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THE SEMON LECTURE, 1954

BRONCHOLOGICAL PNEUMONOLOGY

By Professor EELCO HUIZINGA (Groningen)

THE invitation to give this Semon Lecture is a very great honour to me. Sir Felix Semon: this name still stimulates our imagination. He is familiar to me through his scientific work, his remarkable autobiography and through the stories told by the Nestor of Dutch laryngologists, Prof. Burger, the Semon lecturer of 1933, who was a close personal friend of his.

In his Semon lecture of 1948, Ewart Martin[1] spoke of the "decline of a science", referring to endoscopy of the upper alimentary and respiratory tracts, which is no longer considered an entity in many clinics. In the Netherlands, however, many laryngologists still adhere to it. At present it is called broncho-œsophagology: we will confine ourselves to bronchology.

Bronchology stands for much more than the technique of bronchoscopy. Bronchography[2] has developed into a second important method of examination. The bronchologist must be fully familiar with bronchial abnormalities, the knowledge of which has increased enormously during recent years. The spectacular development of bronchology has only resulted from pulmonary surgery. Many laryngologists had long emphasized the importance of bronchoscopy in pulmonary affections, but success was not obtained until it proved possible to carry out pulmonary resections without too great a risk.

What exactly is the place of bronchology? Fig. 1 gives a schematic representation of this. On the one hand it is closely connected with

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pneumonology; on the other hand laryngology, bronchology and œsophagology have already been intimately associated for a long time. There are œsophageal patients with symptoms suggesting an affection of the respiratory tract, and the reverse is also the case. The very close relationship between the nose and the bronchi is indicated by the word allergy.

The medical area represented by Fig. 1 covers the human body from

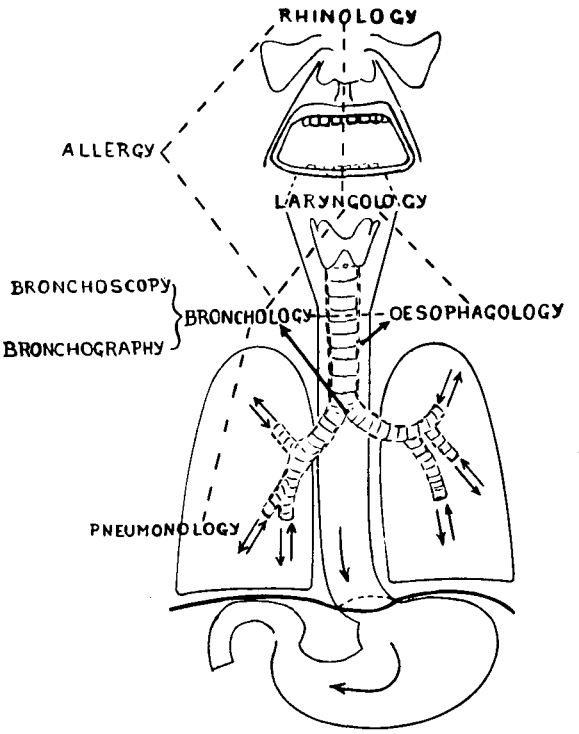


FIG. 1.

the nose to the cardia and lungs. A bronchologist must certainly be familiar with certain aspects of pneumonology. There is a marked contrast between the alimentary and the respiratory tracts. Gastric symptoms do not arise in case of an œsophageal abnormality such as a stenosis, but a bronchial affection very often gives rise to pulmonary changes. A disturbance of the normal supply of air along the respiratory tract soon causes pulmonary affections. It is an important factor that the respiratory tract serves both as a route of supply and of removal for the lung, as indicated by the arrows in Fig. 1. When this route is disturbed, widely varying pulmonary affections may arise ; in practice, these are usually the consequences of broncho-stenosis.

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Bronchological Pneumonology

The great importance of *broncho-stenosis* in pulmonary pathology is now common knowledge. This is especially due to the work of Chevalier Jackson[3] and Soulas[4], who made us familiar with the "syndrome bronchique" many years ago, largely in connection with the treatment of foreign bodies for which rapid diagnosis and localization are necessary. The presence of a foreign body is often demonstrated by certain pulmonary affections resulting from broncho-stenosis.

We may even speak of a *bronchological pneumonology*. Much attention has been paid to this in Groningen, thanks to the co-operation of the roentogenologist Keyser and the physiologist Dirken.

The study of the sequelae of bronchial foreign bodies has greatly contributed to our knowledge of pulmonary pathology. It is well to recall this at a time when the number of bronchoscopies for a foreign body constitutes only a very small percentage of the total number of bronchoscopies. The following table gives some figures from the Groningen laryngological clinic. They demonstrate clearly the development of a thoracic centre. Before the war the number of bronchoscopies in a year was ±50, often half of it were for foreign bodies. Now of more than 600 bronchoscopies only ±2 per cent. are for foreign bodies.

Year	Number of foreign bodies	Number of bronchoscopies
1935	29	53
1938	16	48
1941	5	26
1944	8	154
1947	8	309
1950	14	629
1953	11	626

The symptoms of *broncho-stenosis* are, according to practically all the textbooks: coughing, expectoration, stridor and dyspnœa. It is evident that the two symptoms mentioned first are not characteristic of stenosis; they occur in a great number of bronchial affections. Soulas, in his "syndrome bronchique", made a clear distinction between the "pathologie canaliculaire" and the "pathologie pariétale". Coughing and expectoration occur in many parietal affections, but stridor is a characteristic feature of an abnormality of the canal.

Dyspnœa is also a very frequent symptom in stenosis. It must also be classified under the "pathologie canaliculaire". The dyspnœa can easily be explained when it occurs in connection with severe stenosis of the trachea or of the two main bronchi. Anoxæmia may be the cause, or the patient must use his respiratory musculature more intensely in order to obtain sufficient pulmonary ventilation. This causes a feeling of dyspnœa. On the other hand, in stenosis of only one bronchus it is difficult to find an explanation for dyspnœa in the anamnesis. A typical example is the following patient.[5]

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A 33-year-old woman was admitted with very severe dyspnœa. She had had a right hilar tuberculosis at the age of 12. Complete obstruction of the right upper lobe bronchus had led to atelectasis of the right upper lobe. There was a marked stenosis of the main bronchus, as is clearly visible on the lipiodol photo shown in Fig. 2. The lower and middle lobes were normal. Bronchoscopy revealed a stenosis of 1·5 mm. This was dilated regularly. The dyspnœa always disappeared suddenly after treatment. After a year she developed an empyema, which healed after drainage. Fig. 3 shows that the bronchus has become considerably wider

