Bronchiectasis

By

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With 58 Figures

A. Introduction, Definition and Historical Survey

1. Introduction

One of the most intricate fields of pulmonary pathology is that of the aetiology and pathogenesis of bronchiectasis. Much has remained unexplained, in spite of the extensive literature that has appeared since LAENNEC first described the affection in 1817. There are still many questions unanswered as regards the indications for operative treatment and the results obtained by surgery.

At present there is no longer any difficulty in the diagnosis of bronchiectasis, especially owing to the development of bronchography, eventhough it should be remarked that technically perfect bronchograms are required to arrive at a therapeutically justified plan of campaign.

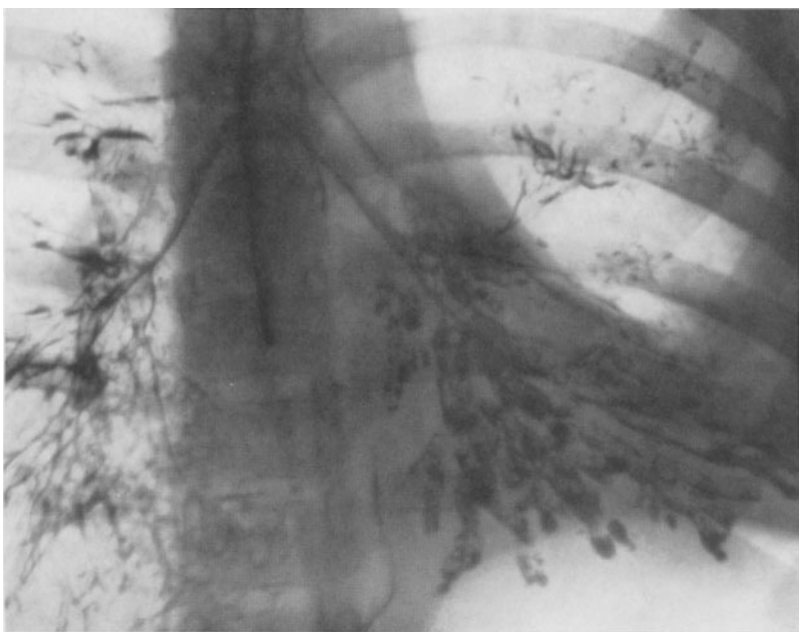

Fig. 1. Dorsoventral bronchogram of 4-year-old boy, who had a so-called left pneumonia four months previously. There is a considerable displacement of the mediastinum. The photo shows ampullary bronchiectasis in the markedly shrivelled left lower lobe. Bronchoscopy reveals very little pus. Treatment was conservative. This was a case of reversible bronchiectasis, as shown by Fig. 2

It must be admitted that the sulphonamides and modern antibiotics have been of inestimable value during the pre- and after-treatment of patients in whom resection of the diseased parts of the lung has been carried out. It is however doubtful whether parenteral or intratracheal administration of these agents alone yields lasting results. An operation is therefore often necessary, but, unfortunately, complete success is not always obtained with pulmonary resection, the only operation that comes into consideration.

E. Derra (ed.), *Handbuch der Thoraxchirurgie / Encyclopedia of Thoracic Surgery*

One of the most important causes of these failures is deficient knowledge of the aetiology and pathogenesis of bronchiectasis.

There are often several factors active in the development, which are not without significance as regards the treatment and the late results.

The localized forms, due to an established cause such as an aspirated foreign body, can usually be completely cured by means of radical resection.

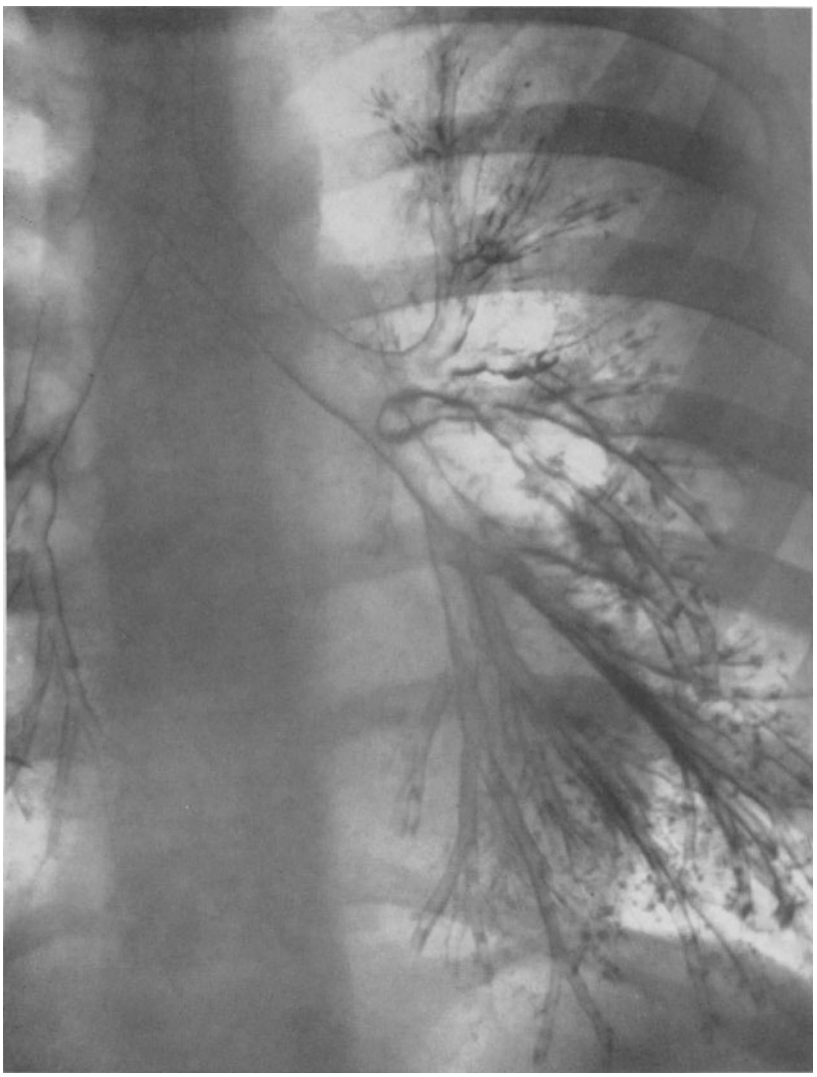

Fig. 2. Dorsoventral bronchogram of the same boy as in Fig. 1, four years later. No induration, no shrinkage of the left lower lobe. No bronchiectasis

Resection also leads to favourable results in cases of long-standing bronchiectasis in a shrivelles atelectatic lobe, as also in cases in which the whole lung is involved. The results are less positive in the bilateral and more diffusely spread forms, of which the cause is not yet known. In many cases the contralateral lesions prove to be asymptomatic after removal of the main focus.

2. Definition

Bronchiectasis can be defined as an affection of the bronchial tree, characterized by dilatation of the distal bronchi. The affection may be chronic, but may also arise acutely and disappear spontaneously, the so-called *reversible type of bronchiectasis* (Figs. 1 and 2).

Others are of the opinion that the term *pseudobronchiectasis* is preferable for the latter form, because these forms of bronchiectasis are different from the permanent ones. Some reserve is still warranted in the use of the term "reversible bronchiectasis"; see for example the bronchograms published by MEYLER & HUIZINGA, and SYPKENS SMIT. It should be realized that bronchi in collapsed parts of the lung may assume the typical aspect of bronchiectasis presumably without any anatomical dilatation.

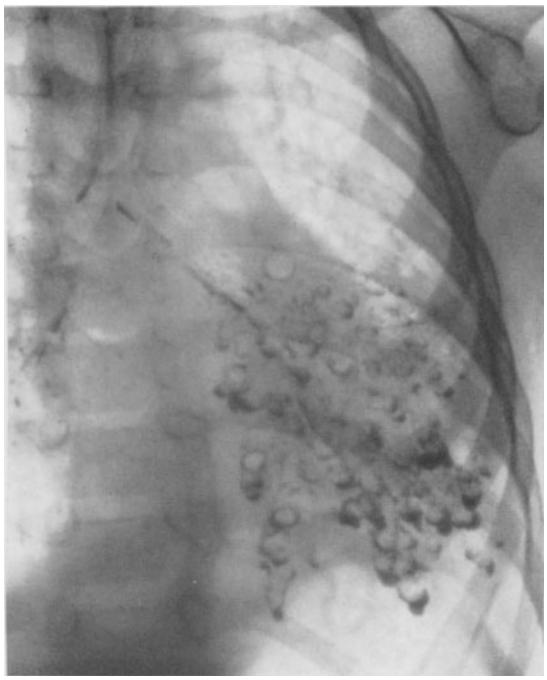

Fig. 3

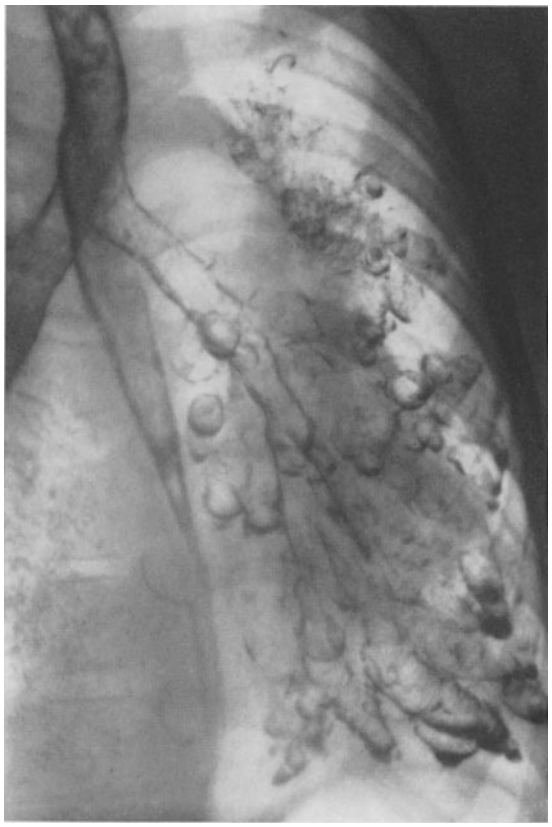

Fig. 4

Fig. 3. Dorsoventral photo of 2-year-old girl. She was formerly in good health, without any history of coughing. Four months previously she fell acutely ill, with coughing and high fever. The diagnosis established by the family doctor was: left pneumonia. Resorption did not take place, however, and the child was therefore referred to the Children's hospital. There were rather severe abnormalities: dull auscultatory sounds on the left side with bronchial respiration and many rhonchi; the mediastinum was markedly displaced to the left. This left displacement of mediastinum and trachea is clearly visible on the lipiodol photo. As far as the bronchial tree is filled, ampullary bronchiectasis is visible in the entire lower lobe and in the lower part of the upper lobe

Fig. 4. The same girl as in Fig. 3, now at the age of four. Increasing shrinkage giving rise to progression of the bronchiectasis

However this may be, in our material the disappearance of bronchiectasis has been confirmed with certainty by a bronchographic follow-up. It is difficult to decide how long a lobe or segment can remain collapsed with dilated bronchi, before the condition becomes irreversible. There are cases known of cylindrical dilatation, in which recovery occurred even after a year. Complete cure has not been observed in the saccular forms of bronchiectasis. Figs. 3, 4 and 5 illustrate the course in such a case, over a period of 25 years.

