first sign that something is going wrong. There are certain features which may suggest that the real lesion is a primary carcinoma, for example, with secondary deposits in the spine, pain over the site of the lesion associated with root pain are always suggestive. Secondly, tenderness of a particular vertebra to percussion is very suggestive that the body of the vertebra may be involved, and if there is evidence of destruction to the vertebra radiologically, the possibility of a primary growth in the lung should always be considered, although, of course, it may be elsewhere. In secondary deposits in the skull the history is usually helpful. The patient complains of headaches, but this is frequently a headache which is localized to one small area of the skull which may be tender to palpation and is unlike the headache which is associated with other conditions, which is usually more generalized and often at the top of the head or unilateral, without localized tenderness to palpation. Lumps occurring in the skin may be the first symptom of a carcinoma of the bronchus. A biopsy of one of the lesions will settle this, but a carcinoma of the bronchus is the most common carcinoma to metastasize to the skin and it may do so when the primary lesion is quite small. Secondary deposits occurring as the initial onset may, of course, appear anywhere. In cerebral lesions the symptoms will depend upon the position of the secondary deposits, and if situated below the tentorium will give rise to early pressure symptoms such as nausea, vomiting and papilloedema. In the presence of secondary cerebral deposits, while there may be alterations in personality and changes in mentality, this is not necessarily so. Rarely there may be a secondary deposit in the retina, giving rise to a localized diminished field of vision in one eye, and this can be seen ophthalmoscopically. It should be pointed out that when the symptoms of the disease are due to secondary deposits it is too late for any radical treatment.

Summary

The unusual manifestations of carcinoma of the lung are those where the main features are non-pulmonary. They occur by involving the veins, nerves, oesophagus, pericardium and myocardium in the mediastinum, and there may be distal lesions due to secondary deposits where the primary lesion is small and gives rise to no symptoms. There is another group in which acute infections of the chest may be the mode of onset, such as pneumonia or a pleural effusion and, lastly, the unusual and unexplained symptoms of polyarthritis and clubbing of the fingers and toes associated with a primary pulmonary neoplasm.

CARCINOMA OF THE BRONCHUS: RADIOLOGICAL ASPECTS

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A radiological examination may yield most valuable evidence in favour of a diagnosis of carcinoma of a bronchus. On the other hand, it is essential to remember that, no matter what the type or site of such a lesion, a plain routine anterior-view radiograph may either fail to show any abnormality at all, or reveal a shadow so small that it passes undetected or is mistaken for an old healed tuberculous focus. Negative evidence derived from a single film must therefore be ignored when this complaint is suspected and must not be used as an excuse for postponing more elaborate radiological or clinical investigations, such as bronchoscopy.

The positive X-ray appearances, which are frequently present when the patient is first examined, depend largely on the site of origin of the neoplasm and, to a smaller extent, on its histological type.

The most useful division is between lesions arising in the more proximal bronchi and those situated more peripherally. Of the peripheral lesions, those arising in an extreme apical site, or in a medial (mediastinal) site, can be separated from the rest. In addition, there are complications
common to both proximal and peripheral lesions which create X-ray appearances of their own.

**Peripheral Bronchial Carcinoma**

The characteristic appearance of a bronchial carcinoma arising in a peripheral site is that of a well-defined, homogeneous, circular or oval shadow between 1 to 6 cm. in diameter. The example shown in Fig. 1 has a fairly clear-cut margin, but by no means all such neoplasms show equally good definition. Sometimes the margins are indistinct due to the invasive character of the growth, or to the surrounding oedema and inflammation. Sometimes, instead of being circular or oval, the lesions are lobulated. Again, this may be due to peculiarities in the direction of growth or to the fact that part of the shadow may be projected by the neoplasm and part by surrounding inflammation or a local bronchiectasis.

The chief problem is that of differential diagnosis.

The larger shadows, 2 to 6 cm. in diameter, do not usually present so much difficulty, though a hydatid cyst should be borne in mind, and a careful search made to exclude a secondary deposit from an unsuspected primary neoplasm elsewhere. On the whole, cysts, benign neoplasms (such as an adenoma or hamartoma) and secondary deposits have very clear-cut margins, whereas a primary neoplasm or a tuberculous lesion often has a slightly hazy margin.

When the shadow is between 1 cm. and 2 cm. in diameter differentiation is often more difficult. In every such case tomograms should be taken, since the demonstration of a small air space, or of satellite shadows nearby, will strongly suggest tuberculosis, these features being very uncommon when a neoplasm is still relatively small. In no circumstances should treatment be postponed in order to assist the diagnosis by serial X-ray examinations for changes in size. Some tuberculous lesions grow from 1 cm. to 2 cm. in a comparatively short time, thus simulating a neoplasm, while others remain unchanged in size for some months and rarely regress within a reasonable time. A neoplasm at this early stage may also remain unchanged in size for months or even a year or more.

