality under investigation but, with the exception of the peripheral lesion, lateral and oblique views are frequently more useful than the antero-posterior.

In a normally-shaped chest the tracheal bifurcation lies 1-2 cm. behind the mid-point between the anterior and posterior chest walls and is often better demonstrated on a slightly oblique rather than an A.P. view since it is projected away from the spine in this position (Fig. 1). A slightly oblique position is also useful for demonstrating the upper lobe bronchi and Locke (1953) described a right posterior oblique position for clearer demonstration of the middle lobe bronchus. A.P. tomograms are unsatisfactory in the demonstration of disease in the left lower lobe behind the heart and lateral cuts should be done in such circumstances. A lateral tomogram is sometimes the only method of obtaining satisfactory demonstration of a posteriorly placed lesion overlying the vertebral bodies on a plain lateral film (Fig. 2). This position is also helpful in differentiating left upper lobe carcinoma from aortic aneurysm and in deciding whether a doubtfully enlarged root shadow is due entirely to pulmonary artery or to some abnormal hilar opacity (Fig. 3) - A.P. tomograms are of less value in this common diagnostic problem because they cannot display the course of the pulmonary arteries so clearly. Lateral cuts at 2-3 cm. from the mid-line also show clearly the orifices of the middle lobe and lower lobe apical segmental bronchi and are easier to interpret than A.P. views when a mass is surrounding the hilum (Fig. 4).

Particular points regarding the uses and limitations of tomography are discussed in the appropriate sections.

## THE OESOPHAGUS

In suspected cases of bronchial carcinoma examination of the barium-filled oesophagus at flouroscopy may give valuable information if a study is made of:

- (A) Lateral oesophageal movement with respiration.
- (B) Deformity of oesophageal outline due to extrinsic pressure.

### LATERAL OESOPHAGEAL MOVEMENT WITH RESPIRATION.

If bronchial stenosis is present, the mediastinum swings towards the affected side on inspiration and away from it on expiration (Holzknecht-Jacobson sign, quoted by Kerley, 1951). This is a well-recognized phenomenon but may be difficult to detect at screening unless a main bronchus is almost completely occluded and mediastinal movement is pronounced. When mediastinal swing is slight, the heart may move across very little with respiration and this is not easily seen on the screen. Cardiac pulsation and respiratory movements add confusion. The lower half of the oesophagus, on the other hand, being freely mobile in its surrounding tissues is a much more sensitive indicator of mediastinal movement and I have tried to assess its value in the detection of bronchial stenosis.

From a study of many hundreds of barium meal examinations it became apparent that the normal oesophagus shows no lateral movement with respiration. Very occasionally deep inspiration produces up to  $\frac{1}{2}$  cm. displacement to the left in the lower oesophagus. Twelve physiotherapists with excellent diaphragmatic excursion were also examined and none showed any lateral oesophageal movement on deep breathing or sniffing.

Provided that diaphragmatic excursion is approximately equal on the two sides and there are no pleural changes, the presence of

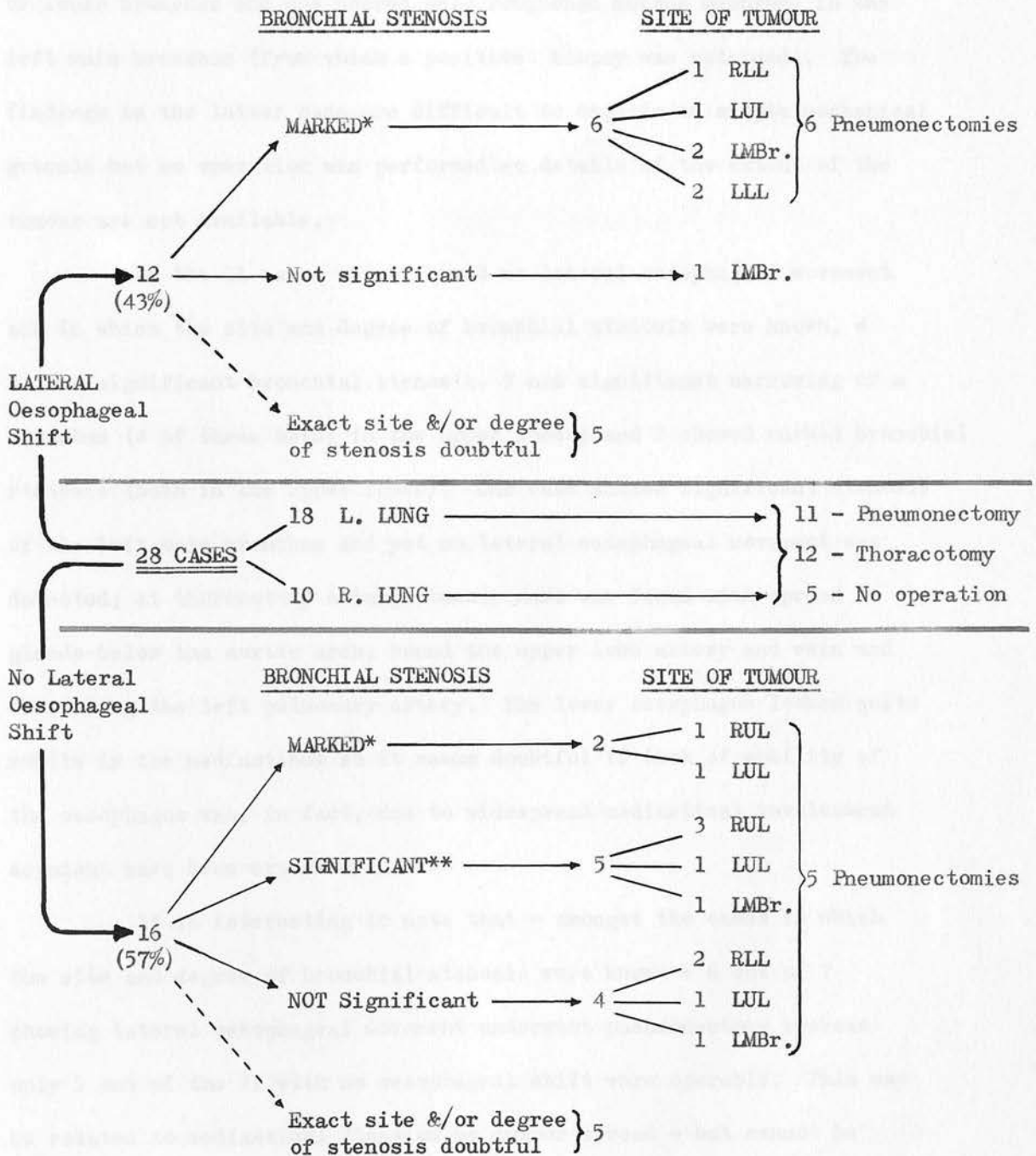
lateral oesophageal shift on respiration indicates deficient aeration of one lung with the oesophagus moving towards the abnormal side on inspiration. Sniffing produces a more sudden deviation of the oesophagus, easier to see at screening than the more gradual movement which occurs on deep inspiration. Obviously this shift may occur when any lesion, such as a lobar collapse, decreases the efficiency of one lung and it provides no further help if unilateral lung or pleural disease is obvious on plain radiographs. When, however, pathology is confined to the lumen of one of the main bronchi this sign, simple to elicit, may be of considerable help in reaching a diagnosis of bronchial stenosis. It is especially useful in the detection of inhaled foreign bodies in children and endobronchial tumours in adults when there is no more than questionable enlargement of one hilar shadow on plain x-rays. Convincing films are difficult to obtain because, when the patient sniffs, oesophageal movement is sudden and momentary. Only on screening are the movements really impressive.

#### Personal findings.

Twenty-eight cases of subsequently proved bronchial carcinoma whose plain x-rays (P.A. and lateral) showed only varying degrees of enlargement of one root shadow and no abnormal appearances in the lungs or pleura were examined with regard to the lateral movement of the lower half of the barium-filled oesophagus on sniffing (Table 8).

In 18 cases it was possible to prove the exact site and degree of bronchial stenosis by bronchoscopy or examination of the excised lung. In the descriptions which follow, "marked" bronchial stenosis indicates that the bronchial lumen was estimated at less than half its normal size and "significant" stenosis that it was more than half its normal size but still obviously narrowed. Seven cases (in which the site and degree of bronchial stenosis were known) showed lateral oesophageal movement

TABLE 8 - ANALYSIS OF 28 CASES OF BRONCHOGENIC CARCINOMA EXAMINED FLUOROSCOPICALLY FOR THE DETECTION OF LATERAL SHIFT OF THE OESOPHAGUS WITH RESPIRATION



\* MARKED stenosis = Bronchial lumen estimated at less than half its normal size  
 \*\* SIGNIFICANT stenosis = " " " " more than half its normal size but still appreciably narrowed

with respiration (Figs. 5, 6) and 11 did not. Six out of the 7 cases with lateral shift of the oesophagus showed marked stenosis of a main or lobar bronchus and one showed only roughened mucous membrane in the left main bronchus (from which a positive biopsy was obtained). The findings in the latter case are difficult to explain on simple mechanical grounds but no operation was performed so details of the extent of the tumour are not available.

Of the 11 cases which showed no lateral oesophageal movement and in which the site and degree of bronchial stenosis were known, 4 had no significant bronchial stenosis, 5 had significant narrowing of a bronchus (4 of these being in the upper lobes) and 2 showed marked bronchial stenosis (both in the upper lobes). One case showed significant stenosis of the left main bronchus and yet no lateral oesophageal movement was detected; at thoracotomy a large tumour mass was found with spread to glands below the aortic arch, round the upper lobe artery and vein and encircling the left pulmonary artery. The lower oesophagus looked quite mobile in the mediastinum so it seems doubtful if lack of mobility of the oesophagus was, in fact, due to widespread mediastinal involvement as might have been expected.

It is interesting to note that - amongst the cases in which the site and degree of bronchial stenosis were known - 6 out of 7 showing lateral oesophageal movement underwent pneumonectomy whereas only 5 out of the 11 with no oesophageal shift were operable. This may be related to mediastinal fixation by tumour spread - but cannot be used as a prognostic sign for many patients with extensive mediastinal (and lung) involvement show considerable deviation of the oesophagus to the affected side on inspiration.

Bronchoscopic biopsy was positive in 9 out of the 12 cases with lateral oesophageal movement and in 11 of the 16 with no oesophageal

shift.

The presence of lateral oesophageal displacement on sniffing may be of considerable diagnostic value in the initial investigation of the enlarged hilar shadow and suggests that bronchial stenosis is present. It is much more likely to occur when the tumour arises in a main or lower lobe bronchus rather than in the bronchus to an upper lobe. Positive findings are helpful, negative findings of no significance.

#### DEFORMITY OF THE OESOPHAGUS DUE TO EXTRINSIC PRESSURE.

Most modern textbooks mention that mediastinal spread from a bronchial carcinoma may produce pressure on the oesophagus but they fail to emphasize how commonly this occurs, how easily it is detected and how valuable it is in the diagnosis and management of the case (Middlemass, 1953). According to Simon (1953) changes in the oesophageal outline in cases of bronchogenic carcinoma are "not common". Fleischner (1952) recorded oesophageal deformity in bronchial neoplasm in an unspecified number of cases but did not show how extensive the abnormalities were on plain films or give any details as to the clinical condition of the patients.

The mediastinum is the favourite site of spread from bronchial carcinoma and so deserves our initial and most careful attention in the detection of metastases. Willis (1948) found that 76 out of 84 fatal cases showed tumour deposits in the mediastinal or hilar glands and Ochsner and DeBaKey (1942) noted spread to regional lymph nodes in 72.2% of 3,047 collected cases of bronchogenic carcinoma.

The pulmonary lymphatics are widely connected with each other and have no lobar barriers (D'Abreu, 1953). The glands which will be involved by a carcinoma arising in a given anatomical site cannot be predicted with certainty, no matter how thoroughly the normal lymphatic

pathways are understood (Gladnikoff, 1948). This, presumably, is due to variations in the anatomy of the lymphatic system, anastomoses between the different lymphatic channels or the blocking of one pathway producing an abnormal route of subsequent drainage.

The oesophagus lies loosely in the posterior mediastinum, accomodating itself to its surroundings and is easily displaced by pressure from any tissue adjacent to it, be it cardiovascular, mediastinal or pulmonary in origin. For this reason the oesophagus acts as an excellent means of assessing the presence of changes in the otherwise relatively inaccessible posterior mediastinum. Mediastinal changes, unless they are fairly gross, are not obvious on plain P.A. or lateral films. The growth itself, if near the medial aspect of the lung, or a metastatic glandular mass in the posterior mediastinum which is often much bigger than the primary tumour itself, may distort the oesophagus to varying degrees.

The screening examination of the oesophagus is carried out after scrutiny of plain films and noting the position of the lesion under investigation so that special attention may be given to likely sites of oesophageal abnormality, bearing in mind that most positive findings occur in the P.A. and L.A.O. positions and less often in the R.A.O. The oesophagus should be examined both with its lumen maximally distended by barium paste and with it in a relatively collapsed state; the former is useful to show abnormal impressions due to glands or a tumour mass which are not in direct contact with the oesophagus, but yet sufficiently near to affect it when it is ballooned out. On the other hand, a minimal abnormal impression confined to one aspect of the oesophagus may be obscured by a well-distended lumen and examination with the oesophagus only partially filled with barium is necessary. Varying degrees of oesophageal distention are easily obtained by examination during inspiration (narrower oesophagus) and expiration (wider oesophagus). Mediastinal shift towards a collapsed lobe

or lung may make an otherwise difficult to detect oesophageal deformity much more obvious (Figs. 12, 28).

Distortion of the oesophagus varies from very obvious, gross displacement to much less apparent changes. In the screening examination, provided no marked oesophageal displacement is seen, a localized, extrinsic oesophageal abnormality is sought. It is important that the deformity should be localized because accompanying conditions such as a collapsed lobe or pleural effusion may produce a more generalized, gentle curving of the oesophagus in one or other direction.

When an undiagnosed chest lesion in the cancer age group is being investigated and the oesophagus shows a normal or doubtfully abnormal appearance, it may be useful to take one or two appropriate views of the barium-filled oesophagus, so that, should follow-up or re-investigation be necessary, slight changes which may have developed in the oesophageal contour can then be more easily recognized (Figs. 7, 8).

Before embarking on the detection of abnormalities of oesophageal outline, especially those of lesser degrees, it is essential to become familiar with the normal variations and changes due to an unusual course of the thoracic aorta. An unfolded aortic arch, often associated with hypertension in older people, may drag the oesophagus backwards and to the left so that, just below the aortic arch the oesophagus, in the L.A.O. position, may take a sudden curve posteriorly. This may be a slightly confusing appearance when evidence of enlarged subcarinal glands is being sought but differentiation should not be difficult because oesophageal distortion due to an unfolded aortic arch (a) begins 1-2 cm. higher, (b) involves a longer segment of oesophagus, (c) shows pulsation transmitted from the aorta and (d) the aorta is obviously unfolded.

Mucklow and Smith (1954) drew attention to the variability in the point at which the descending aorta crosses behind the lower oesoph-

agus and in the degree of anterior displacement of oesophagus at this level. Some of these anomalies may resemble extrinsic pressure on the oesophagus by tumour or glands but the course of the descending aorta can be traced on screening and films towards the segment of compressed oesophagus, transmitted pulsation is present in the oesophagus at the site of compression (Figs. 9, 10) and the patients are usually elderly.

Carcinoma of the trachea is extremely rare but may spread to involve oesophagus (Maier, 1956). The symptomatology - with the exception of wheezing as an early and striking feature - may resemble that of bronchial carcinoma so this remote possibility should be kept in mind if bronchoscopy has not yet been performed.

When it is established that oesophageal deformity is due to extrinsic pressure but no pathological proof of bronchial carcinoma is available, it is possible that some other condition associated with a mass or lymphadenopathy in the posterior mediastinum is responsible for the x-ray appearances. Abnormalities due to extrinsic pressure at the upper end of the oesophagus are most often due to intrathoracic goitre (Fig. 11) or vascular anomalies such as right-sided aortic arch or aberrant left subclavian artery. Relatively common conditions which may produce enlarged subcarinal glands are Hodgkin's disease and carcinoma of the oesophagus. In bronchiectasis the subcarinal glands are often found at operation to be considerably enlarged but I have examined the oesophageal outline in 25 such cases (ages 8 - 29 years) in which obvious lymphadenopathy was present at operation and found no evidence of oesophageal compression from enlarged subcarinal glands such as occurs in bronchial neoplasm. Radiologically demonstrable lymphadenopathy seems to be extremely rare in purely inflammatory lung disease, with the exception of primary tuberculosis and fungus infections. Actinomycosis, though rare, is the commonest of the latter to occur in this country.

According to Lodge (1956) the affected glands in primary tuberculosis usually lie in the anterior mediastinum and pressure effects on the oesophagus are rare. It is difficult to see why the distribution of glandular involvement should be such when primary tuberculosis can occur at any site in either lung. Garamella, Stutzman, Varco and Jackson (1955) recorded 3 cases of oesophageal compression from subcarinal granuloma and were able to find 36 others in the literature. The majority were thought to have been tuberculous. Only a few complained of dysphagia or had normal plain chest x-rays; in the majority a mass was visible nearby on plain radiography.

Any space-occupying lesion near the mid-line in the posterior mediastinum may compress the oesophagus and some uncommon examples have been recorded. D'Abreu (1953) mentioned a neurofibroma in a male, aged 20, which was compressing a bronchus and producing an area of chronic suppurative pneumonia in the right upper lobe. Crowe and Muldoon (1951) recorded a case of thoracic chordoma in a male, aged 30, which was compressing both the oesophagus and trachea from directly behind and producing some dysphagia. Langton and Laws (1954) reported extrinsic pressure on the left side of the oesophagus 2-3 inches above the diaphragm as the first sign of metastases from a pancreatic carcinoma. Asymptomatic smooth muscle tumours of the oesophagus may have the appearance of submucosal tumour or of extrinsic pressure on the oesophagus (Johnston, Claggett and McDonald, 1953).

If oesophageal deformity due to extrinsic pressure is present, appraisal of the patient's age, clinical history and full radiological picture will seldom fail to suggest whether or not a primary carcinoma of lung is likely.

#### Personal findings.

200 consecutive cases of histologically proved bronchial car-

cinoma were examined with a view to detecting the incidence of abnormality of the oesophageal contour. These were patients referred to the Thoracic Surgical Centre and were at least possible subjects for surgical treatment inasmuch as the clinical findings did not suggest inoperability or the presence of metastases and plain x-rays showed no evidence of superior mediastinal lymphadenopathy. (Examination of the barium-filled oesophagus gives no useful information when extensive lymphadenopathy is apparent on the plain films, but it is a useful study to examine some of these cases if one is not familiar with the deformities of the oesophagus which may be produced and, with experience, lesser degrees of the same type of abnormality become more easily recognizable.)

Of the 200 cases (91 in the right lung, 109 in the left) 59 (29.5%) showed oesophageal deformity of varying degrees. None complained of dysphagia, showed a hold-up in the flow of barium above the affected segment or evidence of oesophageal mucosal involvement. All except 9 had had symptoms for less than 3 months.

Extrinsic pressure on the oesophagus must be fairly marked to produce dysphagia because the oesophagus is so elastic and freely mobile in the mediastinum. This symptom is most likely to appear when the compressing agent begins to surround the oesophagus or to invade the oesophageal mucosa. Gootnick (1949) could find only 7 cases in the literature of dysphagia due to oesophageal compression from an enlarged left atrium.

Oesophageal compression deformity was found most frequently in the P.A. and L.A.O. positions (Table 9). The frequency of positive results in the P.A. position is due to the fact that the oesophagus is easily affected by changes spreading from either lung whereas in the oblique positions (particularly the L.A.O.) the oesophagus is compressed much more frequently by lesions in the right than in the left lung. If

TABLE 9 - SITE OF PRIMARY TUMOUR AND POSITION IN WHICH OESOPHAGEAL DEFORMITY WAS DETECTED IN 59 CASES OF BRONCHOGENIC CARCINOMA

SITE of PRIMARY	No. of CASES	POSITION showing OESOPHAGEAL DEFORMITY		
		P.A.	L.A.O.*	R.A.O.*
RUL	5	1	1 (ant.)	3 (1 ant.) (2 post.)
RMBr.	13	8	3 (ant.)	5 (post.)
ML	5	-	5 (ant.)	-
RLL	17	6	9 (ant.)	5 (post.)
LMBr.	3	2	1 (post.)	-
LUL	9	5	3 (ant.)	2 (ant.)
LLL	7	5	3 (2 ant.) (1 post.)	1 (ant.)
TOTALS	59	27	25	16

\* (ant.) or (post.) indicates whether deformity appeared on anterior or posterior wall of oesophagus in the oblique views.

only carcinoma of the right lung is being considered, the L.A.O. position yields a higher proportion of positive findings than does the P.A.

In each position certain appearances are common and more or less characteristic as a result of enlarged mediastinal glands compressing the oesophagus and, in addition, the enlarging tumour mass in the lung may compress the oesophagus directly, particularly if a lower lobe is involved.

In the P.A. position the oesophageal deformity usually takes the form of a localized indentation from the side in question at the site of adjacent tumour or involved glands (Figs. 12, 13). In left upper lobe tumours the R.A.O. position sometimes shows equivocal appearances at the level of the carina which, in the presence of a known carcinoma, may be suggestive of glandular compression of the oesophagus. Variations in the course of the normal oesophagus at the level of the pulmonary artery and left main bronchus frequently make interpretation difficult in this position and the P.A. is often of considerable help in these cases (Fig. 14)

because the normal appearance is more constant, the oesophagus usually curving gently to the left or running straight downwards after it has passed the aortic arch. The tendency of the oesophagus to run to the left again at this level is increased when any collapse is present on the left side so that abnormal impressions on this side of the oesophagus are more easily detected (Fig. 12).

The R.A.O. position, although the one recommended by Kerley (1951), is the least likely to show oesophageal deformity; it provided positive findings on 16 occasions as compared with 25 in the L.A.O. and 27 in the P.A. positions. When an abnormality is present, if the carcinoma is in the right lung, the oesophagus is nearly always encroached on from behind (Fig. 15) - this occurred in 12 out of 13 right-sided carcinomata and in the 3 left-sided lesions the oesophagus was compressed from the front (Fig. 16).

Carcinoma of the middle or right lower lobe is more likely to show oesophageal abnormality in the L.A.O. (Fig. 17) than in any other position and enlarged subcarinal glands - clearly but less simply demonstrated by tomography (Fig. 18) - produce a very characteristic, crescentic impression on the front of the oesophagus, its upper limit usually coinciding with the level of the tracheal bifurcation (Figs. 19, 20, 21). When the primary tumour is in the right upper lobe, evidence of extrinsic pressure on the oesophagus in the L.A.O. position is much less common (Fig. 22). Only if glandular enlargement is gross is the posterior wall of the oesophagus pushed backwards in addition. Anterior deformity is the one commonly found in the L.A.O. position and in only 2 cases has a posterior deformity of the oesophagus been seen - one in an extensive carcinoma arising in the left main bronchus and the other in a carcinoma of the left lower lobe bronchus (Fig. 23).

Oesophageal deformity is usually visible in only one position

TABLE 10 - NINE CASES WHICH SHOWED OESOPHAGEAL DEFORMITY IN MORE THAN ONE POSITION

SITE of PRIMARY	No. of CASES	POSITIONS showing OESOPHAGEAL DEFORMITY
RMBr.	3	P.A. & R.A.O.
RLL	3	<ul style="list-style-type: none"> <li>— P.A. &amp; R.A.O.</li> <li>— P.A. &amp; L.A.O.</li> <li>— R.A.O. &amp; L.A.O.</li> </ul>
LUL	1	P.A. & R.A.O.
LLL	2	<ul style="list-style-type: none"> <li>— P.A. &amp; L.A.O.</li> <li>— P.A. &amp; R.A.O.</li> </ul>

but 9 out of 59 cases showed it in more than one view, usually the P.A. and one of the obliques (Table 10).

Although in the series of 200 cases examined there were 91 right-sided and 109 left-sided growths, 40 (68%) of the 59 positive results occurred in tumours of the right lung. Nineteen of the cases examined had a peripheral carcinoma but none showed evidence of oesophageal deformity. Forty (43%) of the 91 right-sided and 19 (17%) of the 109 left-sided tumours produced oesophageal deformity. This is no doubt due to the lymphatic extensions to mediastinal glands being more extensive on the right side and the aggregations of glands on this side being bigger. The glands also lie closer to most right-sided tumours than they do to similar lesions on the left side, the longer left main bronchus deviating farther from the mid-line than does the shorter right bronchus (Fig. V.)

Except insofar as one can say that carcinoma of the right lower or middle lobe is more likely to produce oesophageal deformity than a tumour arising at other sites in the lung, it does not seem possible to predict with any useful degree of accuracy from the plain films which cases will show oesophageal deformity and which will not. Oesophageal

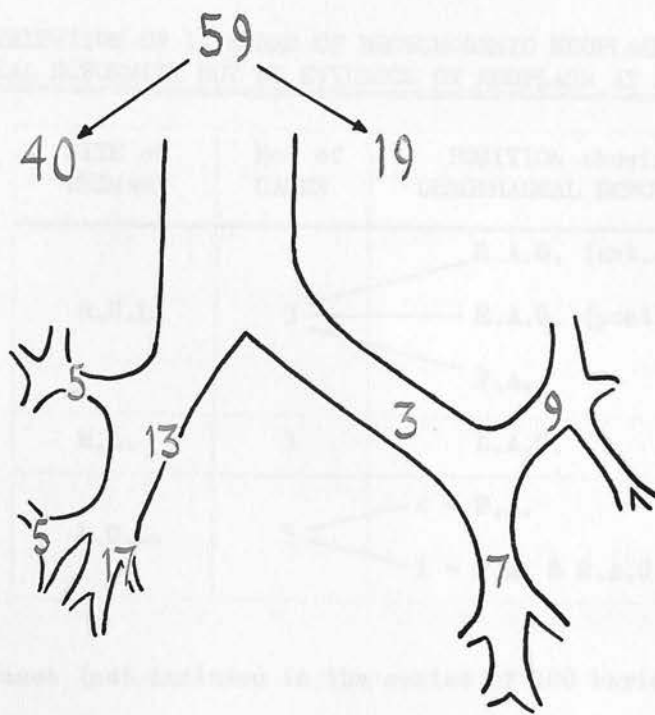


Fig. V - Diagram showing site of primary tumour in 59 cases of bronchial carcinoma which produced extrinsic pressure deformity of the oesophagus.

deformity is not infrequently present when there is relatively little to see on plain x-rays, the changes being predominately in the mediastinum.

The finding of a compression deformity of the oesophagus in a suspected or proved case of bronchial carcinoma can provide useful information as regards (A) Diagnosis, (B) Prognosis.

(A) DIAGNOSIS.

In 11 (19%) of the 59 positive cases bronchoscopy showed no evidence of neoplasm, the tumours being beyond the range of bronchoscopic vision in the middle or upper lobes (Table 11). Bronchography was performed in all the upper lobe and one of the middle lobe cases but before this was carried out, the oesophageal findings in conjunction with an intrapulmonary shadow and the clinical history enabled an almost certain diagnosis of carcinoma to be made. In 2 cases no abnormality was present on plain films of the chest at the time of the positive barium swallow but segmental collapse in one and right lower lobe collapse in the other had been visible several days previously.

TABLE 11 - DISTRIBUTION OF 11 CASES OF BRONCHOGENIC NEOPLASM WITH OESOPHAGEAL DEFORMITY BUT NO EVIDENCE OF NEOPLASM AT BRONCHOSCOPY

SITE of PRIMARY	No. of CASES	POSITION showing OESOPHAGEAL DEFORMITY
R.U.L.	3	R.A.O. (ant.) R.A.O. (post.) P.A.
M.L.	3	L.A.O.
L.U.L.	5	4 - P.A. 1 - P.A. & R.A.O.

Two cases (not included in the series of 200 barium swallows) with a bronchoscopically obvious neoplasm at the main carina but with a normal chest x-ray showed definite evidence of subcarinal lymphadenopathy compressing the oesophagus. Both were bronchoscoped on account of haemoptysis.

Although examination of the barium-filled oesophagus can hardly be described as a measure of major diagnostic value in the majority of cases at a thoracic surgical centre where full investigations are carried out in each case, in the general hospital, where bronchoscopy and even bronchography are not so readily performed, the finding of an appropriate oesophageal deformity in a case suspected of having a bronchial carcinoma may be of great diagnostic help (Fig. 24). Moreover, a higher proportion of rapidly spreading anaplastic tumours with an increased incidence of oesophageal deformity can be expected in a general hospital than in a thoracic centre where there is considerable selection of cases.

Even after tomography and bronchoscopy it is sometimes difficult to distinguish an aneurysm of the aortic arch from superior mediastinal lymphadenopathy due to bronchial carcinoma - especially since left upper lobe collapse may be due to pressure on the bronchus from an aneurysm or



a large heart shadow may be the result of pericardial invasion by carcinoma. However, if a carcinoma is present it is probable that, with the mediastinal glands extensively invaded, the subcarinal glands are also involved, producing the typical oesophageal deformity in the L.A.O. position much lower down than the obvious mass at the level of the aortic arch (Fig. 25). As with oesophageal deformity in other cases of bronchial carcinoma only positive results at barium swallow are of value, negative findings contributing nothing to the diagnosis.

When an upper lobe is collapsed, the carina - seen both bronchoscopically and tomographically - becomes broadened; retraction of the upper lobe draws the main bronchus on the affected side upwards. Since bronchoscopy is often otherwise negative in these cases, it may be difficult to decide whether the carinal deformity is due only to the upper lobe atelectasis or to pressure from subcarinal lymph node metastases. A positive barium swallow in these circumstances suggests the latter.

Two cases (not included in the series of 200) are quoted to show how oesophageal deformity may provide diagnostic information in neoplastic conditions:

(1) Female, aged 31, small, poorly developed and with a low I.Q. had a history of cough and sputum with occasional haemoptyses since childhood and increasing dyspnoea with loss of weight for 2-3 months. Plain x-rays showed collapse of the left lung with considerable mediastinal herniation of the right lung (Fig. 26). In view of the patient's poor physique and long history of chest trouble it was thought that she might have a long-standing collapse or agenesis of the lung (but there were no congenital anomalies of the spine or ribs). Barium swallow showed that, although the oesophagus had travelled to the left along with the mediastinum, its mid-portion was apparently prevented by extrinsic pressure from moving as far across as occurs in simple atelectasis or absence of one lung (c.f. Fig. 27). Bronchoscopy showed an anaplastic carcinoma

in the left main bronchus.

(2) Female, aged 67, with Hodgkin's disease in whom barium swallow gave the first - and for several months the only - indication of lymphadenopathy anywhere in the body (Fig. 29).

(B) PROGNOSIS.

Thoracotomy was performed on 17 of the 59 patients who had some extrinsic pressure deformity of the oesophagus because it was felt that the oesophageal changes were slight and that an operable growth might be found (5 of the 17 patients were under 40 years of age). Sixteen of these were inoperable because of the extent of mediastinal spread. Inoperability was not always directly due to the extent of the glandular or tumour mass compressing the oesophagus but sometimes to other ramifications of the neoplasm. One case with a middle lobe carcinoma and a negative bronchoscopy showed characteristic subcarinal pressure deformity of the oesophagus in the L.A.O. position and a middle lobectomy was performed on what was thought, at operation, to be a benign condition; there was a small anaplastic carcinoma in the excised lobe and one gland removed at operation was found to be involved by tumour. (The patient refused any further treatment.)

Compression deformity of the oesophagus apparently has a high degree of reliability as a sign of inoperability. The detection of this abnormality is important since it may spare the patient an unnecessary major surgical operation. According to Fulton (1949): "The surgeon must, so far as possible, refrain from opening a chest when the probability of his being able to proceed to radical surgery is seriously in doubt, since, in such a case, the chances of effective treatment by radiotherapy are delayed and seriously jeopardized."

Liebow (1955) states that the radiological demonstration of enlarged subcarinal glands cannot be interpreted as an inevitable sign

of a bad prognosis since lymphadenopathy may be entirely secondary to pneumonitis. Whilst acknowledging that many of the enlarged subcarinal glands seen in operative or autopsy specimens of bronchial carcinoma are the seat of purely inflammatory changes I submit that in none of my cases with deformity of the oesophagus due to enlarged glands was the lymphadenopathy due to inflammatory reaction only. As stated earlier (p.44), although subcarinal lymphadenopathy is common in bronchiectasis, oesophageal compression was not found in any of 25 cases examined radiologically.

According to Holmes Sellors (1955): "Oesophageal obstruction resulting from pressure of enlarged glands is suggestive of inoperability, but not always". This, again, is contrary to the results in my series, in none of which was obstruction even imminent when oesophageal compression was first seen. By the time that actual oesophageal obstruction is present (Fig. 8 C), usually a few months later, the pathological changes in the mediastinum are obviously so advanced that the possibility of a resectable growth being present seems remote.

Decrease in size of the tumour or glandular mass in the mediastinum as a result of radiotherapy is readily observed in serial studies of the oesophagus (Figs. 21, 30).

The histological type of the tumour in 59 cases with oesophageal deformity was anaplastic carcinoma in 40, epidermoid in 17 and adenocarcinoma in 2. In the series of 500 cases of bronchial carcinoma which were subjected to operation, epidermoid carcinoma was present in 330 and anaplastic carcinoma in 158. The reversal of the ratios of anaplastic to epidermoid carcinoma in the two groups illustrates the tendency of the anaplastic tumour to spread rapidly with the formation of large glandular deposits which compress the oesophagus.

#### CONCLUSIONS.

- (1) Lateral oesophageal shift with respiration is - in the absence

of other gross radiological abnormality - a useful sign of broncho- stenosis.

(2) Deformity of the oesophagus due to extrinsic pressure from metastatic glands or the tumour mass itself (most frequently anaplastic carcinoma) occurred in more than 1 out of 4 cases of bronchial carcinoma.

(3) Oesophageal deformity is most often seen in the P.A. and L.A.O. positions and tumours arising in the middle and right lower lobes are most likely to produce it. No example of this abnormality was found in association with a peripheral carcinoma.