Six months can be accepted as a period in which reversibility is still possible. Should respiratory exercises and chemotherapy have-remained without result after this period, the condition must be regarded as final.

According to their form, the dilatations can be divided into saccular or cystic, cylindrical, fusiform and varicose types.

"Bronchiectasis" is often used as a clinical term indicating that the dilatation is accompanied by infection of the bronchial walls and pulmonary parenchyma, with production of sputum and fairly often haemoptysis. Bronkhorst correctly pointed out that the symptoms are usually not caused by the bronchial dilatations, but rather by additional anatomical factors (bronchiolitis obliterans). Other authors (Mulder, Israels) also attach much importance to functional influences (asthma).

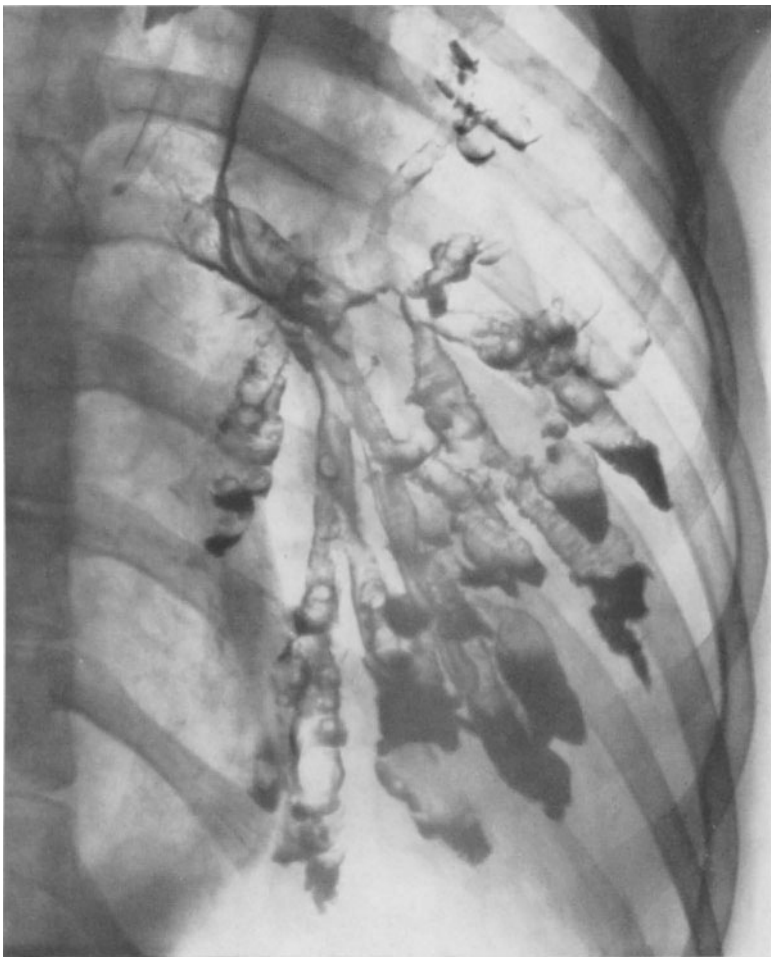

Fig. 5. The same case of Fig. 3. Bronchogram 25 years later, at the age of 27

3. Historical Survey

Until 1922, the direct proof that a patient had suffered from bronchiectasis was only possible on the autopsy table. In that year Sicard & Forestier introduced lipiodol, which initiated the science of bronchography; this enabled us to verify the clinical diagnosis during life, and led to the publication of a great many articles on bronchiectasis. The earliest surgical treatment consisted of measures to promote drainage by pulmonary collapse. Pneumothorax, oleothorax, plombage, various methods of thoracoplasty (Hedblom 1924) and phrenicotomy were tried out and proved inadequate and frequently harmful. Cautery pneumonectomy (Graham 1923) often caused complications (haemorrhage, air embolism and sepsis) rather than being a curative factor. The result of the Graham operation was a reversal of bronchial drainage towards the outside through the many bronchial fistulae that developed. This procedure has become obsolete.

The first lobectomy for bronchiectasis was performed by Heidenhain in 1901, based on the animal experiments of Glück, Bloch & Schmidt (1881) and especially on those of Biondi (1882).

In 1917 Robinson carried out five resections of a lower lobe on account of bronchiectasis, with one fatal case.

The high mortality and post-operative complications rendered the procedure unacceptable as a basic therapy, until in 1929 BRUNN of San Francisco demonstrated the feasibility and relative safety of one-stage lobectomy. He reported six cases in which lobectomy had been performed with one operative death.

SHENSTONE & JONES (1932) introduced tourniquet lobectomy with mass transfixion ligatures. In 1931 NISSEN, an assistant of SAUERBRUCH, carried out a two-stage pneumonectomy for bronchiectasis with mass ligation of the hilus. The lung was allowed to slough off. After eight weeks only a small bronchial fistula persisted.

Shortly after 1933 RIENHOFF introduced a method of individual ligation for the hilar structure in pneumonectomy. At present this technique is still in use, with some modifications.

These notable advances were soon followed by refinements in the technique. In 1939 CHURCHILL & BELSEY described the method of individual ligation of the lobar and segmental vessels and bronchus with resection of the lingular segment of the left upper lobe, for bronchiectasis.

CLAGETT (1946) and OVERHOLT (1948) improved this technique by removing the segment, starting from the hilus.

Finally, in 1942 KENT & BLADES published their investigations into the intrahilar resection technique.

Thus the present operation of intrahilar individual ligation and segmental resection has been completely standardized and generally accepted.

The selection of cases for operation still remains difficult, the more so as progress in the field of antibiotic treatment has made life more comfortable for many patients.

B. Aetiology and Pathogenesis

A discussion of the aetiology is wellnigh impossible without reverting for a moment to what was said about the definition of bronchiectasis. If we speak of dilated bronchi, we have quite another thing in mind than the clinical picture of bronchiectasis. The practically asymptomatic bronchial dilatations are reckoned among the first group. Our fairly good knowledge of this affection is due to its being repeatedly encountered in tuberculosis, in which bronchography is carried out for other reasons, for example because of intended resection treatment or check-up of formerly observed bronchial lesions. We owe part of our knowledge also to the necessity of carrying out bronchography in the event of abnormal-x-ray pictures found in mass examinations, even if the patient is symptom-free. These investigations, usually forming part of the anti-cancer campaign, frequently reveal the existence of asymptomatic bronchial dialations. It is however unknown whether this form of bronchial dilatation also occurs among other groups of the population, while its incidence is still difficult to estimate because the above-mentioned examinations are mostly carried out in selected groups. The investigation of tuberculous patients has shown that this type of bronchiectasis is of frequent occurrence (SCHWARZ, MAGNIN et al., SORGDRAGER, KRAAN, MULLER, VEENEKLAAS, DIJKSTRA). The academical thesis of RIJNBERG gives an extensive survey of this type. The frequencies mentioned vary from 16—76%. The figure stated by BUCKLESS et al. (51,8%) for a fairly extensive and not very closely selected series may give a good impression of the average frequency of bronchial dilatations in tuberculosis. There are only sporadic data on the presence of these asymptomatic forms of bronchiectasis in mass examinations of the population. They are certainly not rare, as witnessed by our personal incidental experiences. The following case report may illustrate this.

Patient I. B. (No. 54. 987), male, age 30, was admitted on July 13th 1954. He had fallen acutely ill on July 12th, with pains in his right side which were aggravated by sighing. He was feverish with chills, but had no cough or expectoration. He had had whooping cough, measles and scarlatina, but no pneumonia or bronchitis. He had previously had a slight cough in the morning and at night, but he attributed this to smoking forty cigarettes a day for years on end. He never brought up any sputum, however. He had neither hayfever, asthma nor any other allergic disease, and these were unknown in his family. He had no tuberculosis or chronic cough. The patient was admitted at once because he had worked with D.N.C. (dinitrocresol) and the possibility of poisoning by this substance was considered. He proved to have a pneumonia in the right lower area, without any causative agent being found. This was conceivable, because he had been having penicillin for the previous 24 hours. No other cause of the pneumonia being traced, the possibility of bronchiectasis as such was considered. The pictures (Figs. 6 and 7) found on bronchography were however very surprising.

Fig. 7. Same patient as in Fig. 6. Asymptomatic bronchiectasis

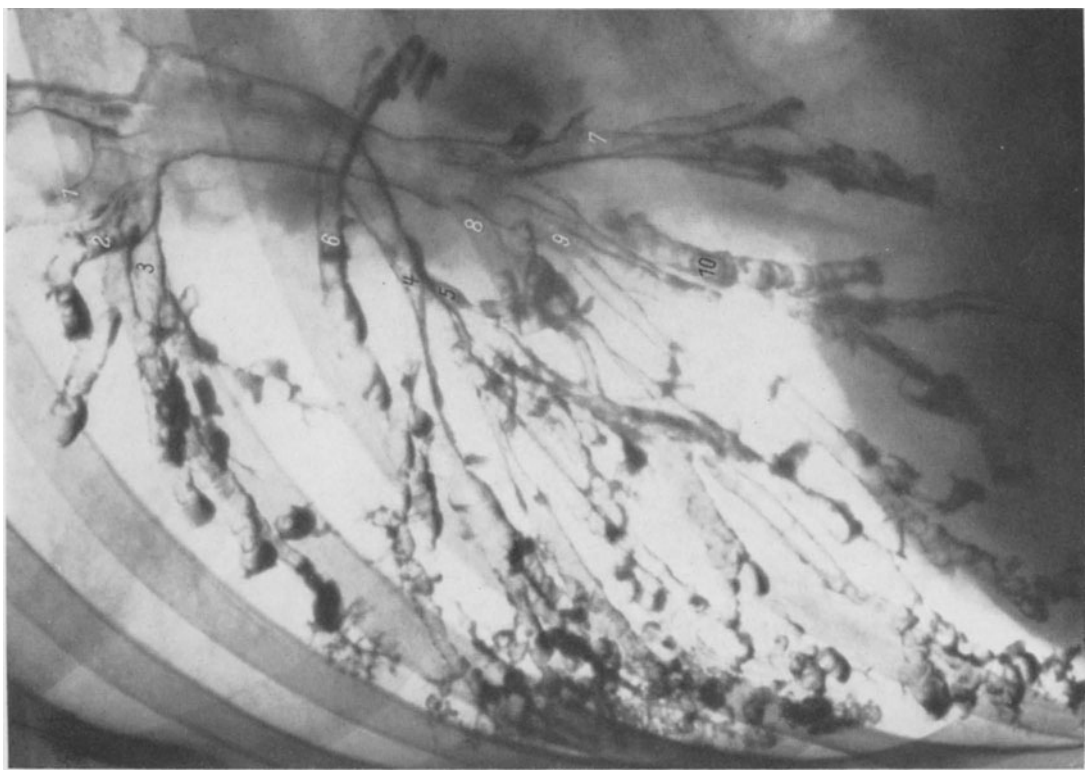

Fig. 6. J. B., male, age 30 (No. 54.987). Asymptomatic bronchiectasis

Apart from this type of (usually very marked) bronchiectasis, which is associated with relatively few symptoms, there is another group of bronchial dilatations, revealed by the bronchographic examination of patients with symptoms, who, therefore, show the clinical picture of bronchiectasis. This is characterized by a number of signs and symptoms: coughing, expectoration of sputum, repeated attacks of pneumonia and often general manifestations of disease, and complications. The symptoms are therefore highly important, but it is questionable whether the dilatation as such is responsible for them. BRONKHORST (1953) and J. MULDER (1952) answer this question in the negative, and we share their opinion completely. Although the name bronchiectasis is therefore not the best one in these cases, and it is doubtful whether there are any good arguments in favour of isolating the second group from many cases of chronic bronchitis, it is impossible, for the time being, to abandon the existing nomenclature. In our opinion, both groups must be involved in our considerations, but, on the other hand, a sharp distinction between them is necessary.