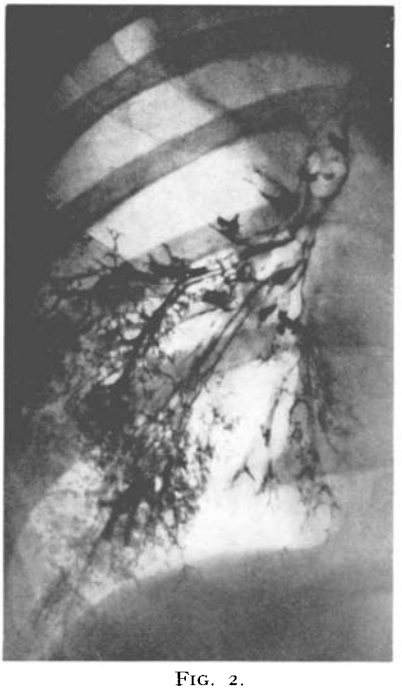


FIG. 2.

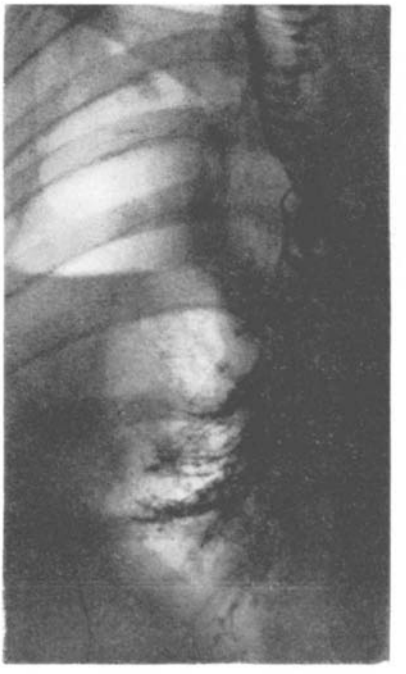


FIG. 3.

following the dilatations. There was still fluid in the pleura, and later a marked shrivelling occurred. The right lung was seemingly in a very unfavourable condition, but she has now remained free from dyspnœa for many years.

Some more of these patients have also been examined carefully. Why were they so dyspnœic? Determination of the blood oxygen always yielded completely normal values (Brinkman). Respiration showed nothing particular—apart from a stenotic sound—and was certainly not abnormally deep. The patients would not have been dyspnœic if there was complete obstruction of the bronchus. Dyspnœa does not occur after a pneumonectomy. The characteristic feature of these cases was that *normal pulmonary tissue was present distal to a marked stenosis.*

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This may afford an explanation for the dyspnœa, for it may easily cause a disturbance of the stretch reflexes of Breuer and Hering.[6] Every inspiration, every expansion of the lung gives rise reflexly to the following expiration, and this again to the next inspiration. In such a marked stenosis a disharmony between the reflexes may readily arise, due to the stretching conditions of the lung distal to the stenosis and the free parts of the lung. It seems possible that such a mechanism causes the dyspnœa, of which, for example, many patients complain in the early stage of bronchial carcinoma.

The two arrows on Fig. 1 in the bronchi are very important, for in the bronchial stenosis the influence on inspiration and expiration may be very different. This is clearly manifest in the *X-ray examination*, which is so important in bronchial stenosis. Two groups can be distinguished broadly and are generally known : those with too much or too little air distal to the stenosis. The first group shows the condition more clearly during expiration, the second one during inspiration. The contrast in air content with the healthy parts of the lung then becomes greater and there is displacement of the mediastinum. This explains the great importance of fluoroscopy and of X-ray photos in inspiration and expiration. The first group A is known as obstructive emphysema, in the second group B often atelectasis arises. This obstructive emphysema at present so important for the diagnosis of broncho-stenosis in general, was first described in the aspiration of vegetable foreign bodies in children by Iglauer[7] and later by Jackson, Spencer and Manges[8] and by van Gilse.[9]

It is less known that two more groups can be discussed as regards the quantity of air, viz. C, a group which we have called the mixed form. The characteristic feature of this form is that at the inspiration there is less air than normally at the affected side and at the expiration more air than normally.

Finally it is interesting to know that there is a fourth group D, where the X-ray examination is completely negative, but where a considerable broncho-stenosis may be present.

These four groups are to be found with all possible forms of broncho-stenosis. We shall confine ourselves to the cases of vegetable foreign bodies, by which our knowledge of the symptomatology of the broncho-stenosis has been specially increased.

Vegetable foreign bodies are frequently aspirated by children. The dimensions of these are such that symptoms of broncho-stenosis are usually observed even in the absence of mucosal swelling, in contrast with, for example, small bones in the bronchi of adults. Before the war aspiration of peanuts occurred very frequently in the Netherlands. The following table gives a survey of the X-ray findings in a continuous series of young children treated in the Groningen clinic for a vegetable bronchial foreign body.

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BRONCHIAL VEGETABLE FOREIGN BODIES IN 186 YOUNG CHILDREN (UNDER 5 YEARS). X-RAY FINDINGS

Obstruction emphysema	99
Obstruction inspiration (*Holzknecht*, atelectasis)	45
Pneumonia, abscess	19
Mixed forms	10
Negative	13

In nearly all cases the foreign body, although itself not visible on the photo, could be localized by the X-ray examination. In the great majority of cases it had caused an obstructive emphysema.

A. TOO MUCH AIR DISTAL TO THE STENOSIS

The mechanism is simple: the bronchi dilate during inspiration and constrict during expiration. In every intrathoracic stenosis of the respiratory tract expiration is impeded earlier than inspiration. The

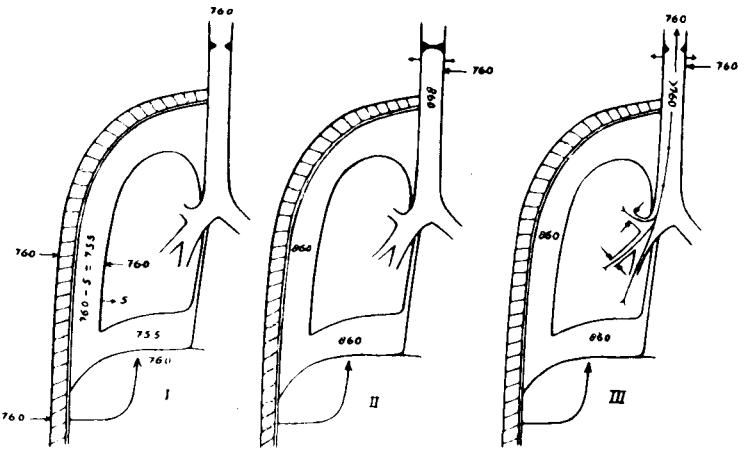


FIG. 4*a*.