(4) Positive findings at barium swallow, along with the clinical history and full radiological picture, are of diagnostic value when bronchoscopy is negative, as is not infrequent in middle and upper lobe tumours.

(5) As a radiological sign, compression deformity of the oesophagus in a case of bronchial carcinoma has a high degree of reliability in indicating inoperability.

(6) The majority of cases of bronchial carcinoma show no evidence of oesophageal deformity, therefore the absence of this sign has little diagnostic or prognostic significance.

(7) There is no evidence that glands which are the site of purely inflammatory change can produce radiologically demonstrable oesophageal compression in cases of bronchial carcinoma.

### EARLY DETECTION

Carcinoma of the bronchus can produce such an infinite variety of clinical and radiological pictures that inevitably many cases are misdiagnosed as benign conditions for varying lengths of time. The presence of pre-existing inflammatory disease greatly increases the difficulties.

Overholt (1951) described bronchogenic carcinoma as the most easily detectable of all internal malignant tumours and believed that because of this there should be a higher cure rate in bronchogenic than in other carcinomata. This optimistic view is not in accord with the known, unpredictable pathological course of these tumours and Davidson (1951) quoted the depressing but realistic figure of at least 75% as the proportion of cases in which there was - or subsequently turned out to be - no hope of cure when the patient was first seen. Resection was possible in only 10% of 2,312 cases reviewed by Allison (1955).

Most textbooks, until very recently, were more out of date in their descriptions of the symptomatology of bronchial carcinoma than of almost any other disease and, as Davidson (1954) pointed out, if cases are to be detected early we must hold a concept of the disease different from that described by the majority of authors.

The exact duration of symptoms is often difficult to assess but they may be present for a considerable time before a correct diagnosis is made. Mason (1949) reviewed 1,000 cases of bronchial carcinoma and found that the average duration of symptoms before admission to hospital was 8.4 months and, of this, 5 months were due to delay by the patients' doctor. It is unlikely that such discouraging figures would still exist to-day in the presence of propaganda regarding the disease, an increased awareness of it by doctors and patients alike and widespread mass x-ray campaigns. Table 1 (p. 7) shows the length of history in 23 cases of bronchial adenoma seen at the same centre and overlapping in time those

carcinomata reviewed by Mason. The much longer interval between onset of symptoms and eventual diagnosis in most cases is noteworthy - an average of over 5 years. Again, this figure is likely to be considerably reduced now that mass x-ray campaigns are run on a bigger scale and bronchoscopy is more readily employed in obscure lung conditions.

Taylor and Waterhouse (1950) found an average duration of symptoms of 4.4 months in several thousand collected cases of bronchial carcinoma and Edwards (1954), commenting on 38 cases seen in Liverpool, found that 26 consulted their doctors within 8 days of the onset of symptoms, the remainder being of the type who seek medical advice only as a last resort. There was an average of 8 weeks between the first visit to the doctor and a chest x-ray being taken.

Physical examination, the usual keystone of diagnosis, is of no value in the detection of early cases (Rigler, O'Loughlin and Tucker, 1953) because, by the time clinical signs are present, the disease is likely to be fairly advanced. Symptoms are often slight and occur relatively late in the disease; Rigler et al. found that x-ray signs preceded the first symptom by an average of 7.8 months in 37 non-operated cases, but the radiological changes were only seen in retrospect in many of them. In 13 operated cases the discrepancy between x-ray signs and first symptoms altered to 17.0 months, suggesting that in patients selected for surgery the disease was either silent longer or was more favourable for early x-ray diagnosis (or both) by an interval of 9.2 months. The time intervals in some cases may have been considerably longer for, in all those under consideration, the first film had been taken fortuitously.

It is evident that, at the present time, routine x-ray examination is the only applicable method for the early detection of lung tumours; the possible value of exfoliative cytology in this field awaits further investigation. Guiss (1952), in a survey of 1,867,201 people in Los Angeles,

found 3,500 "suspects" who were investigated and 144 cases of bronchogenic carcinoma were confirmed; 57% were subjected to thoracotomy and 47% underwent resection. This is a high operability rate amongst those which were explored surgically but indicated a yield of only 1 resectable case for every 27,458 x-rayed so that the cost of the entire undertaking was obviously enormous, quite apart from the investigation of the remaining 3,356 "suspects".

Boucott and Sokoloff (1954) reviewed a series of 142,156 people who had been mass x-rayed in Philadelphia and found an incidence of proved cases of bronchogenic carcinoma of 30/100,000. Only 7 out of 77 cases discovered by this method were truly asymptomatic and 27 had already sought medical advice. The resection rate was 29% and only 18% survived 6 years.

According to Gianturco (1950) 75% of bronchogenic carcinomata arise in the lumen of a large bronchus and can be diagnosed by bronchoscopy, bronchography or cytological examination of the sputum long before x-ray changes are present.

Before a lung segment or lobe collapses there may be a small area of ill-defined lung shadowing due to retained secretions and infective changes which not infrequently resembles tuberculosis or a simple inflammatory lesion (d'Abreu, 1953). Rigler et al. (1953) have given considerable attention to the early x-ray signs of bronchogenic carcinoma. An analysis of their 50 cases which had been fortuitously x-rayed previously showed that the earliest changes observed were:

- (1) In 48% - unilateral enlargement of the hilar shadow.
- (2) In 38% - a nodular shadow in the lung periphery which rarely sheds its cells so that cytological examination of the sputum is seldom positive. It may alter little in appearance over many months but gradually increases in size concentrically and tends to extend

towards the root, finally producing enlarged glands at the hilum.

- (3) In 6% - a solitary abscess or cavity in the lung parenchyma which often sheds malignant cells into the sputum.
- (4) In 8% - obstructive emphysema of a segment, lobe or even the whole lung (see p. 71).
- (5) An area of infiltration along a vascular trunk or minimal, linear atelectasis is rare.

Early radiological signs of bronchial carcinoma may be so slight or so similar to the normal variations in the size of the hilar shadows that mistaken interpretation of x-rays at this stage is not uncommon. Boucott and Sokoloff (1954) reviewed the immediately previous films which had been reported as normal in 22 cases of bronchogenic carcinoma picked up in a mass x-ray campaign and found that 11, in retrospect, had been abnormal. Rigler et al. (1953), reviewing 50 cases of carcinoma all of whom had been fortuitously x-rayed previously, found that half of them had shown a unilateral enlargement of one hilar shadow which had not been interpreted as significant. They emphasized that this is the most commonly overlooked early sign of carcinoma and found that the critical judgement of an expert is a much more practical and reliable method of diagnosis than careful measurements of the hilar shadows and comparison with a known range of supposedly normal values. Even though enlargement of the hilar shadow is due to extension of a tumour in the bronchus to peribronchial tissues and glands it may, nevertheless, be a very early radiological sign of bronchial neoplasm and does not necessarily imply that surgical removal is likely to be unsuccessful, as was suggested by Lodge (1950). Therkelsen and Spørensen (1953), however, reviewing 329 cases, found an operability rate of 26.7% in cases showing atelectasis as the predominating x-ray appearance in comparison with 13.5% in those with hilar enlargement.

Although detection of bronchial carcinoma as early as possible is obviously desirable, it should be remembered that clinically and radiologically "early" cases are not necessarily early from a pathological point of view. Boucott and Sokoloff (1954) found that the prognosis in 77 cases discovered in a survey of 142,156 people was no better than that of non-survey cases. Buchberg, Lubliner and Rubin (1951) suggested that the most favourable cases for operative treatment were those with symptoms for 6 months to a year and no evidence of secondaries because they found that patients who had had symptoms for more than 6 months prior to diagnosis lived longer than those with an abrupt succession of symptoms leading to early diagnosis. This is similar to the experience of d'Abreu (1953) who emphasized that the slowly growing tumour with a long history often had a better prognosis than the much more rapidly growing neoplasm of short duration.

In America it is frequently suggested that routine chest x-rays of people in the cancer age-group should be taken at stated intervals in order to detect early lesions and Ochsner (1953) would like heavy smokers over the age of 40 to have a chest x-ray every 3-6 months. This seems highly impractical and, since transient lung shadows are not uncommon with minor respiratory infections, the number of unnecessary diagnostic problems created would be enormous. Difficulties arise when a small peripheral shadow (1-2 cm. in diameter) is found in an asymptomatic individual. It is often "watched" for some time because thoracotomy appeals neither to the patient nor to the surgeon when symptoms are completely lacking and there is only an ill-defined shadow somewhere in the lung. When the period of "watching" is past, the objective of the scheme for early detection has been lost; this, inevitably, is what happens so often in practice. When the lesion is bigger, 4 cm. or more in diameter, there is less likely to be delay in surgical exploration.

Carcinoma may produce a radiological appearance very similar to tuberculosis and Simon (1952) warned against the danger of accepting a diagnosis of pulmonary tuberculosis on x-ray evidence alone. Care is particularly necessary in patients over the age of 40 although tuberculosis is occurring more often in the elderly and carcinoma is more frequently detected in the younger age groups than it used to be. Lutwyche (1954) described 7 cases of carcinoma in which the correct diagnosis between the latter and tuberculosis was not made until "too late" in 5. Overholt (1950), in a study of 849 cases of bronchogenic carcinoma, found that the commonest errors in diagnosis were to mistake carcinoma for tuberculosis if an abnormal shadow were present in the upper half of the lung and to mistakenly diagnose bronchitis, bronchiectasis and atypical or virus pneumonia if the shadowing were in the lower half.

Personal findings.

In the series of 500 cases 24 were first detected at mass x-ray examination (Table 12). In only 3 (0.6%) did mass x-ray examination reveal an asymptomatic carcinoma which was removable at operation. Fifteen out of the 24 cases were inoperable.

TABLE 12 - OPERABILITY IN 24 CASES OF BRONCHOGENIC CARCINOMA FIRST DETECTED AT M.M.R. EXAMINATION

		<u>OPERABILITY</u>
4	- Asymptomatic	→ 3 Resections → 1 Inoperable
4	- Asymptomatic at time of M.M.R. examination but DEVELOPED symptoms by the time correct diagnosis was made (up to 2 years later)	→ 4 Inoperable
16	- Attended M.M.R. unit on doctor's advice, because of feeling unwell, or with more definite symptoms such as weight loss or haemoptysis	→ 6 Resections → 10 Inoperable

X-ray appearances in the 3 asymptomatic, operable cases were 1) collapse of the right lower lobe apical segment, 2) enlarged left hilar shadow and 3) peripheral mass 5 cm. in diameter in the left lower lobe. In the group of 16 cases mentioned in Table 12 mass x-ray examination was used as the most convenient form of investigation either by the general practitioner or by the patient himself and, in the absence of a mass x-ray unit, most of these were likely to have been x-rayed in hospital at the same time or only slightly later.

An additional 8 cases, all with symptoms, were "picked up" at other radiological examinations: 5 at barium meal, 1 at barium enema and 2 at routine chest x-ray.

Mass x-ray examination had thus remarkably little to offer in the field of useful early diagnosis in these 500 cases. Much time was spent on the investigation of large numbers of "suspects", many of whom were caused considerable anxiety. These patients were seen in the early 1950's when mass x-ray campaigns were run on a much smaller scale than that subsequently developed, so the yield of early tumours is considerably less than might be hoped for eventually.

Routine chest x-ray in all hospital admissions over the age of 40 and during out-patient radiological examinations of the gastrointestinal, biliary and urinary tracts provides a satisfactory scheme for early detection. If the patient is in or attending hospital in any case, it is much easier to carry out thorough investigations without causing the undue (and frequently unnecessary) alarm which is such a feature of all mass x-ray campaigns.

The commonest abnormality to be completely "missed" on the chest radiographs of an early carcinoma is slight enlargement and increase in density of the left hilar shadow (Figs. 31, 32, 33); right hilar enlargement less frequently escapes detection (Fig. 34). There are two

main reasons for these errors. First, the inexperienced or careless radiologist fails to notice the slight alteration from the normal appearance. Second, the more experienced observer, aware of the extreme variations in size and shape of the left hilar shadow, allows his personal concept of the normal range to extend beyond safe limits. Careful study of hilar shadows in as many chests as possible - normal or otherwise - is the only way in which the radiologist can gradually increase his reliability in this sphere (Figs. 35, 36, 37). The prominent left hilar shadow due to a carcinoma in this situation can often be distinguished from pulmonary artery by its lack of a smooth, well-defined border; the gentle curve of a pulmonary artery is clearly shown in a very slight L.A.O. position which resembles a bad P.A. view with the patient turned only a few degrees to one side (Fig. 38). The most useful single step in the elucidation of a doubtful hilar shadow is the comparison of recent films with any which have been taken in the past (Fig. 39).

Lateral tomographic cuts are the most reliable means of investigating a root shadow which remains doubtful after good quality P.A. and lateral (and previous) films have been studied (Fig. 3). Screening provides convincing information less frequently but films taken at fluoroscopy in an appropriate oblique position, especially in thin or emphysematous subjects, are occasionally of considerable help. A glandular mass or tumour adjacent to any portion of the aorta will show (transmitted) pulsation on the screen and this may be misinterpreted as due to aneurysm unless lateral tomography is performed (Fig. 40).

Although unhelpful in the early diagnosis of carcinoma, minor degrees of abnormality in the right superior mediastinal shadow are commonly "missed" on plain films - especially in carcinoma of the left lung - when recognition of the true nature of the shadow would enable an earlier and more certain diagnosis of malignancy to be made (Fig. 42).

The early peripheral lesion is not so often "missed" in the same way as the large hilar shadow - unless it is obscured by overlying bone - for an abnormal opacity is frequently observed but interpretation is at fault because "it doesn't look like a carcinoma". The latter erroneous concept, stemming from ignorance of the infinite variations in the pathology of bronchial carcinoma, can be equally misleading in the interpretation of much more gross radiological abnormalities (Fig. 41). The shadow of a small peripheral carcinoma visible on a P.A. film is most easily dismissed as of no significance if it arises:

- (1) In the upper portion of an upper lobe where it may be regarded as an old tuberculous scar (Figs. 42, 43). The early lesion in any part of the lung frequently has the appearance of a small, poorly-defined opacity resembling an old inflammatory focus but when it lies near the apex confusion with old tuberculous disease is most likely to occur.
- (2) In the region of the anterior end of the fifth rib in males (Figs. 44, 45) and lower down in females (Fig. 46) where it may be mistaken for nipple shadow or obscured by overlying breast - though the former should always be checked by having films with a skin marker in position.
- (3) Closely adjacent to cardiac or mediastinal shadows so that it may be confused with vessel markings if the film is not carefully examined (Fig. 47).

Limitations inherent in the diagnostic x-ray method must be recognized. It is not uncommon for thoracic surgeons to find lung nodules - especially in tuberculous cases - 2 cm. or more in diameter which had not been visible on pre-operative radiographs. Similarly, metastases of this size may be found at autopsy when none had been visible radiologically and with nodules of 1 cm. or less in diameter

the margin of error is much greater. A small tumour in a subsegmental bronchus may be completely overshadowed radiologically and on direct inspection at thoracotomy by collapse and inflammatory changes peripherally. Frozen sections cannot help because they would have to be taken from too superficial a part of the lung. Greening and Pendergrass (1954) at the University of Pennsylvania examined 300 patients radiographically before and after death, the post-mortem films including one of the lungs in situ and one of the excised, inflated lungs. Four cases of carcinoma - unfortunately not illustrated - in the form of a solid nodule varying from 2-5 cm. in diameter were found only on the films of the excised, inflated lung and by the palpating hand of the pathologist. These had all been invisible on good quality ante-mortem and post-mortem x-rays of the lungs in situ.

If malignant disease is to be detected at a time when it is still worthwhile, the slightest departure from normality in the lungs or bronchi is suspicious and needs pursuing (Brock, 1943). On the other hand, over-diagnosis of carcinoma in suspected cases is an equally serious error so that the radiologist must try to maintain a balanced outlook on the problem and this is only possible if he enjoys close co-operation with all his colleagues who are concerned in these cases. Unfortunately, minimal x-ray changes do not necessarily imply an early carcinoma since widespread metastases may arise from a minute primary tumour. Conversely, the slow-growing epidermoid tumour may be observed over a considerable period of time without developing metastases.

A particularly unreliable sign in the assessment of peripheral shadows is their rate of alteration in size over a period of time. Lack of growth - even during 2-3 years - does not necessarily indicate that a peripheral lesion is benign. Rigler (1950) recorded a case in which a lung shadow had been present 7 years before the development of symptoms

due to a carcinoma in this site.

The training, experience and ability of the radiologist and a satisfactory environment for film-viewing are of paramount importance. Apart from these factors, the commonest causes of failure to detect early lesions radiologically, as in the investigation of other systems of the body, are probably:

- (1) Carelessness in viewing films
- (2) Failure to take a lateral view
- (3) Substandard radiographs

in that order of frequency. (2) and (3) are avoidable. The hazard due to (1) can be reduced if its importance is recognized. X-rays are not all black or white but of many shades of grey in between (Sosman, 1950). Great care and thoughtful viewing of films are necessary to detect many of the less obvious, early abnormalities. Meaningless reports such as "No mass shown" may produce a false sense of security in the physician's mind and such wording - and thinking - is to be avoided.

Nevertheless, the importance of carelessness and incompetence in viewing films should not be exaggerated. The results of tests to assess the performance of expert radiologists are of considerable interest. Garland (1949) recorded a series of such investigations involving radiologists (usually in groups of three) who were teachers and authorities of international repute. Many hundreds of carefully chosen chest films of different types were employed and constant results were repeatedly obtained. Between two observers there was disagreement in 16% of cases as to whether or not any lesion was present and in 8% the individual radiologist disagreed with himself on re-reading the group of films; two reports had to be totally contradictory before they were regarded as being in disagreement with one another. The performance of individual radiologists varied but, on average, 7% of the positive cases were "missed"

and there was over-reading in 12% of those which were negative. Each radiologist had his own method of examining a radiograph but it is noteworthy that each one used a system of some kind. Some of the conclusions reached in this study were:

- (1) Negative films are more difficult to read correctly than positive ones.
- (2) The main effect of better films is to reduce over-reading of those which are negative.
- (3) "See and judge" simultaneously seemed to produce a larger number of errors than when these two processes were carried out separately.
- (4) A pessimistic attitude of the reader which attributed the worst possible prognosis to each probable lesion resulted in a reduction in the number of misses (10% as compared with 15%) but an increase in the over-reading of negative cases (7% compared with 4.7%).

Garland's report also showed an extraordinary variation of opinion between three experts who were asked to judge the outline of 75 (previously marked) lesions in the lung as either sharp, fuzzy or a combination of the two: in only 51% was there interindividual agreement as to sharpness. Outside observers evidently felt that they could do much better than the experts but further tests showed that they could not.

In nearly every activity which can be tested it has been repeatedly demonstrated that humans, even experts in a given field, exhibit enormous variations in their ability to be consistent with themselves and with others equally competent. Recognition of personal variability makes us more critical of ourselves and more tolerant in the appraisal of others (Garland).

All radiologists have their own "blind spots" and affinities for certain lesions. The individual radiologist can be tested by specially selected groups of films with a view to detecting - and remedying - his

particular weaknesses. When a series of diagnostic errors - made either by an individual or a group of investigators - is reviewed, a pattern of misinterpretation often emerges (as in Table 19, p.109). The radiologist enjoys a unique opportunity - denied the physician or surgeon - of being able to review his material exactly as it was presented to him when an error in diagnosis was made; much can be learned in this way.

A lateral view is essential for the demonstration of lesions close to the mediastinum and those which lie behind the heart shadow or below the level of the diaphragmatic domes as projected on the P.A. film. Møller (1950) stressed the importance of lateral films in the detection of segmental and subsegmental lesions which may show very little on the P.A. view since their long axes are not parallel with the x-ray beam. If an abnormality in the lung is being followed up and a P.A. view only is taken, errors are not uncommon. A reduction in the area of lung opacity may be misinterpreted as improvement or "clearing"; the true state of affairs is apparent on a lateral film - there is increasing atelectasis, which, projected in the P.A. position, cast a smaller shadow than that previously present. Considerably less useful information is provided by the lateral projection when small peripheral lesions, especially those situated subpleurally in the axilla, are being investigated. In these circumstances oblique films to show the lung fields and give a different projection of overlying ribs are often much more helpful.

A collection of films showing the earliest possible abnormality (often seen in retrospect) in proved cases of bronchial carcinoma is very useful. They provide a clear demonstration of the natural history of the disease and a reminder of the extreme difficulties of early detection. Reference to these when new cases occur and addition to them as more are collected may be helpful in the (tentative) diagnosis of other early cases.

The radiologist can only interpret films satisfactorily when

he has a clear mental picture of the possible underlying pathology. If he can see - or preferably, himself dissect - the resected lobe or lung and at the same time view the appropriate radiographs, then a clearer insight into chest x-ray interpretation is readily obtained. Operative specimens are more instructive than autopsy material for, in the latter, disease may be advanced and appearances confused by terminal changes in the lung. In addition, high quality films taken immediately before death are seldom available whereas, in the operative material, radiographs taken a few days or hours previously provide a picture closely resembling that found macroscopically in the actual specimen.

#### CONCLUSIONS

(1) M.M.R. examination revealed an asymptomatic, operable bronchial carcinoma in 0.6% of cases which came to surgery.

(2) Limitations in the radiologist and the radiological method are recognized but suggestions are made with a view to reducing the number of "missed" carcinomata:

- a) Awareness of the commonest errors in diagnosis should enable many of these to be avoided.
- b) Lateral tomography is a useful method of investigating the questionably enlarged hilar shadow.
- c) A collection of films of proved early tumours should be built up and reviewed from time to time. Re-study of diagnostic errors may reveal a recognizable, repetitive pattern of misinterpretation.
- d) A series of test films can be used to detect the "blind spots" of radiologists. Knowledge of his particular weaknesses should enable the radiologist to reduce the number of mistakes he makes.
- e) Comparison of resected specimens with pre-operative radio-

graphs promotes a clearer understanding of x-ray interpretation.

(3) Great experience and care are necessary to minimize under- and over-diagnosis of malignancy.

### OBSTRUCTIVE EMPHYSEMA

Obstructive emphysema may occur in a lung or part of a lung distal to any endobronchial lesion which is producing almost complete bronchial obstruction. It is most easily detected by comparing inspiration and expiration radiographs.

Rigler and Kelby (1947) described obstructive emphysema as an early sign of bronchogenic carcinoma and recommended chest films taken in expiration to detect it. Five cases were illustrated but only one was asymptomatic at the time of examination; in 3 there was obvious enlargement of the left hilar shadow, in 1 a collapsed right lower lobe accompanied an emphysematous upper lobe on the same side and the remaining case - although apparently showing obstructive emphysema of the left lung - was unfit for surgery. In all 5 cases the radiological abnormality was apparent on the inspiration film alone and in two examples of "expiration" films the diaphragm on the normal side was at the level of the eleventh rib posteriorly. Three further cases of obstructive emphysema in bronchogenic carcinoma were recorded by Rigler (1949): in one, an obviously enlarged right hilar shadow accompanied an emphysematous right upper lobe; in one, segmental emphysema is difficult to detect on the illustrated radiograph and in one, apparent obstructive emphysema of the right lung is shown. The two latter cases did not develop symptoms until 18 months later. Reproduction of radiographs to show obstructive emphysema clearly is difficult and it is fair to remember this when attempting to evaluate cases reported in the literature. Rigler, O'Loughlin and Tucker (1953) detected emphysema of a segment, lobe or whole lung in 8% of 50 cases of bronchogenic carcinoma which had been fortuitously x-rayed before the development of symptoms. Review of these cases shows, however, that three had, in addition to obstructive emphysema, a convincingly enlarged hilar shadow on one side and the remaining example is not illustrated. Schinz, Baensch, Friedl and Uehlinger (1953) regarded

"check-valve" emphysema as the most important early diagnostic sign of bronchostenosis but, in the most profusely illustrated of all radiodiagnostic texts, provided only one entirely unconvincing illustration of it. Møller (1950), on the other hand, thought that obstructive emphysema was rare in bronchogenic carcinoma and had not seen a single instance of it and Simon (1953) described it as "rather uncommon".

A localized increase in translucency of one lung in the absence of significant atelectasis may be due to a variety of conditions. A cyst whose walls fail to show on plain films may suggest obstructive emphysema and emphysema of unknown cause not infrequently involves one lobe. Increased translucency of a segment, lobe or lung may occur when a pulmonary artery is blocked by embolism or thrombosis with resulting diminution in the blood flow to the lung distally. If a main pulmonary artery is involved, there is also increase in size of the hilar shadow (Hanelin and Eyler, 1951; Keating, Burkey, Hellerstein and Feil, 1953) and radiologically this may resemble a main bronchus obstruction due to carcinoma with obstructive emphysema distal to it. But the presence of congestive heart failure with right ventricular preponderance on electrocardiography (or a change from left to right ventricular hypertrophy) with no passive congestion in the lungs should leave little doubt about the diagnosis. Barden (1952) emphasized that correct interpretation of the x-ray appearances in these "anaemic lung infarcts" depended on the history and the absence of distorted lung markings surrounding an area of increased translucency. In bronchostenosis associated with obstructive emphysema the mediastinum moves towards the normal side on expiration (Shapiro and Rigler, 1948).

One lung may be emphysematous in the absence of any endobronchial lesion (DiRienzo, 1949). Swyer and James (1953) reported a case of this in which there was neither lobar collapse nor evidence of a bronchial

block but poor peripheral filling was present at bronchography. The pulmonary artery in the excised specimen was slightly smaller than normal but the authors were unable to decide whether this was the primary defect or secondary to some congenital or acquired abnormality of the lung itself. Nine similar cases were recorded by MacLeod (1954). There may be aplasia of the right or left pulmonary artery (Fleming, 1958) but this is not invariably present in association with unilateral emphysema of obscure origin (Vaughan, 1958) and it is always difficult to determine whether the bronchial or arterial abnormality is the primary lesion. Anomalies of the great vessels and mucosal flaps in the bronchial lumen which may produce lobar emphysema in infancy (Robertson and James, 1951) do not appear to be aetiological factors in these cases in adults.

Occasionally complete collapse of a lobe is not strikingly obvious on plain films and compensatory emphysema of adjacent lung may resemble obstructive emphysema. For example, a right upper lobe completely collapsed against the mediastinum may simulate adenopathy and the compensatory emphysema of the lower lobe might be mistaken for obstructive emphysema.

#### Personal findings.

One out of 500 cases of bronchial carcinoma which came to operation showed obstructive emphysema. Earlier films were not available for study in many of the cases; if they had been, perhaps more examples of this condition would have been found since obstructive emphysema is presumably a transient sign proceeding to more definite lung changes as the bronchial block becomes complete.

Obstructive emphysema is usually thought of as occurring at an early stage in the development of carcinoma but the only example of it in the present series was in a man, aged 35, whose left main bronchus was blocked by an anaplastic carcinoma which had spread ex-

tensively to mediastinal glands (Fig. 48). A similar case was described - but not illustrated radiologically - by Morlock (1934) in which there had been chest symptoms for 9 months with diminished movement and absence of breath sounds over the left side of the chest due to an anaplastic carcinoma producing obstructive emphysema of the left lung. Rigler and his colleagues (1947, 1949, 1953) have studied this problem in considerable detail but very few of their published cases of obstructive emphysema occurred in (pathologically) early cases of bronchogenic carcinoma. Fig. 49 illustrates another example of obstructive emphysema due to advanced carcinoma.

Lobar emphysema of undetermined aetiology (Fig. 50) seems to be a commoner cause of increased translucency in part of a lobe or lung than is valvular obstruction due to early tumour.

#### CONCLUSIONS.

- (1) Obstructive emphysema is rarely seen as the only radiological sign of bronchial carcinoma.
- (2) It is much more frequently associated with an advanced than with an early tumour.

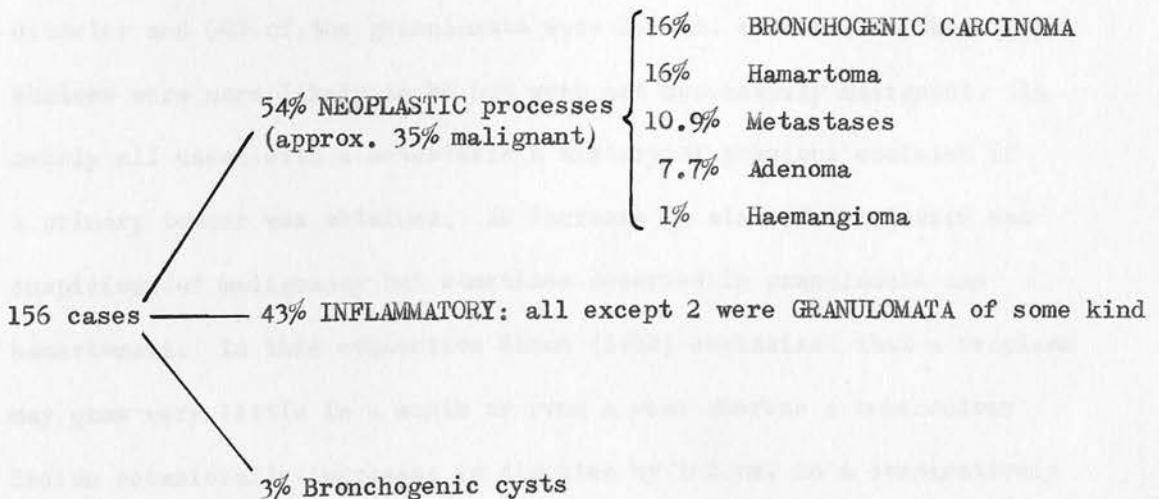
PERIPHERAL CARCINOMA

The pre-operative diagnosis of the true nature of a peripheral circumscribed lesion in the lung which contains no calcification is rarely possible with any degree of certainty. If the patient is asymptomatic, the chances of a correct diagnosis are even less. Good (1953) found that 60% of 156 cases of solitary mass in the lung seen at the Mayo Clinic required thoracotomy before their pathology could be definitely ascertained.

Effler (1951) reported 16 excised asymptomatic lung tumours which consisted of 6 bronchogenic carcinomata, 8 localized tuberculous lesions, 1 hamartoma and 1 metastasis from a carcinoma of the kidney. Woolpew (1952) reported 6 (25%) out of 25 silent, circumscribed lung shadows in apparently normal people as being due to bronchial carcinoma.

One of the best accounts of the problem of differential diagnosis in peripheral lung lesions is that by Hood, Good, Clagett and McDonald (1953), reviewing 156 cases seen at the Mayo Clinic. The relative frequency of the various pathological lesions is summarized in Table 13. All of them were resected and to be included in the series

TABLE 13 - THE NATURE OF 156 CIRCUMSCRIBED LUNG LESIONS (summarized from Hood et al., 1953)



they had to be: (1) intrapulmonary, (2) the only significant change in the lung field, (3) unassociated with obstructive changes in the lung distally and (4) without evidence of cavitation. Bronchial adenoma, because of its potentialities, was included in the malignant group. It was found that primary malignant disease was much more likely than any of the others to be associated with definite symptoms, the latter being absent in only 25% of carcinomata (whereas 84% of hamartomata, 65% of metastases and 55% of granulomata were asymptomatic). Haemoptysis was the single most important symptom; it was absent in all 65 granulomata and, with the exception of one chronic pneumonia and two bronchogenic cysts, a history of haemoptysis signified a malignant pulmonary tumour - bronchogenic carcinoma, adenoma or metastasis. A raised blood sedimentation rate was found to be of serious significance, occurring in 74% of the carcinomata and in only 23% of the granulomata. Cytological examination of the sputum in 15 cases of malignant tumour gave positive results in 8 but a later review of 1,600 positive cytological examinations at the Mayo Clinic by McDonald (1955) revealed a low incidence of positive results in peripheral tumours. The site of the lesion was found to be of no value in differential diagnosis. Benign and malignant lesions of all sizes were encountered but no carcinoma was less than 2 cm. in diameter and 60% of the granulomata were 2.5 cm. or less, so that larger shadows were more likely to be but were not necessarily malignant. In nearly all cases with a metastasis a history of previous excision of a primary tumour was obtained. An increase in size of the lesion was suspicious of malignancy but sometimes occurred in granulomata and hamartomata. In this connection Simon (1952) emphasized that a neoplasm may grow very little in a month or even a year whereas a tuberculous lesion occasionally increases in diameter by 1-2 cm. in a comparatively short time. Fried (1948) recorded a peripheral bronchogenic carcinoma

in a male, aged 25, which remained the same size for 4 years but 6 years after first being seen the right lung was extensively involved by tumour.

The only radiological sign which Hood et al. found to be reliable was the presence or absence of calcification in the peripheral mass. They had never seen calcification in a carcinoma and so used the working rule that the presence of calcification in a lesion means that it is not malignant. On extremely rare occasions calcification has been seen in a primary lung carcinoma but the mechanism of its development may differ from the deposition of calcium which not infrequently occurs in necrotic tumours in other parts of the body. London and Winter (1954) described a peripheral, slowly-growing adenocarcinoma containing spotty calcification which was shown to lie in alveolar spaces lined by malignant cells; it was concluded that calcium production was the result of function of the tumour itself. Alternatively, a pre-existing calcified focus in the lung may be engulfed by a tumour (Good and McDonald, 1956). For this reason review of any previous films is essential in any case where a possible peripheral carcinoma contains a nodule of calcification so that misinterpretation as a benign lesion may be avoided if the calcification was present prior to development of the mass. As Hodgson and McDonald (1953) pointed out, it is essential to be sure that calcification apparently associated with a peripheral lesion, is, in fact, inside it. This is most easily determined by making two or three antero-posterior and lateral tomographic cuts through the mass. 42% of the cases of Hood et al., which showed no calcification, were neoplastic - 28% were carcinomata, 14% metastases and 8% adenomata. Moersch (1951) found that 30% of peripheral lung shadows with no associated calcification were malignant.

In this country the commonest benign peripheral lesion is the tuberculoma, the majority being detected at M.M.R. examination. Calci-

fication is associated with this more often than with any of the other "coin lesions". According to Moyes (1951) tuberculoma is twice as common in women as in men and is often surrounded by satellite shadows in the lung. He found that 31 out of 34 cases treated conservatively were alive and well when followed up 3-15 years later and made a plea for conservative treatment in this condition.