The following possibilities may exist as regards the pathogenesis.

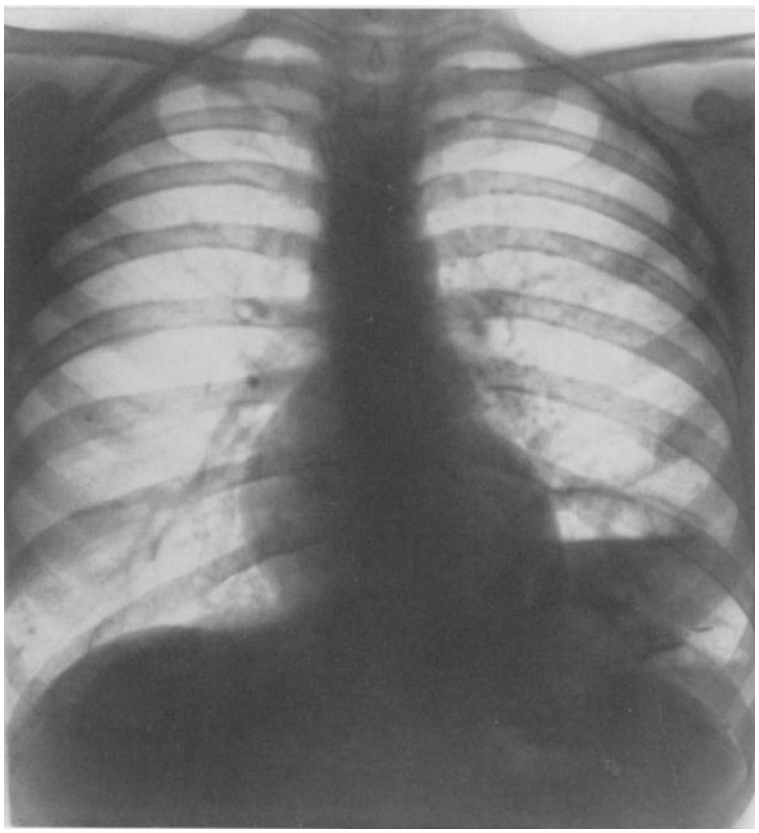

Fig. 8. Antero-posterior photo of 33-year-old female. Large cyst with fluid level in left lower region

1. Congenital Forms

Although the views of SAUERBRUCH, HELLER, and GRAWITZ regarding a congenital pathogenesis in most cases have been almost completely discarded (RUBIN, VACHON, GALY), there are still some particular patients in which other congenital malformations (abnormal vascularization) strongly point in this direction. The following case is an illustration.

Female, age 33, H. M. 29. 4. 1949. "Infected pulmonary cysts with bronchiectasis of the left lower lobe. Dissecting lobectomy of the left lower lobe."

Brief case history. Patient is reported to have already had a haemoptysis at the age of eight months. As a schoolchild she had pneumonia on three occasions, and was always much troubled by bronchitis in winter. She always produced much sputum, sometimes mouthfuls, especially when stooping. Her appetite was bad. She was a slightly built, pale woman in moderate nutritional condition. She had no scoliosis. Slightly clubbed fingers. Blood picture: nothing of note. Sputum (about 60 ml. per day): mixed flora. The antero-posterior thorax photo (Fig. 8) showed a large cyst with fluid level in the left lower region. Bronchoscopy: on the right nothing particular. On the left, large quantities of pus were coming from all segmental branches of the left lower lobe. No pus was present in the lingular branches. Bronchography (Fig. 9): several cavities and ditalations were present in the left lower lobe.

The left upper lobe was free of them. The right bronchial tree was normal. Thorax photo: A number of cavities in the left lower lobe with fluid level. Pulmonary function examination: in spite of the

not very satisfactory findings, operation was considered probably possible. Indication: lobectomy of the left lower lobe. The operation was carried out on May 9th, 1949. The lung showed marked adhesions. A large vessel (4 mm. in diameter) ran from the aorta to the pulmonary cyst; it was clamped and ligated; the operation was completed by the typical dissection technique. The post-operative course was uneventful. The patient was discharged in good condition three weeks post-operatively. *Operation specimen No. 47,214* (Prof. VOS). Macroscopically, the pleura of the extirpated lower lobe of the left lung was covered on the surface with shreds of the severed adhesions. The pulmonary tissue was partially fluffy, partially cystic. The cystic part was separated from the rest by rather deep sulci. A cavity of the size of an orange was visible on the cut surface; it had secondary protuberances filled with purulent mucus. On the distal side of this large cavity, the pulmonary tissue showed numerous tiny cavities close together, which made this part of the lung resemble a honeycomb.

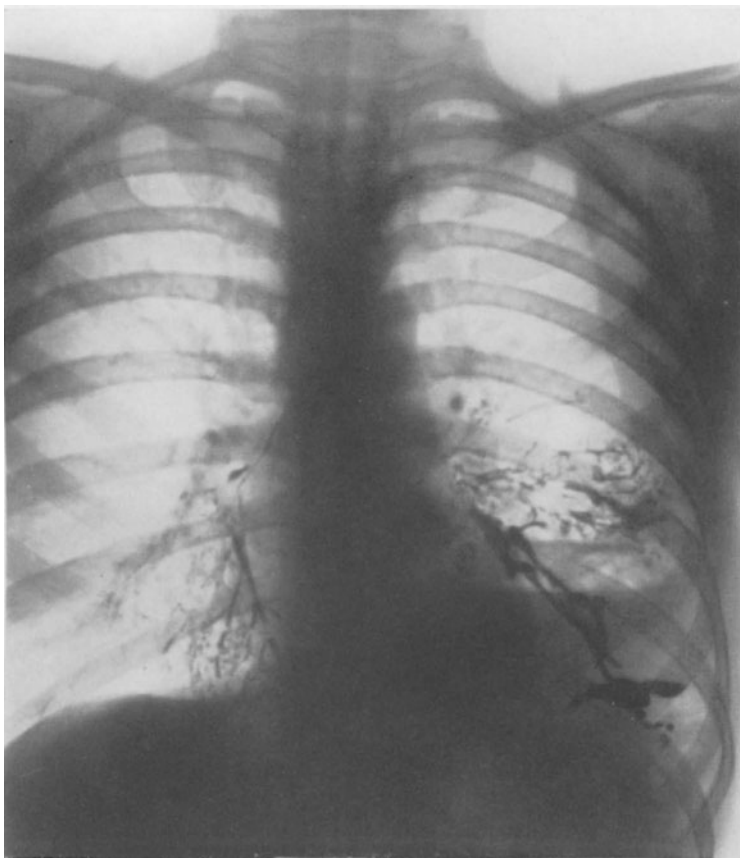

Fig. 9. Same patient as in Fig. 8. Bronchogram showing multiple cysts and bronchiectasis

Microscopically, the walls of the large cavity and those of the dilated bronchi showed chronic inflammatory infiltrates without specific characteristics. The wall was lined with cylindrical epithelium. *Anatomical diagnosis.* Bronchial cyst (?) and bronchiectasis of the left lower pulmonary lobe (Figs. 10 and 11).

Re-examination on June 29th, 1949: No subjective symptoms. There was a gain of 4 kg. in weight. No dyspnoea, no thoracic deformity. The X-ray photo showed nice, clear lung fields. On March 2nd, 1950, the patient was in good condition.

Discussion. Some cysts apparently originate in the bronchi, because their walls are partially composed of cartilage and smooth muscle fibres, and contain mucous glands. Other cysts are derived from the smaller bronchioli and are lined with unciliated cylindrical epithelium as in our case. The latter type probably originates from the respiratory bronchioli, and possesses a thin fibrous wall lined with cubical epithelium. The bronchi communicating with the affected areas are usually dilated.

SWINNEN regards only five of the 126 cases operated in our series (up to 1950) as belonging to the congenital form. The diagnosis of congenital bronchiectasis remains uncertain in the other cases.

The fact that cysts are found per se should certainly not be interpreted as proof of the congenital origin of bronchiectasis (POLICARD et al.). We agree with SWINNEN'S statement: "One of the most intricate and obscure fields of pulmonary pathology is that of the aetiology and pathogenesis of pulmonary cysts and bronchiectasis, and more in particular of the so-called congenital forms of both affections." If the cause of the dilatation is sought for in the non-expansion of parts of the lung at birth, or if congenital syphilis is regarded as the cause of some affections (BESANCON), the abnormalities are indeed congenital, but, properly speaking, they are identical with acquired bronchiectasis in other patients. The same is true if, in agreement with WISSLER et al., the pathogenesis is thought to be associated with disturbances during intra-uterine life.

As regards the first-mentioned phenomenon—in which aspiration of amniotic fluid may be a factor—a definite estimation of the frequency will remain very difficult. Congenital syphilis is to be regarded as a negligible factor, at any rate in our series of cases (Balzer; Sandoz; Besancon et al.; Swinnen).

