Current Practice

RESPIRATORY TRACT DISEASE

Lung Abscess

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Suppurating cavities in the lung are common, diverse, and usually of serious significance. They call for rigorous diagnosis and effective treatment. For historical reasons, and because its management is incidental to the general treatment of the disease, the tuberculous cavity is generally excluded from any classification of lung abscesses. None the less it remains an abscess and is never to be forgotten in differential diagnosis, for not only may a lung cavity be primarily tuberculous but a cavity of different provenance may become secondarily infected by tuberculosis. Bronchiectasis is similarly excluded, though in the severe cystic type the grossly dilated bronchi containing levels of pus might fairly be considered abscesses and resemble them radiologically. They lack, however, that necrosis which is a feature of most, but not all, abscesses.

Classification

No classification is complete or wholly satisfactory, but the following may be helpful:

- (1) MALIGNANT ABSCESSES:
 - (a) *Necrotic bronchial carcinoma.*
 - (b) *Secondary to bronchial obstruction.*
 - (c) *Spill-over.*
- (2) ASPIRATION ABSCESSES:
 - (a) *Acute.*
 - (b) *Chronic.*
- (3) ABSCESSES DUE TO VASCULAR EMBOLUS:
 - (a) *Pyogenic.*
 - (b) *Septic infarction.*
- (4) SPECIFIC ABSCESSES:
 - (a) *Staphylococcal.*
 - (b) *Friedländer's bacillus.*
 - (c) *Tuberculosis.*
 - (d) *Actinomycosis.*
 - (e) *Entamoeba histolytica.*
- (5) SECONDARY INFECTION OF CONGENITAL OR ACQUIRED LUNG CYSTS.

In the investigation of a patient thought to have a lung abscess a detailed and careful history is essential. It is customary to pay lip-service to the importance of physical signs, but let us say instead that no physical examination of the chest is complete without good postero-anterior and lateral x-ray films. Tomography is particularly helpful in distinguishing malignant

abscesses. If a fluid level is radiologically visible the abscess communicates with a bronchus, its contents are being expectorated, and one has but to look in the sputum pot to see how much and what they are. Culture and histological examination should precede the use of antibiotics or bronchoscopy. Bronchoscopy is often mandatory in diagnosis (see below), sometimes helpful therapeutically.

Malignant Abscesses

Apart from tuberculous cavitation these constitute the commonest lung abscesses encountered in Great Britain, and much the commonest in the male over 50 years. So much is this the case that any cavitated lesion seen in the chest x-ray of such a man should be assumed to be neoplastic until the contrary is proved. Such an assumption would save many lives and much expense to the taxpayer. It is not unusual to see such lesions exhaustively investigated in hospital long after their true character should have become manifest and thoracotomy carried out. An example is provided by the case of a man aged 65 with a small abscess cavity in the upper lobe of his right lung. All investigations (save radiography) were negative, but he spent a total of 15 months in hospital being treated with a great variety of antibiotics and acquiring an enormous dossier of x-rays before his bronchial carcinoma was removed. In this he was fortunate; the taxpayer less so: the patient's stay must have cost some £2,500.

There are three kinds of malignant abscess, of which the first is by far the commonest:

(a) *Necrotic bronchial carcinoma.* Well-differentiated primary squamous-celled carcinomas are prone to necrose and cavitate. The patient may be symptomless or have had occasional haemoptyses. There is usually a little purulent sputum but it is seldom offensive or profuse, and toxicity and fever are absent or minimal. Radiographically an abscess is visible in the lung, usually with a fluid level. Its wall is characteristically irregular, consisting of the growth itself, whose centre has necrosed because it lacks adequate blood supply. The irregularity of the wall is apparent in large growths, but in small ones is displayed much more clearly by tomography (Fig. 1). Squamous carcinoma cells can be demonstrated in the sputum of about 60% of subjects by practised histologists. Search for these cells is made before, not after, bronchoscopy, for passage of the bronchoscope results in the production of atypical mucosal cells for a week or more, which may confuse the picture. Bronchoscopy is mandatory in all cases, but is frequently negative. Tuberculous cavities of like dimension usually yield acid-fast bacilli in the sputum and are likely to be adjacent to areas of recognizable tuberculous infiltration. (Occasionally tuberculosis and carcinoma coexist; and the development of a new lesion in a patient over 50 already receiving drugs must always be watched with deep suspicion).