Personal findings.

54 (11%) out of 500 cases of bronchial carcinoma which came to operation were of the peripheral type without evidence of cavitation and showing no evidence of other significant changes in the lung fields. 13 (24%) were inoperable. Four - 3 in the right upper lobe and 1 in the left upper lobe - had conspicuously ill-defined borders giving the impression of the disease creeping through the lung (Fig. 51). During the week preceding operation 3 cases with a tumour in the right lower lobe developed considerable surrounding inflammatory shadowing and 2 in the apex of the left lower lobe developed complete collapse of this lobe.

Several were very large, some being 10-12 cm. in diameter, 33 were 6 cm. or less and none was less than 3 cm. in diameter (Fig. VI). They were evenly distributed throughout the lungs and showed no predilection for any particular site (Fig. VII).

Satisfactory tomograms were available in 36 cases and in only 10 of these could the outline of the lesion be described as circular; in the remainder (26) there was slight or considerable lobulation of at least one aspect of the tumour (Figs. 2, 40) and in 14 this was quite apparent on the plain films (Fig. 52). Rigler (1955), describing this appearance as "notching" of the shadow, regarded it as diagnostic of carcinoma, either primary or secondary. Since then, however, most radiologists of experience have seen the same appearance in various benign lesions, especially tuberculoma. Fig. 53 shows a good example

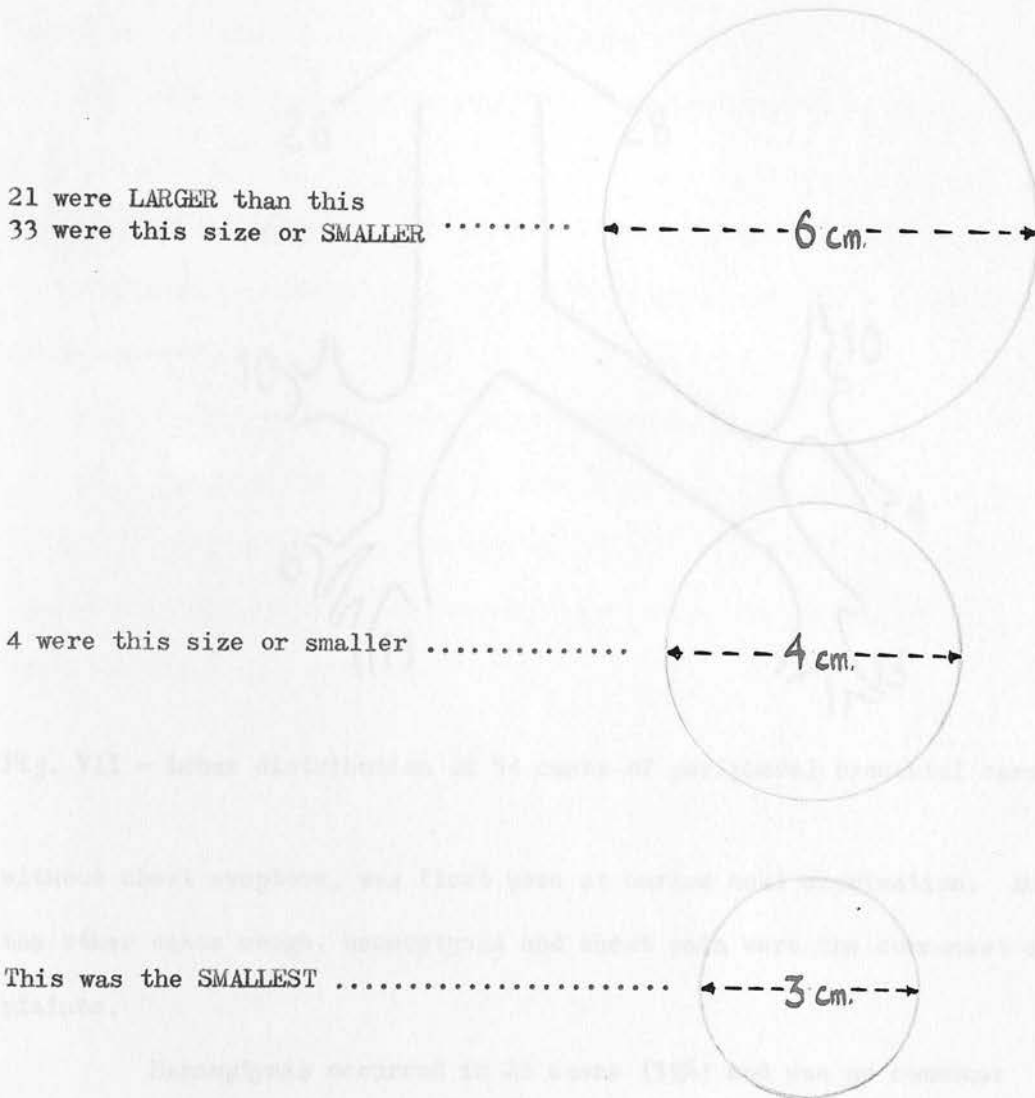


Fig. VI - Showing size of lesion, as measured on a P.A. or lateral film taken at 6 feet, in 54 cases of peripheral bronchogenic carcinoma.

of it in a hamartoma. This appearance which is common in peripheral carcinoma is certainly not diagnostic of malignancy.

In no case was there radiologically demonstrable calcification within the tumour, nor was this seen in any of 23 cases of bronchial adenoma - but Soutter, Sniffen and Robbins (1954) recorded calcification in 6 out of 56 cases of bronchial adenoma seen at the Massachusetts General Hospital over a period of 45 years.

Only 3 patients were completely asymptomatic; 2 were M.M.R. pick-ups and 1 was found on routine chest x-ray. One further case,

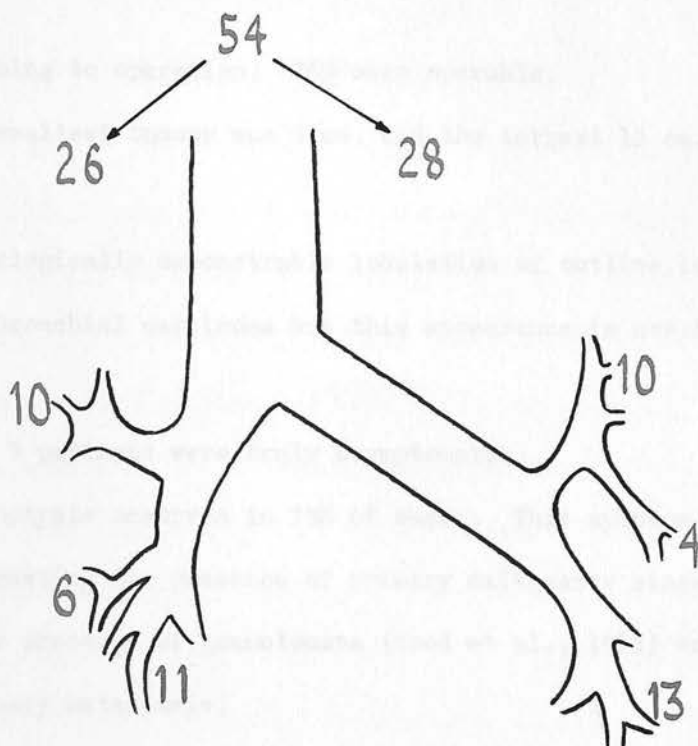


Fig. VII - Lobar distribution of 54 cases of peripheral bronchial carcinoma.

without chest symptoms, was first seen at barium meal examination. Amongst the other cases cough, haemoptysis and chest pain were the commonest complaints.

Haemoptysis occurred in 21 cases (39%) and was no commoner amongst the larger tumours; it was present in only 7 of the 21 which measured more than 6 cm. in diameter. During the period in which these cases were seen, 9 single metastatic tumours in the lung were resected and in none of these was haemoptysis recorded.

Bronchoscopy showed an endobronchial tumour in only 5 cases: 1 in the middle lobe, 1 in the lateral basal segment of the right lower lobe, 1 in the lingula and 2 in the apex of the left lower lobe. Seven others showed some compression of a lobar or segmental bronchus in the neighbourhood of the tumour and the remaining 42 showed no abnormality at bronchoscopy.

CONCLUSIONS.

- (1) Solid, peripheral tumours accounted for 11% (54 cases) of bronchial

carcinomata coming to operation. 76% were operable.

(2) The smallest tumour was 3 cm. and the largest 12 cm. in diameter.

(3) Radiologically demonstrable lobulation of outline is common in peripheral bronchial carcinoma but this appearance is not diagnostic of malignancy.

(4) Only 3 patients were truly asymptomatic.

(5) Haemoptysis occurred in 39% of cases. This symptom may be helpful in suggesting the presence of primary malignancy since it is uncommon in the presence of granulomata (Hood et al., 1953) or an isolated pulmonary metastasis.

### CAVITATING PERIPHERAL CARCINOMA

Brock (1954) found that 56 (13.8%) of 450 lung abscesses were due to bronchial carcinoma and Wigh and Gilmore (1951) recorded 10% of 160 cases of bronchial carcinoma as showing a solitary cavity. They found that a "statistical reversal" of the ratio between cavitating neoplasm and simple lung abscess had been occurring in recent years as a result of the increased use of chemotherapy and antibiotics in infections of the lung. They also said that malignant lung abscess was  $1\frac{1}{2}$  times commoner than non-tuberculous abscess in patients over the age of 40. The figures quoted above refer to all types of cavitation associated with bronchial carcinoma whether they be due to breaking-down of the tumour itself, suppuration distal to the tumour or the formation of distension cavities as a result of valvular bronchial obstruction.

Very many conditions may produce a cavitating lesion in the lung but only a few are likely to resemble closely the typical breaking-down carcinoma with its well-defined margin, thick wall and nodular internal contour. The majority of these can usually be distinguished by consideration of the clinical picture, the results of sputum and blood examinations and, rarely, skin tests.

Cavitation in the lungs occasionally occurs in other neoplastic and related conditions, such as Hodgkin's disease, metastatic carcinoma (Wigh and Gilmore, 1951) or Wegener's giant cell granuloma of the upper respiratory tract (Walton, 1958). Almost all recorded cases of cavitation in metastatic disease have occurred when lung secondaries were multiple (Salzmann, Reid and Ogura, 1953; Katzer and Bass, 1955). A solitary, thick-walled cavitating mass in the lung is rarely the presenting feature in Wegener's giant cell granuloma of the upper respiratory tract (Walton, 1958); ulceration may occur any-

where in the respiratory tract but is most commonly seen in the nose and upper air passages. Eosinophilia is present, sooner or later a wide-spread disease with arthralgia, skin rashes, paraesthesiae and weakness develops, progressing ultimately to a picture of periarteritis nodosa.

Amoebic lung abscess is extremely rare but Edwards (1946) described it as the only condition which can produce a thick-walled cavity in the lung resembling a cavitating carcinoma. Sullivan and Bailey (1951) recorded 4 cases in which there were no other signs or symptoms of amoebiasis, the diagnosis being made on the rapid subsidence of fever and sputum and the closure of cavities as a result of emetine administration, along with a history of having lived in China, Burma, India or the Philippines. A thick-walled cavity in the lung is sometimes due to histoplasmosis or coccidioidomycosis, though the latter disease is better known for its tendency to produce thin-walled, cyst-like lesions.

Commoner conditions which may mimic a cavitating carcinoma are simple lung abscess (Fig. 54), tuberculous cavitation (especially when secondary fungus infection of the cavity occurs - Fig. 55), a breaking-down tuberculoma, or complicated pneumoconiosis after a melanoptysis.

In this country the conditions which cause most difficulty in differential diagnosis are a breaking-down tuberculoma and simple lung abscess. If tomography fails to show any calcification or surrounding satellite shadows, the former may be impossible to distinguish from carcinoma prior to operation.

Table 14, a composite from different authors, shows the most useful points in distinguishing between a simple and malignant lung abscess. The radiological features are most easily seen on tomograms,

TABLE 14 - USEFUL FEATURES IN DISTINGUISHING BETWEEN SIMPLE AND MALIGNANT LUNG ABSCESS

<u>CLINICAL</u> * **	<u>SIMPLE</u>	<u>MALIGNANT</u>
AGE (Average)	39	55
SEX		Extremely rare in ♀
FEVERISH onset	77%	20%
HAEMOPTYSIS	33%	74%
PAIN	Incidence equal but more PER- SISTENT & SEVERE in MALIGNANCY	
FOETID SPUTUM	Commoner	
IMPROVEMENT on PENICILLIN	74%	7%
Gross DENTAL SEPSIS	40%	
 <u>RADIOLOGICAL</u> * *** ****		
WALL of lesion:		
(1) INTERNAL NODULATION	Very uncommon	Most IMPORTANT diagnostic sign
(2) THICKNESS	Usually lesser	Greater
(3) OUTER CONTOUR	Often ill-defined	Often well-defined
 SURROUNDING INFLAMMATORY changes		
RATE of CHANGE of appearance	Quicker	Slower

\* Strang & Simpson (1953)

\*\* Brock (1954)

\*\*\* Wigh & Gilmore (1951)

\*\*\*\* Kerley (1951)

two or three A.P. or lateral cuts through the lesion usually being sufficient. An unexplained cavitating lesion without clinical evidence of lung abscess is very suggestive of malignancy - especially if it lies in a site other than the posterior segment of an upper lobe or apical segment of a lower lobe, where simple lung abscess and tuberculous cavitation occur most commonly. Strang and Simpson (1953), however, made the important observation that cavitating peripheral carcinoma also occurs most often in these two sites.

Personal findings.

(A) THICK-walled cavitating carcinoma.

For purposes of description this may be defined as having the radiological appearance of a thick-walled, centrally or eccentrically cavitating peripheral lesion, usually with an irregular internal wall. Twenty-one cases in which there was radiologically demonstrable cavitation associated with infective changes distal to a carcinoma or breaking-down of a lobe solid with tumour are not included under this heading.

Thirty-one examples of breaking-down peripheral carcinoma occurred in 500 cases of bronchial neoplasm which came to operation, none occurred in a female and 26 (84%) were epidermoid in type (Table 15). This accords with the well-known tendency of the peripheral epidermoid tumour to undergo cavitation (d'Abreu, 1953). Twenty-two (71%) of the 31 cases occurred in the left lung and 15 of these were in the upper lobe (Table 16). Fifteen cases were operable, 16 were not.

TABLE 15 - HISTOLOGY IN 31 CASES OF PERIPHERAL CAVITATING BRONCHIAL CARCINOMA

	EPIDERMOID	ANAPLASTIC	ADENOCARCINOMA
No. of CASES	26	4	1

TABLE 16 - SITE OF 31 CASES OF PERIPHERAL CAVITATING BRONCHIAL CARCINOMA. (Figures in brackets indicate the number which were operable.)

R.U.L.	R.L.L.	L.U.L. & Lingula	L.L.L.
6 (2)	3 (1)	15 (8)	17 (4)

In contrast with the findings in this group subjected to thoracotomy, Strang and Simpson (1953), from a series of 1,930 bronchial carcinomata in varying stages of the disease (also seen at Shotley Bridge), found 70 cases associated with lung cavitation but only 39 of these fell into

the group which I have defined above. The cavitating peripheral carcinoma was thus  $2\frac{1}{2}$  times as common in the relatively earlier cases.

(B) CYST-like cavitating lesions.

Three of these occurred in 500 cases; 1 in the subapical segment of the right lower lobe (Fig. 56), 1 in the lingula (Fig. 57) and 1 in the left lower lobe posterior basal segment (Fig. 58). Only in the third case was the actual development of the cystic lesion observed - distal to a radiologically demonstrable small, peripheral carcinoma - and the rapidity with which this occurred strongly suggested a valvular bronchial obstruction as the underlying mechanism since the operative specimen showed no evidence of infective changes. All three tumours were epidermoid in type and at operation none was thought to be neoplastic.

A thin-walled cavity is a well-recognized but uncommon manifestation of bronchial carcinoma. One case was recorded by Møller (1950), 4 by Strang and Simpson (1953) and 6 by Anderson and Pierce (1954). The walls of the cavities are thin with a smooth internal surface and fairly clear-cut outer margin, they seldom contain fluid levels or exceed 7 cm. in diameter and are not surrounded by lung consolidation. Anderson and Pierce's 6 cases all grew slowly but one in the present series developed a "cyst"  $6\frac{1}{2}$  cm. in diameter over a period of 3 days and re-scrutiny of the earlier films gave no indication of pre-existing localized emphysema or cystic disease. The walls of the cavity may or may not be lined with squamous carcinoma cells and in some cases the neoplasm is confined to the junction between bronchus and cyst. None of the lesions of this type so far recorded seem to have been due to excavation of a solid primary neoplasm but rather the result of valvular obstruction by a tumour. Whether this acts on a cavity which was produced by infection distal to the tumour, on a pre-existing cyst or bulla or on previously normal lung tissue is uncertain. Salzman, Reid and Ogura (1953) recorded

2 cases of multiple lung metastases - one from a seminoma and the other from a pancreatic carcinoma - in which a few of the lung deposits became completely excavated, leaving only "cysts" whose walls were 3 mm. wide at their thickest points. Similar appearances were shown in a case recorded by Curran and MacCarthy (1959) in which a small proportion of multiple metastases from a rectal adenocarcinoma became excavated and developed thin-walled cavities whose walls, at autopsy, were shown to consist of malignant cells. Apparently this means of producing a thin-walled cavity in the lung does not operate in cases of primary tumour.

Two other cases - neither fit for surgery and not included in the present series - are of interest in that emphysematous or cystic change may have been present in the lung prior to the development of carcinoma. In one, a male, aged 65, with an epidermoid carcinoma arising inside the right upper lobe orifice, two "cysts" developed - during a course of radiotherapy - at a considerable distance from, but in the lobe supplied by the affected (right upper lobe) bronchus (Fig. 59). This appearance had not been present on any of the earlier films, the immediately previous one having been at an interval of 2 weeks. The patient died at home 3 months after the "cysts" appeared, a film taken one month before death having shown the appearances to be unchanged. In the absence of operation or autopsy the precise extent of tumour spread in the lung is not known but it seems unlikely that there was neoplastic involvement of the subsegmental bronchus supplying the cystic area of lung, nor was there clinical or radiological evidence of a preceding inflammatory episode. Therefore, any valvular obstruction which occurred may have acted by producing a degree of obstructive emphysema insufficient to affect the hitherto normal upper lobe but enough to overdilate a pre-existing but radiologically invisible pathologic (cystic) area of lung. In the second case (Fig. 60) a cyst

5½ cm. in diameter was present in the apex of the left lower lobe on the initial film of a woman, aged 52, with an epidermoid carcinoma visible bronchoscopically just below the left upper lobe orifice. Symptoms were relieved by radiotherapy and the cyst became slightly smaller over a period of 4 weeks. Here again pathological proof of the extent of the tumour is lacking and it is possible that neoplasm could spread from just below the upper lobe orifice - not necessarily intraluminally - to produce obstructive emphysema of the lower lobe apical segment on the same side. More likely, perhaps, is that the cyst was a coincidental finding and impaired egress of air from the left lower lobe may have been sufficient to overdistend it more than the surrounding normal lung.

A bronchial neoplasm developing in part of the wall of a pre-existing lung cyst was reported by Brünner (1959). Serial radiographs during a period of 20 months showed gradual growth of the neoplasm which was confined to the wall of the cyst farthest from the drainage bronchus; this was confirmed by the lobectomy specimen. Valvular obstruction obviously played no part in the development of this particular lesion.

The development of a cyst-like lesion after an infective lung illness in adults is not common so the possibility of an associated carcinoma should be kept in mind. The mechanism of development of these changes apparently varies from case to case. Tuberculous cavities and infected lung cysts are probably the commonest conditions in this country which may produce a similar radiological picture. When world-wide travel is now commonplace, histoplasmosis and coccidiomycosis have to be considered as possible causes of a thin-walled (or thick-walled) cavity in the lung.

#### CONCLUSIONS.

(1) Cavitating peripheral bronchial carcinoma accounted for 6.2% of cases coming to operation. 84% of these were epidermoid tumours and

71% occurred in the left lung. The operability rate was just under 50% (compared with 76% in solid peripheral tumours).

(2) Cavitating peripheral carcinoma was  $2\frac{1}{2}$  times commoner in a series of cases coming to surgery than in a group of unselected cases.

(3) Three out of 500 cases of bronchial carcinoma coming to operation presented radiologically as a thin-walled cavity in the lung and none was thought to be malignant at thoracotomy. This appearance is produced by different means in different cases.

200 cases of bronchiectasis reviewed but found that there was no causal relationship between the two diseases. A review of 1,177 autopsied cases of bronchiectasis reported by Barlow (1971) showed a 1.2% incidence of pulmonary tuberculosis. He concludes that bronchiectasis and centrally peripheral and bronchopulmonary carcinoma differed in the distribution of their tuberculous foci. If tuberculosis were a factor in the aetiology of carcinoma, then more peripheral lesions would be expected than in the first group. On the other hand, a carcinoma may cause bronchiectasis of a pre-existing tuberculous lesion by producing obstruction to blood supply and haemorrhage in the affected portion of lung.

Tracheal findings and calcification.

Active tuberculosis did not occur in any case (of the 500 series) and only 4 showed evidence of calcified, shell-like disease. No attempt was made to assess the incidence of primary tracheal calcification.

All 4 cases had right upper lobe disease; all tuberculous disease occurred in the affected lobe peripheral to the hilum (Fig. 61) and in the left upper lobe in the remainder. There was no uniformity in the size of the tumour in relation to the tuberculous or in the pathology of the disease. The tumour was operable, 3 were not.

Some difficulty in diagnosis did not occur. Only one case showed x-ray appearances in the right upper lobe which, with the

CARCINOMA AND TUBERCULOSIS

There is no evidence that pulmonary tuberculosis either predisposes to or provides any protection against the development of bronchogenic carcinoma (Willis, 1948). Carcinoma cells do not invade caseated tissue or a tuberculous cavity filled with caseous material; they spread along and invade the cavity wall itself, leaving the caseous material alone (Fried, 1948).

Ellman (1953) found 8 patients with pulmonary tuberculosis in 200 cases of bronchogenic carcinoma but doubted that there was any causal relationship between the two diseases. A review of 1,355 autopsied cases of bronchogenic carcinoma by Nuessle (1953) showed a 6.4% incidence of pulmonary tuberculosis. He commented that tuberculosis was usually peripheral and bronchogenic carcinoma central in its distribution so that, if tuberculosis were a factor in the aetiology of carcinoma, then more peripheral tumours would be expected than do, in fact, occur. On the other hand, a carcinoma may cause breakdown of a pre-existing tuberculous lesion by producing alteration in blood supply and bronchostenosis in the affected portion of lung.

Personal findings and conclusions.

Active tuberculosis did not occur in any case (of the 500 series) and only 4 showed evidence of calcified, adult-type disease. No attempt was made to assess the incidence of primary complex calcification.

All 4 cases had right upper lobe tumours; old tuberculous disease occurred in the affected lobe peripheral to the tumour in 2 (Fig. 61) and in the left upper lobe in the remainder. There was no uniformity in the site of the tumour in relation to the tuberculosis or in the pathology of the tumours. One case was operable, 3 were not.

Undue difficulty in diagnosis did not occur. Only one case showed x-ray appearances in the right upper lobe which, with old tuberc-

ulous disease on the left, could not be readily distinguished from a similar pathology on the previously affected side, but bronchoscopic biopsy showed a right upper lobe carcinoma.

The majority of cases of combined carcinoma and tuberculosis apparently do not come to operation because of difficulty in the diagnosis of malignancy in the presence of pre-existing lung disease; and many of the patients may be in poor general condition. Sakula (1955) recorded 6 such cases in which diagnosis had either been difficult or the patients were extremely ill when first seen and all came to autopsy.

Carcinoma and tuberculosis may occur in opposite lungs, at different sites in the same lung or at similar sites in the same lung. Under the latter circumstances there arises the question of a relationship between the two conditions. This happened in only 2 out of 500 cases; one of these underwent resection and the tuberculosis and malignant disease were found to be separated by several centimetres of macroscopically normal lung tissue, suggesting the two conditions were unrelated to each other.

### LYMPHATIC OBSTRUCTION

"Septal lines" which occur peripherally at the lung bases are most commonly seen in conditions associated with a raised pulmonary venous pressure such as mitral stenosis or left ventricular failure. Lymphatic blockage, such as occurs in pneumoconiosis and many forms of malignant disease, is the other most common cause.

#### Personal findings and conclusions.

Five cases of unilateral "septal lines" were seen in 500 cases of bronchial carcinoma which came to operation; each one was in poor general condition (Fig. 62). All had severe disability and thoracotomy revealed inoperable tumours of the right or left lower lobe (2 on the right, 3 on the left). A very much higher incidence and more obvious changes in the upper lobes occurred in cases judged unfit for thoracotomy. Many of these showed, in addition, linear shadows radiating out from the hilum and the scattered, small nodular opacities of true lymphangitis carcinomatosa (Fig. 63).

The appearance of unilateral "septal lines" in a case of bronchial carcinoma indicates inoperability and no example of it was seen in any of 238 consecutive cases which underwent resection. It is important, however, that this sign be used only in proved cases of carcinoma without evidence of any of the other conditions which may be associated with the same appearance, for example, sarcoidosis or pneumoconiosis in which the changes are usually bilateral but may be more obvious on one side than the other. A similar appearance is sometimes seen in uncomplicated pneumonia - though the lines are, in my experience, fewer and narrower. This point has not been made in various good reviews of the subject (Grainger and Hearn, 1955; Simon, 1956).

### MIDDLE LOBE CARCINOMA

There is considerable disagreement between different authors as to the frequency of carcinoma arising in the middle lobe. Brock (1950) was largely responsible for promoting the idea that carcinoma of the middle lobe bronchus was uncommon and out of 1,200 cases of bronchogenic carcinoma he found only 8 (0.6%) in the middle lobe. All of these presented primarily as a rounded, peripheral mass even though, in some, there was also bronchial obstruction and total consolidation of the middle lobe. In no case did a carcinoma arise in the stem bronchus of the middle lobe and cause obstruction with secondary lobar consolidation - he had seen this occur in only 2 cases of benign bronchial tumour. In comparison with this small number of cases of middle lobe carcinoma Brock recorded 60 in which the middle lobe bronchus was obstructed by active or old tuberculous lymphadenitis and concluded that "the most likely thing to occur" in the middle lobe was a lesion secondary to primary tuberculosis. The symptoms were similar to those of carcinoma, haemoptysis was common and more than half of the patients were over 40 years of age.

Jenny (1952) found the incidence of middle lobe carcinoma to be only 1% in a series of 1,040 malignant tumours of the lung. Fulton (1949) found that 3.6% of 1,610 cases of bronchogenic carcinoma arose in the middle lobe. An incidence of 5% in 185 cases which underwent resection was reported by Baldry (1952), and Fretheim (1952), although agreeing with Brock on the prevalence of the middle lobe syndrome, found the incidence of middle lobe carcinoma in 125 cases to be 8%. Ellman (1953) concluded that, allowing for its size, the middle lobe was the site of bronchogenic carcinoma just as often as the other lobes of the lungs.

Locke (1953) gave an account of the findings in 12 proved and

8 presumptive cases of middle lobe carcinoma seen at the Manchester Department of Thoracic Surgery over a period of  $2\frac{1}{2}$  years. The tumour was visible at bronchoscopy in only 7 cases and he recommended tomography in a  $40^{\circ}$  R.P.O. position to give a cut in the plane of the middle lobe bronchus. The importance of the demonstration of glandular calcification was emphasized as indicating a benign middle lobe syndrome. Some cases showed no significant alteration in x-ray appearances over many months and were easily misinterpreted as non-malignant. Only one showed a cavitating tumour.

Considerable numbers of the "middle lobe syndrome" have been described with atelectasis, consolidation and chronic inflammatory changes due to a variety of benign causes other than tuberculosis. Graham, Burford and Moyer (1948) presented 12, Paulson and Shaw (1949) 32 and Sebestény and Erdélyi (1954) 18 cases, the last authors concluding that carcinoma is not an important differential diagnosis in middle lobe lesions. Giuntoli (1953) studied 11 patients with silicosis whose main radiological abnormality was an atelectasis of the middle lobe; he believed this was due to a cicatricial bronchial stenosis and pointed out the close resemblance to middle lobe carcinoma. Hampton, Bickham and Winship (1955) recorded 4 cases of lipoid pneumonia with complete collapse of the middle lobe and bronchography showed a block of the lobar bronchus in each case, simulating carcinoma.

#### Personal findings.

Nineteen out of 500 cases of bronchial carcinoma (3.8%) occurred in the middle lobe. This figure doubtless errs on the small side since a number of cases in which the intermediate or lower lobe bronchus was involved and in which only thoracotomy was performed, may have originated in the middle lobe. Similarly, in the excised lung it is often difficult to determine the precise site of origin of a tumour when it is of considerable size and lies in this region. There were 18 males and 1 female.

TABLE 17 - 19 CASES OF MIDDLE LOBE CARCINOMA

No. of cases	OPERATION	BRONCHOSCOPY			HISTOLOGY			X-RAY APPEARANCE			
		+	NAD.	±	Epidermoid	Anaplastic	Adenoca.	Peripheral	Consolidation	Atelectasis	Atelectasis-Consolidation
5	Resection	-	5	-	3	2	-	2	2	1	-
14	Thoracotomy	6	5	3	8	4	2	4	4	5	1
19		6	10	3	11	6	2	6	6	6	1

Nineteen (8.5%) of 238 right-sided carcinomata arose in the middle lobe. If the incidence of middle lobe carcinoma were the same as that in other lobes, allowing for its size (Ellman, 1953), this would imply that the middle lobe constituted only  $8\frac{1}{2}\%$  of the right lung whereas, in fact, it makes up about 20% of it. It seems unlikely that the actual incidence of middle lobe carcinoma in the 500 cases could be  $2\frac{1}{2}$  times that recorded, even allowing for the factors mentioned above to make up the discrepancy. It appears, therefore, that carcinoma is less frequent than would be expected in this lobe but not so uncommon as has been suggested by some writers. Although the lingula is smaller than the middle lobe, it was the site of primary tumour in 25 cases as compared with 19 in the middle lobe. This may have been partly related to the earlier spread of middle lobe carcinoma to the mediastinum (because of its proximity) thus reducing the number of cases found in a series coming to thoracotomy.

Some details of the 19 cases are set out in Table 17. Five underwent pneumonectomy and 14 were found to be inoperable at thoracotomy. None of the operable cases showed any abnormality at bronchoscopy whereas a positive bronchial biopsy was obtained in 6 out of the 14 inoperable cases. One case (subsequently inoperable) was bronchoscoped 3 times before any abnormality was seen; once 6 months and again 2 months before the final positive examination.

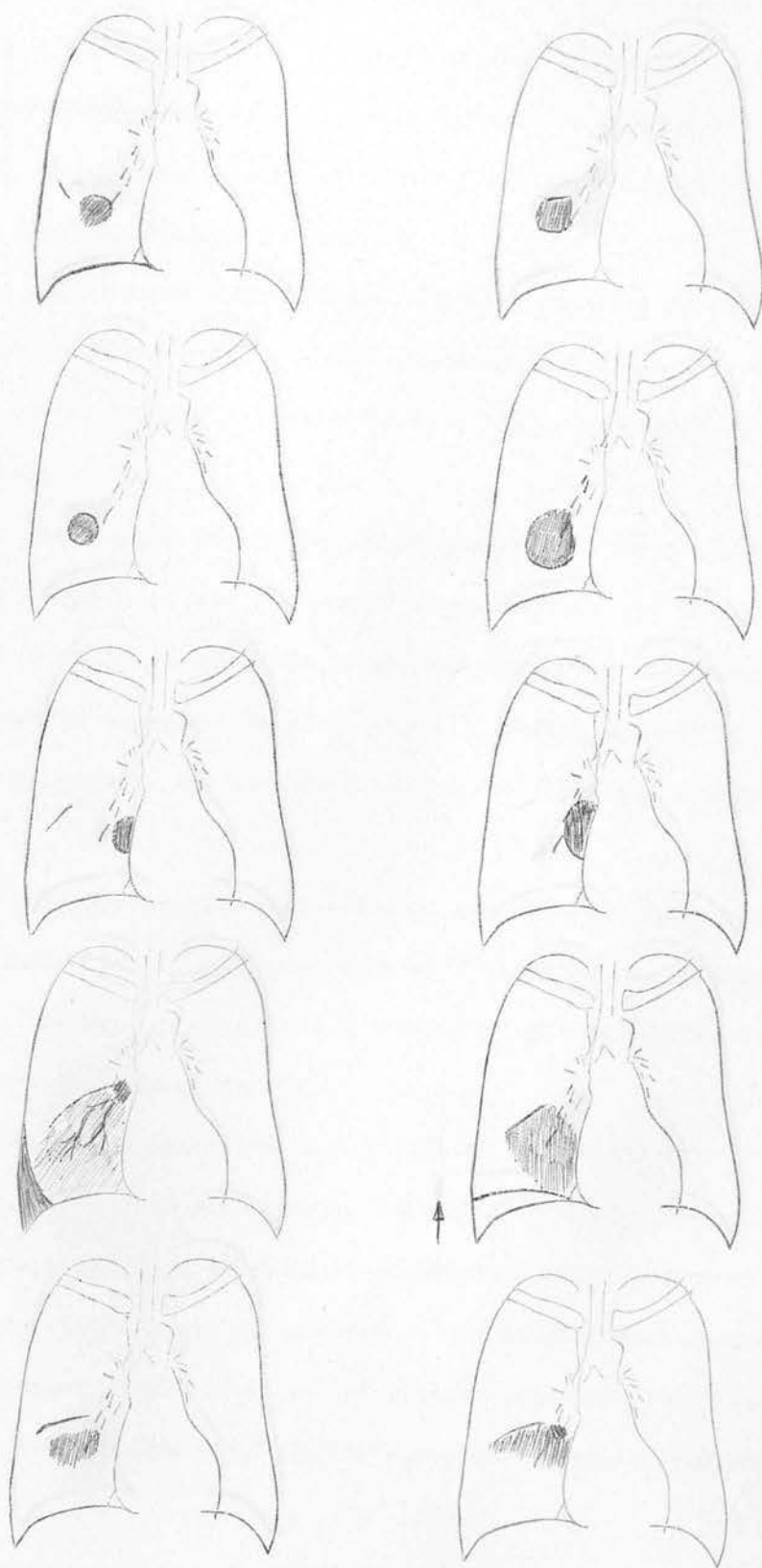


Fig. VIII - Diagrammatic representation of P.A. appearances in 19 cases of middle lobe carcinoma which came to operation.