Congenital proliferation of bronchial epithelium (bronchiolitis obliterans, Buckmann), has been described. Policard & Galy, however, are inclined to regard the hypertrophy

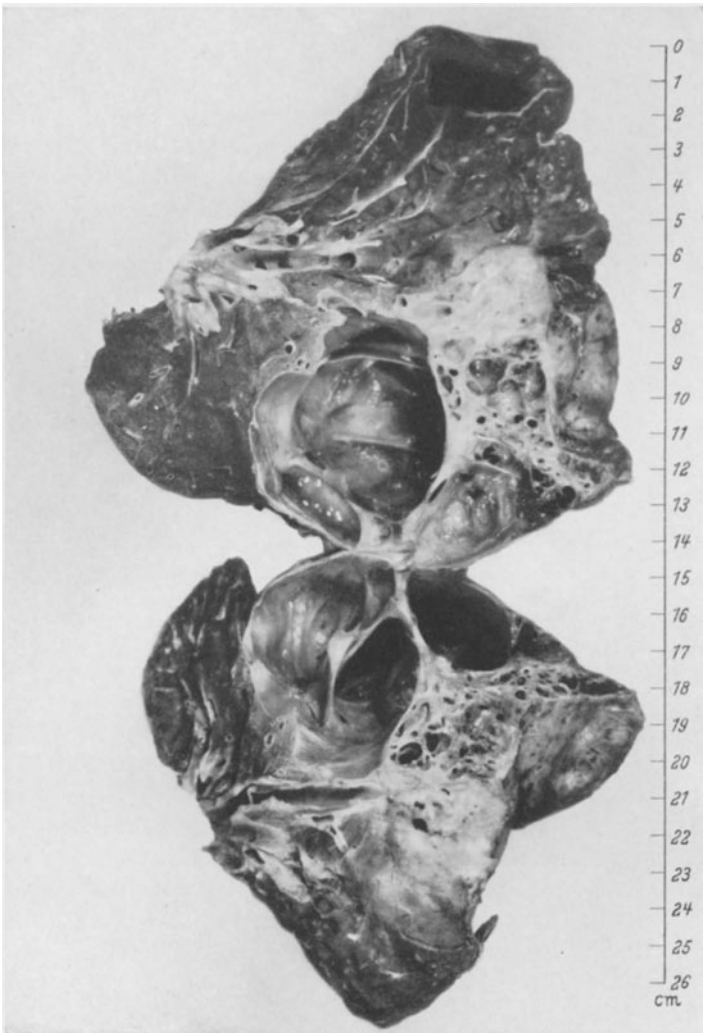

Fig. 10. Operation specimen of left lower lobe of the patient of Figs. 8 and 9. An abnormal blood vessel runs from the aorta towards the pulmonary cyst ("sequestration" of lung tissue)

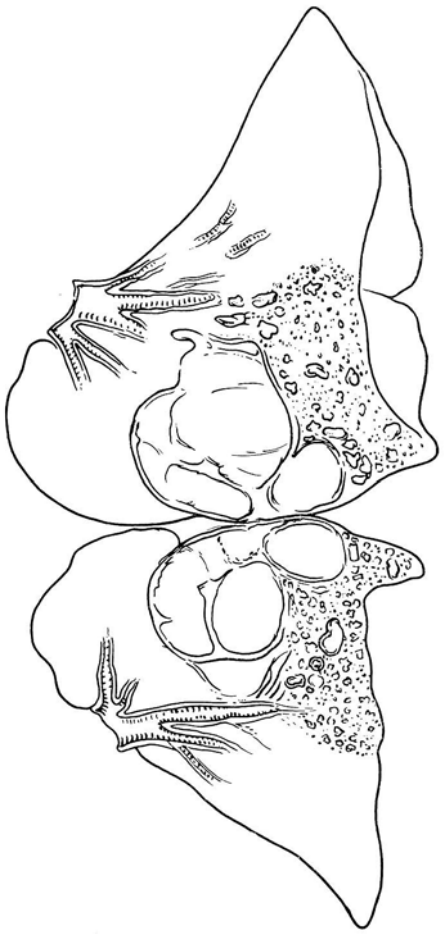

Fig. 11. Diagram of operation specimen of Fig. 10

and proliferation of the bronchioli as secondary, just as most other authors do. It is more difficult to find an explanation for the association with other congenital abnormalities (cysts of other organs, heterochromia, colour blindness). The same holds true for the triad described by Kartagener (situs inversus, agenesis of the sinuses and nasal polyposis, bronchiectasis). Kartagener & Siewert; Oeri and Guenther reported the first cases. Kartagener added new cases to this number, and Kartagener & Gruber and Adams & Churchill in particular gave much attention to this problem. Churchill believes that we are not dealing with bronchiectasis in these cases, but only with a disposition to bronchial dilatations, as shown by other similar cases. The problem seems less difficult

in combination with pancreatic fibrosis, in which case there are sufficient grounds to regard the bronchial dilatations as sequelae of resorption disturbances (Andersen). Disturbances in vitamin A absorption and in fat absorption, which we also believe we observed in a number of cases (unpublished observations) also point in the same direction (Fig. 12). This defective absorption would appear to be due to a hereditary disturbance of the pancreatic function (Bodian).

It is however impossible to prevent bronchial abnormalities in pancreatic fibrosis by the administration of extra vitamin A (Lowe).

This apparently logical relationship is therefore by no means an established fact, and the connection between pancreatic abnormalities and bronchiectasis awaits further elucidation.

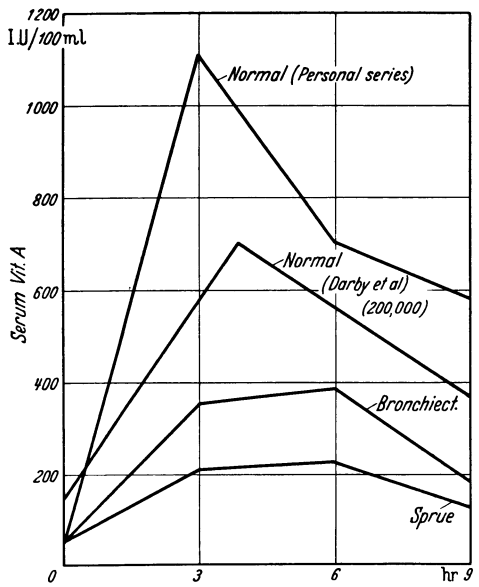

Fig. 12. Vitamin A determinations in eight normal individuals, fifteen cases of bronchiectasis and four cases of sprue. Oral dose of 600,000 i. U. Vit. A

In addition to the vitamin A theory, which is especially supported by Anderson, there is Farber's hypothesis of a general disturbance in the formation of secretions; at present this idea is advocated by many investigators.

2. Acquired Forms

There is considerable controversy within this group, both as regards the aetiology and the pathogenesis. In general it may be said that bronchial stenosis, infection, fibrosis, atelectasis and abnormal negative pleural pressure are the most important pathogenic factors, especially the combination of the two first-mentioned (Huizinga 1940, 1952, inter alia). This is far less certain for these two factors separately.

Experimental data. Adams Escudero did not observe dilatation in complete obstruction of a main bronchus (at any rate in the dog); in their observations this was even true in the event of infection. Tannenberg & Pinner arrived at the same conclusions, but they found that infection is *always* accompanied by bronchiectasis, even in complete obstruction. Total occlusion without infection did not lead to dilatation in either series of observations. Weinberg (experiments on rabbits) always obtained dilatations in the presence of infection. Lee Lander & Davidson (experiments on cats), working with gum arabic, achieved the same results. Duprez (experiments on dogs) produced acute obstruction of a main bronchus (with 20% potassium hydroxide). Bronchiectasis was not obtained either in complete or in incomplete stenosis, and no difference was made by the presence or absence of atelectasis. Neither did chronic obstruction of a main bronchus lead to bronchiectasis, although infections occurred after some time. Only after instillations of potassium hydroxide and silver nitrate into the minor bronchi did dilatations (7/11) usually occur; some were of the cystic type, however.

Lee Lander (as also Corrigan) emphasized the great importance of bearing the fact in mind that it is sometimes difficult to demonstrate at autopsy the bronchiectases that have been manifest during life.

Clinical data. Although the experimental work does not allow of decisive conclusions regarding the significance of the various factors (which need not arouse astonishment in view of the many difficulties involved in the imitation of clinical situations), many indications are obtained from clinical experiences. The great frequency of bronchiectases distal to benign and malignant tumors and in the area behind the place of granulation of an inflamed gland in the bronchus, the extensive bronchiectatic areas which may rapidly

develop behind foreign bodies in the respiratory tract, and the findings in the bronchi in extensive fibrotic processes, not only allow of speculation but also of a well-considered judgment on the influence of the various factors.

a) Bronchiectasis in Tuberculosis

There are two forms of this condition:

1) Bronchiectasis in the region behind a tuberculous hilar gland (either perforated or not). As stated before, the frequency of bronchial dilatations is great in these cases, and SORGDRAGER assumes that bronchiectasis persists as a final condition in about 40% of cases. These dilatations are circumscript and often of considerable size, with remarkably few symptoms in many cases.

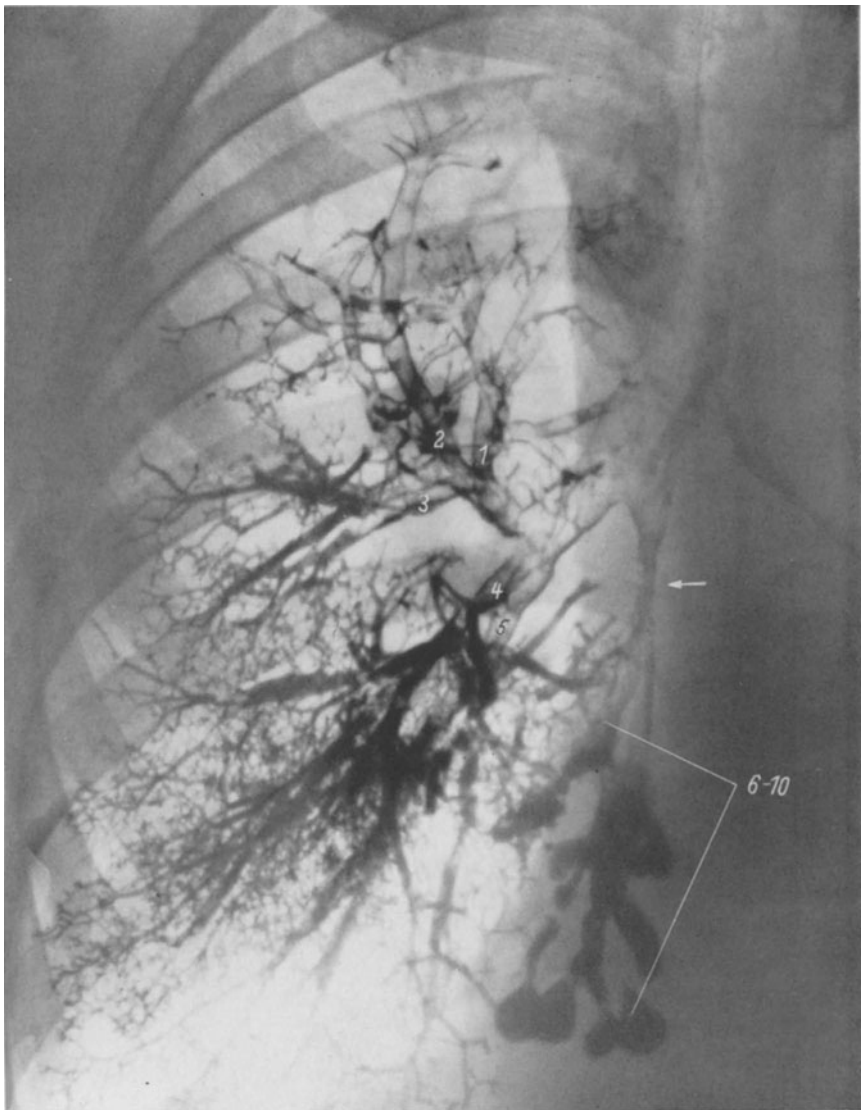

Fig. 13. Dorsoventral bronchogram of 15-year-old boy. Bronchiectasis of all branches of the right lower lobe (6—10) due to a stenosis (near arrow). Local cause: a tuberculous hilar gland, perforated more than 5 years previously. The patient was symptom-free. Recovery followed after resection of the right lower lobe

The observations of SCHWARTZ, MAGNIN et al., BÖHM, DIJKSTRA, KRAAN, VEENEKLAAS, STEINER, HUTCHINSON, GALY et al. and BERGSMA do not leave any doubt as regards the

frequency and the paucity of symptoms of this type, and we may consider this form as generally recognized.