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Pyogenic abscesses are generally accompanied by fever and florid symptoms, though these may be masked by antibiotics. Their walls are more regular, their dimensions change, sometimes rapidly, with therapy.

FIG. 1.—A breaking-down squamous celled bronchial carcinoma as shown by tomography. Note the irregularity of the wall.

Adenocarcinomas and anaplastic bronchial growths very seldom cavitate. Thus the recognition of a necrotic lung neoplasm enables a histological diagnosis and prognosis to be made: well-differentiated squamous-celled bronchial carcinoma; prognosis good. If sputum, histology, and bronchoscopy prove negative, as is quite likely, the next step in investigation is exploratory thoracotomy.

(b) *Pyogenic abscess distal to a growth.* Seventy-five per cent of bronchial carcinomas grow proximally in the bronchial tree and thus cause obstruction early. A suppurative abscess may then occur distally resembling in its symptoms and radiological appearances an aspiration abscess (see below). If effective antibiotics are given these symptoms remit, and the abscess cavity seen on the initial x-ray may greatly diminish or wholly disappear. If the neoplasm is small, or hidden behind the heart shadow, it is likely to pass undetected, especially as the patient's clinical condition improves. It will be revealed only by bronchoscopy, an investigation indicated in all cases of adult lung abscess.

(c) *The "spill-over" abscess.* Occasionally pus or a fragment of slough is aspirated from a small neoplasm during sleep into some other, dependent, part of the bronchial tree and there gives rise to a typical aspiration abscess with fever, toxicity, and profuse expectoration. As in the preceding instance, antibiotic therapy produces remission and resolution, and the inconspicuous lethal source goes undetected.

MORAL: Suspect malignancy whenever lung abscess is encountered in adults, and particularly in middle-aged males. Bronchoscopy is always indicated. Do not sit and speculate too long about irregular cavities in their chest x-rays. When in doubt, have it out. In the unlikely event of its proving to be a tuberculous lesion or a chronic pyogenic abscess cavity the treatment will not be amiss.

Aspiration Abscess

Two factors are required for the development of an aspiration abscess: suppression of the cough reflex, and the inhalation of a septic embolus. The commonest source of the latter is oral or dental sepsis—a bead of pus from infected gums, a minute fragment of tartar, or tonsillar debris—and about 80% of patients with an aspiration abscess also have gross dental sepsis. Such tiny emboli, which must frequently be inhaled, are normally expelled from the bronchial tree by coughing. If, however, the cough reflex is for any reason seriously impaired or wholly suppressed the stage is set for an aspiration abscess, especially if the patient's resistance is low and the embolus contains virulent organisms.

Factors suppressing the cough reflex are: anaesthesia; head injury; coma (whether it be diabetic, epileptic, barbiturate, or alcoholic); and semi-drowning.

Obstructive disease of the oesophagus may be associated with pulmonary suppuration due to overspill and aspiration of food particles during sleep. Aspiration lung abscess may thus complicate achalasia, simple stricture, or cancer of the oesophagus; and occasionally symptoms such as fever and purulent expectoration precede (and should direct attention to) the more insidious development of an oesophageal lesion.

In all cases where aspiration abscess is suspected a recent history of an episode in which the cough reflex may have been suppressed should be sought, and is likely to be found in some 70% of subjects. In the remainder, irrespective of sex or social state, the possibility of alcoholism must be borne in mind, as this is most likely to be concealed. It provides suitable conditions. A National Service recruit on his first night in barracks got stuporously drunk, fell down, and aspirated some of his vomit. He developed a typical lung abscess and was invalided out of the Army forthwith. When last heard from he was still being paid a 90% disability pension by a grateful country.

Site of Abscess

The site of the abscess in the lung is determined by the posture of the patient at the moment of inhalation. Thus if he is lying on his back the embolus is more likely to go down the right main bronchus than the left because the right more nearly continues in the line of the trachea. The first dependent bronchial orifice on its floor is that leading to the apical segment of the lower lobe of the right lung; and this in fact is the commonest situation in which to find an aspiration abscess.