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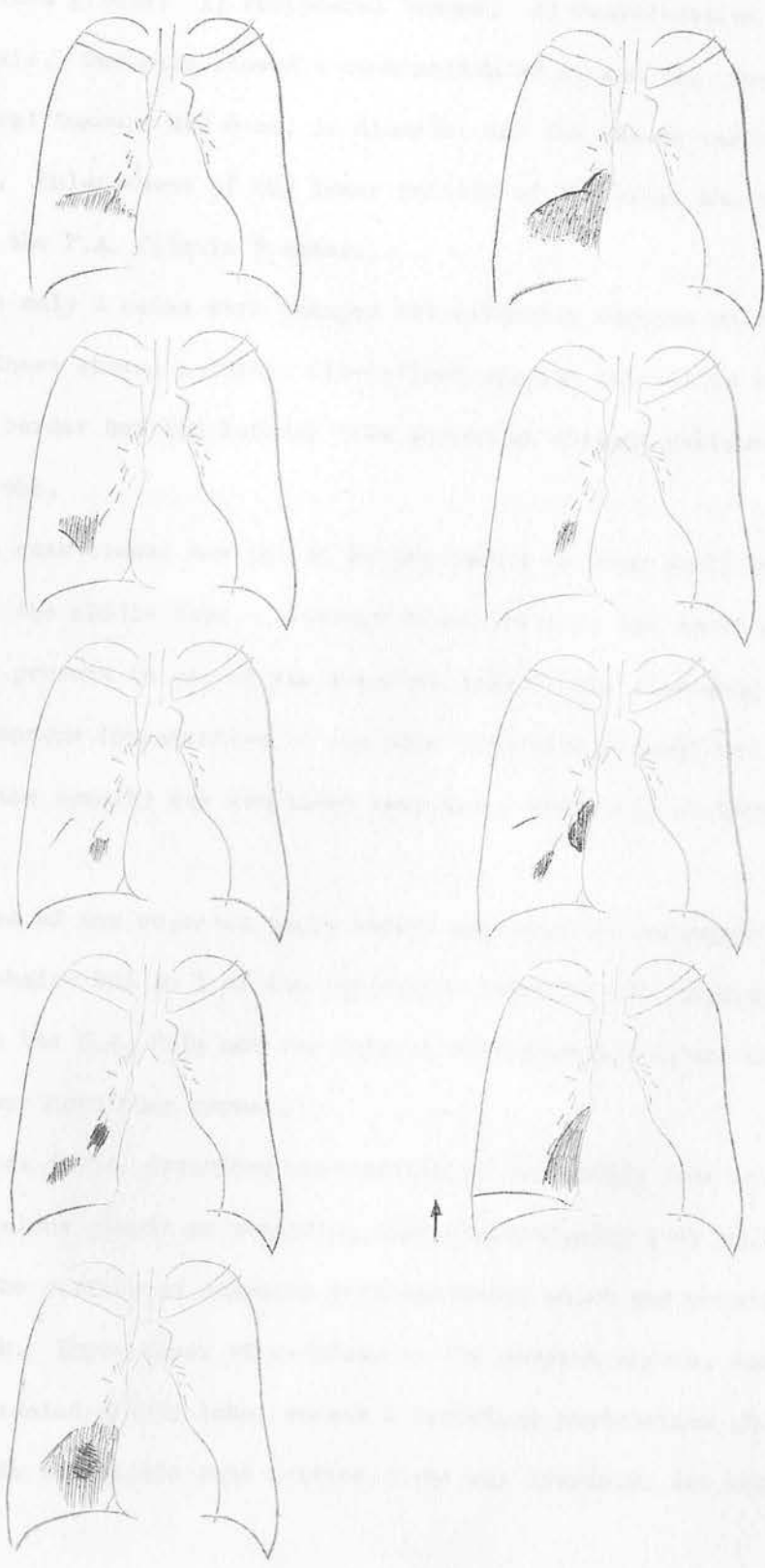


Fig. VIII continued.

Radiological appearances (Fig. VIII) fell into three fairly clearly defined groups: 1) Peripheral tumour, 2) Consolidation and 3) Atelectasis. One case showed a combination of 2) and 3). One of the peripheral tumours was 6 cm. in diameter and the others varied from 3-5 cm. Enlargement of the lower portion of the hilar shadow was apparent on the P.A. film in 5 cases.

In only 2 cases were changes not extremely obvious on the P.A. film; these showed a faint, ill-defined opacity lateral to the right heart border but the lateral film showed an obvious collapse of the middle lobe.

No case showed cavitation in the tumour or even small translucencies in the middle lobe - although bronchiectasis and small abscesses were present in one of the resected lobes. The shadowing was always homogeneous irrespective of the type of lesion present but on a P.A. film the opacity was sometimes very faint when only atelectasis was present.

None of the resected cases showed any apparent enlargement of the root shadow but in 5 of the inoperable cases it was enlarged inferiorly on the P.A. film and the lateral view showed a hilar shadow extending lower down than normal.

Brock (1954) described obstruction of the middle lobe bronchus due to tuberculous glands as occurring characteristically  $\frac{1}{2}$ - $1\frac{1}{2}$  cm. from the middle lobe orifice as compared with carcinoma which was usually near the mouth. Three cases of neoplasm in the present series, each with a consolidated middle lobe, showed a bronchial obstruction at  $1-1\frac{1}{2}$  cm. inside the middle lobe orifice - one was operable, two were inoperable.

A barium swallow was performed on 5 of the inoperable cases and 2 had characteristic deformity of the oesophagus in the L.A.O. position due to the presence of enlarged subcarinal glands; one showed

middle lobe consolidation and enlargement of the root shadow on the plain x-ray (Fig. 17) and the other atelectasis-consolidation of the middle lobe. Bronchoscopy was negative in both so that a presumptive diagnosis was made in these two cases as a result of the barium swallow findings.

Only 6 out of the 19 cases were definitely diagnosed (by bronchoscopy) pre-operatively, 2 were presumptively diagnosed by barium swallow and in the remaining 11 surgical exploration was necessary before a definite diagnosis could be made. In all of the latter except one - in which biopsy of an enlarged "inflammatory-looking" gland between the middle lobe artery and bronchus was necessary first - the diagnosis was obvious at thoracotomy.

During the period when these 19 cases of carcinoma were seen, no case of middle lobe collapse or consolidation due to pressure from tuberculous glands was observed in a patient over the age of 35. Three cases of middle lobe atelectasis-consolidation due to tuberculous granulation tissue in the middle lobe bronchus were seen in patients under this age but none showed associated glandular calcification. Tomography showed glandular calcification in relation to the middle lobe bronchus in 2 of the carcinoma cases; bronchoscopy was negative in both. However, both were correctly diagnosed radiologically - one was a peripheral carcinoma and the other had atelectasis-consolidation of the middle lobe with subcarinal lymphadenopathy producing extrinsic pressure on the barium-filled oesophagus. Two cases of right upper lobe carcinoma were initially wrongly diagnosed as analogous to Brock's middle lobe syndrome on account of glandular calcification closely related to a blocked anterior segmental bronchus (Fig. 64).

In this series of cases from the north-east of England middle lobe carcinoma was very much commoner in the carcinoma age-group than were benign conditions in this site. It seems unwise to accept a middle

lesion as being due to the "middle lobe syndrome" unless it is known (from previous x-rays) to have been present for at least 2 years. Because of the frequency of glandular calcification in the chest the demonstration of calcification in relation to the middle lobe bronchus, either by plain radiography or tomography, should not be taken to indicate a benign bronchial stenosis due to tuberculous glands. It seems hardly necessary, however, to go to the other extreme of Woodruff, Sen-Gupta, Wallace, Chapman and Martineau (1952) who, after emphasizing the importance of not attaching undue importance to glandular calcification as indicating a benign lesion, go on to suggest that the presence of glandular calcification makes carcinoma an even more likely diagnosis than otherwise because of the chronic irritant and possibly carcinogenic effect of cholesterol in the neighbouring tissues.

Isolated, recent middle lobe consolidation or atelectasis in adults, in the absence of a clinical picture of pneumonia, is uncommon and should immediately raise the question of underlying neoplasm.

Text-book descriptions go into considerable detail regarding the appearance of interlobar (lesser fissure) effusion and its distinction from middle lobe atelectasis but the former is very uncommon unless it is related to adjacent lung disease or is the residuum from a more generalized pleural effusion (Neuhof and Copleman, 1940). Occasionally loculated fluid in the lesser fissure is the only manifestation of pleural transudate in cardiac decompensation, but antidiuretic therapy will clear the opacity within a few days.

#### CONCLUSIONS.

(1) Bronchial carcinoma occurred in the middle lobe in 3.8% of cases coming to operation. This is a lower incidence than would be expected from the size of the lobe itself but higher than has been suggested by some writers. There were 18 males and 1 female.

(2) No case of middle lobe atelectasis or consolidation due to bronchial compression by old tuberculous lymphadenitis was seen in a patient over the age of 35 during the period in which 19 cases of middle lobe carcinoma were encountered. This suggests that carcinoma should be considered very much more as the first possibility in cases of middle lobe disease - with an appropriate clinical history - than has frequently been asserted.

(3) Bronchoscopy was positive in one third of cases of middle lobe carcinoma and negative in all five which were operable.

(4) Evidence of subcarinal glandular compression of the oesophagus is a valuable diagnostic sign in favour of middle lobe carcinoma when bronchoscopy is negative.

(5) Radiologically demonstrable calcification related to a bronchus supplying an area of diseased lung is unreliable evidence that the underlying condition is non-malignant.

No. of cases	OPERATION	OPERATION			Sputum	Histology	Non-diagnostic	Metastases	Survival	Total	Cancer
		+	0	-							
15	Resection	7	7	1	13	4	6	2	3	2	2
10	Thoracotomy	2	2	2	4	6	4	3	1	2	1
25		13	9	3	17	10	10	5	4	4	3

Bronchial biopsy provided a definite diagnosis of carcinoma in 13 of the 25 cases; in 2 the tumour was visible; in 3 a positive biopsy was obtained from a thickened lingular bronchus and in 1 from a normal looking lingular orifice. In 3 others some abnormality was seen (slight inward bulging of the antero-lateral wall of the lower lobe bronchus) but biopsy was negative and in the remaining 2 cases no abnormality was detected at bronchoscopy. Bronchoscopy provided a positive histological diagnosis of carcinoma in 13 out of 25 (52%) of hospital and in 6 out of 19 (31%) of middle lobe tumours. No abnormality was seen in any

LINGULAR CARCINOMA

Lemoine and Finet (1949), presenting 3 cases of lingular carcinoma, said the condition was usually difficult to diagnose because of accompanying suppuration and that bronchoscopy was seldom helpful in diagnosis.

Personal findings and conclusions.

Twenty-five out of 500 cases of bronchial carcinoma (5%) arose in the lingula (Table 18). All occurred in males, 15 were operable and 10 inoperable.

TABLE 18 - 25 CASES OF LINGULAR CARCINOMA

No. of cases	OPERATION	BRONCHOSCOPY			HISTOLOGY		X-RAY APPEARANCE				
		+	NAD	±	Epidermoid	Anaplastic	Root shadow + atelectasis-consolidation	Atelectasis	Peripheral	Root shadow + lung translucencies	Consolidation
15	Resection	7	7	1	11	4	6	2	3	2	1
10	Thoracotomy	6	2	2	4	6	4	3	1	2	1
25		13	9	3	15	10	10	5	4	4	2

Bronchial biopsy provided a definite diagnosis of carcinoma in 13 of the 25 cases; in 9 the tumour was visible, in 3 a positive biopsy was obtained from a thickened lingular carina and in 1 from a normal-looking lingular orifice. In 3 others some abnormality was seen (slight inward bulging of the antero-lateral wall of the lower lobe bronchus) but biopsy was negative and in the remaining 9 cases no abnormality was detected at bronchoscopy. Bronchoscopy provided a positive histological diagnosis of carcinoma in 13 out of 25 (52%) of lingular and in 6 out of 19 (31½%) of middle lobe tumours. No abnormality of any sort was

detected in 9 out of 25 (36%) of lingular and in 10 out of 19 (53%) of middle lobe lesions. Apparently lingular growths are commoner and more accessible to bronchoscopic examination than are those in the middle lobe.

The commonest x-ray appearance was that of enlargement of the hilar shadow with atelectasis-consolidation in the lingula; this occurred in 10 cases, in 3 of which the "hilar shadow" was just sufficiently separate from the true hilar shadow to suggest its origin in the lingula. Four cases showed an ill-defined opacity with one or more translucencies in the lingula; 3 of these were resected and bronchiectasis and abscess formation were found in the affected segment. This appearance was not seen in any case of middle lobe carcinoma (p. 95). Four of the tumours were peripheral; a positive bronchoscopic biopsy was obtained in one of these.

### MISDIAGNOSIS OF CARCINOMA

A most serious misdiagnosis occurs when a patient with a benign lesion not requiring radical surgery is subjected to pneumonectomy in the belief that malignancy is present. This is especially liable to occur when fear of missing the "early" carcinoma is at the forefront of current medical thought as it is to-day. Smithers (1955) pointed out that many cases of bronchogenic carcinoma are diagnosed on insufficient evidence and emphasized the difficulties of diagnosis, even in special hospitals with every facility for investigation.

Strang and Simpson (1953) recorded 3 cases of simple lung abscess which underwent pneumonectomy. Therkelsen and Sørensen (1953) reported 4 cases in which misdiagnosis resulted in pneumonectomy: (a) Chronic pneumonia - male, aged 51 with a collapsed left upper lobe and enlarged hilar glands. Tomography showed a central tumour in the left upper lobe and this was removed at pneumonectomy. (b) Actinomycosis - male, aged 46 with a short history of cough, fatigue and malaise whose chest x-ray suggested collapse of the middle and right lower lobes. Bronchoscopy showed no abnormality but bronchography demonstrated a stop in the middle lobe and anterior basal bronchi. At operation a mass which felt, in places, as hard as bone was removed. (c) Two cases of sarcoidosis. The same authors also recorded 4 instructive cases of the same type illustrating the similarity which may occur between simple and malignant conditions:

(a) Male, aged 47 with a large, dense shadow in the right upper lobe. At operation this was found to be a large "tumour" which was thought to be inoperable but lung biopsy showed only chronic interstitial pneumonia. Five years later the patient was alive and well and the affected lung looked almost clear.

(b) Male, aged 42, had pneumonia 2 years previously and a few months

later drainage of an empyema. Since that time there had been frequent attacks of high fever. There was a well-defined mass the size of a grape-fruit in the left lower lobe and tomography showed that the vessels in the lung were displaced towards the mid-line. Only pus was seen in the left lower lobe bronchus at bronchoscopy and on bronchography the dense area failed to fill so that the lesion was thought to be either a carcinoma or chronic abscess. Operation was advised and refused. Eight years later the patient was alive and well.

(c) Male, aged 39, with repeated colds and cough for 6 months had a collapsed right lower lobe and bronchoscopy showed a broadened, fixed main carina with a pale, soft tumour in the right lower lobe bronchus. Histological examination showed that the material removed from the bronchus was tuberculous. Eight years later the patient was alive and well.

(d) Female, aged 56, had shadows in her left upper lobe which suggested cavitation in long-standing tuberculosis and in her right upper lobe was a large cavitating tumour with an enlarged hilar shadow. The lesion on the right side was thought to be an inoperable carcinoma. Ten years later she was alive and well.

Marengo and Martinez (1949) recorded the case of a male, aged 54, with right upper lobe atelectasis who was thought to be suffering from tuberculosis. Five months later carcinoma and unresolved pneumonia were considered as alternative diagnoses and bronchography showed occlusion of the right upper lobe bronchus. A further bronchogram 10 days later showed the bronchial obstruction to be incomplete. After an interval of 4 months - by which time the patient was asymptomatic - a third bronchogram showed the right upper lobe bronchus to be completely patent. This was interpreted as a non-tuberculous inflammatory lesion.

The clinical as well as the radiological picture in benign conditions may closely resemble malignant disease. Ashe, McDonald and

Clagett (1951) reported a female, aged 33, pregnant, who - following a cough - developed pain in the left shoulder and arm with a supraclavicular swelling but no Horner's syndrome. X-rays showed a dense, rounded shadow in the left upper lobe and bronchoscopy was negative. The appearance at thoracotomy suggested neoplasm and an upper lobectomy was performed. The resected lobe contained a dense, fibrous mass with non-specific chronic inflammatory changes and enlarged hilar glands but no evidence of malignancy.

Obviously the diagnosis of bronchial carcinoma should be accepted with reserve in the absence of pathological proof.

Holmes Sellors, Blair, Houghton, Thompson and Pryce (1946) drew attention to what they called spreading suppurative pneumonitis and emphasized its close resemblance to the breaking-down of lung tissue which may occur distal to a carcinoma. They recorded 23 cases, 17 on the right side and 6 on the left; 15 of the 23 occurred in the upper lobes. The radiological progress of the disease was described as being diagnostic. A massive consolidation develops in the affected segment or lobe and soon translucencies begin to appear in it. The consolidation "creeps" to immediately adjoining portions of lung while the first involved areas show some resolution and in a large proportion of cases the entire lung is involved at some time during the disease. It differs from tuberculosis in that the spread of the lesion is due to extension from its original site and not to shadows developing at a variable distance from the first one; nor is the characteristic mottling so often seen in tuberculosis present. Non-specific suppurative pneumonia was the name given to 25 similar cases described by Logan and Nicholson (1949). All the patients were males, aged 18-43 and were seen in the Middle East between 1941 and 1945. The onset was sudden in 15 and more gradual in 10. Recurring bouts of fever occurred and there was copious purulent

sputum in 24 cases. Finger-clubbing occurred in 23 and one had hypertrophic pulmonary osteoarthropathy. Films taken at the onset of the disease in 22 cases showed initial involvement occurred in the right lung in 15 cases; the right upper lobe was involved during the course of the illness in 10. Resection of the affected lobe or lung was regarded as the treatment of choice.

Lipoid pneumonia is becoming increasingly recognized (Swenson and Leming, 1950) and Weissman (1951) stressed the importance of a careful history as regards habits and occupation in case these give a clue to the diagnosis. Waddell, Sniffen and Sweet (1949) recorded 10 cases in whom the pre-operative diagnosis in 6 was bronchogenic carcinoma. The main symptoms were cough and sputum, haemoptysis, pleural pain and weight loss; the duration of these varied from 9 weeks to 5 years. X-rays showed consolidation and atelectasis and on bronchography 3 out of 10 showed no filling of the affected segment. Davis, Hampton, Bickham and Winship (1954) emphasized the clinical, radiological and gross pathological similarities between lipoid pneumonia and carcinoma and pointed out that only histological examination could definitely differentiate the two conditions. Five out of 6 of their cases gave a history of oil ingestion after oil had been found in the resected lung. Hampton, Bickham and Winship (1955) recorded 35 cases, 10 of which died (autopsy was performed in each one) and 9 others were operated on for a tumour-like lesion in the lung. Twenty-one out of the 35 lesions were bilateral and 14 unilateral, 12 of the latter being on the right side and usually presenting as a single, nodular area in the lung. In all but 2 cases there was a history of oil ingestion - mineral oil in 22, nasal drops in 8, cod liver oil in 2 infants and petroleum jelly in 1. Twenty-four patients sought medical advice because of chest symptoms and 11 were picked up at a chance x-ray examination.

The x-ray appearances were described as being of 2 main types: (a) Diffuse (24 cases) in which fine linear densities faded off into the lung fields and mingled with areas of increased translucency, the general impression being one of fibrosis. (b) Nodular (11 cases) - a homogeneous shadow varying from a few centimetres in diameter to a very large mass, well- or ill-defined, was present in the lung; in 5 of these a lobar bronchus was occluded (middle lobe in 4). A mass of this sort may diminish in size as a result of shrinkage but Davis et al. reported one of their 6 cases removed at operation as having shown a slow increase in size.

Fungus infections may resemble carcinoma closely (Good, 1951) with intrapulmonary, hilar and perhaps mediastinal shadows present. Diagnosis depends on the isolation of the fungus and study of its characteristics. Hinson, Moon and Plummer (1952) reported 8 cases of aspergillosis which showed changing appearances of consolidation and collapse and they emphasized the occupational history and eosinophil count as being the two most important diagnostic features (there was an eosinophil count of over 1,000/cu.mm. in all their cases). Whenever an odd radiological picture is present, fungus infection should be remembered as an uncommon possibility.

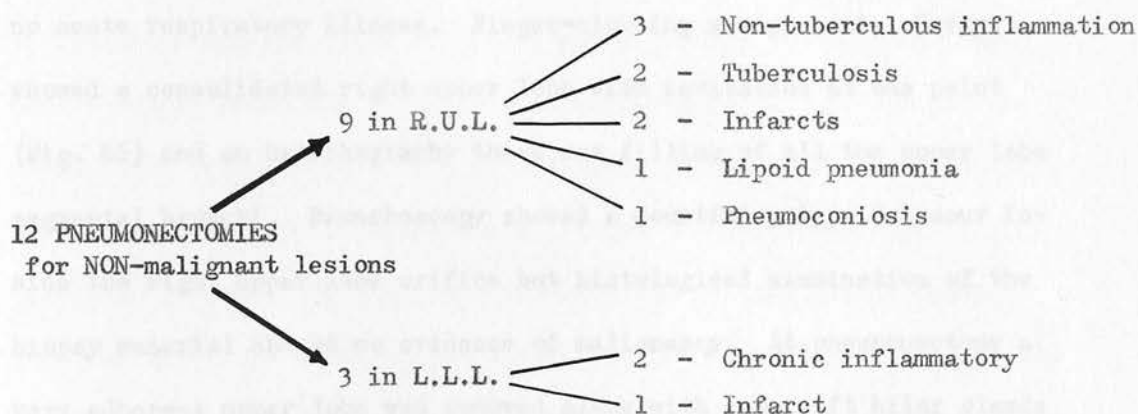
Kergin (1952) commented on the occasional close resemblance between silicosis and bronchogenic carcinoma when basic lung changes are apparently absent and a unilateral massive shadow is present. He recorded 8 cases, 7 of whose symptoms were consistent with the presence of a carcinoma and who underwent operation. All the patients were males, 5 had a long history of dust exposure but 2 had been exposed for only 1 and 2 years respectively and in each one this had occurred over 30 years previously. Lymph glands were often adherent to neighbouring vessels so that there were considerable technical difficulties in performing a segmental resection, making pneumonectomy necessary.

The massive lobar or segmental consolidation which is said to occur in tuberculosis complicating diabetes may resemble a carcinoma (Kerley, 1951).

Personal findings.

During a 3 year period (1952-1954 inclusive) at Shotley Bridge 12 patients, all males, underwent pneumonectomy because of a mistaken diagnosis of carcinoma (Table 19).

TABLE 19 - 12 CASES SUBJECTED TO RADICAL SURGERY ON ACCOUNT OF MISDIAGNOSIS OF MALIGNANCY



In one case the operation was desirable as the only satisfactory method of extirpating extensive disease - case 3) below. In the remainder it was a grave diagnostic error, especially as 3 patients had to undergo an additional seven- or eight-rib thoracoplasty because of an empyema. When the lesion was examined by the surgeon at thoracotomy, it was thought to be a carcinoma in 6 of the cases. The true nature of 2 of the inflammatory lesions was suspected. One of the inflammatory lesions was thought equally likely to be inflammatory or neoplastic in origin. One of the infarcts was thought to be an inflammatory lesion. The true nature of one of the tuberculous cases was suspected. No provisional diagnosis was made in the pneumoconiotic lesion but it felt much too hard for a carcinoma.

Brief details are given below of each of the 12 cases. All sputum examinations were negative for tuberculosis and, except where stated, bronchoscopy showed no abnormality. Tomography was performed in 9 cases but yielded little additional information. Bronchography - which should perhaps have been exploited more fully - was employed in 5 cases and 3 of these showed a blocked bronchus in the affected portion of lung.

1) Male, aged 47, complained of cough with purulent sputum and dyspnoea on exertion for 3-4 months but did not feel ill. He had had no acute respiratory illness. Finger-clubbing was present. X-rays showed a consolidated right upper lobe with cavitation at one point (Fig. 65) and on bronchography there was filling of all the upper lobe segmental bronchi. Bronchoscopy showed a doubtful polypoid tumour inside the right upper lobe orifice but histological examination of the biopsy material showed no evidence of malignancy. At pneumonectomy a very adherent upper lobe was removed along with some soft hilar glands and the lesion was thought to be inflammatory. The specimen showed chronic inflammatory changes in the right upper lobe with a large abscess in the posterior segment.

2) Male, aged 49, complained of cough, occasional haemoptysis and dyspnoea on exertion for 3 months but had never been off his work as a postman. X-rays showed an ill-defined dense shadow in the right upper lobe adjacent to the mediastinum (Fig. 66). Thoracotomy revealed a hard mass 7 cm. in diameter above the lung root which was thought to be a carcinoma. The resected specimen showed only chronic inflammatory changes with much fibrosis in the apical and posterior segments of the upper lobe.

3) A labourer, aged 38, had a history of chest trouble with cough, yellow sputum and dyspnoea on exertion for 6-7 years. In the last year

he had had two attacks of "pneumonia" and on admission had extensive consolidation and cavitation in the right upper lobe anteriorly; the hilar region looked relatively clear (Fig. 67). During the next 3 months, in spite of intensive antibiotic therapy, the lung changes spread to the middle lobe and remainder of the upper lobe and regressed at other points. At no time was there much shadowing near the lung root. He ran an intermittent fever of  $101^{\circ}$  -  $102^{\circ}$ F., coughed up a great deal of foul, occasionally blood-stained sputum, steadily lost weight and went downhill. Direct and cultural examinations of the sputum showed no evidence of tuberculous, staphylococcal, Friedlander's or fungus infections. The diagnosis was certainly in doubt but it was felt that there was probably an underlying carcinoma. At thoracotomy there was nothing definite to suggest neoplasm but pneumonectomy was performed as the best treatment irrespective of the primary pathology present. The resected specimen showed very thick pleura over the upper and middle lobes which were the site of multiple, fairly large abscesses, bronchiectasis and chronic inflammatory changes. This was apparently a case of non-specific suppurative pneumonia (Logan and Nicholson, 1949).

4) Male, aged 57, complained of loss of energy and loss of weight for 2 months, a dull aching in the right upper chest for 6 weeks and occasional haemoptysis in the last two weeks. X-rays showed some loss of volume of the right upper lobe with dense consolidation in its posterior segment bulging into the greater fissure (Fig. 68). Bronchography showed blocking of the anterior and posterior segmental bronchi of the right upper lobe. At thoracotomy a solid mass was found in the posterior segment of the upper lobe and was thought probably to be tuberculous in origin but a pneumonectomy was performed. The specimen showed caseating tuberculosis in the posterior segment of the right upper lobe.

5) Male, aged 36, who had smoked 60 cigarettes/day for at least 12 years complained of some dyspnoea on exertion after a recent cold and x-rays showed a cavitating mass in the anterior segment of the right upper lobe (Fig. 69). At thoracotomy the lesion was thought to be neoplastic and pneumonectomy was performed with removal of a chain of hard glands alongside the oesophagus. The upper lobe contained caseating tuberculous material and several cavities. An empyema developed and an eight-rib thoracoplasty was performed.

6) Male, aged 48, had recovered satisfactorily from a right-sided "pneumonia" but x-rays (Fig. 70) showed elevation of the lesser fissure and considerable homogeneous shadowing in the right upper lobe posteriorly which, over a period of 3-4 weeks, gradually increased in size. The patient felt well during this time. Bronchography showed filling of all the segmental bronchi of the right upper lobe but on lateral tomography the shadow was seen to be bulging markedly into the greater fissure. At thoracotomy two hard masses were palpated in the upper lobe and it was felt that these were most likely inflammatory but a pneumonectomy was performed. The lesion in the upper lobe was found to be an infarct. Subsequent seven-rib thoracoplasty was carried out because of an empyema.

7) Male, aged 55, who had had "flu" 5 weeks ago complained of occasional haemoptysis since then although he felt fit in himself. X-rays (Fig. 71) showed appearances very similar to the previous case. At thoracotomy a mass the size of a tennis ball was found in the upper lobe and was thought most likely to be a carcinoma; pneumonectomy was performed. This was another infarct.

8) Male, aged 60, complained of intermittent aching pain in his right upper chest for 2 months with increasing dyspnoea and cough but very little sputum. X-rays (Fig. 72) showed a dense, ill-defined mass posteriorly in the right upper lobe and the posterior segmental bronchus

was blocked at bronchography. At pneumonectomy a mass the size of an orange which was thought to be a carcinoma was removed. The specimen showed lipoid pneumonia. The large amount of intracellular lipoid was thought to indicate that the latter was exogenous but no history of occupational or habitual ingestion of lipid-containing material was obtained on close questioning of the patient.

9) A labourer, aged 55, who had been a coal-miner for 22 years complained of an increasing dry cough for 6 months with loss of energy and loss of  $1\frac{1}{2}$  stones in weight. X-rays (Fig. 73) showed category 2 or 3 simple pneumoconiosis with a well-defined, dense mass in the posterior segment of the right upper lobe; 2 smaller nodules in the apex of the lower lobe were visible on lateral tomograms. The radiological appearance did not really suggest carcinoma. At thoracotomy a mass much harder than carcinoma was found bulging into the greater fissure and several smaller nodules were felt in both the upper and the lower lobes. Pneumonectomy was performed. The specimen showed massive fibrosis of complicated pneumoconiosis with laminated collagen bundles, much anthracotic pigment and central necrosis.

10) Male, aged 52, who had smoked 40 cigarettes/day for 30 years developed cough, haemoptysis, dyspnoea, left-sided chest pain, loss of weight and loss of energy after "flu" 4 months previously. Clubbing of the fingers was said to have developed during this time. X-rays (Fig. 74) showed atelectasis-consolidation in the apex of the left lower lobe and a bronchogram demonstrated a sudden block  $\frac{1}{2}$  cm. inside the apical segment orifice. At thoracotomy a hard mass thought to be a carcinoma was found in the apex of the left lower lobe and pneumonectomy was performed. Only chronic inflammatory changes with bronchiectasis and abscess formation were present in the resected specimen.

11) Male, aged 58, complained of increasing dyspnoea for 3 months

and loss of weight and frequent small haemoptysis for one month. X-rays showed atelectasis-consolidation of the left lower lobe and at bronchoscopy there was narrowing and rigidity below the upper lobe orifice but bronchial biopsy was negative. At thoracotomy no mass was felt in the collapsed left lower lobe and there was nothing definite to suggest neoplasm but pneumonectomy was performed. The specimen showed chronic inflammatory changes with bronchiectasis and considerable fibrosis. An empyema developed and thoracoplasty was subsequently necessary.

12) Male, aged 50, who had smoked 25-30 cigarettes/day for many years had "flu" seven weeks ago when he had complained of dyspnoea, haemoptysis and severe pain in the left chest. These symptoms had disappeared but he had lost 2 stones in weight since then and x-rays showed a fairly well-defined, dense shadow in the apical and subapical segments of the left lower lobe (Fig. 75). At thoracotomy a mass was found which was thought to be "probably but not definitely carcinoma" and pneumonectomy was performed. The specimen showed considerable pulmonary fibrosis and pleural thickening and the appearances suggested the results of infarction rather than an organizing pneumonic exudate.

In retrospect, some of these diagnostic errors appear to have been unnecessary. They are worth more detailed consideration.

Self-evident but sometimes forgotten is the fact that no matter how closely malignancy is simulated clinically and radiologically, in the absence of histological proof, there is always the possibility that a lesion is benign.

On radiological grounds alone pneumonectomy should definitely have been avoided in case 9) with the complicated pneumoconiosis. Simple pneumoconiosis was obviously present and, although the massive shadow was entirely unilateral, this is known to occur from time to time and marked weight loss should hardly have been sufficient in itself to cause

such a diagnostic error. The usual difficulty, however, in pneumoconiosis is underdiagnosis rather than overdiagnosis of carcinoma since, inevitably, initial alterations in the x-ray appearance are usually regarded as benign associated changes such as progressive massive fibrosis or tuberculosis.

Four other pneumonectomies might have been avoided - in case 11) with the collapsed left lower lobe and in cases 6), 7) and 12) with the infarcts. If a bronchial carcinoma had produced the collapsed lower lobe in case 11) it would almost certainly have been visible at bronchoscopy or, at least, bronchial biopsy at the site of some narrowing would have been expected to be positive. When radiographic appearances suggest that - if a carcinoma should be present - bronchial biopsy will be positive and it is, in fact, negative then a repeat bronchoscopy is desirable.

Two out of the 3 infarcts were thought to be neoplastic at operation so a correct pre-operative diagnosis is the only way in which a resection could have been avoided. In all 3 cases, if a more careful history had been taken and the possibility of pulmonary infarct considered, the correct diagnosis or, at least, a fairly strong possibility of its being correct might have been arrived at. It is not easy to determine whether an illness some months previously has been a pneumonia or pulmonary infarction and 2 of the 3 patients were not attended by their general practitioners at that time. However, the important lesson to be learned is the consideration of infarct as a possible diagnosis in cases similar to those recorded. The most striking feature in each of the 3 was the grossly abnormal chest x-ray associated with no complaints - other than some weight loss in two. Another similar case (Fig. 79), not included in the series, was also asymptomatic. The frequency with which a pulmonary infarct can produce a slowly-resolving, extensive abnormality in the lung is probably not fully appreciated.