Clearly visible calcification is uncommon in a bronchial neoplasm, and when present is often the result of an old tuberculous lesion being overrun by the growth. Nor does the sort of tuberculous lesion which is likely to be mistaken for a growth often show any calcification.

The surgeon's attitude to these clinically silent small circular shadows is referred to by Mr. L. L. Bromley.

**Extreme apical site.** The two special types of peripheral growth, namely, those in the apex and those lying very medially, show very different radiological features.

The growth in the extreme apex is usually not circular nor clearly demarcated, and is apt to be mistaken in its early stage for a cap of thickened pleura over the apex. In some cases the only chance of a correct diagnosis may be in the availability of a fairly recent previous radiograph showing the absence of an apical pleural shadow. The finding of an eroded rib next to the shadow (a complication which tends to occur early) would be another clue to the diagnosis. This may necessitate additional radiographs taken specially for the ribs. A suitably exposed chest film will show them, but a film taken with a moving grid (Potter Bucky type), or even a tomogram, is better.

The radiographic evidence may precede the pain which is a common result of neoplasm in this site. The radiographic appearances will be the same whether it is an ordinary squamous carcinoma or whether it has the histological appearances suggestive of a Pancoast type of tumour. A peripheral carcinoma rather lower down may also cause extensive rib erosions. It is a very rare complication of lower zone carcinomas.

**Medial site.** The medially placed bronchial carcinoma, especially one arising from the upper
As it grows larger it will eventually cast a recognizable abnormal shadow distinct from the vessels, but long before this stage it will usually have caused bronchostenosis, and the resulting changes in the lung distal to this will be the first or most prominent X-ray evidence of this serious condition.

Obstructive atelectasis. One of the most common findings resulting from such a bronchostenosis is obstructive atelectasis. This is really a radiological term meaning a homogeneous shadow cast by a much shrunken lung, lobe or major segment. Pathologically, in addition to the atelectasis or airlessness, there are invariably a variety of other changes, oedema and bronchiectasis of some degree being nearly always present; and there is frequently some true chronic pneumonia. When the carcinoma is in or near the left or right main bronchus, it may produce obstructive atelectasis of the whole lung on that side, and the radiograph will show a homogeneous opacity from the apex to the base, with the heart and trachea considerably displaced towards that side.

When the carcinoma is rather more distal, so that only a lobar bronchus is involved, then the homogeneous shadow of the shrunken lobe will be seen on the radiograph. Such a shadow can be assumed to represent a shrunken lobe if the heart and trachea are displaced towards it. If there is no displacement, or if it cannot be detected because of a slight scoliosis or rotation of the patient, the lobar shrinkage may be recognized by the relatively small size of the shadow, by the displacement of an interlobar fissure and the altered pattern of the pulmonary vessels. Since the unaffected lobe or lobes occupy more space than they normally would, there is not only vessel displacement, but the vessels are also more widely spaced, so that there is an apparent diminution of the number of vessels to the square inch in the affected lung field relative to the other side. In addition, there is often slight hypertranslucency due to the compensatory emphysema. These appearances may be the only sign of a collapsed lobe in the routine anterior view.

The fissure displacement in the case of an upper or middle lobe is best seen in a lateral-view radiograph or lateral-view tomogram.

In the case of obstructive atelectasis of the left lower lobe the atelectotic lobe and fissure and vascular abnormalities may all be inconspicuous on the routine radiograph, but the characteristic triangular shadow will easily be seen through the heart shadow if an additional film is taken with double the normal exposure. Sometimes the physical signs are a sufficient indication in themselves for this fuller investigation, which should be undertaken in any case of suspected bronchial

lobes, tends to spread medially and invade the mediastinum either directly or in the form of extensive glandular secondary deposits. The X-ray appearances are therefore frequently similar to those of a primary mediastinal neoplasm (Fig. 2). This type of lesion (which is, fortunately, uncommon) is nearly always found to be inoperable on thoracotomy and is not particularly sensitive to radiotherapy.

Exact diagnosis is often difficult, neither bronchoscopy, bronchography nor tomography yielding any decisive evidence. The exclusion of leukaemia by a blood count, or of extrathoracic glandular enlargements, will narrow the list of possible types of mediastinal tumour, and the absence of a response to small doses of X-rays will exclude the more sensitive types.

Since operation is so rarely of value, serial X-ray observation may be justified. A benign inflammatory lesion or benign mediastinal mass will probably come to no harm provided a reasonable time limit is set.

Proximally Situated Bronchial Carcinoma

In its early stage a carcinoma of a main bronchus or its first division is commonly invisible on a plain anterior-view radiograph, being hidden by the shadows of the normal hilar vessels.
carcinoma in a lower lobe, when the routine radiograph is insufficiently exposed to show lung vascular markings through the heart shadow.