Should the subject be on his right side it is the right upper lobe bronchus which becomes dependent, and the embolus is then likely to find its way into the axillary part of the posterior segment of the lobe. When there is a leftward inclination the corresponding segments of the left lung will be involved according to the degree of tilt. So constant are these locations that a diagnosis of aspiration abscess in other pulmonary segments, especially those lying anteriorly, must be viewed with a good deal of doubt. Males, however, float face down in the water when drowning, and if revived may develop an abscess in an anterior segment such as the middle lobe or lingula. Females generally lie face upwards.

With improved anaesthetic techniques lung abscess from this cause has become much rarer. The patient is usually now awake almost as soon as he leaves the operating table. If not, he is not allowed to lie supine so that secretions are aspirated, but placed semi-prone with dependent mouth, his pharynx being kept clear by an attendant nurse until consciousness is regained. When it is, the first word spoken by his attendant to him should be "Cough!" It is important that post-operative sedative drugs are prescribed in such dosage as to allay pain and thus encourage the effort of coughing, but not to depress the cerebral centres so that the cough is ineffectual. Dehydration renders bronchial secretions sticky and difficult to

shift. If a patient's tongue is dry so is his bronchial mucosa. He needs fluids.

In the past many aspiration abscesses followed the injudicious extraction of decayed teeth. If this were performed under a summary gas and oxygen anaesthetic with the patient semi-upright in the dentist's chair, his mouth aswirl with blood and pus, perfect conditions were established for septic inhalation. Nowadays such operations are carried out, if not always with a highly skilled anaesthetist in attendance, at least with head lower than the lung.

Pathogenesis

The aspirated septic embolus lodges (according to its size) in one of the smaller bronchial branches of the chosen segment, there giving rise to an area of acute suppurative pneumonia. This area varies in extent according to the virulence of the organisms and the resistance of the patient, but often involves a whole broncho-pulmonary segment and may extend to the consolidation of an entire lobe. Its progress is accelerated and intensified by vascular thrombosis in the affected parenchyma. Local areas of gangrene thus result, and if the necrosis is extensive a slough may separate and come to lie free within the abscess cavity. Massive sloughs are a feature of acute infection by Friedländer's bacillus. In most aspiration abscesses the infecting organisms are, as one would expect from their genesis, a mixed brew of the flora of the mouth and throat, including Vincent's organisms, spirochaetes, *Escherichia coli*, and anaerobic streptococci. The latter are responsible for the characteristically offensive odour and taste of the pus these abscesses contain.

The clinical course of the infection thus far is that following the initial episode of anaesthesia or unconsciousness a latent period of several days elapses, during which the patient remains relatively well, although there may be a dry irritative cough. As inflammation in the lung extends to reach the surface of the involved segment there is likely to be pleural pain, and pleurisy is often the presenting symptom. It might be expected that the abscess then ruptures into the pleural space, giving rise to empyema, but ischaemic necrosis very seldom extends into the cortical areas of the lung because their rich vasculature provides a protective barrier. Consolidation and local gangrene proceed within, however, and are accompanied by marked toxicity and an intermittent fever with high peaks. The subject is now acutely ill. If he is x-rayed at this point a homogeneous opacity with mottled edge is visible occupying most of the affected segment, usually the apex of the right lower lobe (Fig. 2) or the axillary part of an upper lobe.

The abscess develops and distends with pus, but its peripheral extension is limited by the lung cortex. Instead it eventually ruptures proximally into an adjacent bronchus. This event is signalled by a haemoptysis, followed by profuse expectoration of brown, stinking, and evil-tasting pus. At once, and for the first time, the consolidated area is now seen radiologically to be cavitated, and it contains a fluid level (Fig. 3).