Pulmonary infarcts which occur in association with broncho-

genic carcinoma usually contribute minor radiological changes compared with those of the underlying tumour. Hanbury, Cureton and Simon (1954) found a 10% incidence of pulmonary infarcts in a series of 100 cases of bronchogenic carcinoma. In all these cases except one, however, a diagnosis of neoplasm was apparent on radiological and/or bronchoscopic grounds and no difficulty in the diagnosis of primary lung carcinoma was experienced; only one was asymptomatic. The infarcts produced areas of ill-defined opacity peripheral to - and often separated by a considerable distance from - an obvious, more centrally placed tumour. In one case two 1 cm. circular shadows in the left upper lobe represented an infarct peripheral to a carcinoma measuring 8x4x4 cm. which had not been demonstrated radiologically.

Careful study of the other misdiagnosed cases and comparison (especially of tomograms) with proved carcinomata has failed to reveal any diagnostic feature which should have enabled a correct pre-operative diagnosis to have been made. Nevertheless, it is essential to be aware of the extreme difficulties which often occur and to investigate all undiagnosed upper lobe lesions most vigorously with a view to excluding tuberculosis. Tracheal displacement of different types is occasionally helpful in the differential diagnosis of upper lobe disease. Poppel, Jacobson and Dewing (1953) described buckling of the trachea due to lung scarring in 54.3% of 115 cases of upper lobe tuberculosis. No example of this was seen in 263 cases of upper lobe carcinoma - the trachea was bent gently, rather than suddenly angled, towards the affected side when atelectasis was present. These were obviously tuberculous cases of considerable duration and this sign is less likely to be useful to-day than it was 8-10 years ago. The trachea is displaced towards a collapsed lung or upper lobe and, to a lesser degree, towards the side of a collapsed lower lobe. If such a trachea be

deviated away from the affected side just above the bifurcation this indicates the presence of mediastinal glandular deposits at this level. This appearance is valueless in early diagnosis but may be helpful when an upper lobe tumour is beyond the range of bronchoscopic biopsy. When there is right upper lobe atelectasis, a right aortic arch must be excluded before attributing tracheal compression at this point to neoplastic lymphadenopathy.

Abnormal shadowing in the "axillary" segments of adjacent bronchi is more likely to be the result of inflammatory disease than of endobronchial tumour - for the subsegmental bronchi do not share a common origin and such changes could not be accounted for by a tumour at one particular point in the bronchial tree. Simple anatomical reasoning may, however, be misleading if infected material distal to a tumour should be aspirated into other lung segments, if there be anatomical variations in the bronchial tree or if a glandular mass should invade bronchi remote from the primary site. The latter phenomenon is most often seen when a subcarinal mass of tumour extends to involve one or other main bronchus. Neuhof and Copleman (1940) recorded a case in which the glandular mass associated with a carcinoma in the posterior segment of the right upper lobe had spread to involve the middle lobe bronchus; there was a mass in the upper lobe and collapse of the middle lobe.

Benign lesions tend to be of less segmental distribution than malignant disease and their maximum density to lie some distance from the lung root; chronic inflammatory disease situated near the mediastinal aspect of the lung is particularly difficult to distinguish from carcinoma. The response of a lesion to antibiotic therapy is often an unreliable differential diagnostic sign since infective changes distal to a tumour may respond to such treatment and some inflammatory lesions

are highly resistant to therapy. The rate of onset of symptoms is also an extremely variable factor in both benign and malignant lung disease.

The difficulty or impossibility of establishing a correct pre-operative or even operative diagnosis in some cases is obvious and we must appreciate the limitations of our methods. Nevertheless, every effort can be made to minimize errors and this may be achieved in some measure if we can review our mistakes from time to time and subject them to a searching analysis suitably stimulated by the critical views of our colleagues, preferably those in specialties other than our own. It is suggested that a complete record of all misdiagnoses be kept so that, when a new diagnostic problem arises, it may at once be compared both clinically and radiologically with previous similar cases which either did or did not turn out to be neoplastic. This is likely to be particularly useful in dealing with the many doubtful lesions which occur most often in the right upper lobe and in which the possibility of a benign condition always requires careful consideration, especially if shadowing is less dense in the hilar than in the peripheral regions of the lung. If thorough bronchographic and tomographic studies are performed in many such cases, perhaps they will be helpful when they are available to compare with each new diagnostic problem.

Nine (75%) of the wrong diagnoses occurred in the right upper lobe, therefore, - in the absence of histological proof - particular care and thought is required before reaching a tentative diagnosis of carcinoma in this site.

There were no females in this group of 12 mistaken diagnoses, probably because a diagnosis of bronchial carcinoma - on account of its considerably lower incidence - is less readily made in the female.

A history of heavy smoking may have swayed the diagnosis in the wrong direction of carcinoma in cases 5), 10) and 12) who smoked

60, 40 and 25-30 cigarettes per day respectively.

A bulging fissure, best shown by tomography, is said to be a valuable sign of malignancy (Lodge, 1955) but Brock (1954) described swelling of the affected segment and consequent bulging of the fissure which occurs in acute inflammatory disease. This appearance seems most misleading in lateral tomograms of benign upper lobe lesions such as tuberculosis or infarction when apparent bulging of the fissure is not uncommon (Figs. 66, 68, 70, 73).

Any solid lesion in the lung whether it be an infarct, unresolved pneumonia, cyst, abscess or tumour, looks strikingly dense on tomography. Density, in itself, cannot be taken as an appearance of any diagnostic significance. A collapsed upper lobe from any cause produces splaying of the main bronchi, so tomographic appearances of a subcarinal glandular mass must be interpreted with care in these circumstances.

When bronchography shows a blocked bronchus, carcinoma is always the first possibility to consider but it is important to appreciate that (a) benign conditions less frequently but not infrequently produce the same appearance and inflammatory disease may be particularly misleading in the upper lobes. The significance of a blocked bronchus becomes progressively less the more peripherally it occurs, for secretions are more likely to obstruct the smaller bronchi. (b) Bronchograms occasionally show no evidence of bronchial obstruction in the presence of carcinoma, the latter having extended peribronchially so that bronchi may run, unobstructed, through a large tumour mass in the lung.

Lodge (1955) emphasized the rarity of unresolved pneumonia and the necessity for suspecting an underlying carcinoma in such cases. There is, however, considerable variation in the rate of resolution

of bacterial and virus pneumonias and it is not uncommon for residual shadowing to persist for 2-3 months. The slowly-clearing lung shadow certainly requires careful investigation but unless there is clinical or radiological evidence of deterioration in the condition, carcinoma need seldom be suspected before the elapse of this time - especially if a course of antibiotics were stopped as soon as fever subsided. Shadowing which clears slowly over a period of 2-3 months after a chest illness may also be due to an infarct (Fig. 79). Earlier suspicion than this will undoubtedly reveal cases of bronchial carcinoma a few weeks earlier than otherwise but there is a general tendency to suspect carcinoma too early and too frequently in resolving inflammatory disease, especially in older patients (Figs. 76, 77, 78). The ability of right upper lobe inflammatory disease to mimic carcinoma is shown by a group of 23 slowly-resolving pneumonias in this site reported by Kirby, Waddington and Francis (1957) from the Indiana University School of Medicine. Bronchogenic carcinoma was considered a strong possibility in each one and thoracotomy recommended in the majority. Gradual clearing occurred over a period of 2-6 months (22 of the 23 patients were chronic alcoholics). The "high index of suspicion" which is necessary if early cancer is to be detected must be controlled within limits gauged by experience if unwarranted diagnoses are to be avoided. Suspicion of carcinoma is much higher when pneumonia, in the absence of known bronchiectasis, recurs in the same segment or lobe or when a consolidated portion of lung, in spite of adequate therapy, gives not the slightest indication of clearing over a period of 3-4 weeks. The latter may be due to a diffusely infiltrating tumour (Moyer and Ackerman, 1951).

Diaphragmatic paralysis is commonly due to malignant disease of some kind, especially mediastinal spread from a bronchial carcin-

oma but any chest lesion associated with phrenic palsy most not - in the absence of histological proof - be assumed to be malignant. The best-known non-malignant intrathoracic condition which may produce phrenic paralysis is aortic aneurysm. It is important to be aware of other possibilities in these circumstances and Freedman (1950) recorded 4 post-pneumonic cases, 3 of which lasted several weeks and one which appeared permanent. Phrenic paralysis may also occur when apical inflammatory disease - tuberculous or otherwise - involves the nerve in scar tissue (Fig. 80). Retrosternal goitre and pulmonary infarction are other benign conditions which on rare occasions may produce phrenic palsy. A bronchial adenoma occasionally spreads to involve hilar glands and produces phrenic paralysis; this is not necessarily inconsistent with a good prognosis.

#### CONCLUSIONS.

(1) Misdiagnosis of a benign lesion as malignant is most likely to occur in a male with disease in the right upper lobe.

(2) No matter how closely the clinical and radiological appearances resemble those of malignancy, in the absence of histological proof there is always the possibility that a benign lesion is present.

(3) Benign disease may be present when x-ray appearances suggest that - if there be malignancy - bronchoscopy is likely to be positive, and it is, in fact, negative. In these circumstances, repeat bronchoscopy is desirable.

(4) The following features, although frequently associated with malignancy, are not invariably reliable and may lead to a mistaken diagnosis of carcinoma in doubtful or difficult cases:

a) History of heavy smoking.

b) Slowly-resolving lung shadowing, such as may occur in non-specific inflammatory disease and pulmonary infarcts.

- c) Phrenic paralysis.
- d) A bulging fissure, shown by tomography.
- e) Bronchial obstruction, shown by bronchography, particularly if it should be at segmental or subsegmental level.

(5) Diagnostic errors should be fully documented and kept under constant review. Awareness of our previous mistakes may prevent other similar ones being made.

Alveolar cell carcinoma and bronchiolar carcinoma are two terms which may be regarded as synonymous. Gold, Harwood, Clayton and Griffith (1954) found that only 1 out of 12 cases in the literature in which category had been employed, but regarding all having been recorded as sarcoma. The first case to be diagnosed during life in Britain was published in 1933 by Robinson and Beard.

From (1954) this term should be fulfilled before a satisfactory diagnosis of alveolar cell carcinoma can be reached:

- (1) Impingement of the growth by tall, columnar, mucin-secreting cells.
- (2) Presence of an indistinct margin of the bronchus.
- (3) Absence of a primary alveolar carcinoma elsewhere in the lung.

Alveoli may be lined by epithelial cells in inflammatory diseases, fungus infections being especially likely to produce epithelial overgrowth, but many pathologists are unable to decide whether or not there is a cellular lining of the alveolus in the normal lung. Thus, although the alveoli are lined by cuboidal epithelial cells in bronchiolar carcinoma, the outstanding issue is whether the cells originate from elsewhere lining the alveolus or from the epithelium of the respiratory bronchioles. Willis (1953) said that he had never seen a lining of a report of one for which it should be necessary to postulate an alveolar origin. Fisher and Bailey (1951) regard the "leucocytes" arising from bronchiolar epithelium being probably misdiagnosed as sarcoma.

## BRONCHIOLAR CARCINOMA

Most of the earlier papers on this uncommon and debatable condition came from the U.S.A. under the heading of Alveolar Cell Carcinoma, Bronchiolar Carcinoma or Pulmonary Adenomatosis and the vast majority of cases had been observed only at autopsy. The problematical nature of the pathology is reflected in the 35 synonyms which Liebow (1952) listed as having been used by various authors in their descriptions of the disease but alveolar cell carcinoma and bronchiolar carcinoma are in common use and may be regarded as synonymous. Good, McDonald, Clagett and Griffith (1950) could find only 3 out of 52 cases in the literature in which surgery had been employed, the remaining 49 all having been recorded at necropsy. The first case to be diagnosed during life in Britain was published in 1953 by Hutchison and Fraser.

Swan (1949) laid down criteria which should be fulfilled before a satisfactory diagnosis of alveolar cell carcinoma can be reached:

- (1) Lining of the alveoli by tall, columnar, mucus-secreting cells.
- (2) Absence of an intrinsic tumour of the bronchus.
- (3) Absence of a primary adenocarcinoma elsewhere in the body.

Alveoli may be lined by epithelial cells in inflammatory diseases, fungus infections being especially likely to produce epithelial overgrowth, but many pathologists are unable to decide whether or not there is a cellular lining of the alveolus in the normal lung. Thus, although the alveoli are lined by neoplastic epithelial cells in bronchiolar carcinoma, the debatable point is whether the cells originate from others lining the alveoli or from the epithelium of the respiratory bronchioles. Willis (1948) said that he had never seen a tumour or a report of one for which it seemed necessary to postulate an alveolar origin. Fisher and Holley (1953) regard the tumour as arising from bronchiolar epithelium, being probably multicentric in origin. Good

et al. (1950) found it impossible to settle this point and emphasized that other conditions can produce a very similar histological picture:

(a) Alveoli lined with epithelial cells in response to inflammation. In a lung showing these changes the alveolar septa are thickened and contain inflammatory cells; in bronchiolar carcinoma neither of the latter changes should be present.

(b) Secondary adenocarcinoma, especially from the alimentary tract or thyroid.

(c) A peripheral bronchogenic carcinoma, usually an adenocarcinoma, arising in the terminal air passages. The alveolar septa, however, are not intact in this condition. Hutchison (1952) has commented on the close similarity in histological appearances of metastases from ovarian carcinoma. These sources of error in diagnosis make assessment of the true incidence of the condition difficult to obtain. According to Liebow, bronchiolar carcinoma comprises between 3% and 4% of the malignant tumours of the lung. Hutchison reviewed 324 post-mortem examinations in cases of primary lung carcinoma conducted at the Western Infirmary, Glasgow, over a period of 25 years (up to 1951); he found 9 cases (2.8%) in which there was no anatomical or histological evidence of a bronchial origin of the tumour and concluded that these might be examples of this disease. Increased awareness of the condition is resulting in reports of larger number of cases and Storey, Knudtson and Lawrence (1953) recorded 39 cases from the American Forces Institute of Pathology.

None of 8 cases which underwent resection at the Mayo Clinic showed evidence of metastases (Griffith, McDonald and Clagett, 1950) but a review of 51 cases from the literature at that time showed that 43% had metastases and 77% of these were in the regional lymph nodes. 22% of all the cases showed some cavity formation in the lungs.

Five cases seen at autopsy by Fisher and Holley (1953) showed involvement of both lungs which were firm, voluminous and did not collapse. The tumour was either nodular (varying in size from miliary deposits to some of 1 cm. in diameter) or diffuse. Gross necrosis was not seen, the lymphatic channels were extremely infiltrated and hilar glandular involvement was present in all cases, with widespread metastases in two.

No abnormality is seen at bronchoscopy (except for, in some cases, excessive amounts of clear bronchial secretion) but cytological examination of the bronchial washings or sputum is said to be a most useful diagnostic procedure. Watson and Smith (1951) found that cytological examination of the bronchial washings in 15 cases of alveolar cell carcinoma showed results which were "positive or strongly suggestive of carcinoma" in 12. Good et al. (1950) obtained positive results from cytology in 4 out of 6 cases; in 3 cases sputum and in one bronchial secretions aspirated at bronchoscopy provided the material for examination. In two alveolar cell carcinoma was suggested as the diagnosis and in the other two "carcinoma" was diagnosed on the basis of the cytological findings.

The history does not differ significantly from that of other types of lung disease (Good et al., 1950) but thin, watery sputum is said to be characteristic of alveolar cell carcinoma (Paul and Juhl, 1950; Moersch, 1953) and is described as resembling "soap-suds" (Dennis, Raby and Hildebrand, 1952). Since there is no obstruction of major bronchi and thus no atelectasis or obstructive pneumonitis, the onset is often more insidious than in bronchial carcinoma. When symptoms have developed, the course leading to ultimate fatality is brief (Liebow, 1952).

Fisher and Holley (1953) recorded 5 cases which came to autopsy and found that the clinical course was shorter than in other untreated

pulmonary neoplasms. Watson and Smith (1951), reviewing the largest series (33 cases) reported from one centre - The Memorial Hospital, New York - observed that the rate of growth varied considerably, some cases dying within a few months and others living 5 years or more.

No radiological appearance seems to be characteristic or capable, in itself, of establishing a correct diagnosis. King and Carroll (1950) described widespread, discrete or confluent nodular densities which sometimes gave a coarse miliary pattern and no evidence of lymphadenopathy. Four out of 5 cases of Fisher and Holley (1953) showed a pleural effusion and 3 of these had miliary shadows in both lungs. Good et al. (1950) described the x-ray appearances in 12 cases seen during the previous 7 years at the Mayo Clinic. Eight were unilateral and 4 bilateral. Six were described as showing consolidation in a segment or lobe and in 3 of these neoplasm had been suggested as the probable diagnosis on radiological grounds. In 4 the lung shadows were sufficiently well-defined to be called a mass (the lesions were bilateral in 3 cases and there were multiple shadows in one lung in the other); the suggested radiological diagnosis in all 4 cases had been primary or secondary neoplasm. In the remaining 2 cases the lung changes were bilateral and diffuse with no localized mass present. The earliest x-ray appearance is described as being a small, poorly-defined area of consolidation - similar to a pneumonitis due to bronchial obstruction or atypical pneumonia - which gradually spreads, with the development of further lesions in the other lobes or other lung. In the earlier stages appearances may be confused with lung abscess, chronic pneumonitis secondary to bronchial obstruction or with bronchogenic carcinoma (which is always a possibility in the age-group concerned). When changes are bilateral and diffuse, secondary malignancy, tuberculosis, sarcoidosis, fungus infections or pneumoconiosis may be closely simulated.

Curious bronchographic appearances have been described in one case of alveolar cell carcinoma by Zheutlin, Lasser and Rigler (1954) in which the affected parts of the lung showed many narrowed bronchi completely filled rather than coated with Lipiodol and the pattern of contrast medium resembled opaque threads scattered throughout the lung. There was no alveolar filling and this was attributed to blockage of bronchioles and alveoli by tumour cells. In view of possible confusion in diagnosis it is worth noting that Kergin (1952) quoted a case of sarcoidosis in which bronchography showed narrowing of several bronchi in the affected parts of the lung.

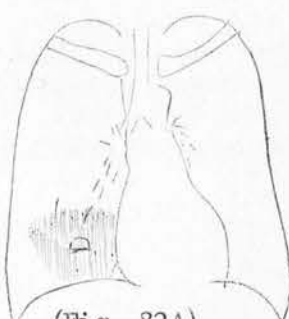
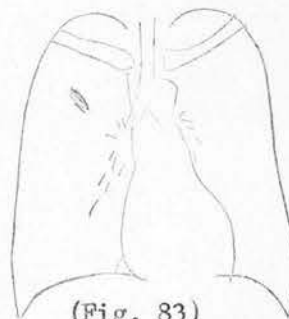
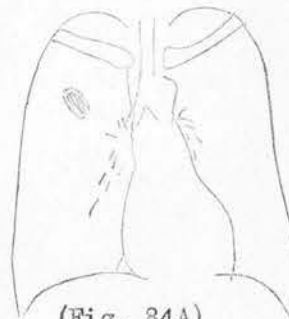
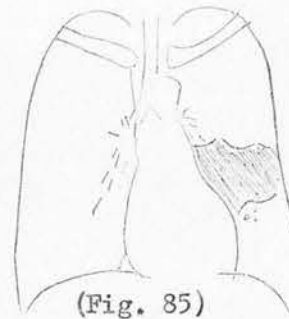
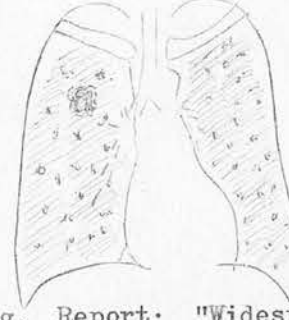
#### Personal findings.

Ten cases of bronchiolar carcinoma are reviewed (Table 20). I had personal experience with 7 and the remaining 3 were found on searching the records of the Royal Victoria Infirmary, Newcastle-on-Tyne, and the Newcastle General Hospital. Eight cases occurred in the Newcastle region and 2 in Dundee.

The diagnosis was made in 5 cases at autopsy, in 4 from a resected lobe or lung and in the remaining case from biopsy material removed at thoracotomy. In no case was there evidence of a primary tumour in the bronchus or elsewhere in the body or histological appearances to suggest inflammatory changes in the lung. Evidence for the diagnosis must be incomplete in the 5 cases in which no autopsy was performed but it seems justifiable to include these in the series - for the pathologists exercised much thought and care in their interpretation and there are no available facts to contradict the diagnosis in any of them. Histological studies were carried out in the Departments of Pathology at the Universities of Edinburgh (4 cases), Durham (4 cases) and St. Andrews (2 cases) and in each one the pathologists considered the appearance to be that of a bronchiolar or alveolar cell carcinoma.

<p>1. ...</p>	<p>... of ...</p>	<p>... of ...</p>	<p>... of ...</p>
<p>2. ...</p>	<p>... of ...</p>	<p>... of ...</p>	<p>... of ...</p>
<p>3. ...</p>	<p>... of ...</p>	<p>... of ...</p>	<p>... of ...</p>
<p>4. ...</p>	<p>... of ...</p>	<p>... of ...</p>	<p>... of ...</p>
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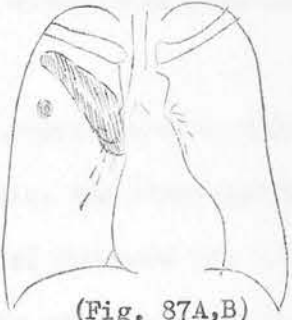

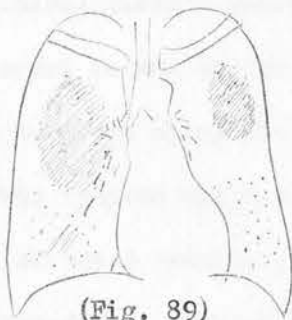

TABLE 20 - SUMMARY OF MAIN FEATURES IN 10 CASES OF BRONCHIOLAR CARCINOMA

SEX	AGE	HISTORY	X-RAY APPEARANCE	OPERATION	PATHOLOGY	FOLLOW-UP
M	51	"Flu" 3 months ago, lost 2 stones in weight.	 (Fig. 82A)	PNEUMONECTOMY R.L.L. very adherent to diaphragm & felt solid - probable growth. Many enlarged hilar glands.	R.L.L. infiltrated by cavitating tumour of no obvious origin: alveolar cell carcinoma with many mucus-secreting cells lining alveoli (Fig. 82B). Glands - lymphadenitis only. (Univ. of Edinburgh.)	Alive and well 18 months later.
M	56	Asymptomatic M.M.R. pick-up.	 (Fig. 83)	LOBECTOMY Rubbery "tumour" deep in R.U.L. - "probably not a growth".	Collapsed lung alveoli lined by columnar epithelium similar to that lining normal bronchioles but cells plumper and nuclei malignant-looking: probably a bronchiolar carcinoma. (Univ. of Edinburgh.)	Alive and well 3 years later.
M	60	M.M.R. pick-up with vague symptoms - slight dyspnoea and non-productive cough 1 year. M.M.R. film 1 year earlier reported as normal but lesion, though smaller, clearly visible	 (Fig. 84A)	LOBECTOMY	A largely necrotic tumour: alveolar cell carcinoma (Fig. 84B). Several glands examined but no evidence of neoplasm. (Univ. of Edinburgh.)	Alive and well 2 years later.
M	64	Dyspnoea, dry cough 5 months. Pain in left chest 3 months.	 (Fig. 85)	PNEUMONECTOMY Several enlarged glands round bronchus and hilar vessels.	Solid anterior segment of L.U.L. and lingula - ? growth. No endobronchial lesion seen. Scattered nodules in L.L.L. A very unusual tumour, described as malignant adenomatosis arising from bronchioles. (Univ. of Edinburgh.)	DIED 2 years later - no autopsy. No x-ray evidence of deposits in other lung 3 months before death.
M	69	Cough, white sputum and loss of 2 stones in weight during the last year. Mental confusion 2 months, vomiting and very ill 1 week. Afebrile, no A.F.B. in sputum. DIED.		-	AUTOPSY - Ill-defined mass in anterior segment R.U.L. Scattered nodules up to 0.7 cm. diameter in both lungs, fewest in lower lobes; lesions looked bronchopneumonic. No endobronchial abnormality. Many glands involved. Deposits up to 2 cm. diameter in liver, brain. No other primary tumour. Alveolar cell carcinoma. (Univ. of Durham.)	-

Film missing. Report: "Widespread mottling both lungs and dense shadow in R.U.L. - ? T.B. bronchopneumonic"

cont'd over

TABLE 20 - cont'd

SEX	AGE	HISTORY	X-RAY APPEARANCE	OPERATION	PATHOLOGY	FOLLOW-UP
M	71	Lung changes first seen at barium meal - increasing dyspnoea and yellow sputum 1 year. Deterioration with bronchopneumonia twice in following year. DIED.	 (Fig. 86A,B)	-	AUTOPSY - Parietal pleura very adherent to lungs which contained many poorly-defined nodules. Bronchi looked normal. Alveoli lined by columnar, mucus-secreting cells: alveolar cell carcinoma (Fig. 86C). One right hilar gland involved; no evidence of neoplasm elsewhere in body. (Univ. of Durham.)	-
F	44	Cough with watery sputum, pain right chest and weight loss since "chill" 5 weeks ago. No clubbing. Bronchoscopy - profuse, unusually clear secretion from R.U.L. orifice; no other abnormality, but malignant cells found in sputum (Fig. 87C).	 (Fig. 87A,B)	THORACOTOMY Pink mass in R.U.L. which pitted on pressure. Enlarged hilar glands. Biopsy from ulcerating lesions in R.L.L.	Much atypical hyperplasia of bronchiolar epithelium. Adjacent lung shows vascular congestion and even exudation of blood into alveoli. Appearance in highest degree suspicious of alveolar cell carcinoma. (Univ. of St. Andrews.)	DIED 3 months post-op. No autopsy.
F	46	Cough, yellow sputum 6 months. Pain in left chest 2 months. Large numbers of malignant-looking cells in pleural fluid. DIED.	 Portable film	-	AUTOPSY - Bilateral pleural effusions, left larger than right; pericardial effusion. Thick left visceral and parietal pleura studded with tumour nodules. Left lung diffusely infiltrated with alveolar cell carcinoma (Fig. 88B). Extensive axillary, cervical and mediastinal lymphadenopathy and gross involvement of bone marrow. No evidence of primary tumour elsewhere. (Univ. of Durham.)	-
F	60	"Flu" 1 year ago. Tiredness, increasing dyspnoea and loss of 1 stone in weight since then. No cough, sputum, haemoptysis, fever, clubbing. Hard glands right side of neck. DIED.	 (Fig. 89)	-	AUTOPSY - Lungs very bulky and upper lobes had appearance of grey hepatization but no impression could be made on them by finger pressure. Dilated pleural lymphatics visible to naked eye. Tumour tissue replacing lymph nodes in right side of neck, paratracheal, mediastinal, coeliac and para-aortic regions. Alveolar cell carcinoma with much lymphatic permeation. (Univ. of St. Andrews.)	-
F	74	Interscapular pain, increasing dyspnoea, loss of weight 2 months. DIED.	 Portable film	-	AUTOPSY - 1 litre of fluid in right pleura and both lungs riddled with tumour nodules (largest 0.8 cm. in diameter). Bronchi normal: alveolar cell carcinoma. Metastases in hilar glands, right kidney, both adrenals. No other primary tumour found. (Univ. of Durham.)	-

The youngest patient was 44 years of age, the oldest 74 and the average age 58. There were 6 males and 4 females, a proportion which is in agreement with other series; Good et al. (1950) found 5 males and 7 females in 12 cases reported from the Mayo Clinic and Liebow (1952) recorded an equal incidence in the two sexes. When the condition is found in a female it is especially important to exclude primary ovarian carcinoma as a source of metastases for, according to Hutchison (1952), these may closely resemble bronchiolar carcinoma in histological appearance.

Two of the 4 cases which underwent resection were picked up at mass x-ray examination; one was asymptomatic, the other had minimal symptoms. The other two operable cases had had symptoms for 3 and 5 months respectively. The duration of symptoms prior to death in the 6 cases who did not have surgery was 2 months, 5 months, 6 months, 1 year, 1 year and 2 years respectively.

**SYMPTOMS** did not differ from those occurring in other chest diseases except that pyrexial illness was strikingly uncommon. This is similar to the experience of others (Liebow, 1952). In two features, however, my cases did not accord with the clinical picture painted in the literature: (a) Haemoptysis was not recorded in any of the cases. (b) Only one example of clear, watery sputum occurred among the 7 cases of which I had personal experience. This symptom was not recorded in the notes of one other case. The records of the 2 remaining cases were inadequate to be of any help in this connection. Similar sputum was seen in one patient with lung metastases from a primary carcinoma of the colon and in another with metastases from a carcinoma of the kidney (Fig. 31). The close resemblance of the chest appearances to Fig. 36 (bronchiolar carcinoma) is noteworthy. Since radiological and even histological appearances in such a case may resemble bronchiolar carcinoma, the limited diagnostic significance of watery sputum should

be appreciated. Expectoration of clear, watery sputum in excessive quantities has become associated with the popular clinical picture of bronchiolar carcinoma as a result of the publication of several striking cases in which remarkable quantities of sputum were produced. Notable amongst these was the patient of Lewinsky and Kern (1952) whose sputum often exceeded his urinary output in volume, with a maximum of nearly 2,000 c.c. in one day and who produced 20 gallons of sputum over a period of 4 months. Cytological examination of the sputum suggested the correct diagnosis and radiotherapy produced a marked reduction in the quantity of expectoration. Storey, Knudtson and Lawrence (1953), reviewing 83 collected cases in which there was a reliable history, found that the vast majority of cases did not produce excessive amounts of sputum but that the character of the sputum was clear and watery in 71 of the 83 cases.

X-RAY APPEARANCES (Figs. 82-89 inclusive) varied considerably and are shown diagrammatically in Table 20. The disease appeared as single or multiple, unilateral or bilateral foci which varied in size from miliary shadows (Case 10) to a single deposit occupying most of a lobe (Case 1). Three cases showed a solitary lesion in one lung; one was a large, cavitating neoplasm, one a peripheral mass 3 cm. in diameter and one a small, ill-defined lesion. Four showed multiple lesions in both lungs, one being of miliary type (Case 10), one a combination of miliary deposits and massive tumour involvement of both upper lobes (Case 9) and the remaining two showed scattered, ill-defined shadows of varying size which resembled areas of pneumonitis and scarring (Cases 5 and 6). In one (Case 4) there was a lobulated mass in the lingula with small nodules scattered in the left lower lobe - others were present in the upper lobe in the resected lung but had not been visible pre-operatively. In another, similar case, a large tumour

mass in the right upper lobe was accompanied by several nodules in the lower lobe on this side (Case 7). The remaining case showed a large pleural effusion with scattered lung lesions on one side and a small effusion on the other (Case 8).

The diagnosis of bronchiolar carcinoma is not possible from the x-ray appearances when only a small peripheral or large, single nodular lesion is present; cytological examination of the sputum seems more likely to be helpful in these cases. It should, however, be considered as a possibility when a middle-aged or elderly patient develops miliary or patchy shadowing resembling chronic pneumonitis throughout the lungs - especially if commoner diseases such as bronchiectasis with patchy pneumonitis, tuberculosis, pulmonary fibrosis, occupational disease, sarcoidosis or metastases seem less likely. The x-ray picture associated with severe dyspnoea but without pyrexia or evidence of cardiac or renal disease may suggest the correct diagnosis (as in Case 9).

None of the 4 cases which underwent resection showed visible evidence of local glandular involvement by tumour at the time of operation but hilar or mediastinal glandular spread was present in all 5 cases which came to autopsy and in the one case in which thoracotomy only was performed. Extrathoracic metastases were present in all except one of the autopsied cases: Case 5 had metastases in the brain and liver, Case 8 in the cervical and axillary lymph nodes and Case 10 in the liver, one kidney and both adrenals.

A much discussed question is whether the multiple lesions found in the lungs in advanced cases are due to metastases or to multifocal origin of the disease. Certainly the disease is capable of producing metastases for they are commonly found in other organs and multifocal origin does not seem to be a feature of those cases

which have a relatively good prognosis after excision of a local lesion - as in Cases 1, 2 and 3.

#### CONCLUSIONS.

(1) Bronchiolar carcinoma resembles bronchial carcinoma in its age incidence and bronchial adenoma in its sex incidence.

(2) The symptoms in bronchiolar carcinoma are the same as those occurring in any chronic lung disease. Clear, watery sputum may be expectorated but this also occurs in other conditions which may resemble bronchiolar carcinoma clinically, radiologically and histologically. Large quantities of "soap-suds" sputum are apparently uncommon.

(3) Cytological examination of the sputum seems to offer the best possibility of diagnosis, certainly of the presence of malignancy and perhaps of the precise nature of the tumour. This method was used in only one of the present cases.

(4) X-ray appearances are unlikely to be diagnostic of bronchiolar carcinoma except, possibly, in the late (bilateral) stages of the disease and when full regard is paid to the clinical picture. If the lesion is unilateral, a precise radiological diagnosis is impossible but if the abnormality is of sufficient size then, at least, malignancy may be strongly suspected.

(5) Bilateral disease carries an extremely poor prognosis but if a lesion is unilateral, resection may result in survival for a number of years (Cases 1, 2 and 3).

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I L L U S T R A T I O N S

Fig. 1 - Oblique tomograms (different cases) give clear demonstration of trachea, main bronchi and their immediate surroundings. M.L. bronchus shown in (B).

Fig. 2 - Lateral tomography. Slightly lobulated contour of peripheral epidermoid carcinoma in subapical segment L.L.L.