contrast-oil method has made it possible to photograph the bronchi both during inspiration and expiration. We[10] were also much surprised by the marked changes of lumen which are possible. The increase of the lumen during inspiration is primarily based on a passive stretching due to enlargement of the whole lung. The volume of the lung may change from 1 to 4 during maximal respiration. The expansion of the lung during inspiration causes a radial traction on all bronchi. The respiratory differences of pressure are also of importance, especially in deep breathing or coughing. One sometimes comes across peculiar ideas in the literature on this subject, for example, that coughing leads to increased pressure in the bronchi, giving rise to bronchiectasis. This was also the opinion of no less an authority than Laennec, the first man to describe bronchiectasis. On Fig. 4a gives I a schematic representation of the condition at rest, the pleural scissura being drawn here as a space. In the lung there is

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everywhere atmospheric pressure; outside it is the negative pleural pressure, estimated here at 5 mm. Hg. The width of the bronchi is completely dependent on the filling condition of the lung in this static condition. A strong pressure is exerted on II when the glottis is closed. The pressure in the pleural space then becomes markedly positive, amounting to 100 mm. Hg at most. In this static condition nothing will happen except that the whole lung becomes somewhat reduced in size, in all its parts.

III shows the consequences of sudden opening of the glottis in this case. In bronchi and trachea the pressure falls from 860 mm. Hg, until

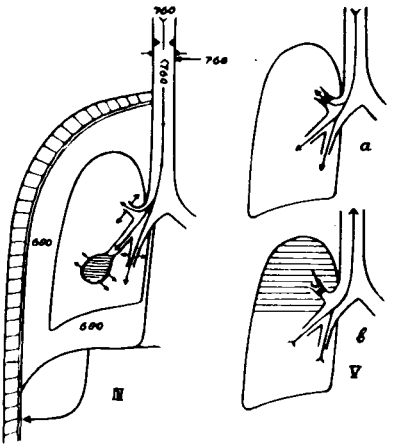


FIG. 4*b*.

atmospheric pressure is reached. Now the pressure *around* the bronchus is higher than that *in* it; the bronchi therefore become narrowed. This is confirmed by an old experience of bronchoscopists, that during coughing the bronchi may collapse almost completely, especially in children.

The pressure relationships of III are more or less true for every expiration. The pressure outside the bronchus is always higher than that in it. II and III together give an impression of what happens in every single cough: first the air is compressed with the glottis closed; this is then suddenly opened, resulting in a forcible outflow of air. The Jacksons[11] especially have taught us that the bechic blast with the tussive squeeze and the ciliary drainage constitute the natural peroral drainage. The two first factors can be demonstrated very clearly by bronchography, which has also brought an end to the belief in bronchial peristalsis.

IV on Fig. 4b shows what happens in a maximal inspiration. A negative pressure of 80 mm. Hg is possible. The bronchi show the reverse change of pressure compared with expiration; the pressure changes towards the periphery from atmospheric pressure to the pleural pressure

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of minimally about 680 mm. Hg. It is important that the pressure round the bronchus is always lower than that in it. This causes a radial traction on the walls, as shown by the arrows. This radial traction will undoubtedly contribute to the development of bronchiectasis in an inferior bronchial wall, as indicated schematically in IV for the middle lobe.

The narrowing of the bronchi during expiration, caused by these two factors, makes it quite understandable that a condition arises as shown in V: a broncho-stenosis of the right upper lobe. The air may enter during inspiration, but cannot escape during expiration: "the air is trapped."

B. Insufficient air distal to the stenosis

The second group, with too little air distal to the broncho-stenosis, has already been recognized for a long time. If the air in the lung is not replenished continuously, *resorption atelectasis* arises. This has already been demonstrated by the experiments of Traube[12] and Lichtheim.[13] The literature shows how difficult it often is to understand how the air, which consists largely of nitrogen, can disappear so rapidly. It is overlooked that the diffusion of every gas proceeds according to its own partial pressure, completely independent of the presence of other gases. If oxygen is absorbed, which is of course quite easy in the lung, there is no fall of pressure but the space is reduced (less expansion of the lung or transudation). The pressure of the nitrogen becomes higher than in the blood, where it always corresponds with the inspired air. The blood therefore also absorbs nitrogen. In this way all air behind the occlusion disappears. In this respect we mention the very interesting investigation of Hilding[14] into the disappearance of air in a closed space.

The otorhinolaryngologist has, properly speaking, never had any difficulty in understanding how this resorption atelectasis may arise so quickly, because he observes the development of it some hours following the aspiration of a foreign body. He is familiar with completely analogous conditions in the middle ear on occlusion of the Eustachian tube, and in the frontal sinus on occlusion of the nasofrontal duct. The comparison may even be stretched further. In all these cases of resorption of air, an inflammation arises quite readily behind the stenosis. This is a combination of "pathologie canaliculaire" and "pariétale".

Another important factor is that the resorbed air can to a greater or lesser extent be replaced by a transudate. This was also observed in experiments on animals, a.o. by Coryllos and Birnbaum[15] and Herrmann and Schopper.[16] This transudate changes into exudate, should infection arise. The absence of drainage may cause an accumulation of pus from the bronchitis behind the stenosis. This is Jackson's "drowned lung".

On X-ray examination a metal foreign body was found in the left main bronchus of a 5-year-old girl, who had already been under treatment

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for pneumonia for three weeks (Fig. 5). The whole left lung was markedly shadowed, but this was no nice regular shadow, such as is typical of *atelectasis (the so-called ground glass shadow of van Allen). In this case* the shadow showed a patchy picture. The left lung had not become smaller; the heart was in its normal place. This is a characteristic example of "drowned lung". Bronchoscopy had been carried out in another hospital, where the foreign body was seen, but attempts at its removal failed. Great quantities of pus were expectorated. Fig. 6 is the photo made on admission to our clinic. The left main bronchus is clearly visible.

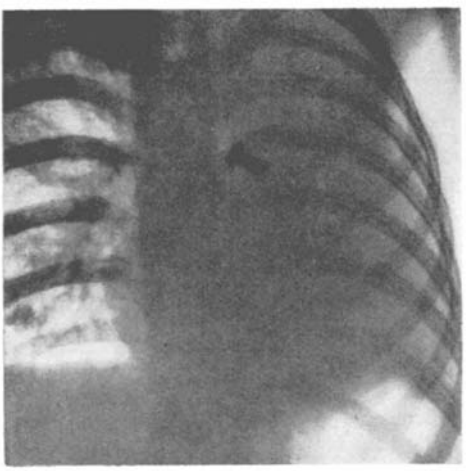


FIG. 5.