Treatment

If antibiotics have been used from an early stage in the disease these florid manifestations may all be masked, though most patients complain at some time or other of their sputum being at least foul tasting. Antibiotics must be given in large doses—for example, penicillin 2–5 mega-units with 1 g. of streptomycin daily—as lesser amounts do not find their way from the blood-stream into the cavitated areas. Therapy is usually continued for several weeks. The appearance of purulent sputum enables accurate prescription to be made according to the nature and sensitivity of the predominant organisms, which may, for example, better respond to 500 mg. of tetracycline six-hourly, or, if they are otherwise resistant staphylococci, to similar doses of erythromycin or novobiocin. The daily quantity of sputum

is always measured and recorded and should progressively diminish.

Attention is now directed to ensuring adequate and, if possible, continuous drainage of the abscess. This is generally secured by posture for as long a time as the patient will tolerate. In the case of an abscess in the apex of a lower lobe he will lie face and head down; in the axillary part of an upper lobe, on his opposite side. He is encouraged to sleep in these positions, and periodic firm percussion by the physiotherapist over the related chest wall helps evacuation of the pus.

FIG. 2.—Aspiration abscess in apical segment of right lower lobe before rupture into a bronchus has occurred. No fluid level is therefore visible.

FIG. 3.—An aspiration abscess after rupture into a bronchus. It is situated characteristically: the apical segment of a lower lobe.

Once spontaneous rupture of the abscess has taken place it is usual for fever and toxicity to lessen, and there is a steady diminution both in the volume of sputum and in the size of the cavity visible in the chest x-ray. If any of these things do not follow, drainage is inadequate and means are sought to improve it. Bronchoscopy may discover the communicating bronchus to be obstructed by slough, which is then extracted; or it may reveal an unsuspected foreign body or neoplasm. Larger sloughs within the abscess cavity itself sometimes act as ball-valves and prevent emptying.

Should an abscess cavity not diminish steadily (as monitored by regular radiographs) once adequate antibiotics and drainage have been begun, or should spontaneous rupture not have occurred at all, so that the x-ray opacity grows larger and toxicity increases, surgical removal of the affected lobe may be indicated. The appearance of a pleural effusion is a danger-signaling warning of imminent empyema.

There is no longer any place for open surgical drainage by rib resection. Transpleural aspiration should never be attempted, as it is likely to lead to empyema.

Chronic Aspiration Abscess

When virulence is low, or symptoms are masked by early empirical antibiotics, or when antibiotics have been discontinued too soon, an acute aspiration abscess may not resolve but lapses instead into one of two states: chronic suppurative pneumonitis or the epithelized cavity.

In chronic suppurative pneumonitis infection grumbles on throughout the affected lobe, which is often an upper one. The sputum, though it may be profuse and purulent, is usually not offensive, because by this stage in the disease natural resistance (with or without the aid of antibiotics) has overcome the anaerobic organisms. Confluent areas of low-grade suppuration result in an irregular honeycombing of the lung parenchyma. Remissions and exacerbations are frequent, the latter associated with irregular pyrexia and occasional "spill-over" aspiration of infected material into other, dependent, parts of the lung, so that the disease appears to wander, dying out in one lobe only to flare up in another. Therapy is directed to overcoming infection by the use of antibiotics in large dosage, the drug chosen being that to which the predominant flora in the sputum is sensitive. Once this has been achieved and the condition is quiescent, bronchography is carried out to determine the degree of damage in the affected lobe. If there is general destruction, as is the rule, lobectomy or segmental resection is indicated.

In those instances where an acute abscess does not completely resolve the passage of time permits the epithelium of the bronchus with which it communicates to grow into the residual cavity and eventually to line it, thus rendering it a permanent structure. (This process also occurs to a greater or lesser degree in chronic suppurative pneumonitis.) These epithelized cavities then closely resemble gross cystic bronchiectasis both in form and in clinical effect, the patient coughing up varying amounts of thick white non-putrid sputum, especially first thing in the morning. The only effective treatment is excision of the epithelized cavity, usually by segmental resection.

Abscesses Due to Vascular Embolus

Pulmonary embolus is a relatively common post-operative accident, but infection of the infarcted areas is exceedingly rare. On occasions, however, a peripheral consolidated patch of this kind may cavitate and give rise to fever and purulent expectoration. Resolution following suitable antibiotic therapy and postural drainage is the rule.