A



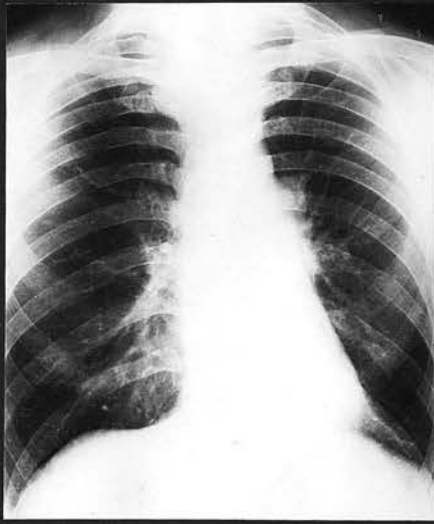
B

Fig. 1



Fig. 2

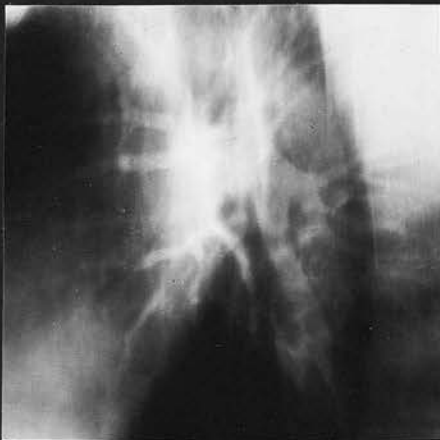
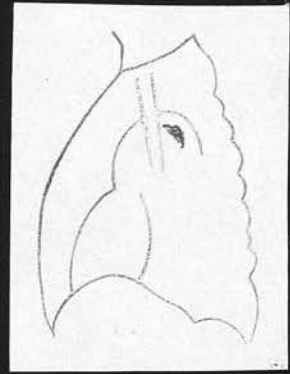
Fig. 3 - Male, aged 47, lost 20 lbs. during the previous 3 months. No chest symptoms. Prominent left hilar shadow (A) shown by lateral tomography (B) to consist of mass above left pulmonary artery - compare with lateral tomogram of normal left pulmonary artery (C). Bronchoscopy - negative. Thoracotomy - inoperable epidermoid carcinoma.



A



B



C

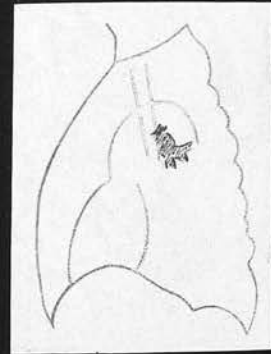
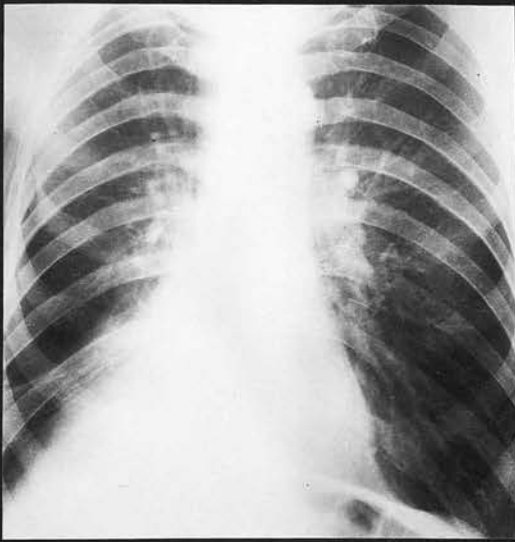


Fig. 3

Fig. 4 - Male, aged 43, collapsed R.L.L. Lateral tomogram (B) shows clearly mass round hilar region, particularly its extent below right pulmonary artery and posterior to R.L.L. bronchus. Anaplastic carcinoma.

Fig. 5 - Male, aged 42, shadow at left hilum. Screening - oesophagus moved to the left on inspiration, indicating bronchostenosis. Bronchoscopy - epidermoid carcinoma just below L.U.L. orifice.

Fig. 6 - Female, aged 67, slightly prominent right hilar shadow. Lateral oesophageal shift to the right on inspiration. Bronchoscopy - epidermoid carcinoma R.M.Br.



A



B

Fig. 4

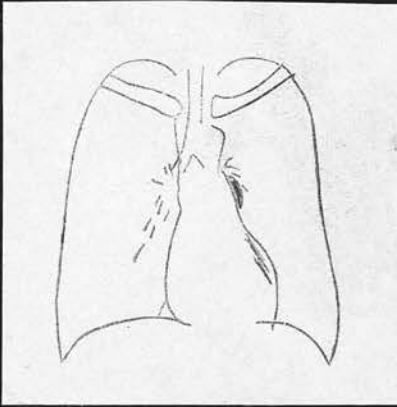


Fig. 5

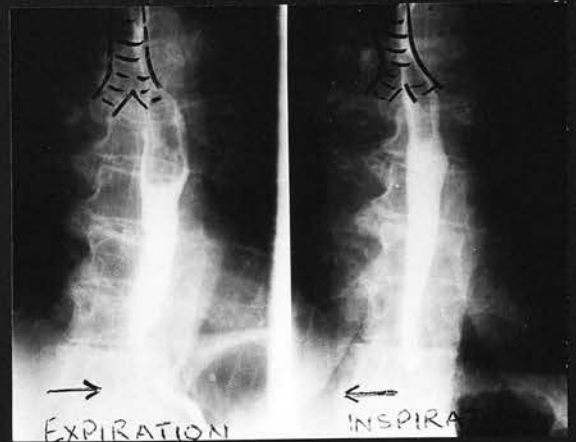
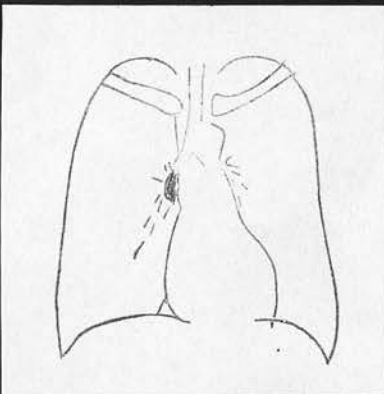


Fig. 6

Fig. 7 - Male, aged 54. Basal segmental consolidation R.L.L. (A). Oesophagus probably normal (B). Bronchoscopy - tumour in R.L.L. bronchus but histology inconclusive. Took his own discharge from hospital. 4 months later (C) bronchoscopy showed a fungating epidermoid tumour blocking R.L.L. bronchus. Oesophagus now compressed by subcarinal adenopathy (D). Thoracotomy - inoperable.

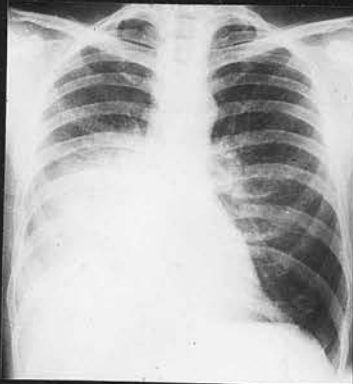


A

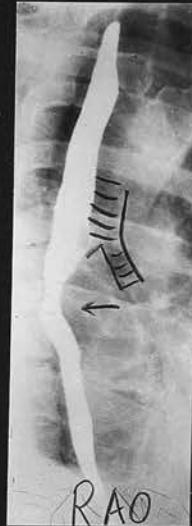


B

Fig. 7

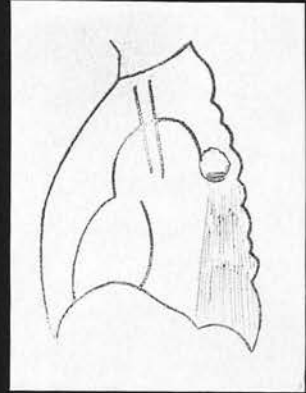
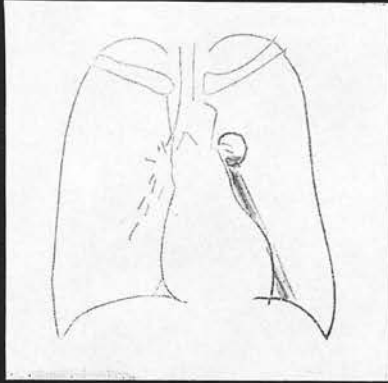


C



D

Fig. 8 - Male, aged 29. L.L.L. atelectasis with abscess cavity in its apical segment, normal oesophagus (A). Bronchoscopy - mucopus in lower lobe orifices and easily bleeding mucosa in L.M.Br., no evidence of neoplasm. 6 weeks later (B) extrinsic pressure on oesophagus in subcarinal region now apparent, especially when comparison is made with (A). Blocked L.L.L. bronchus clearly shown. Bronchoscopy - adenocarcinoma producing irregular stricture below L.L.L. apical segment orifice. Thoracotomy - pleural metastases, inoperable. 4 months later (C), after radiotherapy - complete obstruction of oesophagus and metastasis in D.V.8.

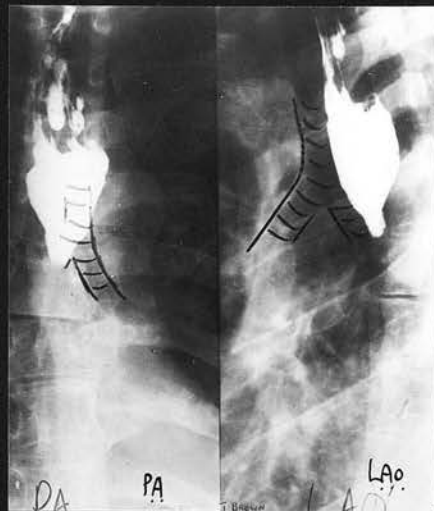


A



B

Fig. 8



C

Fig. 9 - Female, aged 66. Anterior displacement of lower oesophagus as it is crossed posteriorly by descending aorta.

Fig. 10 - Male, aged 61. Aorta crosses oesophagus at a higher level (R.A.O. position) than in Fig. 9.

Fig. 11 - Extrinsic pressure on upper oesophagus by intrathoracic goitre. Impression made by left subclavian artery well shown on P.A. view of displaced oesophagus.

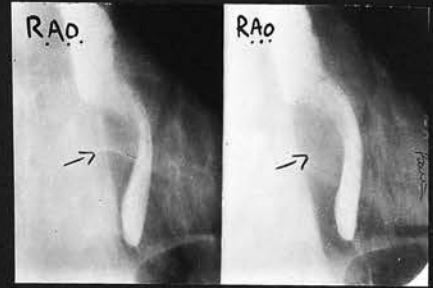


Fig. 9

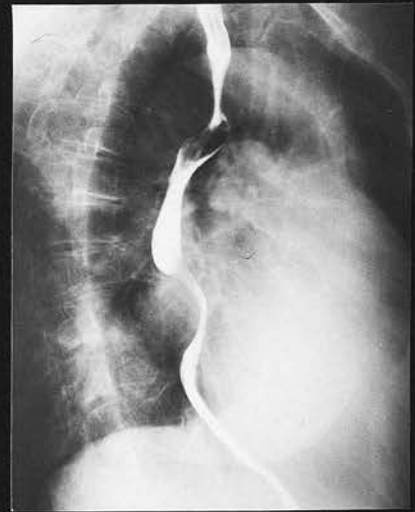


Fig. 10

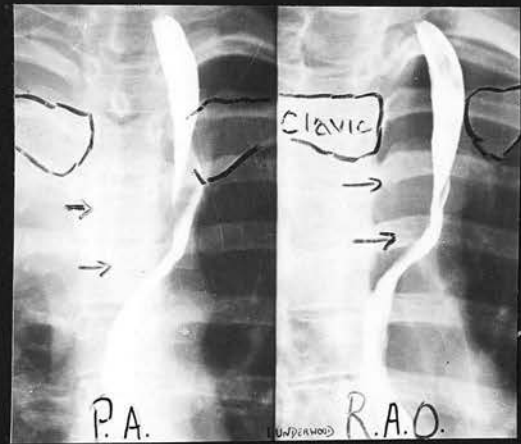
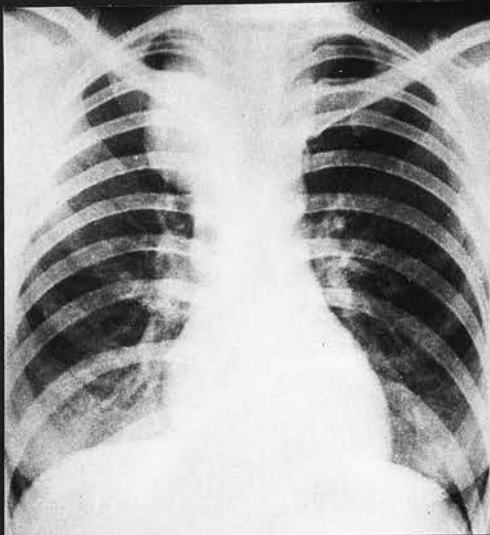


Fig. 11

Fig. 12 - Female, aged 58. Collapsed L.L.L. due to anaplastic carcinoma. Oesophageal displacement towards the affected side accentuates effect of extrinsic pressure upon it. Thoracotomy - inoperable.

Fig. 13 - Male, aged 54. Bronchoscopy - anaplastic carcinoma R.L.L. Oesophageal deformity in L.A.O. and P.A. positions. No operation.

Fig. 14 - Male, aged 58. Bronchoscopy - anaplastic carcinoma in L.U.L. orifice. Slight oesophageal compression from left side just below level of aortic arch. Thoracotomy - inoperable.



Fig. 12



Fig. 13

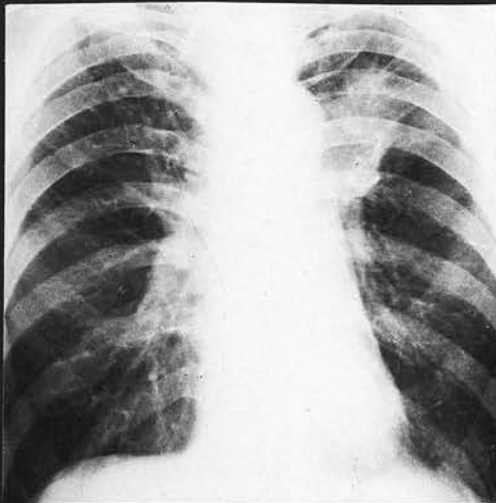


Fig. 14

Fig. 15 - Male, aged 47. Bronchoscopy - adenocarcinoma just below M.L. orifice. Thoracotomy - inoperable. Oesophageal compression due to direct extension of tumour mass in lung.

Fig. 16 - Male, aged 49. Bronchoscopy negative. Bronchogram - block L.U.L. bronchus. Extrinsic pressure on oesophagus in sub-carinal region shown in R.A.O. and P.A. positions. Thoracotomy - inoperable. Hilar mass of anaplastic carcinoma invading aorta.



Fig. 15

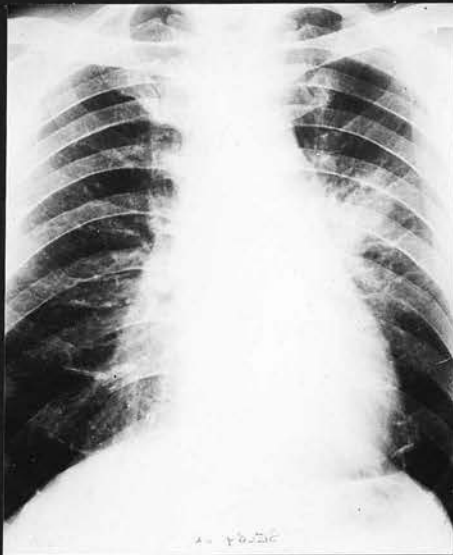


Fig. 16

Fig. 17 - Male, aged 43. Consolidated M.L. and prominent right hilar shadow (A). Bronchoscopy negative. L.A.O. position (B) shows extrinsic pressure on oesophagus in subcarinal region. Thoracotomy - inoperable anaplastic carcinoma. (C) is an enlargement of (B) to show better the typical appearance of enlarged subcarinal lymph nodes compressing the oesophagus.



A



B



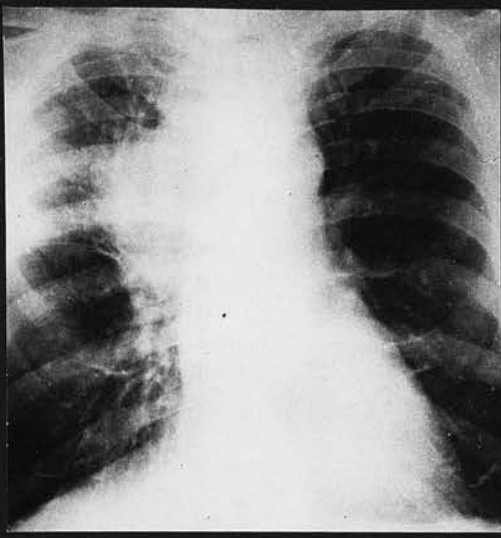
C

Fig. 17

Fig. 18 - Male, aged 60. Extrinsic pressure on oesophagus from subcarinal mass (B) which is also producing slight compression of L.M.Br., shown on oblique tomogram (C). Bronchoscopy - no endobronchial lesion but considerable pulsation of R.U L. bronchus which was pushed anteriorly. Biopsy of neck gland - anaplastic carcinoma.

Fig. 19 - Male, aged 50. 2 months aching in right chest. Subcarinal glands compressing oesophagus in L.A.O. position. Bronchoscopy - anaplastic carcinoma at M.L. orifice. Thoracotomy - inoperable.

Fig. 20 - Male, aged 45. Cavitating mass in R.L.L. Subcarinal glands compressing oesophagus in L.A.O. position. Bronchoscopy - anaplastic carcinoma. No operation.



A



B



C

Fig. 18

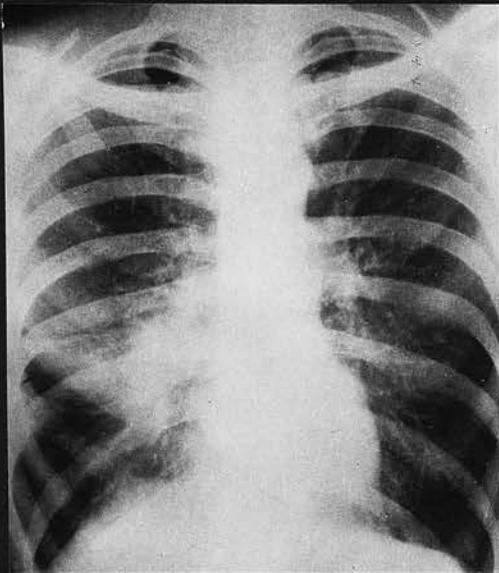


Fig. 19

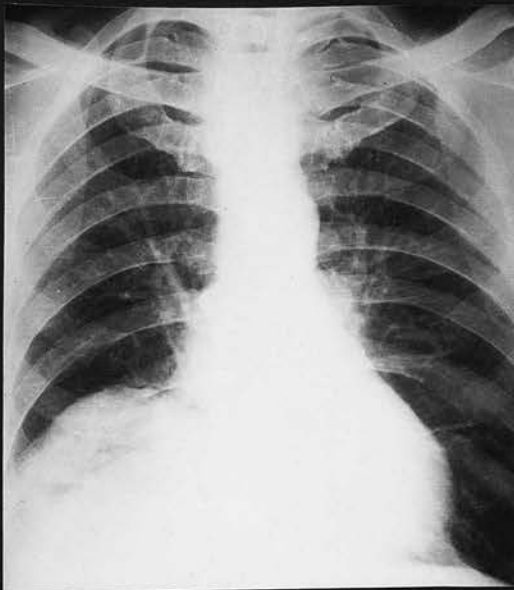
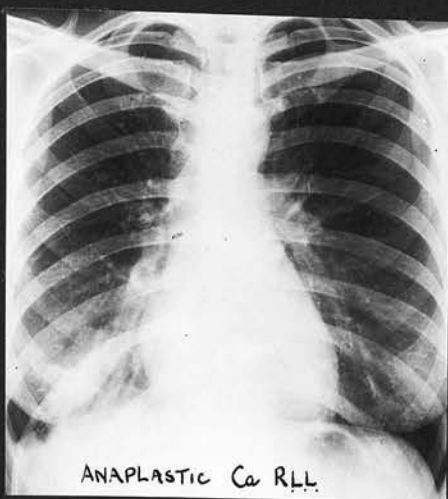


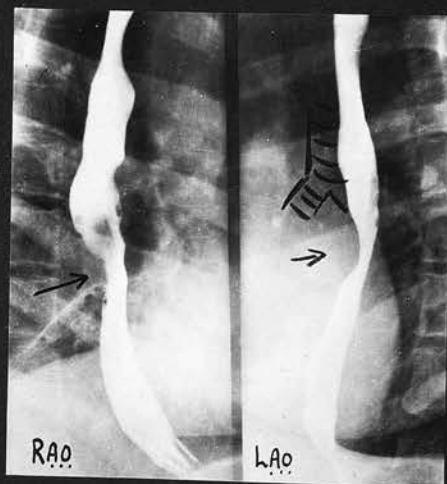
Fig. 20

Fig. 21 - Female, aged 31. Haemoptysis when 7 months pregnant. Segmental atelectasis in R.L.L. (A). Extrinsic pressure on oesophagus in both oblique positions (B). Operation refused. Radiotherapy after pregnancy - reduction in size of mass adjacent to oesophagus (C).

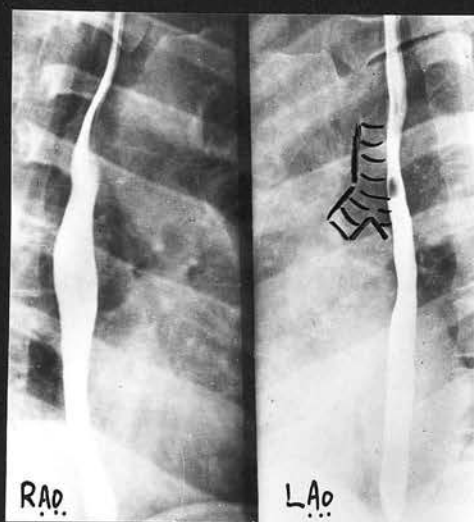
Fig. 22 - Male, aged 54. Slight extrinsic pressure on oesophagus in subcarinal region in L.A.O. position. Bronchoscopy - anaplastic carcinoma R.U.L. bronchus. Thoracotomy - inoperable.



A



B



C

Fig. 21



Fig. 22

Fig. 23 - Male, aged 53. Anaplastic carcinoma producing L.L.L. atelectasis. In spite of the latter, oesophagus displaced to opposite side by the tumour mass in the P.A. position (whereas heart shifts towards the collapsed lobe). L.A.O. position shows anterior displacement of oesophagus. Thoracotomy - inoperable.

Fig. 24 - Male, aged 54. Cough and haemoptysis for 3 months. Prominent right hilar shadow but changes are not marked. Subcarinal pressure deformity of oesophagus. Bronchoscopy - epidermoid carcinoma just below R.U.L. orifice. Thoracotomy - inoperable.

Fig. 25 - Male, aged 47. Bronchoscopy negative. Oesophagus compressed by subcarinal mass. Thoracotomy - inoperable. Anaplastic carcinoma in L.U.L. and surrounding hilum.

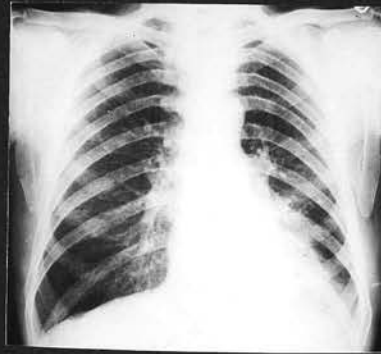


Fig. 23

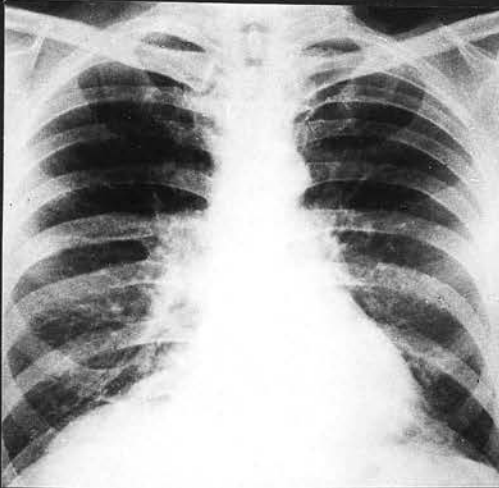


Fig. 24

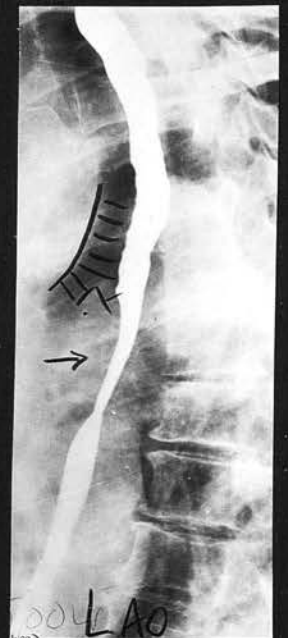
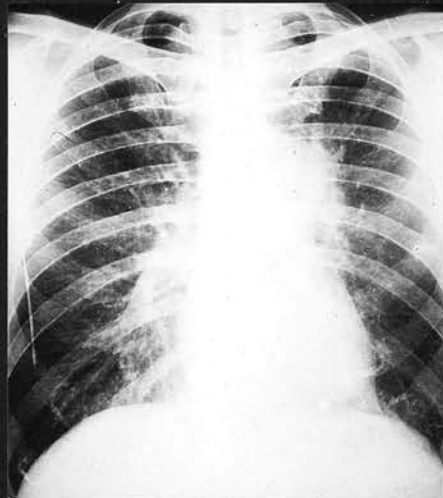


Fig. 25

Fig. 26 - Female, aged 31. Pituitary dwarf, low I.Q., said to have had cough, sputum and occasional haemoptysis since infancy. Collapsed left lung and extrinsic pressure on mid-oesophagus (P.A. position). Bronchoscopy - anaplastic carcinoma L.M.Br. No operation.

Fig. 27 - Agenesis of left lung. Oesophagus displaced in a smooth curve far to the left (A). Angiocardiogram (B) illustrates small lateral shift of the heart and pulmonary artery in comparison with that of the oesophagus.

Fig. 28 - Male, aged 47. Collapsed left lung due to anaplastic carcinoma just below main carina. Extrinsic pressure on oesophagus by large neoplastic mass shown in P.A. and R.A.O. projections. Deformity on P.A. view would not be visible unless oesophagus were shifted towards the collapsed left lung. No operation.



Fig. 26

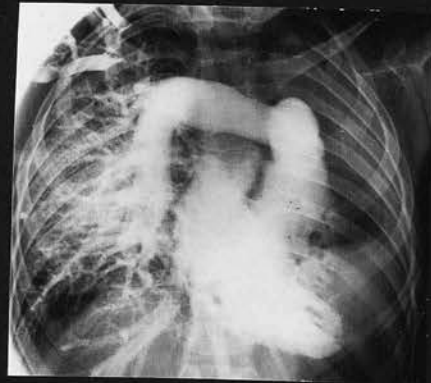


Fig. 27

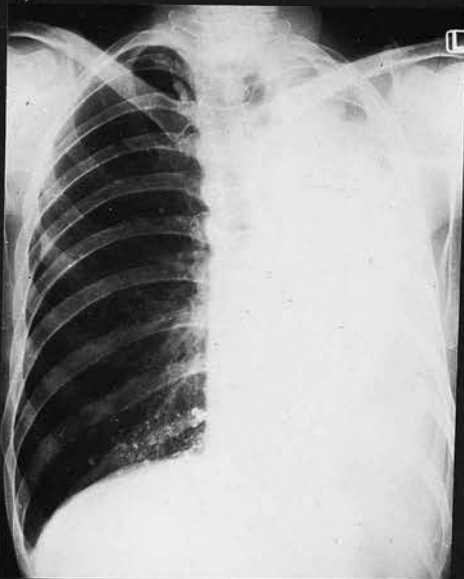
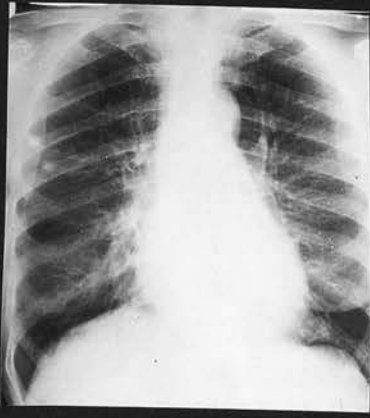


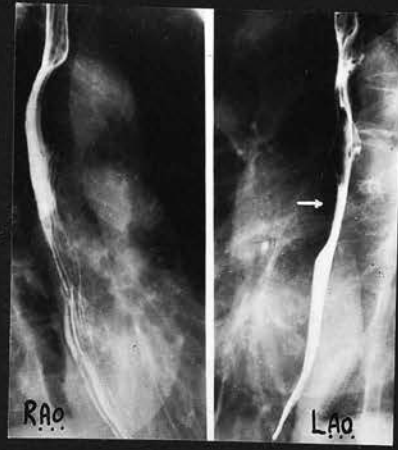
Fig. 28

Fig. 29 - Female, aged 67. Anaemic, feeling unwell but no local signs or symptoms. Normal chest film (A). Barium meal showed subcarinal lymphadenopathy compressing oesophagus in L.A.O. position (B). Gradual deterioration in condition and 5 months later lymphadenopathy developed on left side of neck; biopsy - Hodgkin's disease. Chest film 11 months after (A) showed right paratracheal and right hilar lymphadenopathy (C). Autopsy 3 months later - extensive lymphadenopathy throughout neck, mediastinum and abdomen with very large mass of subcarinal glands.

Fig. 30 - Male, aged 53. Collapse of M.L. and R.L.L. due to anaplastic carcinoma. P.A. view shows oesophagus compressed from the right and displaced to the left at and below the level of the carina (A). 15 days later, after 2,500 r., oesophagus is no longer distorted (B).



A

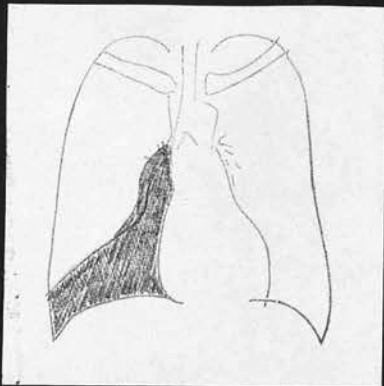


B



C

Fig. 29



A



B

Fig. 30

Fig. 31 - Male, aged 45. Aching in left chest since injury 2 weeks previously. Prominence of lower left hilar shadow "missed". More obvious 2 months later when bronchoscopy showed epidermoid carcinoma in L.L.L. bronchus. No operation.

Fig. 32 - Male, aged 34. "Pleurisy" 2 months ago. Enlargement and increase in density of lower left hilar shadow "missed". During the next 7 months complained of cough, occasional haemoptysis, loss of weight and energy, and dyspnoea on exertion. Bronchoscopy - anaplastic carcinoma below apical segmental orifice L.L.L. Pneumonectomy.

Fig. 33 - Male, aged 61. R.U.L. pneumonia 2 months previously - slight residual shadowing in R.U.L. was noted but increased density of upper portion of left hilar shadow and a convex opacity, between this and the aortic arch, were "missed" (A). 1 year later, complaining of weight-loss, increasing dyspnoea and left chest pain for 4 months and recent cough and haemoptysis - collapsed L.U.L. due to epidermoid carcinoma (B).

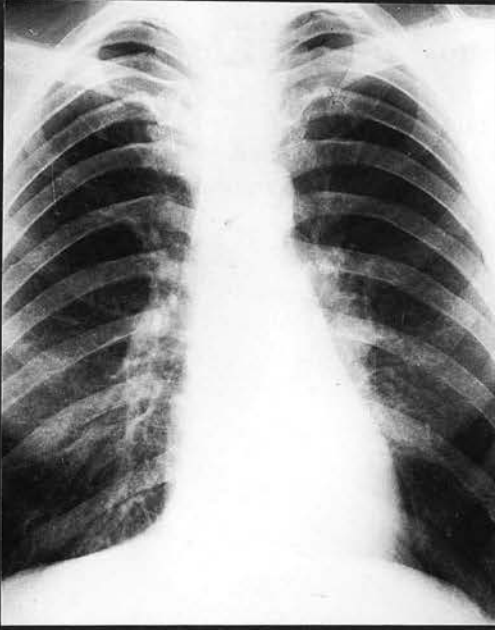


Fig. 31

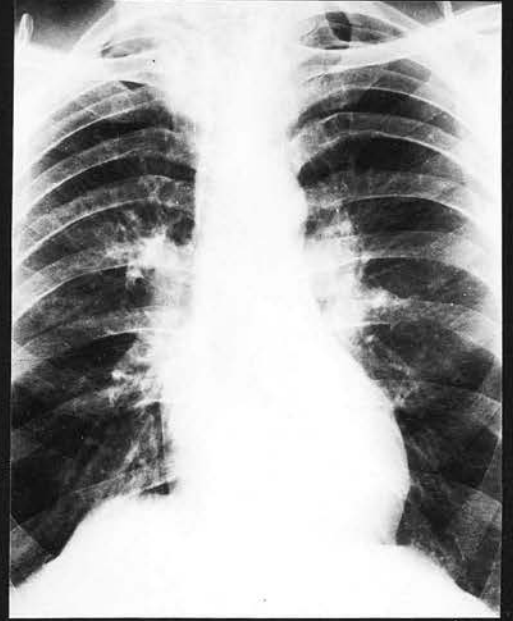
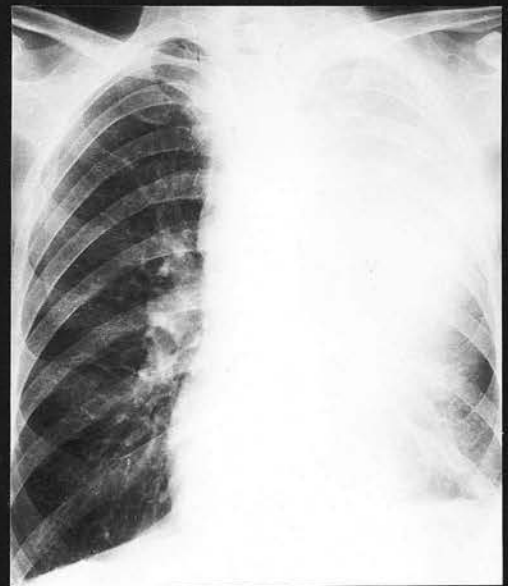


Fig. 32



A



B

Fig. 33

- Fig. 34 - Male, aged 51. Increasing dyspnoea, right chest pain and 3 episodes of haemoptysis during the previous 2 months. Increased size and density of right hilar shadow "missed". 6 months later - after 3 negative bronchoscopies - pneumonectomy performed. Epidermoid carcinoma R.U.L.
- Fig. 35 - Male, aged 46. Ill-defined enlargement and increased density of left hilar shadow. Bronchoscopy - epidermoid carcinoma just below L.U.L. orifice. Pneumonectomy.
- Fig. 36 - Male, aged 51. Ill-defined enlargement and increased density of left hilar shadow. Bronchoscopy - epidermoid carcinoma just below L.U.L. orifice. Pneumonectomy - tumour surrounding main bronchus 5 cm. from carina, no collapse; 2 out of 6 glands round bronchus showed histological evidence of invasion.
- Fig. 37 - Male, aged 47. Enlarged left hilar shadow. Bronchoscopy - epidermoid carcinoma just above L.L.L. apical segment orifice. Pneumonectomy.