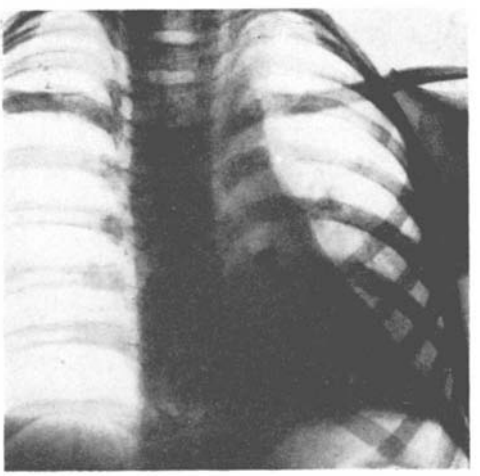


FIG. 6.

The foreign body was now in the lower lobe bronchus. The upper lobe bronchus was free and this lobe filled with air again. Notwithstanding this reventilation, there was a marked displacement of the mediastinum to the left, with on the right—quite typically—a "bare spine". The reason is that the secretions had been expectorated. There was now a pure atelectasis of the left lower lobe, which has caused a considerable reduction of the volume. The foreign body, a rivet for leather belts, was removed through the bronchoscope.

There is a gradual change from pure atelectasis (Fig. 6) to drowned lung (Fig. 5). Atelectasis means literally: incomplete expansion, but it has more and more developed into a clinical idea in which the disappearance of the air is thought of primarily. It is sometimes called collapse, but it has already been emphasized earlier[17] that it is better to use this term only in a condition in which the lung has been emptied passively by an intrathoracic space-reducing process. This is usually indicated as compression atelectasis. It is incorrect to use the word atelectasis both in connection with resorption and compression. The term atelectasis

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should be reserved for resorption. The two conditions show such great differences that using the same word for them causes confusion. There are marked differences in (1) ætiology; (2) clinical signs; and (3) microscopy.

(1) *Ætiology*. If the causes of disappearance of air from the lungs are considered, the following four possibilities are found:

(*a*) the air behind the obstruction is absorbed;
(*b*) the air is forced out of the lung by an expansive process;
(*c*) the air is replaced by a transudate, exudate or secretion;
(*d*) in cases of blocking, the air is replaced as a result of ciliary activity in the bronchi (Hilding).

(2) *Clinical signs*. Whereas process (*b*) is usually more or less harmless, so that after many years complete recovery of the lung is possible (at least anatomically), process (*a*) is nearly always attended by infection; this may involve dangerous complications and even more frequently irreversible changes with bronchiectasis of the lung.

(3) *Microscopy*. Apart from the infection, there are still other anatomical differences between (*a*) and (*b*). The compressed lung in (*b*) is ischæmic, the lung in *a* is hyperæmic. This is so because venous blood flows in as soon as absorption of air commences. The transudate into the alveoli which replaces the absorbed air partially or sometimes even completely is probably a result of capillary dilatation.

It is important for the bronchologist to know that bronchography in a case of collapse often yields a picture strongly reminiscent of bronchiectasis. The periphery of the lung shows a compressed area of pulmonary alveoli, bronchioli and small bronchi. Only the compact mass of large bronchi are filled, and these naked filled bronchi easily give the impression of bronchiectasis. In resorption atelectasis we are probably also dealing with a dense area of alveoli, bronchioli and small bronchi.

C. Mixed forms

An interesting third group is formed by the cases mentioned as *mixed forms* in the above statistics on vegetable foreign bodies. This group comprises those cases in which both symptoms of impeded expiration and inspiration are observed. They are very probably transitional forms: mucosal swelling makes the stenosis worse; this impedes the inspiration visibly, and atelectasis arises.

The following case is a characteristic example of the mixed form.

Four days previous to admission a 3-year-old girl had aspirated a coffee-bean; she coughed and had a temperature up to 39° C. Fig. 7 is the chest photo on inspiration, Fig. 8 that on expiration. The right side showed a marked shadow, probably caused by atelectasis. On inspiration, the mediastinum was displaced to the right (symptom of Holzknecht). On expiration, the mediastinum moved to the left passing the median line; on the right there was obstructive emphysema, especially

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of the lower lobe. The coffee-bean was removed from the right main bronchus by means of bronchoscopy; there were many signs of inflamma-

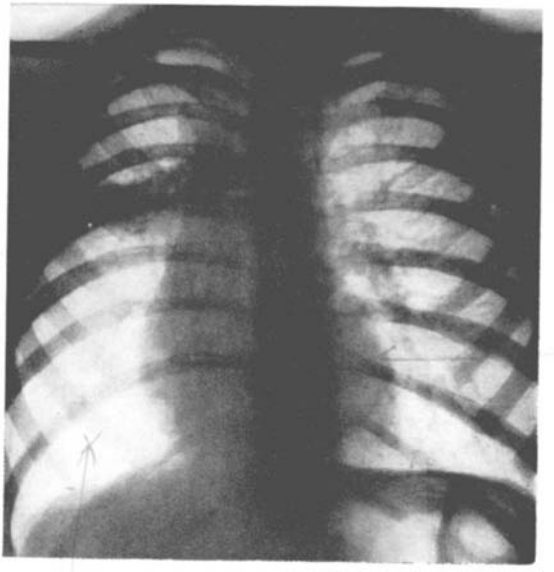


FIG. 7.
Inspiration.

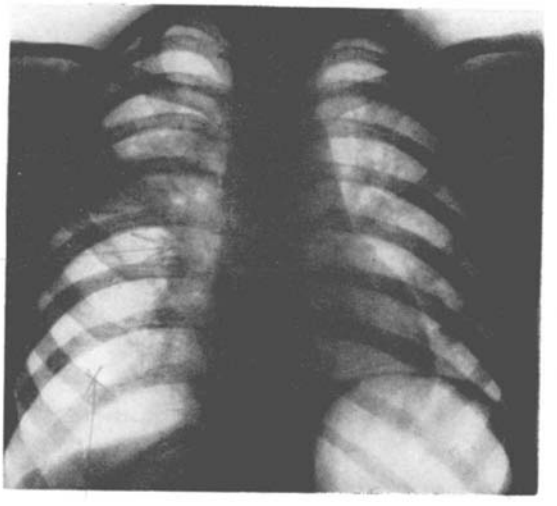


FIG. 8.
Expiration.

tion. The temperature became normal at once and the radiological abnormalities disappeared.