Lung abscesses accompanying general pyaemia are scattered throughout both lungs as the septic emboli in the blood-stream are filtered off. When patent ductus arteriosus is complicated

by bacterial endocarditis similar infected fragments may be swept into the pulmonary circulation to cause embolic lung abscesses.

Specific Abscesses

Staphylococcal Abscess

Specific infection of the lung by *Staphylococcus aureus* occurs in several ways and frequently results in abscess formation. Staphylococcal pneumonia in infancy is perhaps the commonest of these. Patchy consolidation of a lobe or lung is rapidly followed by the appearance of very characteristic peripheral thin-walled abscess-sacs, containing principally air, but also a little staphylococcal pus. They may be single or multiple, but in either case rapidly alter in size, usually distending like soap bubbles and (because they are so peripheral) bursting into the pleural space, thus giving rise to a pure staphylococcal empyema. This event sometimes occurs so early that it obscures the pneumonia which has preceded it. The essential feature common to these cyst-like abscesses is that they are subjected to an internal positive pressure resulting from distortion or partial obstruction of the terminal bronchioles, permitting air to enter the distended alveoli during the inspiratory efforts of coughing or crying when the bronchiolar lumen dilates, but not to escape when they contract on expiration. Pressure within thus rapidly mounts, inflating a group of inflamed alveoli into a ballooning cyst which is likely soon to burst through the visceral pleura, transmitting to the pleural space not only contamination by staphylococci but often the same positive pressure mechanism, so that the lung becomes compressed and the mediastinum displaced to the opposite side as pressure mounts. This process is often more dangerous to life than is the infection which accompanies it, and calls for prompt relief. Occasionally a cyst-abscess fails to burst, so that instead of the more usual pyopneumothorax the pseudo-cyst itself distends to fill the hemithorax (Fig. 4).

The reason for these phenomena must clearly be that the staphylococci themselves are, during the initial infection,

FIG. 4.—Typical staphylococcal cyst-abscesses in an infant's right lung. The mediastinum is markedly displaced to the left, compressing the left lung.

filtered off very peripherally in the bronchial tree, so that it is in the alveoli and terminal bronchioles leading to them that inflammatory damage occurs. If the organisms reached the lung in the blood-stream one would expect the lesions to be diffuse and bilateral (as are pyaemic abscesses), but as this is not commonly the case an inhalatory origin seems more probable. Blood-stream invasion sometimes follows the pulmonary infection.

Staphylococcal pneumonia with similar abscess formation is less often seen in adults than in infants, but when it occurs the subject is usually elderly or debilitated. Rupture of the abscesses into the pleural space is much less common in adults, perhaps because the visceral pleura is tougher and adhesions more frequent. Apart from the characteristic radiological appearance of the abscess-cysts, diagnosis depends on the pure growth of *Staph. aureus* in the sputum.

In all cases treatment is directed first to mastering the infection with adequate dosage of penicillin or other appropriate antibiotics, and secondly to countering the mechanical disturbance to respiration caused by a distending cyst or pyopneumothorax. Surgery is almost never indicated, and the insertion of drainage tubes into infant chests is likely to cause more harm than good. The relief of pressure and consequent re-expansion of the compressed lung is usually achieved by needle aspiration, the removal of air being considerably more important than that of pus, which may in any case be extremely scanty. The opportunity should, however, always be taken of instilling a suitable antibiotic into the contaminated space. Often a single aspiration suffices, but should the lung not fully re-expand the process is repeated as is necessary. It is undesirable to needle a cyst in the lung itself, as pyopneumothorax is likely to ensue, but if one is distending to such a degree as to cause serious respiratory embarrassment this must be done.

In addition to the primary type of infection described above staphylococci supervene in lung disease as secondary invaders. When they do so they are frequently penicillin resistant. For example, the mixed oral organisms giving rise to an aspiration abscess may be largely cleared after penicillin therapy, so that a resistant staphylococcus becomes predominant in the sputum. The abscess cavity will then persist or extend into chronic suppurative pneumonitis unless the alteration of flora is recognized and a change made to such other antibiotics as erythromycin, novobiocin, or methicillin. Similarly staphylococci may infect congenital cysts or chronic lung cavities.