The case history illustrated by Fig. 13, and the pathological specimen represented in Fig. 14, may serve as examples.

The "middle lobe syndrome" (described by Brock 1950, Rubin, Hekking, Graham, Bufford & Mayer, Paulson & Shaw, Sebesteny and others, in which there are many more symptoms, forms perhaps an exception.

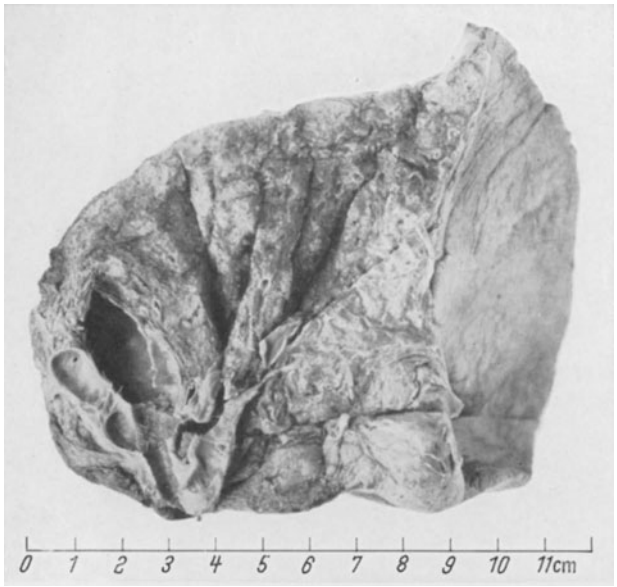

Fig. 14. 24-year-old woman. Circumscribed bronchiectasis in the apical segment of left lower lobe (cause: tuberculous hilar gland). Basal bronches were normal

Although this constitutes an indication that the explanation of this paucity of symptoms should be sought for in the easy drainage of the secretions, this explanation is, in our opinion, too incomplete: infection, the anatomical condition of the bronchioli and the absence of allergic factors are also of decisive importance. It is a remarkable feature that Sorgdrager found stenosis or remnants of perforation in the lower lobes of only eight out of 56 cases, but in the other 48 cases in the upper and middle lobes; this is in sharp contrast to the spread of primary tuberculous foci [Leitner, Bronkhorst (1949) and others]. Leitner's figures (only 10 % in the apical segments) completely agree with Bronkhorst's theoretical considerations on the localization of these processes in the well-ventilated parts of the lungs.

Secondary infections in tuberculous primary (and also secondary) processes are of far lesser importance than in cases of foreign bodies or tumours (see Table 1; figures only slightly differing from the similar data of J. Mulder (1939) and R. Mulder (1954).

Table 1. *Types of bacteria found in various pulmonary diseases*

	I 1947—1953 Tuberculosis	II 1947—1950 Bronchiectasis	III 1950 Bronchial carcinoma	IV 1944—1950 Obstructive pneumonia	V 1949—1953 Asthma	VI 1931—1943 Lobar pneumonia Bullowa
Total number	95	110	75	63	300	
No sputum	—	$7^1/_2$ %		10 %	7 %	
No flora	63 %	14 %	72 %	10 %	62 %	0 %
Mixed flora	3 %	$9^1/_2$ %	5 %	27 %	3 %	1 %
Staph. aureus.	2 %	0 %		12 %	1 %	0,2 %
Streptoc. haemolyticus.	—	3 %	1 %	12 %	10 %	2 %
anhaemolyticus . . .	—			8 %		
Pneumococcus	4 %		5 %	2 %		96.8 %
Pneumococcus + . . .		$14^1/_2$ %				
Haemophilus infl. . . .	17 %	46 %	12 % (+)	19 %	17 %	
Haemophilus infl. + . .		$58^1/_2$ %	1 %			
Klebsiella pneum. . .	1 %		1 %	—	2 %	
Tubercle bacilli	100 %		3 %	0 %	2 %	0 %

Note: percentages < 100 % are due to repetition of results under different headings.

Lubsen found a mixed flora in a somewhat higher percentage of cases, but he also pointed out that these "infections" (?) are often very transient.

We must therefore conclude that tuberculous infection, in association with bronchial stenosis, may probably give rise to the formation of bronchial dilatations (GALY et TOURAINE). Pathogenically, this group also shows the possibility of dilatation after collapse, due to increased intrapleural suction action (DAVIDSON; LEE-LANDER). The problem is still unsolved whether this constellation may lead to dilatations, the more so as it is clear that the picture of "pseudo-dilatation" may also be evoked for example by collapse in diaphragmatic elevation (MEYLER & HUIZINGA, HUIZINGA & SYPKENS SMIT) which is therefore probably not accompanied by an abnormal negative pressure.

Table 2. *Secondary infections in pulmonary tuberculosis and in cases of bronchiectasis of tuberculous origin*

	Number of cases	Infected	Non-infected	?
Active pulmonary tuberculosis	45	2	34	9
Reactivation of pulm. tuberculosis .	11	1	10	—
Bronchiectasis of tuberculous origin .	34	4	30	—
Bronchiectasis under thoracoplasty . . .	12	4	8	—

According to R. MULDER (1954).

Another solution—which is however not well tenable in the light of SORGDRAGER'S data—would be that the majority of these cases of bronchiectasis in tuberculosis would belong to the second group namely:

2) Bronchial dilatations in fibrotic (phthisic) tuberculous processes (Figs. 15 and 16). However this may be, the frequency of dilatations in these processes is an established

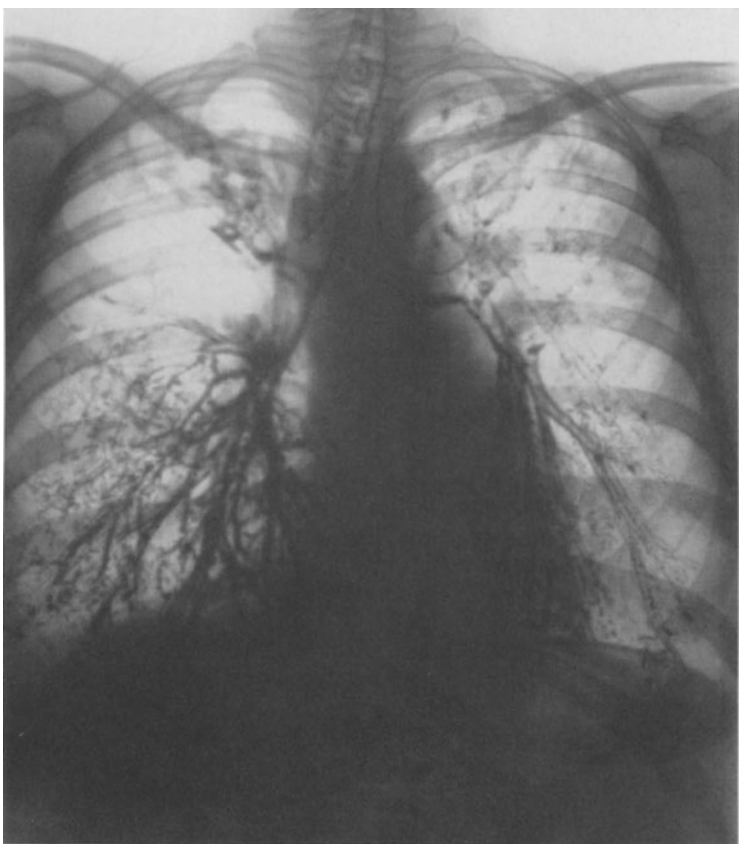

Fig. 15. N. U. E., female, age 44, in poor health since 1933, presumably due to a tuberculous process. Treatment not until 1951. The family history showed a marked incidence of the disease. The sputum was weakly positive. X-ray photo: bilaterally in the apices a stripy and patchy pattern, probably associated with fibrotic processes. Bronchography revealed extensive dilatations in the whole left upper lobe, and also distensions in the right upper lobe with presumably stenosis of the right upper lobe bronchus

fact, and, on the strength of this often present association there can hardly be any doubt as regards a causative relationship. However, when studying the pathogenesis of these cases, we consider always whether there is anything suggestive of glandular obstruction in the history. This question may arise because fibrosis of other origin (e.g., in silicosis: Lee Lander, and in sarcoidosis: personal observations) often leads to only a low degree of bronchiectasis. This solution, however, is unacceptable; the localization and the bilate-

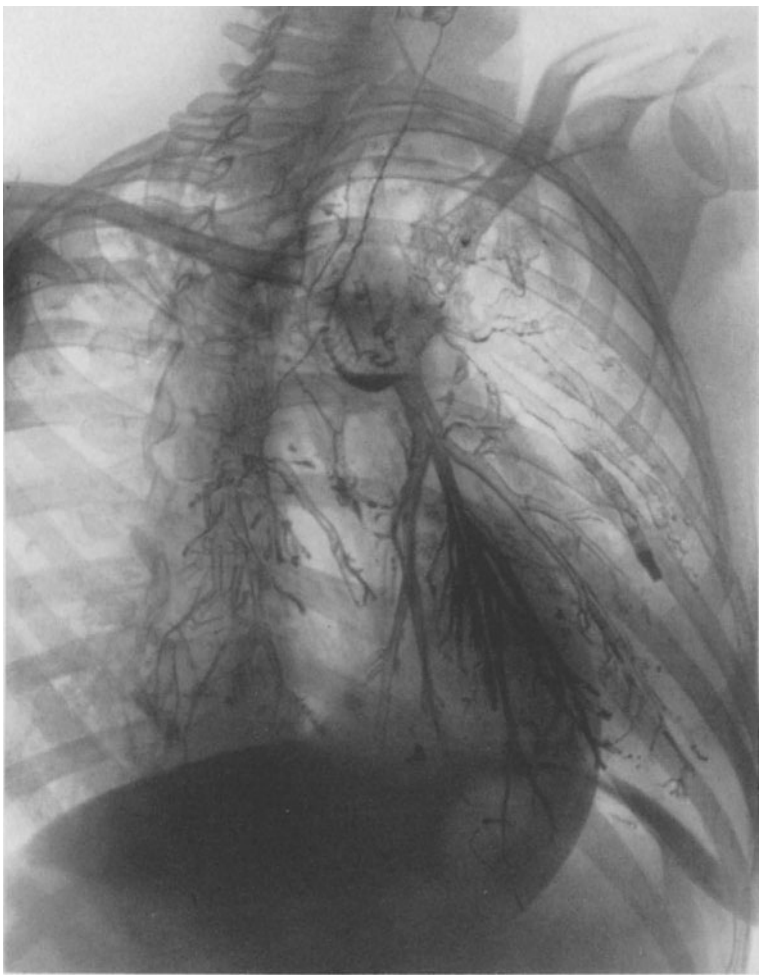

Fig. 16. Same patient as in Fig. 15. Oblique bronchogram. Bronchiectasis of whole left upper lobe

rality make it improbable. An explanation of this difference should perhaps rather be sought for partly in simultaneously existing pleural adhesions, and partly in the peripheral tuberculous abnormalities of the bronchi (Galy & Touraine, Dijkstra).