If this patient had been seen by us some days later, the whole right

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lung would probably have become atelectatic. Such a change has also been observed by other authors (e.g. Jackson and Soulas, and also in Groningen). The earlier these cases of foreign bodies are referred to the laryngological clinic, the greater will be the number with obstructive emphysema in the statistics and the smaller the number with atelectasis. In this way it is quite well possible to determine a proportional number, indicating the bronchological education of the general practitioners in the various countries.

This obstructive emphysema may easily be taken for compensatory emphysema when the lobe is markedly reduced by atelectasis. Important factors are here also fluoroscopy and photos on inspiration and expiration. The marked displacement of the mediastinum to the left in Fig. 8 constitutes proof of an obstructive emphysema.

D. X-ray examination was *negative* only 13 times in the above statistics. The cause may have been: (1) The foreign body was small and there was no mucosal swelling, so that no symptoms of broncho-stenosis arose. The lumen of a main bronchus must be reduced to one-third before symptoms occur. (2) It is possible that occasionally the foreign body was in the trachea during the X-ray examination. (3) In a few cases in which the foreign body was situated deep in the lower lobe, it is certain that there were no symptoms owing to the action of a collateral ventilation. The existence of a *collateral ventilation* was demonstrated by van Allen[18] *et al.* in dogs. My collaborator Baarsma and Dirken[19] confirmed van Allen's findings in rabbits. It was proved, with the collaboration of Baarsma and Dirken[20], that collateral ventilation also exists in man. This ventilation is effected through the stomata of Kohn and is only possible between parts of the lung connected by pulmonary parenchyma. Baarsma and Dirken have proved that the collateral ventilation may replace the normal one up to 66 per cent. It is of importance to know that a bronchus may be occluded completely, but that the pulmonary tissue concerned can still be ventilated satisfactorily through these stomata, so that symptoms of broncho-stenosis are completely absent.

It was again a foreign body that directed our attention to the collateral ventilation: a small metal bulb hermetically obstructed the lower lobe in a 2-year-old boy. Collateral ventilation was however possible through the apical bronchus of the lower lobe. Our attention once directed to it, various cases of foreign body with collateral ventilation were observed. It was also seen in some cases in which the bronchus was occluded by a tumour.[21]

If respiration becomes shallow and the stomata are blocked by inflammation, collateral ventilation is impossible and atelectasis develops.

The following law can be recognized in bronchology: atelectasis arises

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only if collateral ventilation is impossible. This is always so in occlusion of a main bronchus or lobular bronchus, with exceptions in the latter case if there is a bridge of pulmonary tissue to another lobe. Anatomical variations, also of the pulmonary segments (continuous fissures), are of high importance in pulmonary pathology.

Churchill[22] drew attention to the *presence of collateral ventilation in certain cases of bronchiectasis*. This has also been observed in the Groningen clinic. Sometimes ampulla-like dilated bronchi are found, ending blindly, not only by bronchography but also on inspection of the operation specimen. These bronchi are, however, often surrounded by pulmonary tissue containing air, sometimes even emphysematous tissue. How does the air get into this tissue? This cannot be explained except by collateral ventilation *via* a healthy side branch of the same lobe, as is indicated by *A* of the schematic representation of Fig. 9. This is often the apical one of the lower lobe.

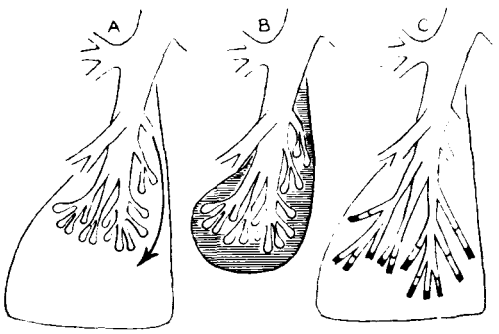


FIG. 9.

The presence of a collateral ventilation in bronchiectasis explains why some cases with marked bronchial abnormalities do not show anything special on the X-ray photo. The presence or absence of a collateral ventilation may be the cause of striking differences, as clearly demonstrated by Figs. 10-12. These pictures are of two children with bronchiectasis of the left lower lobe, operated on by Professor Eerland. The two cases have the same past history: both had repeatedly had a left pneumonia; and bronchoscopy had yielded much pus from the left lower lobe.

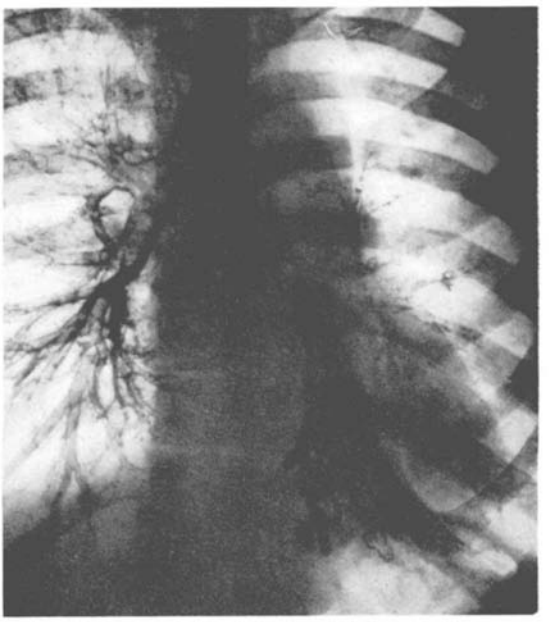
Fig. 10 represents the dorsoventral bronchogram of a 7-year-old girl. It shows manifest bronchiectasis with large ampullae low in the left lower lobe. The ordinary photos did not show any changes at all; there is no displacement of the mediastinum.