Staphylococcal pneumonia features as a secondary invasion of the lung in many influenza epidemics and may then assume a virulent and septicaemic form, the patient being cyanosed and producing profuse frothy sputum streaked with blood. A positive blood culture is often obtainable.

Friedländer's Bacillus

Lung infection with this organism is commonest in elderly debilitated subjects. It is characterized by abscess cavities, usually occupying the whole of one lobe, and accompanied by massive sloughing of the necrotic lung. Such sloughs may be seen floating in a pool of pus within the ragged cavity and by their presence impede drainage. Diagnosis depends on the growth of predominant *Klebsiella pneumoniae* from the sputum. In the later stage these organisms may be obscured by secondary invaders.

Prognosis is in general bad, but the infection may be mastered by large doses of streptomycin. If it is not, lobectomy is indicated where the general condition of the patient permits.

Actinomycosis

This condition is now rare. The fungus (*Actinomyces israeli*) reaches the lung by inhalation from the mouth, by the blood-stream, or by invasion from neighbouring structures. It

is characterized by its disregard for tissue barriers, extending across lung, pleura, fascial planes, and into the chest wall, giving rise to intercommunicating chronic abscesses and sinuses discharging pus containing typical "sulphur granules." The fungus itself is grown from the pus, from biopsy of sinus walls, or from the sputum. Involvement of the pleura and chest wall often gives rise to pain.

Treatment consists in massive dosage with penicillin, 6 mega units being given daily for six weeks. Thereafter the dose is halved for a further six weeks.

Tuberculosis

The differential diagnosis of chronic pulmonary cavitation always includes tuberculosis. In most cases, but not in all, acid-fast bacilli are present in the sputum, or can be cultured from it or from gastric washings. Radiologically other evidence of pulmonary tuberculosis, with or without calcification, is probable. One must nevertheless be alert to the possibility of a breaking-down carcinoma appearing in a tuberculous lobe and even on occasion being accompanied by positive sputum. Most tuberculous cavities close with adequate antituberculous drug therapy. If they do not they should be removed by segmental resection.

Amoebic Abscess

Amoebic dysentery is seldom complicated by lung abscess, but when this does occur the patient may expectorate pus resembling anchovy sauce. Ova or cysts confirm the diagnosis; but where doubt exists parenteral administration of emetine hydrochloride in doses of 60 mg. daily will produce resolution of the lung lesions if *Entamoeba histolytica* is responsible for them. Treatment is then continued for a fortnight.

Secondary Infection of Congenital or Acquired Lung Cysts

If infection proves refractory, and cavitation persists in a lung after appropriate treatment, the possibility of a secondarily infected lung cyst must be considered. Such cysts may be congenital or acquired. Examples of the former are bronchogenic and dermoid cysts, or sequestered pulmonary segments.

If a bronchogenic cyst communicates with a proximal bronchus secondary infection is probable and the patient will produce purulent sputum from it until it is excised. Radiologically the wall of such cysts is delicate, spherical, and constant, and a fluid-level of pus is visible within it. If the cyst is distal in the bronchial tree infection is much less likely.

Dermoids lie outside the lung in the anterior mediastinum but may establish fistulous communication with the bronchial tree after infection has occurred within them. Their contents, including hairs, are then expectorated ("trichoptysis").

A sequestered segment, divorced from the normal pulmonary blood supply and bronchial tree, may lie postero-inferiorly in a child's chest and become secondarily infected, so that the pus ruptures into the base of the normal lower lobe and is persistently expectorated. The condition is mistaken for chronic lung abscess or basal empyema but drainage does not lead to resolution. Bronchography shows the area to lie wholly outside the normal bronchial tree, and the treatment indicated is excision of the segment.

Acquired lung cysts seldom cause diagnostic difficulty. Bullae and emphysematous blebs arise too peripherally in the bronchial tree for them often to become secondarily infected even when they are very large. Rare instances occur. Infection within a hydatid cyst, however, is the rule if it ruptures into the bronchial tree. Diagnosis depends on the discovery of scolices or daughter cysts in the sputum and treatment lies in enucleation of the cyst.