The finding of the shadow of an atelectatic lobe is, in itself, only suggestive of a neoplasm, since there are other causes of bronchostenosis, such as tuberculosis. Brock (1950) considers the latter to be the commoner cause when the middle lobe is involved. In most cases bronchoscopy will be required to determine the cause of the stenosis.

The X-ray appearances may be altered by complicating factors. For instance, the size of the growth, or the presence of associated pneumonia, may limit the possible amount of shrinkage of the airless lobe. The shadow of the opaque lobe will then be relatively large, almost the size of a consolidated lobe, and the fissure and vessel displacements will be less. A complicating pleural effusion will push the heart and trachea back to their normal position, even in a total unilateral atelectasis.

Obstructive emphysema. A rather uncommon result of bronchostenosis produced by a neoplasm is that of distal emphysema or over-inflation, air passing into the lung during inspiration, but returning with difficulty on expiration. In a doubtful case a radiograph should be taken in full suspended expiration in addition to the standard chest radiograph taken during suspended inspiration. In expiration the normal side tends to become more opaque, while the over-inflated area remains unchanged and therefore relatively translucent.

Distal inflammation. Other common complications of a small proximal neoplasm, itself invisible on the plain radiograph, are distal inflammation, bronchiectasis and abscess formation.

Distal inflammation may take the form of an acute pneumonia involving a lobe or segment, and the radiological appearances will then be identical with such a condition occurring independently of a local bronchial lesion. There will be a more or less homogeneous area of clouding with minimal fissure or vessel displacement. Slow or incomplete resolution of such a lesion in an elderly man should always arouse the suspicion of an underlying neoplasm (Davidson, 1951). With modern antibiotic therapy, however, the pneumonic lesion may resolve rapidly and completely, frequently only to recur in a month or two. This early recurrence should excite a strong suspicion of the underlying cause.

In another form the inflammatory process is much less acute and the radiological picture is then often that of a localized group of 3 to 5 mm. circular opacities, which closely simulate tuberculous foci. Such a case is likely to have long continued medical treatment under a provisional diagnosis of tuberculosis before the true nature of the shadows is realized (Livingstone, 1952), and serves as a warning against a diagnosis of tuberculosis being based on the radiological appearances alone, especially in a patient over 40 years of age.

Distal bronchiectasis. Instead of a pneumonic process, localized bronchiectasis with or without superadded inflammation is sometimes seen. The radiograph may then show a local area of honeycomb shadowing or, more commonly, tubular shadowing. Should a bronchogram be done before the true nature of the lesion is discovered, the small filling defect caused by the neoplasm is often not observed, attention being fixed on the more spectacular bronchial dilatations and deformities.

Spontaneous pneumothorax. Rarely a proximal bronchial neoplasm may present as a spontaneous pneumothorax, possibly the result of distal emphysema and bullous formation. The growth itself may sometimes be visible in the routine anterior-view film as the lung re-expands, but in many cases it can only be detected by means of more elaborate investigations.

Bronchial Carcinoma and Abscess Formation

Two kinds of intrathoracic abscess are found in bronchial carcinoma. One is an inflammatory lung abscess in the lobe or segment distal to the neoplasm. The radiological appearances of this will not differ from those of an abscess due to other causes. The abscess may consist of a single cavity with only a little surrounding consolidation or, more rarely, if a suppurative pneumonia is present, of multiple small cavities in an area of massive consolidation.

The other type of abscess is a cavity in the neoplasm itself. Poor blood supply and infection may result in central necrosis of the tumour and the radiological appearances are then commonly those of a cavity with a 1 to 2 cm. thick irregular wall. Now and then quite a large cavity, 4 to 6 cm. in size, is seen, with a thin 1 to 2 mm. wall (Fig. 3). This simulates a cyst or simple lung abscess. The thin wall and frequent absence of any cough or sputum make it most unlikely that such an X-ray appearance represents a breaking down neoplasm. Nevertheless, in the case shown in Fig. 3, and in other similar cases, it was found after resection that the wall consisted of squamous carcinoma cells. It is possible that the cavity originated as a single large distension bronchiectasis distal to the growth and that the tumour cells grew into this and replaced its bronchial lining with the tumour cells. It is thus apparent that the differentiation of an abscess or cyst from a carcinoma cannot always be made on the radiological appearances alone.

Carcinoma with Pleural Effusion

Pleural effusion may be either a presenting symptom of a bronchial carcinoma, or a late mani-
gestation in a known case. A blood-stained effusion frequently results from involvement of the pleura by the neoplasm. A serous effusion may be the result of a similar cause and would therefore suggest that operative removal of the tumour would be of little value. On the other hand, such an effusion may only be a complication of the distal inflammatory changes, in which case pneumonectomy might well eradicate the disease. A purulent effusion is quite a common complication of severe distal inflammation. The radiological appearances of such an effusion will naturally be the same as those due to inflammation without an underlying neoplasm.