Fig. 11 is the dorsoventral bronchogram of an 11-year-old girl. There is a marked displacement of the mediastinum to the left. A remarkable

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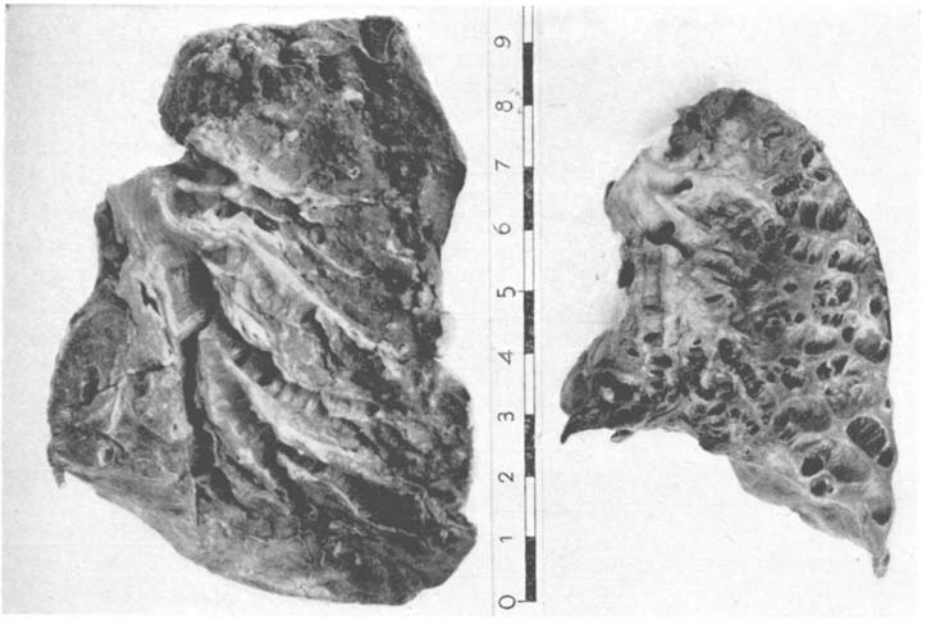
FIG. 10.



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feature of this bronchogram is the triangular shadow in the heart shadow, which is typical of a reduction of the volume of the left lower lobe; this shows an ampullary bronchiectasis.

Fig. 12 is an illustration of the operation specimens of these two lower lobes, preserved in their natural size. The left lower lobe of the 7-year-old girl (*a*) was much larger than that of the 11-year-old one (*b*). In the first case (*a*) the markedly ampullary dilated basal bronchi, which ended blindly, were surrounded by pulmonary tissue containing air. A



a. FIG. 12. *b*.

collateral ventilation was possible through the apical segment, as indicated schematically in Fig. 9A. The second case (*b*) showed a maximal shrinkage of the whole lower lobe, the cause of the well-known triangular shadow on the photo. The condition of (*b*) is schematically indicated in Fig. 9B. There is an ampullary bronchiectasis of all branches. The bronchi are surrounded by a layer of very fibrous connective tissue; pulmonary tissue is nowhere to be seen any longer.

Bronchography has afforded a much better understanding of the *localization* and also of the mechanics of *development of bronchiectasis*. The basal bronchi of the two lower lobes constitute a site of predilection, in all statistics *more on the left* than on the right, which is also our experience. This has sometimes been regarded as a congenital abnormality (Sauerbruch).[23] Congenital bronchiectasis occurs, but is very rare. At

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present practically all authors assume that most cases of bronchiectasis are acquired. We have shared this standpoint for many years.[24]

The acquired forms of bronchiectasis may be divided into two groups, the first with a *general cause* and the second with a *local cause* as the factor of primary importance. The first group shows a predisposition to it, due to degeneration of the mucous membrane of the whole respiratory tract. This bronchiectasis is often bilateral; frequently the disease involves segmental branches of different lobes. Orie[25] and his collaborators, from the Groningen clinics, also demonstrated that many cases of bronchiectasis show a relationship with allergy.

What idea should we form of the relationship between allergy and bronchiectasis? In allergy we find abnormally reacting mucous membranes, often mucosal swellings, impeding drainage of certain parts of the lung. The same holds true for the accessory nasal sinuses; this is the reason why the combination of bronchiectasis and sinusitis is so often observed. My collaborator, Warringa,[26] found more than 48 per cent. of cases of purulent sinusitis among our series of ordinary bronchiectasis cases, and in addition a number with serous sinusitis and nasal polyposis.

The relationship is not that the bronchiectasis develops from the sinusitis by aspiration, as has sometimes been contended, because in this case the bronchiectasis would actually be localized more on the right. Perhaps the following explanation is the right one: due to the anatomical factors in the bronchial tree, aspiration on the right side is easier than on the left. The same factors lead more readily to retention of secretion and bronchial occlusion on the left side.

Many years ago Aeby,[27] Braune and Stahel[28] found that the diameters of the main bronchi show the same ratio as the volumes of the lungs supplied by these bronchi. The ratio right main bronchus to left main bronchus is 100 to 70-80. This was confirmed by study of bronchograms[29] in Groningen.

In contrast to the ratio of 100 to 80 in adults, this figure is lower in children; in children up to 3 years it is even 100 to <70. The probable explanation is that the heart is relatively larger in small children than in adults, less space being available for the left lung. But because of this is the anatomy on the left side even more complicated than with adults. The main bronchus and the lower lobe bronchus have to curve more widely round the heart and are relatively narrower. The risk of retention of secretions on the left side is in young children greater than in adults. It is common knowledge that the symptoms of bronchiectasis often arises subsequently to the acute infectious diseases of childhood. This bronchiectasis is strikingly often localized in the left lower lung.

This obstruction of a large bronchus is of primary significance in the second group. This type of bronchiectasis is usually unilateral, due to special local conditions. Bronchology has revealed the great importance

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of broncho-stenosis in this respect. Bronchiectasis has already been long observed in cases of foreign body. Bronchiectasis also develops regularly in obstruction by a tumour. At present we know that many cases of bronchiectasis are due to early broncho-stenosis caused by tuberculous hilar glands. This type of bronchiectasis is, in contrast to that caused by foreign bodies, localized rather in the upper and middle lobes, usually ventrally.

The relationship between broncho-stenosis and bronchiectasis is easy to understand. Broncho-stenosis practically always leads to inflammation,

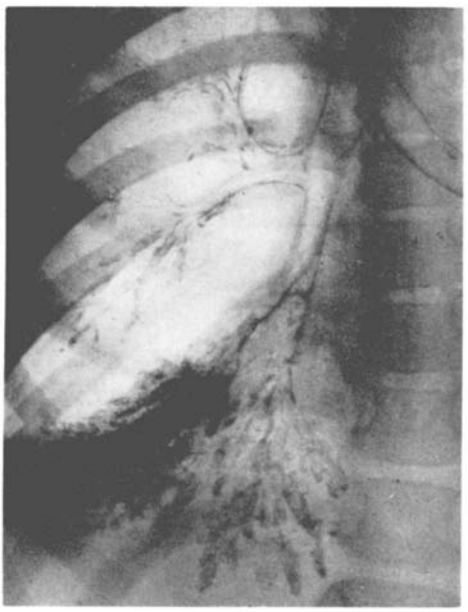


FIG. 13.

the bronchial wall distal to the stenosis becomes weakened, cartilage, elastic tissue and muscles may disappear completely. It may be that the retention of pus gives rise to bronchial dilatation by pressure from the inside (Laennec[30]). Broncho-stenosis causes atelectasis, leading to a markedly increased negative pleural pressure, and a radial traction is exerted on the bronchial walls (Jacobaeus and Westermark[31]). If the atelectasis is not cured, induration follows; shrinkage of the connective tissue also causes a radial traction on the bronchial walls. All kinds of factors evidently co-operate in the pathogenesis of bronchiectasis. The bronchologist sees so many patients with atelectasis and bronchiectasis caused by stenosis, that he is inclined to assume the same mechanism, also in cases of obscure ætiology. This is mainly due to obstruction by viscid secretion or mucosal swelling.