The recognition is of prime importance, because the bronchial dilatations in this form of tuberculosis are often no longer associated with an active tuberculous process, and may therefore be regarded more or less as abnormalities sui generis. Operation is usually not indicated in this asymptomatic form, however inviting such cases may often be to the surgeon, due to their sharp demarcation and their frequently good pulmonary function.

b) Bronchiectasis in Malignant and Benign Tumours

This group probably offers the fewest problems. The relationship is practically incontestably established from the aetiological point of view, and pathogenically the association is best demonstrated by the experimental findings.

The combination of gradual, often partial occlusion with almost always bronchial infection, should fairly certainly be regarded as the pathogenic cause. In other respects also there is no necessity for profound consideration, because the bronchial dilatations are only rarely of importance compared with the serious primary affection.

This aetiology deserves attention for two reasons: a) because the tumour is often overlooked and the predominant secondary character of these dilatations (and symptoms) is not recognized, and b) because in some cases carcinomas develop in patients already affected with bronchiectases (or forms of bronchitis) of "idiopathic" character, and the examination for "secondary" tumors is unfortunately omitted in these chronic coughers. In our experience this frequent coincidence of chronic respiratory affections with tumours not only holds true for (squamous-cell) carcinoma (SWIERINGA, even 50 %), but perhaps also for bronchial adenoma. This is also pointed out by VISMAN, but it is clear that such a relationship is difficult to establish with certainty in a disease, one of the features of which is indeed the long-standing presence of the symptoms.

c) Bronchiectasis in Fibrosis

This has already been touched upon in the discussion of tuberculosis. We shall revert to this problem when dealing with the idiopathic form.

d) Bronchiectasis Following Pneumonia

A discussion of this type is postponed until the analysis of the so-called idiopathic form, because it is often difficult to decide whether the pneumonia is the cause of the bronchial dilatations, or conversely. In most of the cases we are inclined to the latter view, except in pneumonia associated with measles and whooping cough.

e) Bronchiectasis after Diphtheric Paralysis, Poliomyelitis and Other Neurological Disorders

This relationship is repeatedly observed, and we believe that it should be regarded as a real aetiological factor. The pathogenesis lies in the combination of obstruction and infection, in which the obstruction can be considered as caused by the impediment of expectoration.

LEE LANDER gives a striking example in which a tracheotomy scar later made the impression of a sustained diphtheria + bronchiectasis. This tracheotomy had however been carried out on account of acute dyspnoea without diphtheria being present.

f) Bronchiectasis behind Aspirated Foreign Bodies

This type represents a very important type and frequent lesion. In the majority of the cases there is a strictly localised lesion, usually accompanied with rather severe complaints.

Even in clearcut cases of this type the history of aspiration however is sometimes difficult to obtain because the patient don't like to recognise the relationship of his complaints with the undeniable foreign body aspiration. By not giving the correct history the patient runs the risk of missing the ideal solution of his problems, extraction of the foreign body and if recovery is not immediate and complete: resection of the lung tissue involved.

g) Other Forms of Bronchiectasis after Aspiration

are occasionally met with (following drowning, dental extractions, etc.).

h) "Idiopathic" Bronchiectasis

Finally there is a group of abnormalities, of which no unanimity exists as regards aetiology or pathogenesis. It is nevertheless a very important group because it comprises a great many cases, especially among those with symptoms. Therefore it is evident, that

this group will be abundantly represented among the patients in whom operation is contemplated. Many of these cases are affected bilaterally. Bronchi with mild changes are frequently observed in addition to marked dilatations. The abnormality is mainly localized in the basal bronchi of the left lower lobe and lingula. The past history shows the

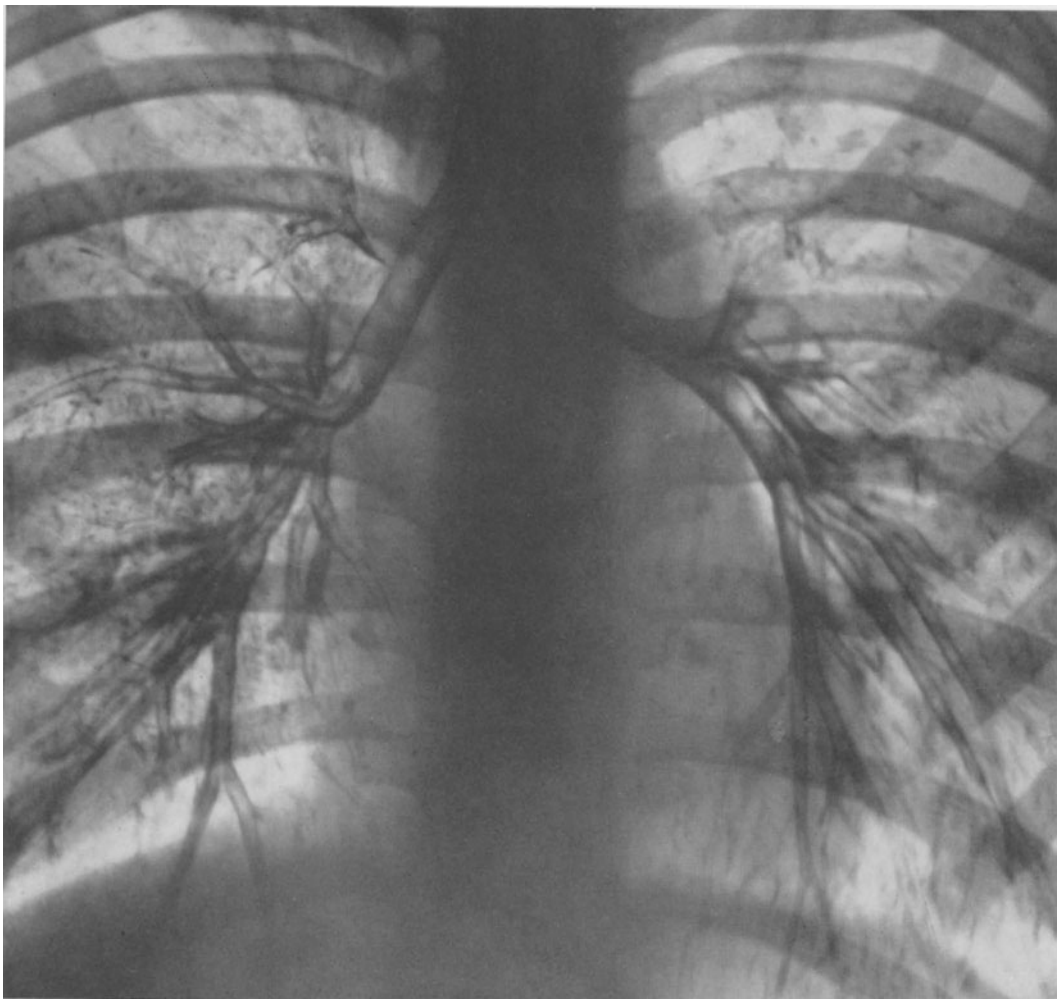

Fig. 17. Dorsoventral photo of 5-year-old girl. Normal bronchial tree. She had had a bilateral bronchopneumonia when an infant. Since that time she had been suffering from coughing and expectoration, which became worse after she had contracted whooping cough at the age of 3. In the Children's hospital, moist rhonchi were constantly heard infrascapularly on the left back side. Percussion did not reveal any abnormalities. The Pirquet was negative. The thorax photo did not show changes

more or less classical picture of bronchiectasis. Pneumonia is also frequently found in the history, often in association with measles or whooping cough. In the great majority of cases the history goes back to early youth.

We agree with Bronkhorst (1953) that this symptom complex is probably not only determined by the dilatation, because several of these cases show the whole syndrome, while dilatations are only present to a mild degree or not at all (Fig. 17). Bronchiolitis obliterans is probably an important factor, especially in the cases that relapse persistently.

Juvenile pneumonia, whether superimposed or not on abnormalities due to measles or whooping, is regarded by many as *the* aetiological and pathogenic factor in these cases.

Without wishing to deny the significance of this, we are still of the opinion that Watson & Kibler's views should also be considered in the aetiology, and that the course

and treatment of a great number of these "idiopathic" bronchiectases is difficult to understand if these views are not given due regard.

SWINNEN mentions pneumonia, bronchitis and "common colds" as the cause in 40 % of his series, 30 % being of unknown cause. On the strength of the observations of WATSON & KIBLER in 1938, of ISRAELS in our clinic, of GEELEN, and of ORIE, HUIZINGA,

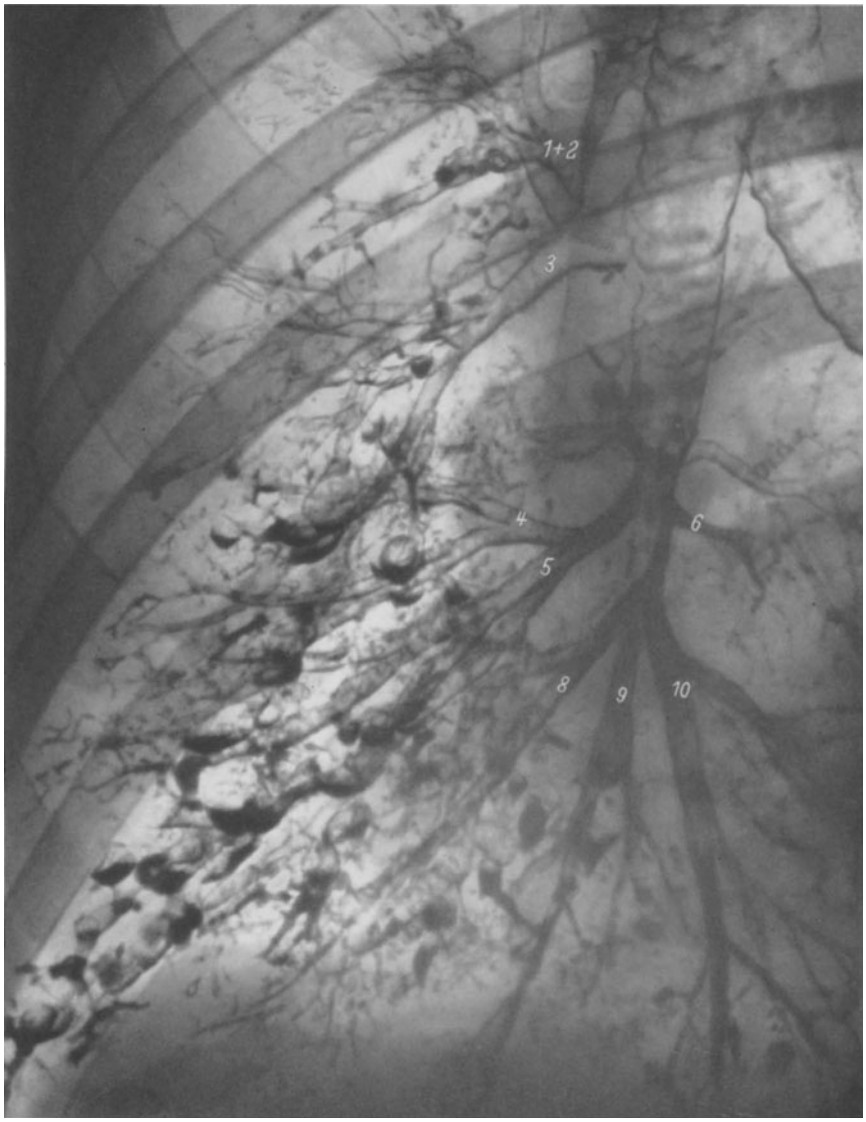

Fig. 18. Diffuse bronchiectasis. Oblique photo of right side. Bronchiectasis in 3, 4, 5, 8, 9 and 10. Patient was a 55-year-old man with a typical history of coughing and marked expectoration, which had started at the age of 4 following pneumonia. The patient had repeatedly suffered from pneumonia since that time