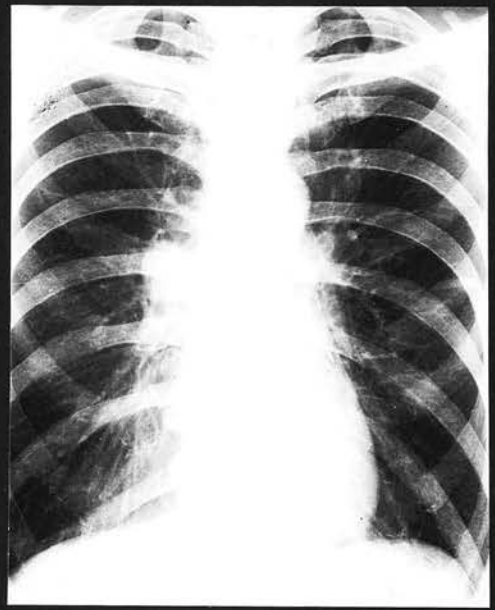


Fig. 34



Fig. 35

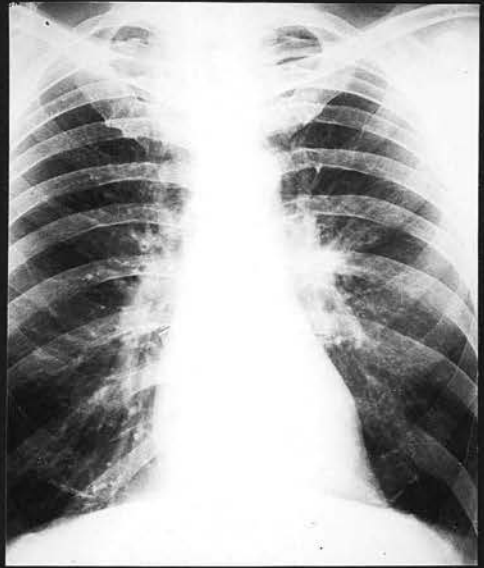


Fig. 36

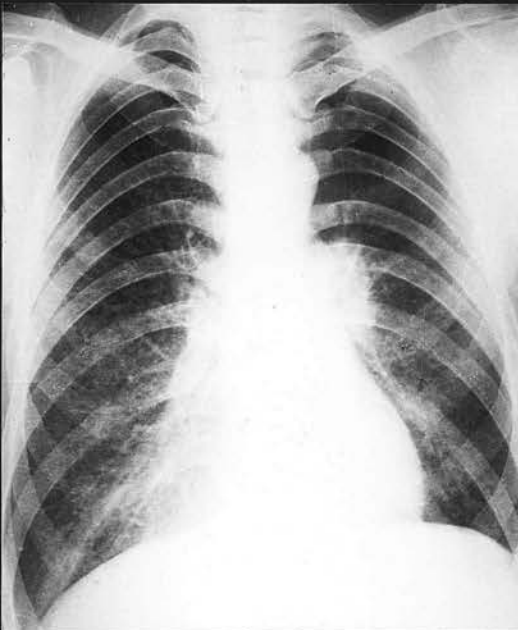


Fig. 37

Fig. 38 - Male, aged 47. Large left pulmonary artery - smooth downward sweep of its contour shown in very slight L.A.O. position.

Fig. 39 - Male, aged 29. Inoperable anaplastic carcinoma distal to M.L. orifice (A). Abnormal shadowing adjacent to upper right heart border is much more convincing when comparison is made with film of 5 years ago (B) prior to removal of bullet from left lung.

Fig. 40 - Male, aged 48. Lateral tomogram shows lobulated mass in sub-apical segment L.L.L. Obvious pulsation visible on screening when such a lesion is closely related to (descending) aorta. Epidermoid carcinoma.

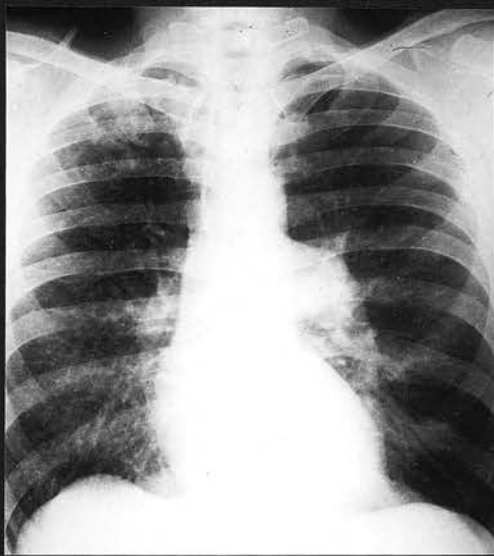
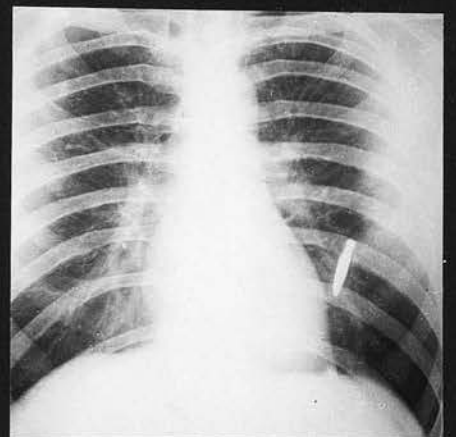


Fig. 38



A



B

Fig. 39

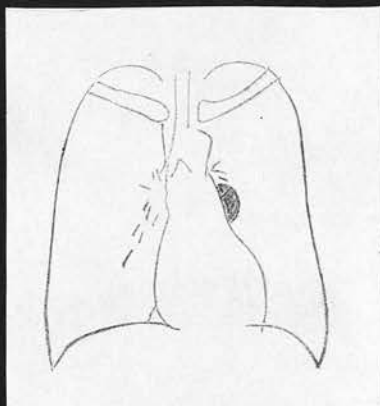


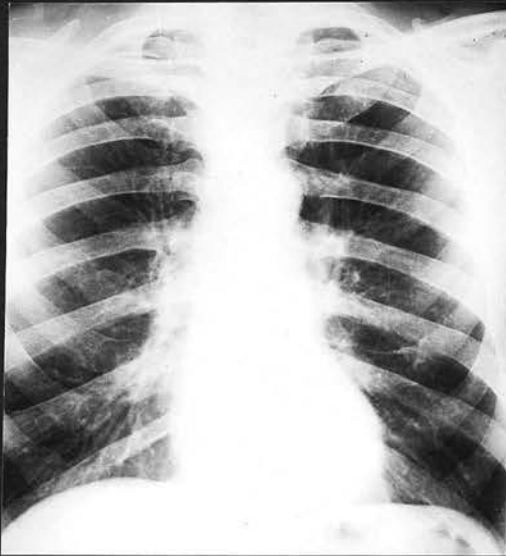
Fig. 40

Fig. 41 - Male, aged 54. Unwell since bronchitis 3 months ago and producing 1-2 oz. white sputum daily. Pattern of shadowing in L.U.L. suggested old inflammatory disease with consequent elevation of the hilar shadow. Bronchoscopy - redness of L.U.L. orifice but no tumour seen. Pneumonectomy - epidermoid carcinoma 2 cm. in diameter arising in L.U.L. bronchus, bronchiectasis and abscess formation peripherally.

Fig. 42 - Male, aged 54. Faint left infraclavicular shadowing thought to be tuberculous scarring (A). 22 months later shadow in left first anterior interspace remains vague but is larger and right superior mediastinal lymphadenopathy - which was "missed" - is present (B). Thoracotomy - epidermoid carcinoma L.U.L. with extensive mediastinal involvement.



Fig. 41



A

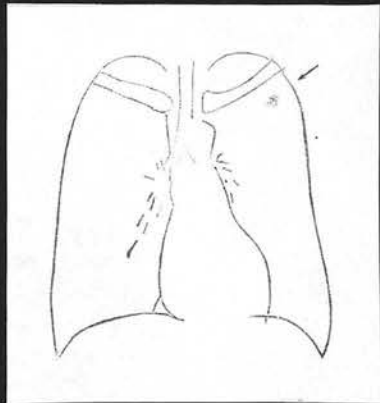
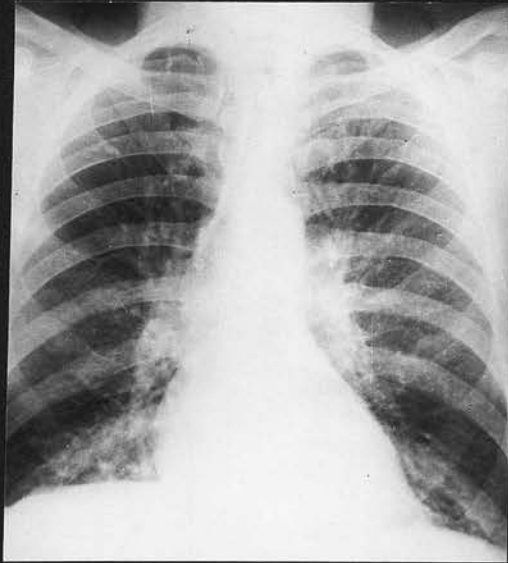


Fig. 42

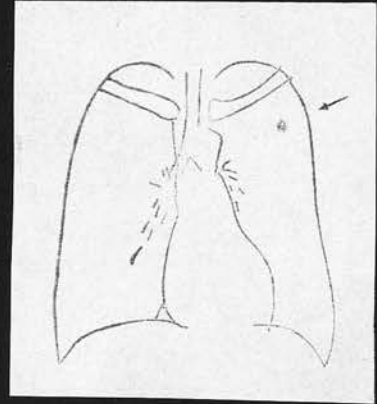


B

Fig. 43 - Male, aged 63. Recurrent chest trouble since gassing 40 years ago. Scarring in R.U.L.; shadow 1 cm. in diameter in left second anterior interspace - partially obscured by posterior end of fifth rib - was "missed" (A). 10 months later the opacity had increased to  $1\frac{1}{2}$  cm. in diameter (not shown) and  $3\frac{1}{2}$  years after (A) its diameter was 5 cm. (B). There was now marked finger-clubbing and he had had intermittent haemoptysis for 3 months. Epidermoid carcinoma L.U.L. No operation.



A

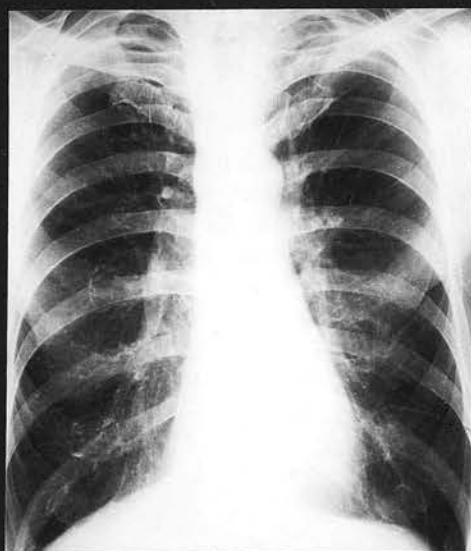


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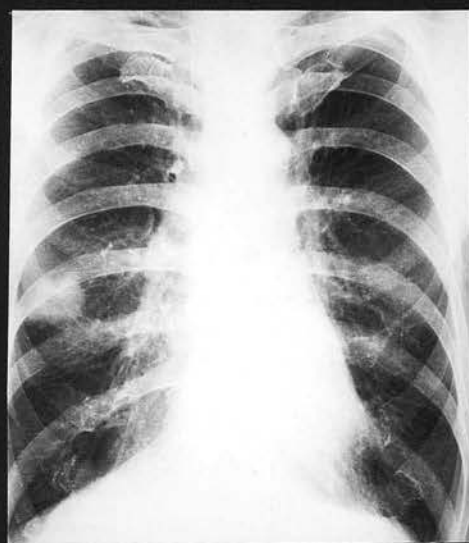
Fig. 43

Fig. 44 - Male, aged 49. Very faint, rounded opacity overlying right fifth rib anteriorly "missed" at first examination (A). 21 months later tumour is 3 cm. in diameter (B). Pneumonectomy - epidermoid carcinoma in M.L.

Fig. 45 - Male, aged 63. Small opacity in left fifth anterior interspace "missed" - ? regarded as due to nipple (A). 13 months later diameter had grown to 4 cm. (B). Pneumonectomy - epidermoid carcinoma in lingula extending across fissure into L.L.L.; enlarged, firm hilar glands but none involved by neoplasm (7 sectioned). Died 2 days after operation - autopsy showed no malignant tissue anywhere in the body.

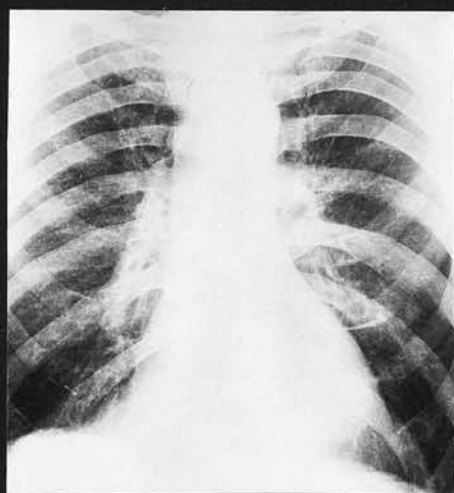


A



B

Fig. 44



A

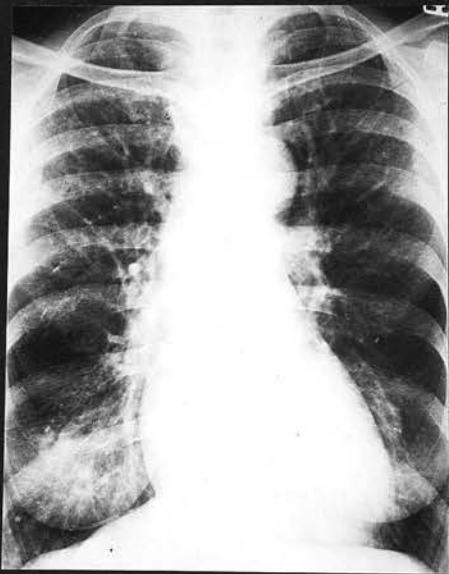


B

Fig. 45

Fig. 46 - Female, aged 61. Appearances at right base confused by overlying breast and prominent nipple shadow on the opposite side (A). Tomogram shows cavitating lesion in R.L.L. (B). Lobectomy - epidermoid carcinoma.

Fig. 47 - Female, aged 44. Circular opacity 2 cm. in diameter below left hilum "missed" on routine film during hospital admission for unrelated complaint (A).  $4\frac{1}{2}$  months later mass much bigger (B). Thoracotomy - inoperable epidermoid carcinoma apical segment L.L.L.



A

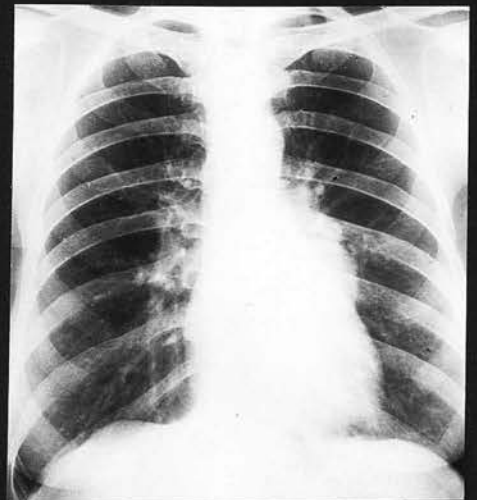


B

Fig. 46



A



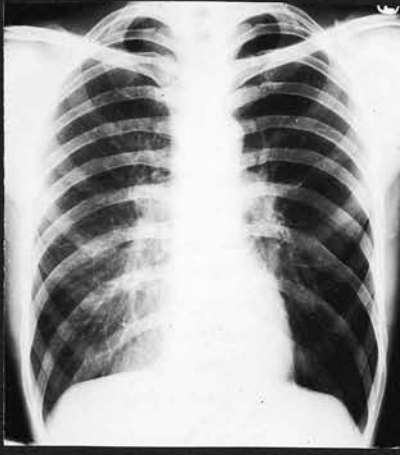
B

Fig. 47

Fig. 48 - Male, aged 36. Severe dyspnoea on exertion 6 weeks, aching pain left chest 2 weeks; no other symptoms. Obstructive emphysema of left lung "missed" at initial examination (A). Complete absence of air-entry on auscultation of left lung led to review of film when abnormality was then appreciated. Bronchogram shows L.M.Br. completely blocked above L.U.L. orifice (B). Inoperable anaplastic carcinoma: mass extending from main bronchus as far as "lung" and probably further, many involved hilar glands but pulmonary artery not invaded.

Fig. 49 - Male, aged 53. Marked dyspnoea for 2 months, recent chest pain and haemoptysis. Poor general condition, skin secondaries. Emphysema of left lung and large mass in lingula. Bronchoscopy - large tumour projecting from L.U.L. orifice and apparently occluding L.M.Br. Epidermoid carcinoma.

Fig. 50 - Female, aged 31. Emphysematous R.L.L., bronchiectasis and minimal diminution in volume of R.U.L. No evidence of bronchostenosis. I.S.Q. during the last 9 years.



A



B

Fig. 48



Fig. 49



Fig. 50

Fig. 51 - Male, aged 66. Peripheral epidermoid carcinoma in R.U.L. showing irregular margin with appearance of its "creeping" out into the lung.

Fig. 52 - Female, aged 50. Peripheral epidermoid carcinoma in L.L.L. showing slightly lobulated contour on plain film.

Fig. 53 - Male, aged 55. Asymptomatic M.M.R. pick-up. Deep notch on supero-medial aspect of rounded mass in R.L.L. Lobectomy - hamartoma.

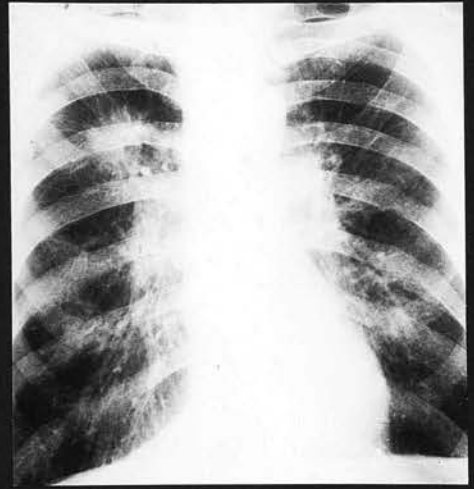


Fig. 51

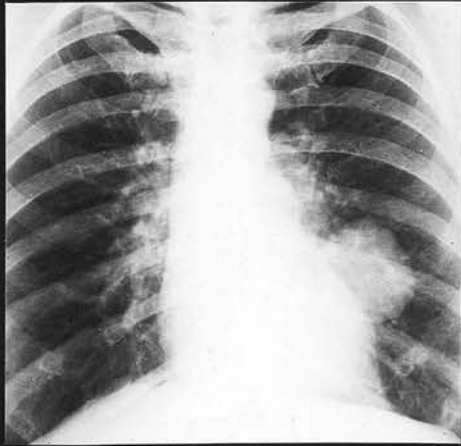


Fig. 52



Fig. 53

- Fig. 54 - Male, aged 42. Productive cough and right chest pain for 3 months, not been in bed. A.P. tomogram shows thick-walled cavity with smooth internal contour in R.U.L. Simple abscess.
- Fig. 55 - Female, aged 54. A.P. tomogram shows mycetoma in the larger of two cavities in L.U.L. Lobectomy. The appearance of a halo does not occur in breaking-down peripheral carcinoma, but Liebow (1952) has illustrated a necrotic sarcoma of the lung with an appearance more similar to this.
- Fig. 56 - Male, aged 38. Haemoptysis 1 year ago. Thin-walled cavity in R.L.L. treated as tuberculous. Remained well. Further haemoptysis recently and cavity slightly bigger (illustrated). Bronchoscopy negative. Bronchogram - blocked R.L.L. subapical segmental bronchus apparently leading towards cavity. Thoracotomy - thought to be benign lesion so apical and subapical segments R.L.L. resected. Pathology - epidermoid carcinoma 1 cm. in diameter at mouth of thin-walled abscess cavity (not lined by malignant cells).
- Fig. 57 - Female, aged 44, asymptomatic. Well-defined, circular opacity in lingula. Appearance 3 days before operation (A). Pre-op. film taken on her way to theatre showed a cyst-like cavity  $6\frac{1}{2}$  cm. in diameter just below the original opacity (B). Pneumonectomy - thin-walled cavity in lingula with epidermoid carcinoma at its junction with a branch of inferior lingular bronchus.

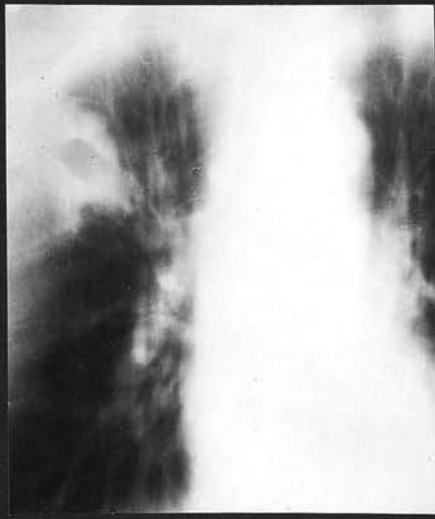


Fig. 54

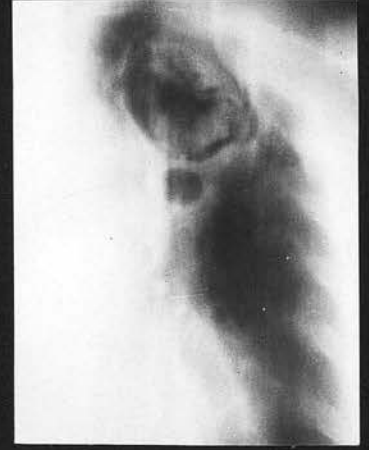


Fig. 55



Fig. 56

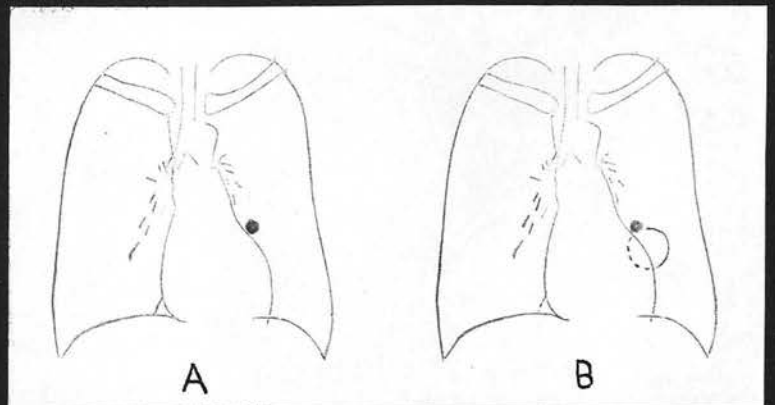
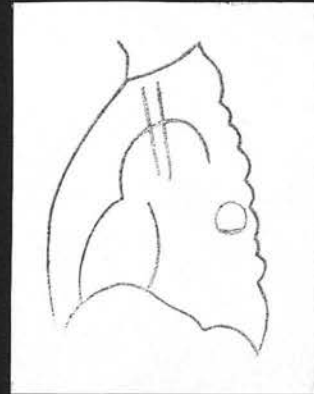


Fig. 57

Fig. 61 - Male, aged 50. Old tuberculosis R.U.L. Recent haemoptysis and pain in right chest. Bronchoscopy - anaplastic carcinoma inside R.U.L. orifice. Thoracotomy - inoperable.

Fig. 62 - Male, aged 59. Extremely dyspnoeic, general condition poor. Anaplastic carcinoma below L.U.L. orifice. Left hilar mass, diminution in volume of L.L.L. which is site of inflammatory changes, horizontal lines at left base peripherally. Thoracotomy - inoperable.

Fig. 63 - Male, aged 57. Severe disability. Anaplastic carcinoma in R.M.Br. at level of M.L. orifice. Unilateral enlargement of interlobular septa is most obvious at the right base on P.A. film and as a network pattern in the anterior portion of R.U.L. on the lateral view. No operation. Autopsy showed that small opacity in left third anterior interspace was due to a metastasis.

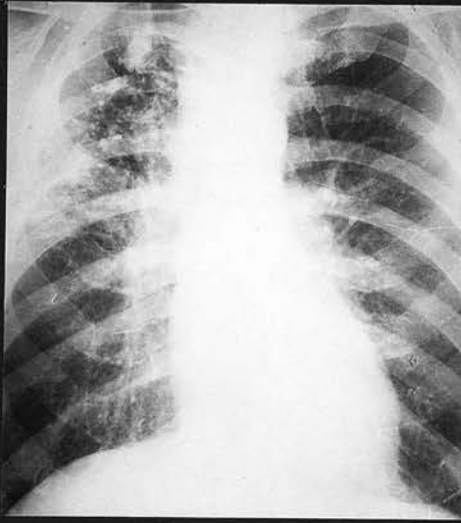


Fig. 61

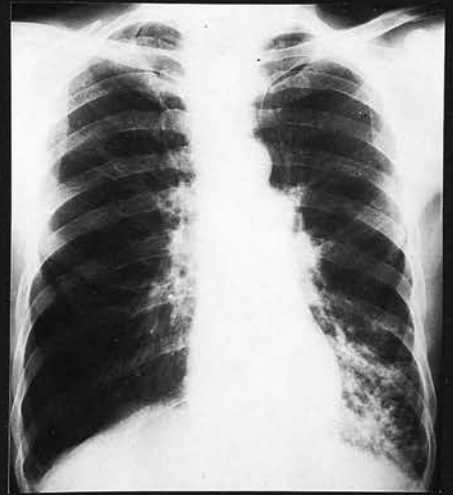


Fig. 62

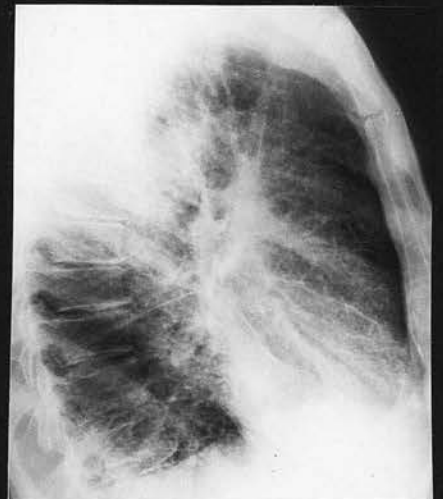
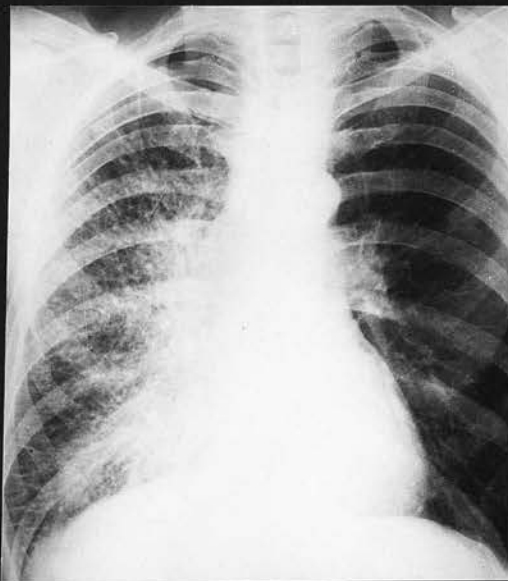


Fig. 63

Fig. 64 - Male, aged 64. Cough and sputum  $2\frac{1}{2}$  years, worse when he lay on his back. Scarring with associated calcification in anterior segment R.U.L. (A). Bronchoscopy - negative. Bronchogram - obstructed anterior segmental bronchus R.U.L. (B). Interpreted as probably bronchiectasis beyond a stricture related to old tuberculous glands. 8 months later (C) - collapse anterior segment R.U.L., shown on tomography (D). Bronchoscopy - anaplastic carcinoma inside R.U.L. orifice. Pneumonectomy - tumour small and not infiltrating lung; no glandular involvement. Emphysema and bronchiectasis in affected segment.



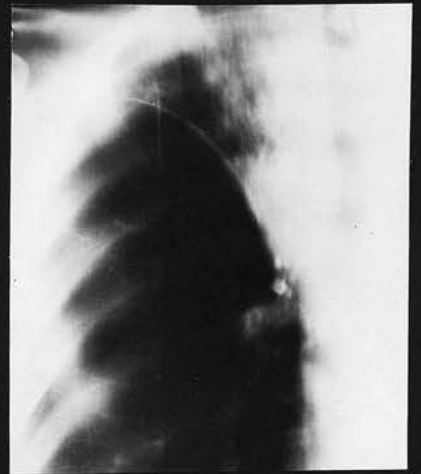
A



B



C



D

Fig. 64

Fig. 65 - Male, aged 47. Cough, dyspnoea, finger-clubbing 3-4 months. No history of acute episode. Bronchoscopy - ? small tumour in R.U.L. orifice but biopsy negative. Pneumonectomy - R.U.L. very adherent, soft glands at hilum. Pathology - chronic inflammation and abscess formation.

Fig. 66 - Male, aged 49. Cough, haemoptysis, dyspnoea on exertion 3 months; not off work. Bronchoscopy negative. Pneumonectomy - mass 7 cm. in diameter in R.U.L. just above hilum. Pathology - chronic inflammatory lesion with much fibrosis.

Fig. 67 - Male, aged 38. Dense shadowing with cavitation in R.U.L. - fluctuating, migratory lung changes in spite of intensive antibiotic therapy (A). 3 months later there is further excavation in R.U.L. and M.L. is involved too (B). Repeated bronchoscopies - only reddening of bronchial tree on the right side. Pneumonectomy - almost completely destroyed R.U.L. and M.L. No evidence of neoplasm or tuberculosis - non-specific suppuration.

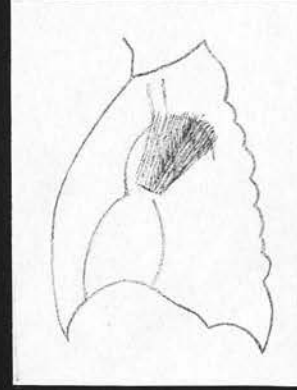


Fig. 65

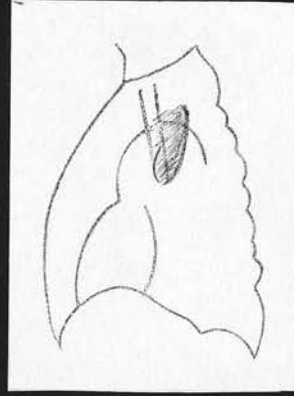
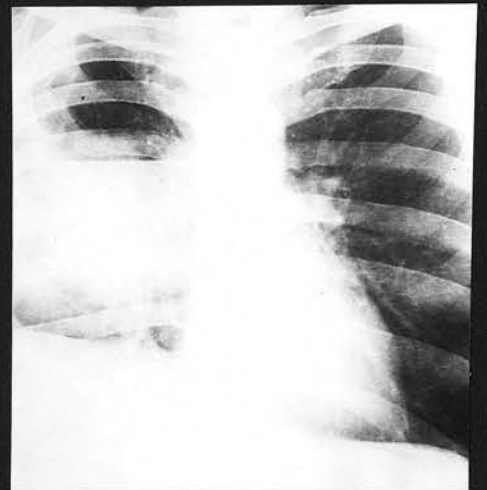
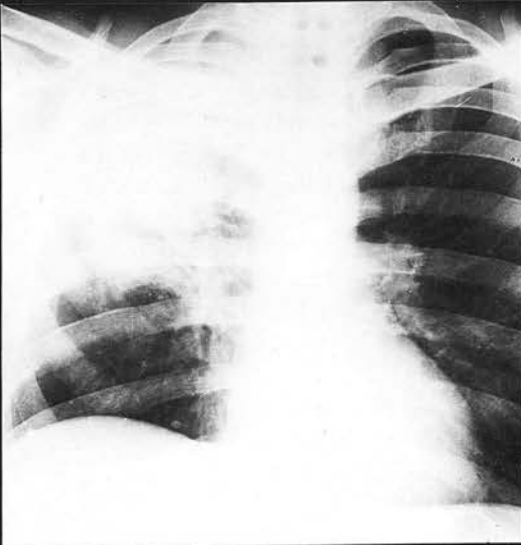


Fig. 66



A

B

Fig. 67

Fig. 68 - Male, aged 57. Loss of weight and energy 2 months, aching in right upper chest 6 weeks and one haemoptysis 2 weeks ago. Bronchoscopy negative. Pneumonectomy - solid mass posterior segment R.U.L., probably tuberculous. Pathology - caseating tuberculosis.

Fig. 69 - Male, aged 36. Slight dyspnoea after a "cold". Smoked 60 cigarettes/day for 10 years. Cavitating lesion in anterior segment R.U.L. (A) shown on lateral tomogram (B). Bronchogram - filling stopped short of area of opacity; nothing diagnostic. Pneumonectomy - mass in R.U.L. and chain of enlarged glands along oesophagus removed. Pathology - caseating tuberculosis. Developed empyema and had an 8-rib thoracoplasty (C).