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Five weeks previous to admission a 10-year-old boy had aspirated a tooth. The X-ray picture showed the well-known triangle of atelectasis in the right lower lung; a shadow of a foreign body was visible in the main bronchus. The tooth was removed by bronchoscopy. Fig. 13 is the lipiodol photo, made after 11 days. The triangle was still visible; this was formed by the atelectatic lower and middle lobe. Ampullary bronchiectasis had already developed in the lower lobe. The triangle had disappeared on the photo made after three months. The right middle lobe had expanded satisfactorily again; but the bronchiectasis in the reduced lower lobe persisted.

This is a clear case. The occlusion by the foreign body is primary;



FIG. 14.

this gives rise to atelectasis and this again to bronchiectasis. The following case is one of obscure ætiology.

Some months prior to admission a 9-year-old girl fell ill, with coughing and fever. The areas over the right lung showed auscultatory dullness; the respiratory souffle was weakened. Much sputum was expectorated in a bout of coughing. A chest photo showed the atelectatic triangle in the right lower lung. Bronchoscopy showed much secretion but no foreign body. The triangle was still clearly visible on the lipiodol photo, made two days later (Fig. 14). This triangle comprised again the lower and middle lobes. Ampullary atelectasis was observed in the lower lobe. A bronchogram made after 18 months (Fig. 15) showed that the middle lobe had expanded again; the bronchiectasis in the reduced lower lobe persisted.

The resemblance between these two cases is so striking that the supposition seems warranted that in the second case, mucosal swelling or secretions had caused an obstruction at the same site as the tooth

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had done in the first case. There is also always the possibility that there was an obstruction rather towards the periphery of all smaller bronchi.

In both cases the atelectasis of the middle lobe disappeared while that of the lower lobe persisted; bronchiectasis developed in the latter lobe. We already have pointed out the preference of bronchiectasis for the lower lobe, where the anatomical factors are more unfavourable for drainage.

Bronchostenosis, which is certainly of the utmost importance in the second group, is possibly also of significance in the first group, by occlusion through secretion or mucosal swelling. For even if a certain predisposition due to degeneration of the bronchial mucous membrane is accepted, the



FIG. 15.

bronchiectasis must always be explained by mechanical causes. The bronchial wall, which has become weakened by inflammation, is displaced in an outward direction mostly by traction from the outside, probably sometimes also by pressure from the inside. In many cases, especially of cylindrical bronchiectasis, the dilated bronchi are surrounded by normal lung tissue. Warringa found it in ± 100 of the ± 200 cases operated in Groningen. We should, of course, guard against exaggeration. We can hardly accept that in all these lungs without any induration the origin of the ectasis is a stenosis of a large bronchus. We have seen previously that even during normal respiration traction is exerted on the bronchial wall. In some cases the photos of inspiration and expiration gave the impression that a very lax wall markedly gave way under this traction.

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The bronchograms of Figs. 13 and 14 show a remarkable picture of the middle lobe. This is atelectasis, with a marked acinous structure, however. The atelectatic parts soon expanded again; the atelectasis was probably no longer complete in this case. If the atelectasis is complete, bronchography does not show an acinous structure.

Should resorption atelectasis have arisen, this does not always disappear after abolition of the stenosis. The cause may be that the atelectasis is already of too long duration and that induration has formed. There are, however, also cases in which the atelectasis persists without this formation of connective tissue. What is the reason? A certain force is necessary for the re-expansion of the atelectatic area. This force antagonizes the retraction of the lung. There are three factors: the elasticity of the lung, the tonic function of the smooth muscles, and the superficial tension in the alveoli. Probably the last factor is the most important one.

If we are dealing with such a case clinically, an attempt should be made to assist nature to abolish the atelectasis as rapidly as possible. Important experiments in this field have been carried out on dogs by my collaborator Sinninghe Damsté in Groningen, under the direction of the physiologist Dirken.[32] The left lower lobe was made atelectatic. A large number of experiments led to determining which method of ventilation of the test animal gave the best re-expansion of the atelectatic lobe. Normal ventilation and carbon dioxide caused only a slight re-expansion. Hyperventilation with gas mixtures deficient in oxygen resulted in very good re-expansion of the lobe. The higher respiratory frequency in oxygen deficiency as compared with carbon dioxide hyperventilation, seems to be very important in regard to the re-expansion of the atelectatic lobe. This is due to the quicker respiratory movements. It is also of importance that with this respiration there is a marked alteration of the pleural pressure to the inspiration. The atelectatic lobe is drawn open, as it were, due to the marked increase of the negative pleural pressure.

The results of Sinninghe Damsté and Dirken's experiments were applied clinically. Hyperventilation was caused by giving the patient a gas mixture to breathe containing 5 per cent. oxygen and 5 per cent. carbon dioxide. The patient is able to keep this up for about 1½ minutes. Respiration becomes very rapid. This, as said before, is probably an important factor in recovery.

Atelectasis may still disappear spontaneously after a long period (as shown by the case of the Figs. 19 and 20), but our impression, gained over a period of several years, is that hyperventilation is of great therapeutic significance.

A 15-year-old boy, no less than two months previous to admission, had aspirated the tip of a ball-point pen (Fig. 16). The photo is deceptive; the foreign body was much larger in reality. The whole tip of the pen

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FIG. 16.



FIG. 17.
Lateral bronchogram.

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plus the attached plastic ink-tube was in the bronchus. The extraction was therefore very difficult.