ISRAELS, GEELEN & SLUITER, we believe that in by far the majority of the 70 % of pneumonic or, as called elsewhere, "idiopathic" cases, the conditions leading to obstruction are created by the functional bronchial stenosis in asthma at a very early age. This facilitates the development of the pneumonic process. These two together cause the bronchial dilatations. The remarkably high frequency of the symptoms in this type of dilatation is also explained by this asthmatic factor, which is alternatingly more or less in the foreground. The localization, characteristic of this group, is not explained, however, by this

theory, but it does give a better understanding of the markedly familial character. The same holds true for the diffuse aspect (in contrast to the usual local lesions in tuberculosis or after aspiration of a foreign body) and for the great tendency to (seeming) relapses (Crellin) in other less seriously changed parts of the lung after resection. The great

Fig. 19. Diffuse bronchiectasis. Oblique photo of left side. Bronchiectasis in 3, 4, 5, 8, 9 and 10. Same patient as in Fig. 18

tendency to operative collapse and post-operative complications should also be attributed to earlier mild lesions. Figs. 18 and 19 are examples of diffuse bronchiectasis. The frequently described affections of the sinuses, the bronchiectases and the "mucus cysts" which are so often observed in the main bronchi on the bronchogram (see Fig. 20), can also be considered of common origin.

All three of them are the manifestation of alternating mucosal swellings with accumulation of secretions (and infection) on the distal side of the stenosis. They are the cause of the dilatations as well as the pacemaker of the ever recurrent symptoms. This conception completely agrees with Bronkhorst's (1953) emphatically expressed opinion that the bronchiectasis per se is only of minor importance, and it also tallies very well with

the observations of CHURCHILL, WHITWELL, and DUPREZ who observed that there is commonly a bronchiolitis obliterans behind the dilatation proper, which in itself is usually confined to the first 6—10 ramifications. This bronchiolitis obliterans is, in our opinion rightly, considered by BRONKHORST an (other) important cause of relapse. It is however

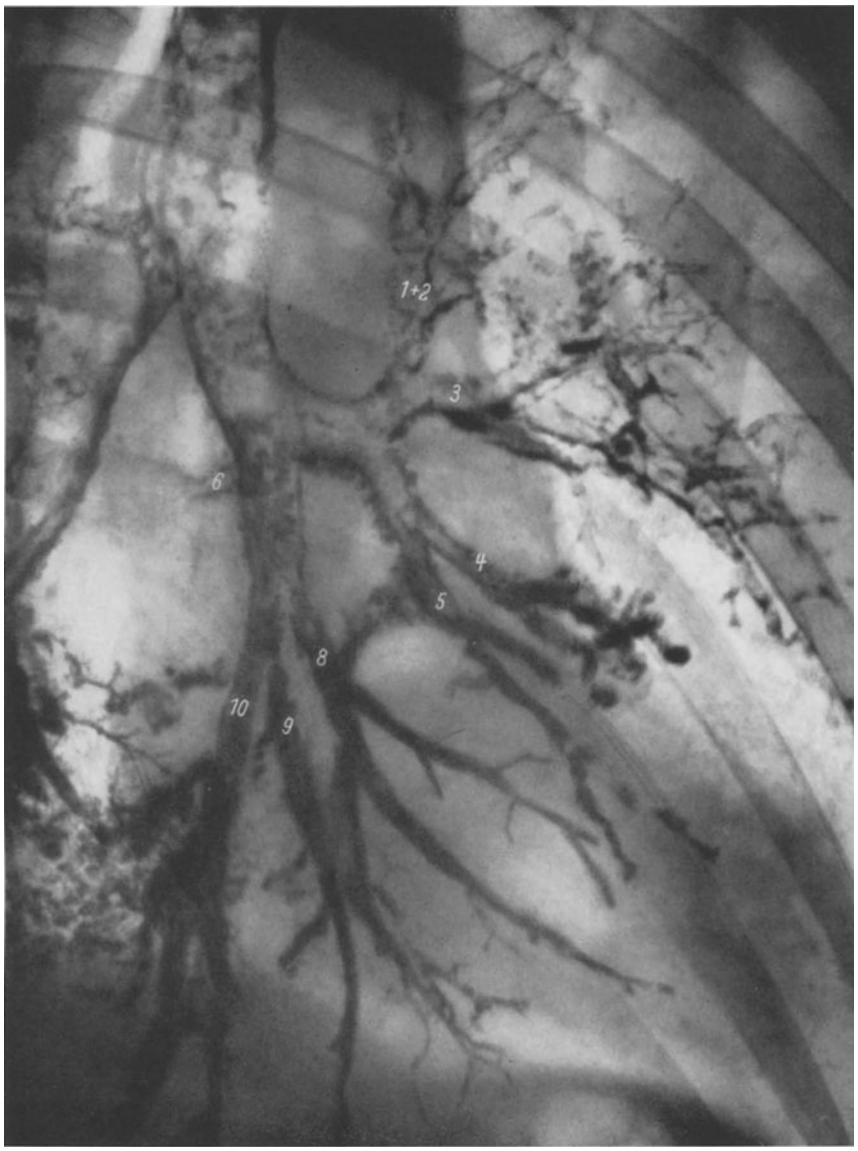

Fig. 20. Mucus cysts. 36-year-old male, with a history of coughing since childhood. Cylindrical bronchiectasis on both sides. Oblique photo of left side. On this side a fringe is visible in the lingula (4 and 5) and in the postero-basal (10) segment, and on the bronchi at 3, 4 and 5: swollen mucous membranes, characteristic of chronic bronchitis. The right side showed the same picture. This case was unsuitable for operation

subjekt to doubt whether there is sufficient proof to regard this bronchiolitis obliterans as due to infection with a virus of a primary atypical pneumonia. The development of bronchiectasis due to irritation of bronchial mucosa and infection has been clearly demonstrated by DUPREZ. It is however questionable whether in the nonasthmatic individual this combination ever existed for a sufficiently long time to produce bronchiectasis. This does not seem to be so, and this mechanism seems to be no longer active even in adult asthmatics, for, while the development of pulmonary abcesses is observed in the latter,

that of dilatations occurs only rarely. The bronchiolitis obliterans however does not explain the manifold asthmatic factors, the not unusual eosinophilia, and the affections of the sinuses. The high frequency of infantile eczema, for example, in the past history of chronic forms of bronchitis in children, also remains unexplained.

For a more extensive survey of the arguments we refer to the pertinent articles of WATSON & KIBLER; MULDER; ISRAELS; GEELEN; ORIE et al. SOUDERS, while not giving an extensive discussion of the pathogenesis, mentions 28% of cases with a definite allergic history (77 out of 277). SLOOFF postulated the possibility that the allergic factor would not be the cause of the bronchiectasis, but rather the cause of its persistent manifestation. Although bronchial dilatations of indifferent origin undoubtedly will not manifest themselves in sporadic cases, it still needs to be proved that, for example after pneumonia complicating measles and whooping cough, there is a frequent occurrence of dilatations, which do not become manifest for lack of an allergic background. This proof will be difficult, due to the deficiency of data on this subject in the healthy population. Only in incidental cases do the data obtained in mass examinations of the population lend any support to this view. The data on the pulmonary function examination (GEELEN) point especially to the great practical significance of asthmatic factors. This is particularly clearly demonstrated by the difference in functional results in bronchiectasis with and without adrenaline effect (see operative results).

Table 3. *Familial occurrence of allergic manifestations and asthma in the families of asthmatics and sufferers from chronic bronchitis*

	Mild asthma	Severe asthma	Chronic bronchitis
Father allergic	16.6	16.7	18,9
Mother allergic	14.8	14,3	7.
Both parents allergic .	2.2	2.9	4.9
Asthma in the family .	24.5	20	35.7
Seborrhoea in the family	7.	10.0	4.8

F. DOELEMAN, personal communication.

It is evident that the above hypothesis involves important consequences regarding the indications for operative treatment of bronchiectasis. On the one hand, the symptoms in patients with sharply localized bronchial dilatations, based on a local bronchial stenosis, are often so few that they do not justify an operation, although, properly speaking, they constitue an ideal indication. On the other hand, the patient with many symptoms and repeated infections and attacks of pneumonia is, unfortunately, too often anything but a suitable case for surgical treatment, due to the extent of the (often not very serious, lesions and the incurable asthmatic diathesis.

The final results are therefore often unsatisfactory, on account of the persisting basic affection.

C. Frequency

It is impossible to give accurate figures for the frequency of bronchiectasis, because its presence can only be demonstrated with certainty by bronchography. A moderate dilatation is often overlooked even at autopsy.

CAMPBELL & MOERSCH found 47 cases of bronchiectasis in their series of 1,191 autopsies (= 3.9%).

According to a report of JORENS & ROBINS, a certificate of unfitness for military service was given to 32 soldiers of the U.S.Army, out of a total number examined in a hospital of 1,753 (= about 2%).

FINE & STEINHAUSEN detected 41 cases of bronchiectasis in routine chest examinations of 156,000 aviation candidates. Of the 36 who were followed up, 20 (= 77.7%) had minimal or no symptoms.

In the Bedford area (England, WYNN WILLIAMS), 214 cases of bronchiectasis were found out of a total population of 150,000 (= 1,3‰) during a period of five years (1947 till 1951). There are often geographical differences as regards the frequency. The impression is gained that there is a higher incidence in the industrial areas (England, for example) than in regions with less pollution of the air. Bronchiectasis is often observed in our part

of the Netherlands. During the years 1949—1953 we have clinically observed 458 cases of the disease.