**Bronchial Carcinoma with Pulmonary Osteoarthropathy**

Now and then the presenting symptom is pain in the limbs or joints. The sudden onset of such pain in a man over 40 is an indication for a radiograph of the hand and wrist, the knee, or the foot and ankle. If the lesion is a pulmonary osteoarthropathy, the tell-tale periosteal new-bone formation around the shafts of the bones near the joint will point to the correct diagnosis and the necessity for a radiographic examination of the chest. These periosteal changes are nearly always found in the presence of joint symptoms due to pulmonary osteoarthropathy; they are not seen in chronic non-specific arthritis.

**Indications for Bronchography or a Tomogram of a Bronchus**

Occasionally a shadow is seen fairly near the hilum, but no abnormality is seen on bronchoscopy. This is liable to happen with an upper lobe neoplasm, or a middle lobe neoplasm about 2 cm. down the main bronchus, or in the proximal parts of the medial or lateral segments of this lobe. In such instances bronchostenosis may be demonstrable by tomography. Should the diagnosis still be uncertain, a bronchogram may be of great value. Fig. 4 is an example of stenosis of the superior division of the lingula from an early bronchial carcinoma which was invisible on bronchoscopy.

A carcinoma in the posterior part of the lung may lie medially near enough to the hilum to be obscured by the great vessels or heart in an anterior view. It may also be indistinguishable in a lateral view or on fluoroscopy. A lateral-view tomogram will reveal the shadow clearly, unobscured by scapula, vertebrae or great vessels.

**Radiology and Operability**

The radiograph may reveal certain absolute
contraindications to pneumonectomy. The most important is the presence of contralateral secondary deposits. This is, in fact, not a very common finding and may be suggested if one or several 3 to 30 mm. circular shadows are seen. An isolated circular shadow may, of course, be due to a tuberculous caseous area or even an old healed infarct, and such lesions cannot always be excluded unless previous radiographs show they are of recent origin. Secondary deposits in ribs, clavicles, vertebrae, etc., will be very discouraging. On the other hand, local rib erosion by direct extension of the tumour mass is only a relative contraindication; and on some occasions the neoplasm and eroded rib have been removed at the same operation with apparent success.

Restriction of movement of one side of the diaphragm is unimportant, since it may be the result of distal inflammation. On the other hand, true paradoxical movement, often best seen when the patient sniffs, is very suggestive of phrenic nerve involvement by glandular secondary deposits. However, it may be possible to remove the offending gland if it is on the left side near the pericardium (Tubbs, 1951).

When pneumonectomy is under consideration for the treatment of a carcinoma of the bronchus the oesophagus should be examined radiologically by means of a 'barium swallow.' A fairly thick paste of barium sulphate is made up with water and its passage down the oesophagus is observed by fluoroscopy, the patient being rotated so that it can be seen from several angles. Any abnormal indentations or local deviation should be observed and radiographed. Deviation or indentation unassociated with the atelectasis or the bulk of the neoplasm itself will suggest the presence of mediastinal secondary deposits. Local irregular filling defects, or localized alterations in the mucosal pattern, will strongly suggest invasion of the oesophageal wall by the carcinomatous deposits and will preclude successful resection. The finding of such changes is, fortunately, not common, but this is no reason for neglecting the simple procedure.

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CYTOLOGICAL EXAMINATION OF THE SPUTUM AND PLEURAL EFFUSION IN CARCINOMA OF THE BRONCHUS
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Introduction
Cytological and histological procedures are the most precise pathological methods available to the clinician in his attempt to make a diagnosis of carcinoma of the bronchus. The former have the advantage that surgery is not required in order to obtain the specimens and on this score alone there is a strong case for developing the specialized technique that is required in their use.

Historically the method has been evolved along two independent channels, one in England having Dudgeon as the fount and inspiration and the other in the United States with Papanicolaou as the pioneer. Sporadic reports of the presence of neoplastic cells in sputum appeared in the Continental literature early in the century (von Hoesslin, 1921), but Dudgeon and his co-workers (Dudgeon and Wrigley, 1935; Barrett, 1938) and his successor Bamforth (1946) were the first to make this diagnostic method the subject of intensive study. They gained their initial experience by making scrapings from solid tissues such as the breast (Dudgeon and Patrick, 1927; Dudgeon and Barrett, 1934). Papanicolaou's prime interest was in the cytology of the female genital tract (Papanicolaou, 1933), and his studies were the stimulus for the release, a decade or so after Dudgeon's original publication, of a flood of papers in America on the application of cytological technique to malignant conditions all over the body, culminating in a thorough and well illustrated monograph by Graham and her co-workers (Graham, 1950).