The chest photos showed a marked shadowing in the right lower lung, which did not disappear after removal of the foreign body. Bronchography was carried out after nine days. The right lower lobe seems far too small on the lateral photo of Fig. 17; there is a dilatation of the basal branches. The child was subjected to hyperventilation with a gas mixture containing 5 per cent. oxygen and 5 per cent. carbon dioxide, on four

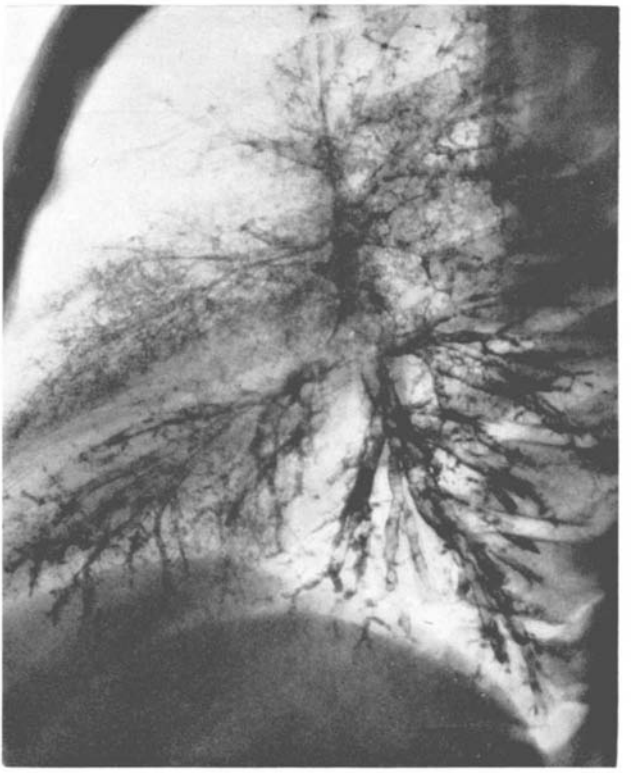


FIG. 18.
Lateral bronchogram.

successive days; duration of each session was 1-1½ minutes. Fig. 18 is the lateral bronchogram, which was made later; it shows a re-expansion of the lower lobe. The shadow in the stage of Fig. 16 was evidently still atelectasis; the bronchiectasis had markedly regressed, although these bronchi did not look quite normal yet.

In Groningen several cases have been observed, in which aspiration of a foreign body had led to bronchiectasis, which regressed completely after a few months. There is undeniably a reversible form of bronchi-

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ectasis. On the other hand, we have often observed a severe, permanent bronchiectasis caused by a foreign body, for which resection was necessary afterwards.



FIG. 19.

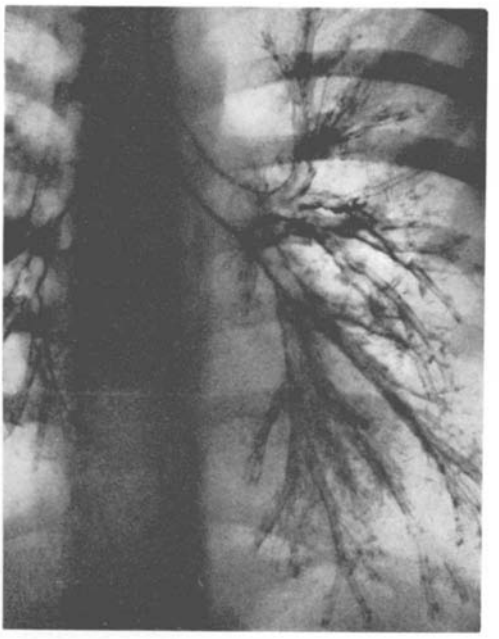


FIG. 20.

The following case is a typical example of a reversible bronchiectasis.

A 4-year-old boy was reported to have had pneumonia in the left lower lung more than three months previous to admission. The broncho-

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gram of Fig. 19 clearly shows the abnormalities. There was a marked displacement of the mediastinum to the left; on the right a "bare spine". The left lower lung showed a shadow with an ampullary bronchiectasis. The left lower lobe showed nothing of an acinous structure. The bronchial tree was completely normal on the right. We thought of a shrivelling process caused by an unresolved pneumonia. Lobectomy was considered. On bronchoscopy, the affected bronchus yielded very little pus. An expectant attitude was therefore adopted. Four years later we again had the opportunity of carrying out bronchography (Fig. 20). The shadow had disappeared completely; the heart was again in its normal position. Nothing was left of the ampullary bronchiectasis.

The shadow on Fig. 19 was therefore not caused by pulmonary induration with shrinkage, but there was still a reversible atelectasis.

The picture of a markedly shadowed, usually reduced pulmonary lobe with ampullary bronchiectasis such as in Fig. 19 and schematically indicated by *B* in Fig. 9, generally points to an irreversible indurative process, usually with shrivelling as was demonstrated by Fig. 11 and Fig. 12b. It is useful to know that in case of a still reversible atelectasis bronchography may yield quite the same picture as in the irreversible form. The bronchiectasis sometimes disappears together with the atelectasis, or a picture arises such as in Fig. 20 and schematically indicated by *C* in Fig. 9, the "branches cassées", pointing to secretion, and in which we never know with certainty how the condition is in the periphery.

The ætiology is obscure in the child of Figs. 19 and 20. The most probable explanation seems that the atelectasis has developed from an obstruction of the left lower lobe bronchus or of the peripheral bronchi, owing to an inflammation. It seems acceptable that many of the so-called pneumonias during the infectious diseases of childhood are nothing but atelectasis.

"Bronchological pneumonology", this is a new name for an at present generally known conception. The use of this new name has advantages, because it emphasizes the fact that pulmonary abnormalities are so often the result of a bronchial affection. This is nearly always a broncho-stenosis. The name indicates that bronchoscopy should always be considered in pulmonary affections. This is the end of every story on bronchology.

I suppose I ought to come back to Sir Felix Semon now. I have asked myself: "Would Semon have been satisfied with the choice of this subject?" He no doubt showed very little interest in bronchology, as this branch of our science was still in its infancy, even in the last years of his professional career. In those times life was not yet so hurried as nowadays. As early as 1897 Killian removed the first foreign body by means of the bronchoscope, but it was not until the first years of this century that the technique became common knowledge to laryngologists. The spectacular development of bronchology is even of later date. I am

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convinced that Semon would have shown a great interest in it, had he lived.

McBride[33] said in the first Semon lecture: "Those of you who have carefully studied Semon's writings will agree with me that most of them touched the borderland between general medicine and laryngology." I therefore do not doubt that he would have approved of my choice. The important science of bronchology has now also become borderland. The laryngologist must show continued interest in it and wage the peaceful battle which it is the fate of every medical man to do who loves his profession; and Semon himself was a great fighter !

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