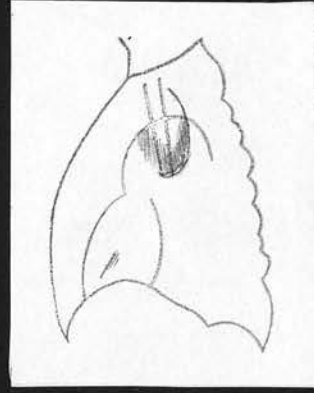
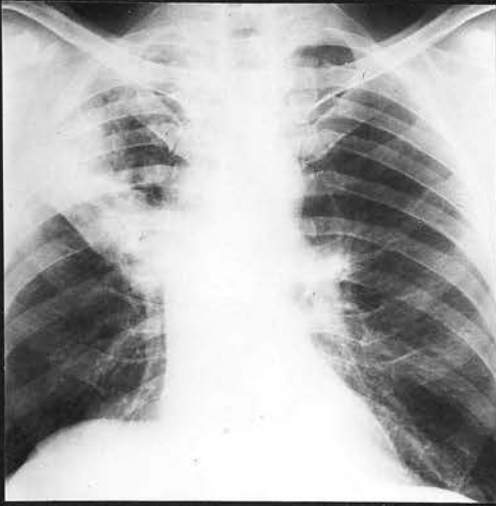
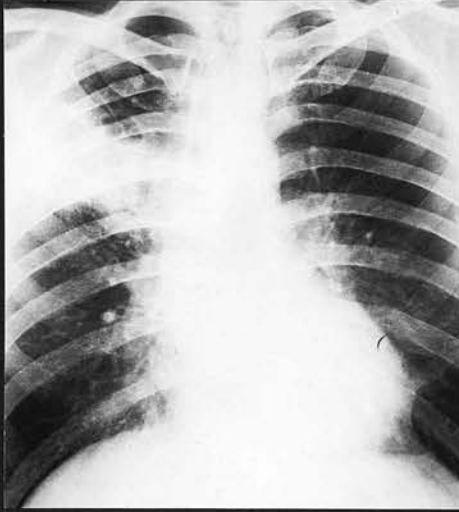


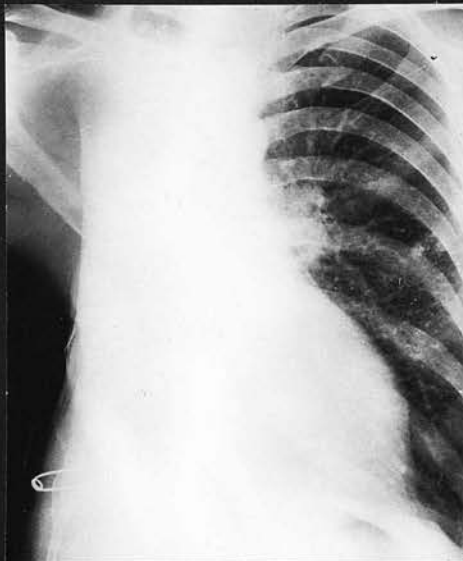
Fig. 68



A



B



C

Fig. 69

Fig. 70 - Male, aged 48. Recovered from "pneumonia" and feeling well but x-rays showed progressive increase in R.U.L. shadowing. Tomography - posterior bulging of greater fissure. Bronchoscopy negative. Bronchography - all R.U.L. divisions normally filled. Thoracotomy - 2 masses felt in R.U.L., ? inflammatory, but pneumonectomy performed. Pathology - pale grey infarct in R.U.L. with only a shadow of normal lung structure remaining. Developed empyema, had 8-rib thoracoplasty.

Fig. 71 - Male, aged 55. "Flu" 5 weeks ago, occasional haemoptyses since and loss of  $\frac{1}{2}$  stone in weight. Bronchoscopy negative. Thoracotomy - tumour the size of a tennis-ball in R.U.L.; pneumonectomy performed. Pathology - infarct.

Fig. 72 - Male, aged 60. Increasing cough, dyspnoea, pain right upper chest for 2 months. Shadowing in R.U.L. increased in extent during the next month. Bronchoscopy negative. Bronchogram - blocked posterior segmental bronchus R.U.L. Thoracotomy - firm mass the size of an orange in R.U.L., hilar glands did not feel malignant; pneumonectomy. Pathology - chronic lipoid pneumonia.

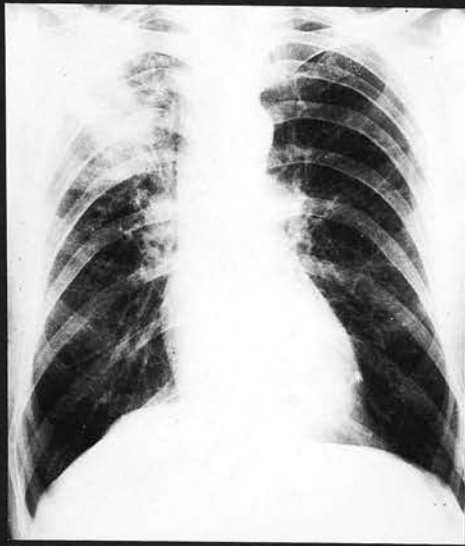


Fig. 70

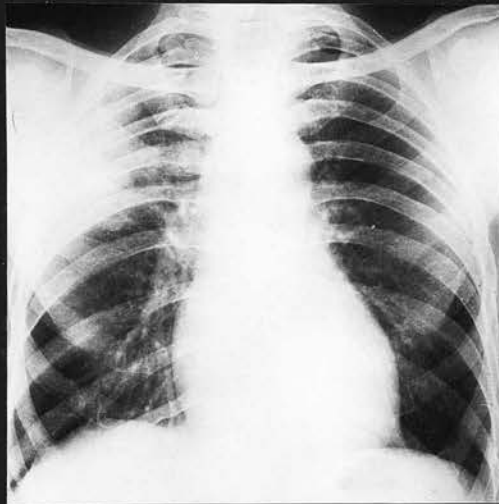
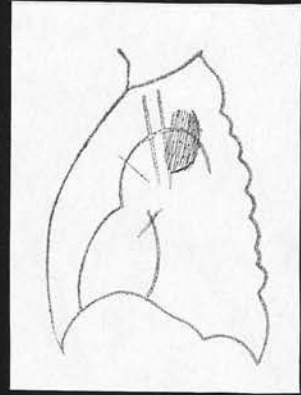


Fig. 71

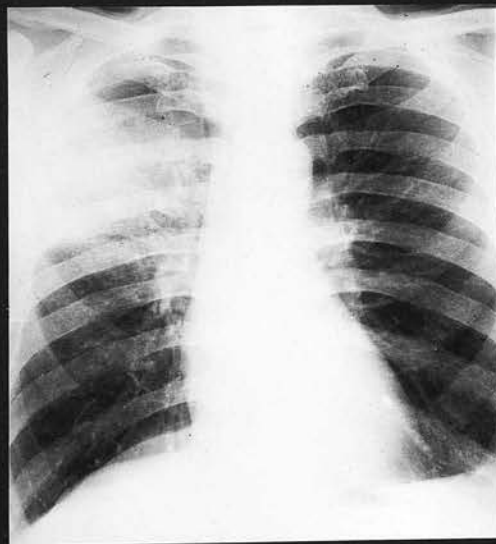
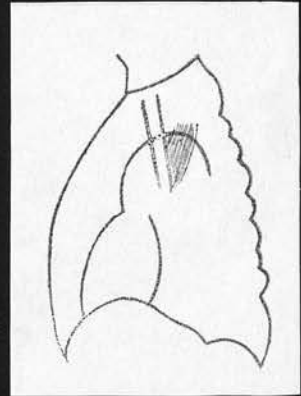
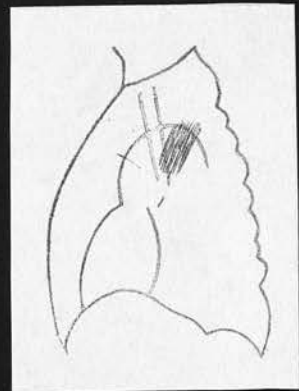


Fig. 72



- Fig. 73 - Male, aged 55, former coal-miner. Loss of energy and of  $1\frac{1}{2}$  stones in weight during previous 6 months, slight cough. Chest abnormality first seen at barium meal examination: category 2 or 3 simple pneumoconiosis with oval mass in posterior segment R.U.L. (A). Lateral tomography showed bulging of upper end of greater fissure and 2 smaller masses in apex of R.L.L. (B). Bronchoscopy negative. Thoracotomy - mass in R.U.L. bulging into fissure, felt too hard for carcinoma; several other smaller nodules in upper and lower lobes. No enlarged hilar glands. Pneumonectomy. Pathology - massive fibrosis of complicated pneumoconiosis.
- Fig. 74 - Male, aged 52. During 5 months subsequent to attack of "flu" developed cough, dyspnoea, pain in left chest, loss of weight and energy, occasional haemoptyses and finger-clubbing. Smoked 40 cigarettes/day for 30 years. Shadowing in apical segment L.L.L. initially resolved, then became more extensive (illustrated) on Estopen therapy. Bronchoscopy negative. Bronchography - block  $\frac{1}{2}$  cm. inside apical segment orifice. Thoracotomy - mass in apex of L.L.L. thought to be neoplastic; pneumonectomy. Pathology - chronic inflammatory lesion with bronchiectasis and several small abscess cavities.
- Fig. 75 - Male, aged 50. Left chest pain, dyspnoea, haemoptysis since "flu" 7 weeks ago. Smoked 25-30 cigarettes/day for many years. Bronchoscopy negative. Thoracotomy - mass in apical and subapical segments L.L.L. but not definitely malignant; pneumonectomy. Pathology - pulmonary fibrosis and pleural thickening, most probably an infarct or organized pleural exudate.



A

Fig. 73



B

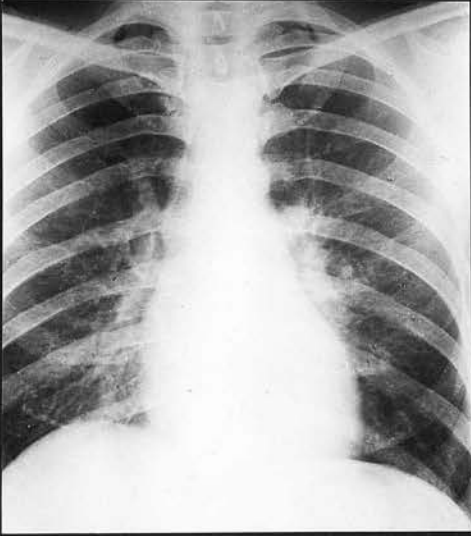


Fig. 74

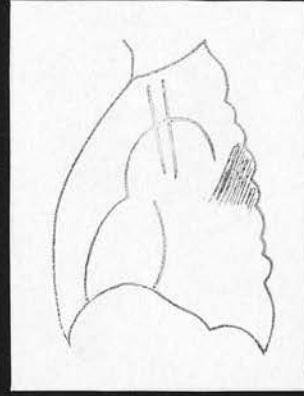


Fig. 75

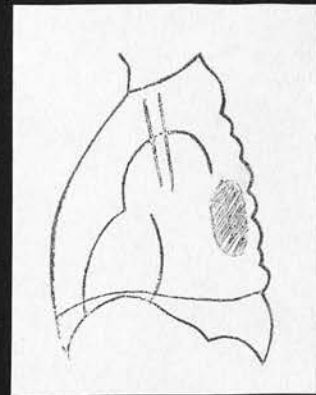
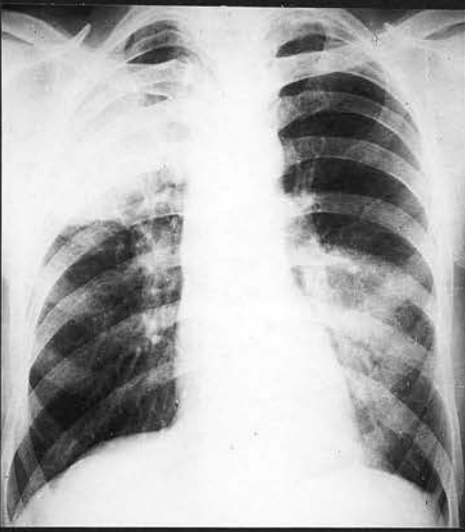


Fig. 76 - Male, aged 60. Unwell since "flu" 9 weeks ago (A). Penicillin, cholomycetin, streptomycin produced clearing of L.L.L. shadowing but no change in R.U.L. opacity during the next 3 weeks - A.P. tomogram of R.U.L. (B). A further month of intensive chemotherapy brought some improvement but chest was not completely clear radiologically until 4 months after start of chemotherapy (and over 6 months after "flu").

Fig. 77 - Male, aged 64. Non-specific subacute inflammatory lesion R.U.L. which remained I.S.Q. for over 3 months in spite of intensive chemotherapy. Eventually resolved completely 8 months after onset.

Fig. 78 - Male, aged 50. Pneumonia 3 months ago, still complaining of left upper chest pain. Bronchoscopy negative. Thoracotomy - no evidence of neoplasm. Gradual clearing during the next 9 months. Slowly resolving pneumonia.



A



B

Fig. 76



Fig. 77

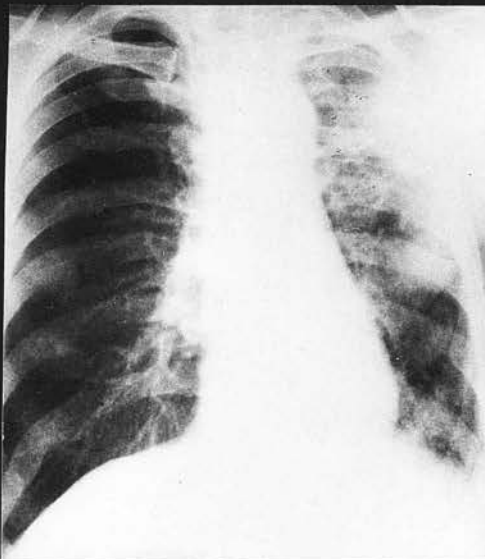
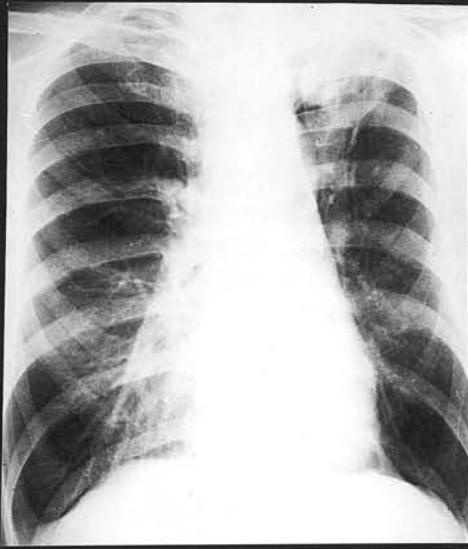


Fig. 78

Fig. 79 - Male, aged 52. Asymptomatic but 2 months ago had a "cold" associated with left upper chest pain, mild fever, no haemoptysis (A). A.P. tomogram of L.U.L. (B). Bronchoscopy negative. Left upper lobectomy - lung largely replaced by fibrous tissue and only dilated bronchi visible; obliterative endarteritis of vessels, some containing organized thrombus. Most probably an old infarct.

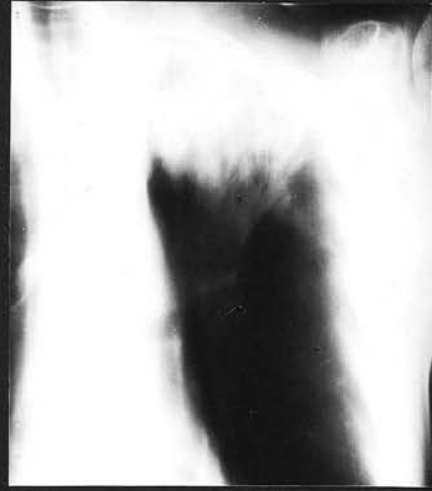
Fig. 80 - Male, aged 43. Cough, haemoptysis, left chest pain intermittently for 4 months. Left phrenic paralysis, elevation of hilar shadow, shrinkage and linear, spotty shadowing in L.U.L. suggesting old inflammatory disease. Bronchoscopy negative. Pneumonectomy - adherent mass in apical segment L.U.L. involving phrenic nerve. Pathology - diffuse pulmonary fibrosis; no evidence of neoplasm or tuberculosis.

Fig. 81 - Male, aged 64. Dyspnoea, weight loss 3-4 months. Clear, watery sputum which contained malignant cells. Palpable mass in left hypochondrium. I.V.P. - large space-occupying lesion in left kidney. Note resemblance of x-ray appearance to that of bronchiolar carcinoma in Fig. 86.



A

Fig. 79



B

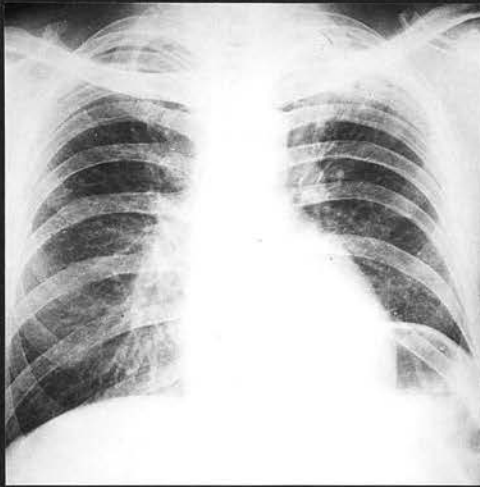


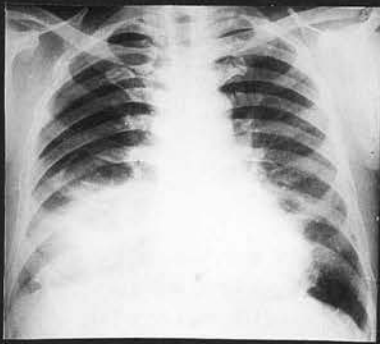
Fig. 80



Fig. 81

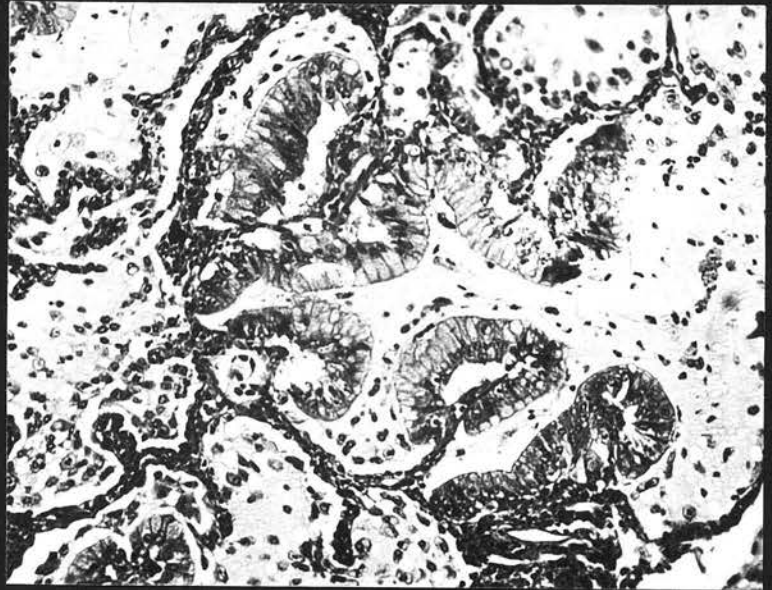
Fig. 82 - Case 1. Male, aged 51. "Flu" 3 months ago, lost 2 stones in weight since then. Cavitating lesion in R.L.L. (A). Pneumonectomy. Section of lung (haematoxylin and eosin x 125) shows arrangement of columnar epithelium and mucus in alveoli (B). Alveolar cell carcinoma.

Fig. 83 - Case 2. Male, aged 56. Asymptomatic M.M.R. pick-up. Ill-defined shadowing anterior segment R.U.L. Lobectomy. Probably bronchiolar carcinoma.



A

Fig. 82



B

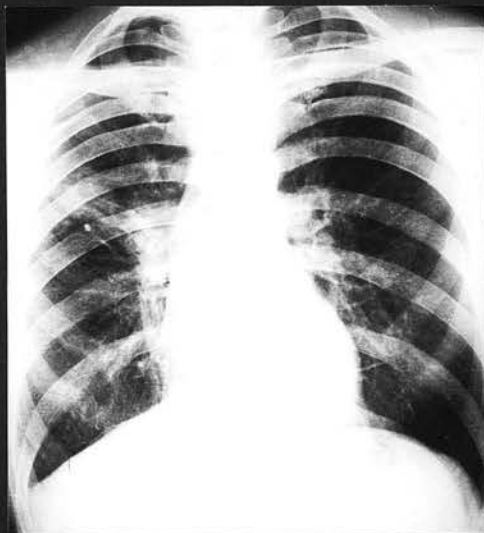
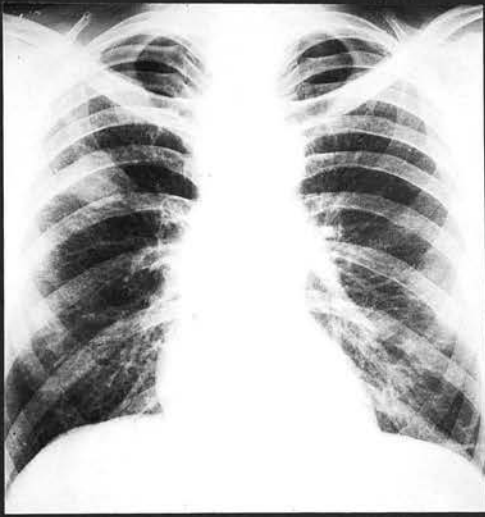


Fig. 83

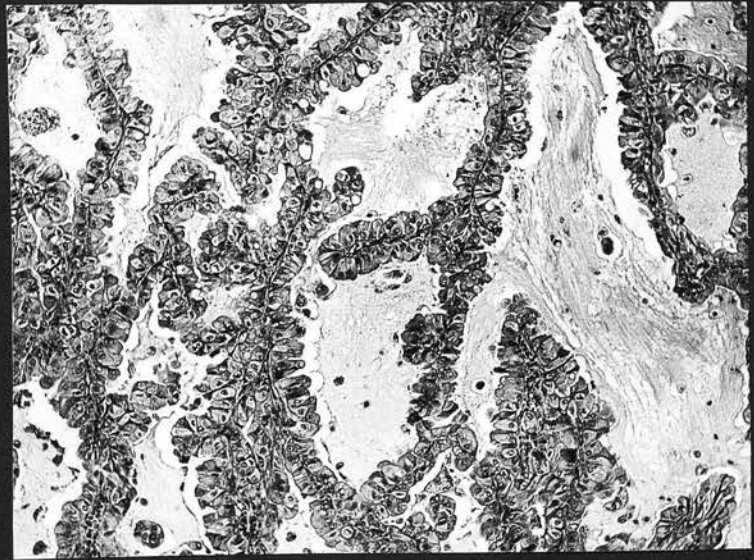
Fig. 84 - Case 3. Male, aged 60. M.M.R. pick-up. Slight dyspnoea and non-productive cough 1 year (A). Right upper lobectomy. A largely necrotic tumour; section (haematoxylin and eosin x 125) shows single layer of columnar epithelium lines the mucus-containing alveoli (B). Alveolar cell carcinoma.

Fig. 85 - Case 4. Male, aged 64. Dyspnoea, dry cough 5 months; pain in left chest 3 months. Lobulated mass in lingula and anterior segment of L.U.L.; several small, discrete shadows in L.L.L. Pneumonectomy. Histological appearance described as malignant adenomatosis.



A

Fig. 84



B

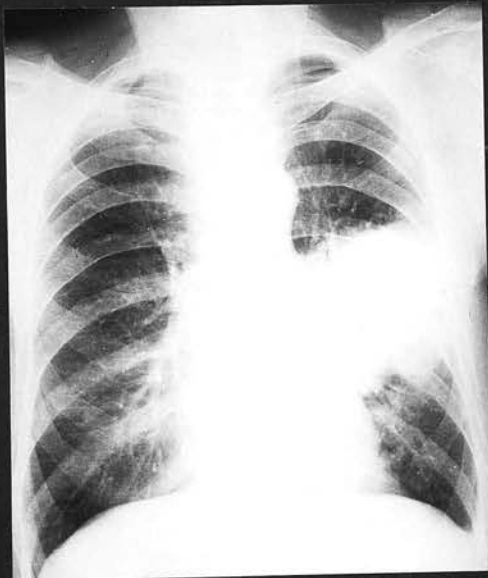
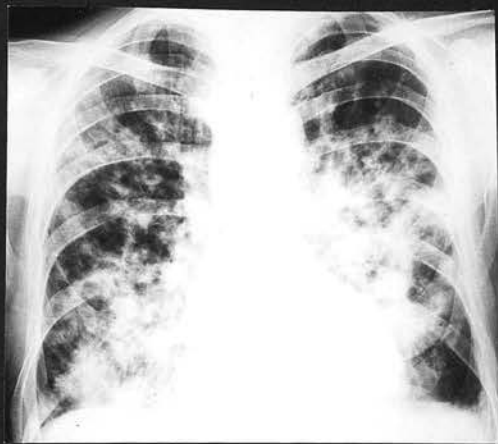


Fig. 85

Fig. 86 - Case 6. Male, aged 71. Lung changes first seen at barium meal and interpreted as chronic inflammatory disease (A). Increasing dyspnoea and gradual progression of lung changes during the next year (B) when sarcoidosis and alveolar cell carcinoma were suggested diagnoses. In retrospect, many discrete nodules were visible on the earlier film. Autopsy - bronchi normal; section (haematoxylin and eosin x 125) shows alveoli lined by mucus-secreting cells (C). No evidence of neoplasm elsewhere. Alveolar cell carcinoma.

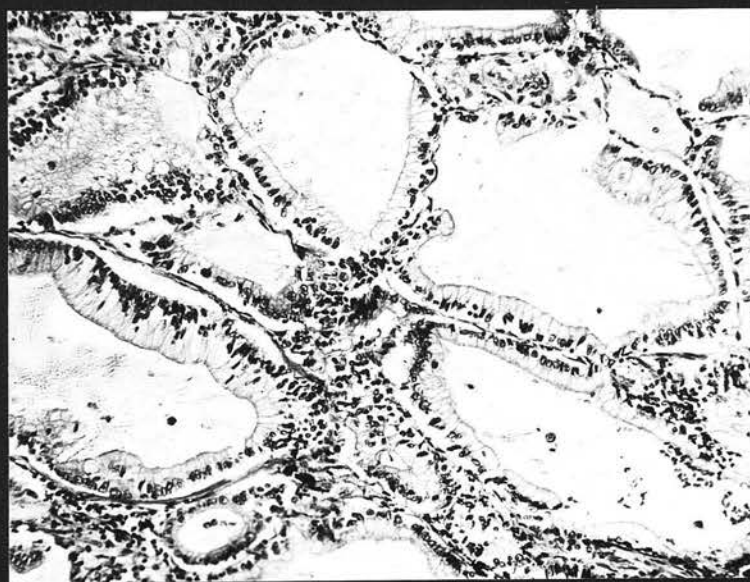


A



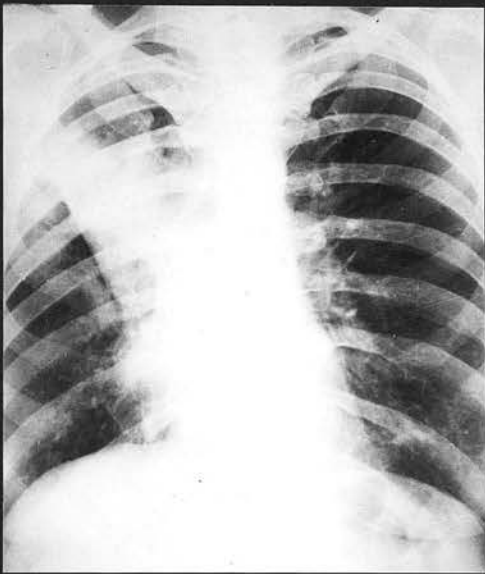
B

Fig. 86



C

Fig. 87 - Case 7. Female, aged 44. Cough with watery sputum, pain in right chest and weight loss since "chill" 5 weeks ago. Some loss of volume R.U.L. with dense opacity in posterior segment (A). A.P. tomogram shows additional rounded nodule in R.L.L. (B). Bronchoscopy - profuse, clear secretion from R.U.L. orifice. Cytological examination of bronchial aspirate (Papanicolau x 600) - clumps of adenocarcinoma cells, so-called "tumour acini" (C). Thoracotomy - pink mass in R.U.L. which pitted on pressure. Biopsy of ulcerating lesions in R.L.L. - alveolar cell carcinoma. Died 3 months later. No autopsy.



A

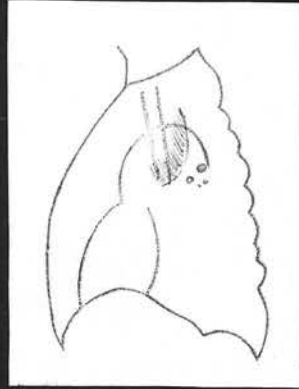
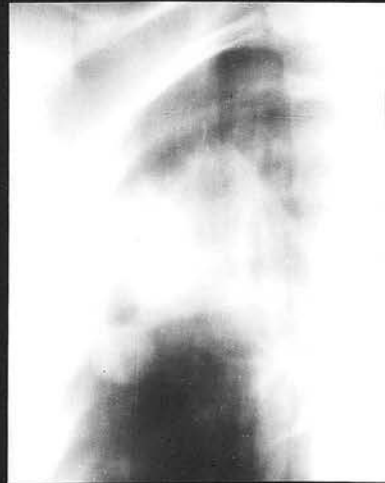
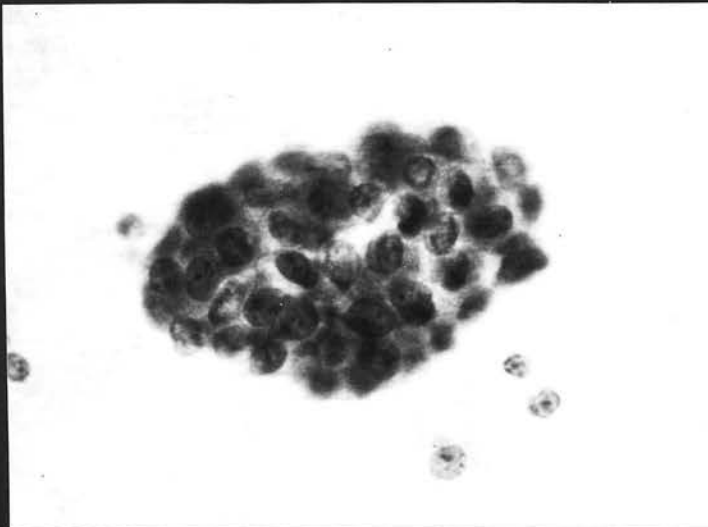


Fig. 87



B



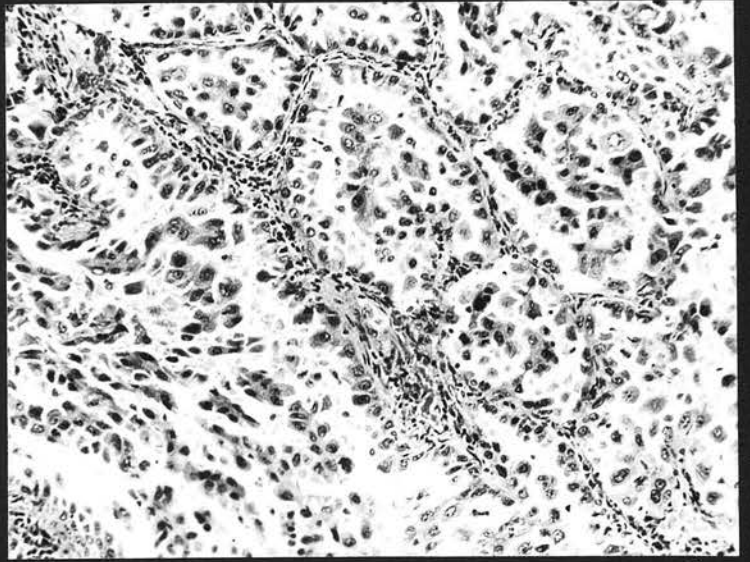
C

Fig. 88 - Case 8. Female, aged 46. Cough and yellow sputum 6 months, pain in left chest 2 months. Portable film showed bilateral pleural effusions and patchy consolidation in L.U.L. (A). Large numbers of malignant-looking cells in pleural fluid. Died. Epithelial desquamation present in lung alveoli (B). Alveolar cell carcinoma.

Fig. 89 - Case 9. Female, aged 60. Tiredness, increasing dyspnoea and loss of 1 stone in weight since "flu" 1 year ago. Ill-defined, large, homogeneous opacities both upper zones resembling pulmonary oedema, faint miliary shadowing both lower zones, convexity of upper right mediastinal shadow and prominent right hilar shadow. No clinical evidence of cardiac lesion, normal blood urea and blood count, no response to antidiuretics or antibiotics - tentative diagnosis of alveolar cell carcinoma (Dr. R. McNeill). Confirmed at autopsy.



A



B

Fig. 88

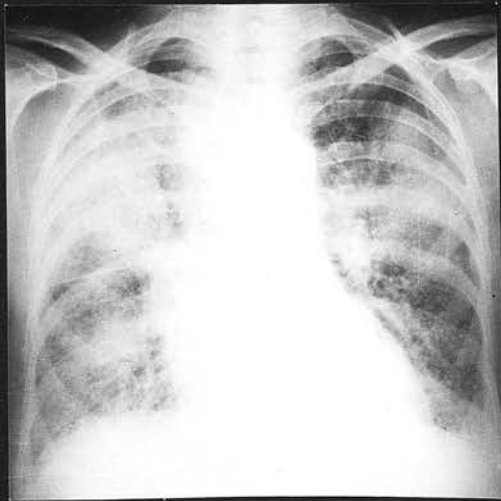


Fig. 89