Based on a comparative estimation, the frequency of bronchiectasis in the Northern provinces of the Netherlands, is about $1{,}30^0/_{00}$, a figure corresponding remarkably well with the Bedford figure mentioned above. The real frequency is probably even somewhat higher, as shown by a limited questionnaire sent to thirteen general practitioners, covering a group of the population of 40,000 persons. This random investigation yielded a proportion of bronchiectasis cases of $2{,}2^0/_{00}$. Not included in these statistics, however, were the number of chronic and relapsing cases of bronchitis ($6^0/_{00}$), a group which in our experience usually shows more or less severe bronchiectasis. A rough estimate of $5^0/_{00}$ certainly does not seem too high for our part of the Netherlands.

D. Surgical Anatomy of the Lungs and Localization of the Bronchiectasis

Resection therapy in bronchiectasis is only possible (just as in malignant tumours, cysts and tuberculosis) if one has an accurate knowledge of the structure of the lungs, not only as regards the lobes but also with respect to the various segments. A further subdivision of the lungs to that into lobes is that into segments. A segment is usually a wedge-like part of the lung with the tip near the hilus; it is supplied by a so-called segmental bronchus, which is in fact a bronchus of the third order.

A segment is an anatomical and surgical unit, supplied by the branch of the pulmonary artery bearing the same name. If an efficient resection is to be carried out, the surgeon should be familiar with the ramifications of the pulmonary veins and arteries, in addition to his knowledge of the course of the bronchi.

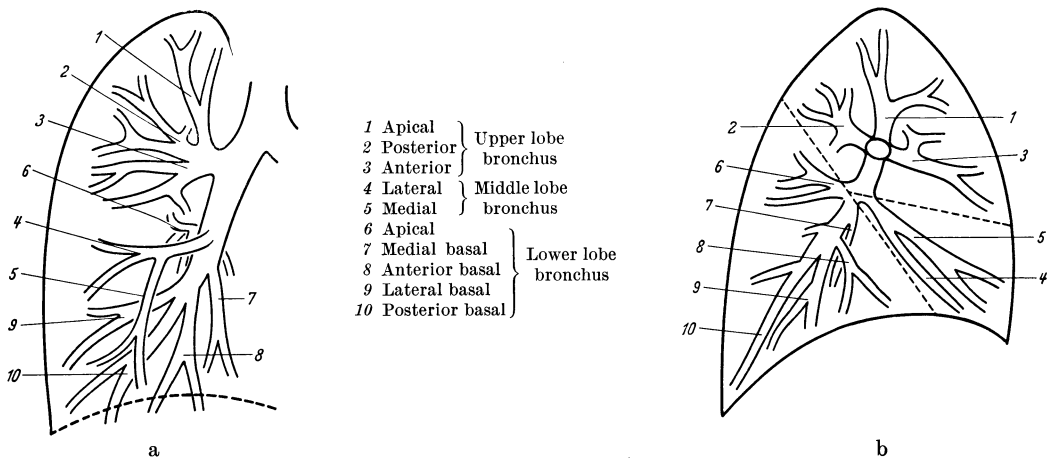

Fig. 21a and b. Right bronchogram, antero-posterior (a); lateral (b)

The segments are often separated from each other by partitions, sometimes by a deep fissure, so that a separate lobe is formed. This is observed, in 10 % of cases, in the apical segment of the lower lobes.

Accurate descriptions and schemas of the structure of the segments are given by Nelson (1934), E. Huizinga c.s. (1938—1942), Forster-Carter (1942), Jackson & Huber (1943), Appleton (1944), Boyden & Scannell (1945—1950), Brock (1947), Lucien & Beau (1947) and many others.

The subdivision into segments is very important from the clinical point of view, because a morbid process is often limited to one or more segments of a lobe; segmental resection introduced the possibility of removing only the diseased part and of sparing the residual healthy tissue of the lobe.

A great step forward was made when, in 1949 in London, agreement was reached on the terminology of the various branches of the bronchial tree. The terminology of the bronchial tree used by our team is as follows:

Right upper lobe bronchus: 1. apical; 2. posterior; 3. anterior.

Middle lobe: 4. lateral; 5. medial.

Lower lobe bronchus: 6. apical; 7. medial basal (cardiac); 8. anterobasal; 9. laterobasal; 10. posterobasal.

Left upper lobe bronchus (upper division): 1. apical; 2. posterior; 3. anterior.

Lingula (lower division): 4. superior; 5. inferior.

Lower lobe bronchus: 6. apical; 8. anterobasal; 9. laterobasal; 10. posterobasal.

The usual numbering of the bronchial branches is shown in the diagrams printed below.

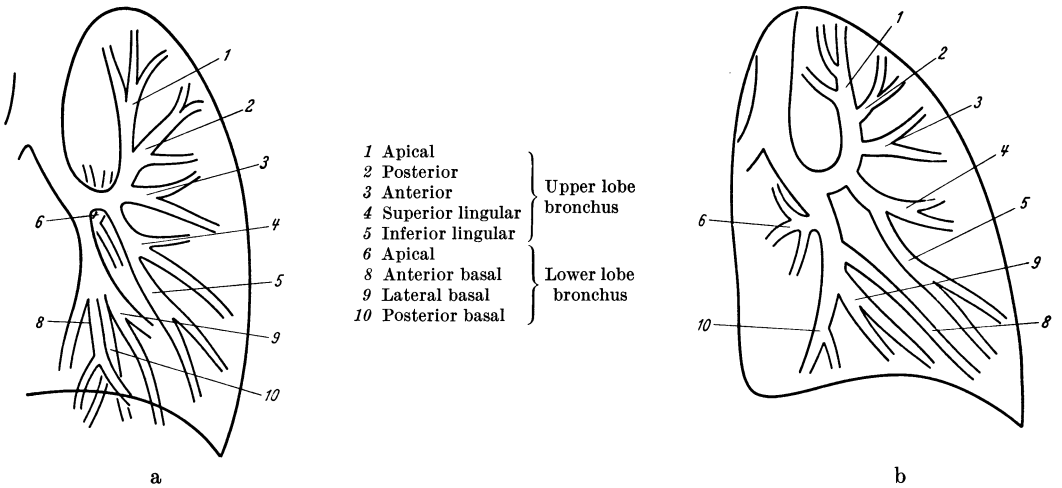

Fig. 22a and b. Left bronchogram, anteroposterior(a); oblique (b)

Topography

According to their topography, the various forms of bronchiectasis can be divided into four categories:

I. The segmental group, in which only one particular segment or several adjacent segments of one lobe are involved, without the total number of segments of the lobe being affected.

II. The lobar group, in which all segments of one or several lobes are bronchiectatic.

III. The "extended" lobar group, comprising the cases in which, in addition to one completely bronchiectatic lobe, one or more segments of the adjoining lobe are affected.

IV. The scattered or diffuse bronchiectases, the group comprising all other cases. A knowledge of the surface projection of the borders and fissures of the lung affords valuable aid in the localization of pulmonary diseases. Comparison of the anatomical and X-ray data showed that the projection of the main pulmonary fissures onto the thoracic wall deviated from what was formerly assumed. It transpired that the great oblique fissure of the lungs, formerly considered to start posteriorly at the level of the fourth rib or the third spinal process, is actually at a lower level, usually at that of the fifth or sixth rib. If one is dealing with a localized bronchiectasis or abscess of the apical segment of the lower lobe, this fact is of course of importance both for topical diagnosis and for a good operative technique.

It is evident that pathological processes in lobes may cause considerable changes in the normal anatomical relationships and the course of the fissures. The removal of the diseased parts of the lung may be effected successfully by starting the dissection in the hilus of

the various lobes and segments. It must always be kept in mind that the parietal pleura should not be sacrificed unnecessarily in these dissections, because it is of great importance in the covering of the bronchial stump.

Bronchiectasis may involve any of the eighteen segments contained in the five lobes of the two lungs. The disease is frequently bilateral, but only rarely are all the segments of any upper or lower lobe affected. The disease is bilateral in one third of bronchiectatic patients (KERGIN, SWIERINGA). OVERHOLT & LANGER found involvement of several segments in 85 % of 100 patients treated for bronchiectasis; in 30 % at least the affection was bilateral. SOUDERS even mentions 121 bilateral cases in a series of 266 patients, and WARRINGA mentions 130 out of 282.

Table 4. *Unilateral localization*

Localization		Cause of bronchiectasis									Number
Lung	Lobe	Foreign body	Stenosis	Congenital	Children's disease	Pneumonia	Bronchitis	Empyema	Abscess	Unknown	
Right	upper	—	—	—	—	—	—	—	—	1	1
	middle	—	—	—	1	—	—	—	—	—	1
35	lower	3	1	—	—	1	1	—	—	4	10
	upper + middle	—	—	—	—	—	—	—	—	1	1
	uper + lower	—	—	—	—	—	—	1	—	1	2
	middle + lower	1	—	—	2	5	1	1	—	8	18
	all	1	—	—	—	—	—	—	—	1	2
Left	upper	—	—	—	—	2	—	—	—	—	2
75	lingula	1	—	—	—	—	1	—	—	—	2
	lower	2	1	1	2	6	3	—	1	4	20
	lower + lingula	1	—	—	6	14	5	—	—	9	35
	all	1	1	3	—	4	—	1	2	4	16
		10	3	4	11	32	11	3	3	33	110

The right upper lobe, the apical and dorsal segments of the left upper lobe, and the apical segments of both lower lobes are rarely affected, and they usually compensate in size and function for the diseased parts of the lungs.

Table 5. *Bilateral localization*

Localization of the bronchiectasis	Number	Cause
A. Right lower lobe + left lower lobe	2	unknown 1 bronchitis 1
Right lower and middle lobe + postero- and latero-basal branches of left lower lobe	1	pneumonia
B. Left lung + pectoral and apical branches of rihgt upper lobe	1	congenital
Left lung + postero-basal branch of right upper lobe	1	unknown
Left lower lobe + pectoral branch of rihgt upper lobe	1	unknown
Left lower lobe + postero-basal branch of right lower lobe	2	childrens' disease 1 pneumonia 1
Left lower lobe + 3 basal branches of right lower lobe	2	bronchitis 1 unknown 1
Left lower lobe + cardial and postero-basal branches of right lower lobe	1	bronchitis
Left lower lobe + lingula + lateral branch of right middle lobe + cardial branch of right lower lobe	1	children's disease
Left lower lobe + lingula + middle lobe	1	pneumonia
Left lower lobe + lingula + postero-basal branch of right lower lobe	1	pneumonia
Left lower lobe + lingula + 3 basal branches of right lower lobe	2	pneumonia 1 unknown 1
Total	16	

The disease occurs 2—3 times as frequently in the left as in the right lung. This is especially true for children, in whom the left lower lobe particularly is affected. The most frequent localization of bronchiectasis is in the left lower lobe, and especially the three basal branches and the lingula of the upper lobe.

The site of predilection on the right is in the middle lobe and in some basal branches of the lower lobe. It is difficult to explain the preference for the basal bronchi. In the chronic phase, the most marked dilatations are usually found in the branches of the second to fourth order in the segmental bronchi. The maximal extent is in general as far as the bronchi of the tenth order (REID, DUPREZ, WHITWELL).

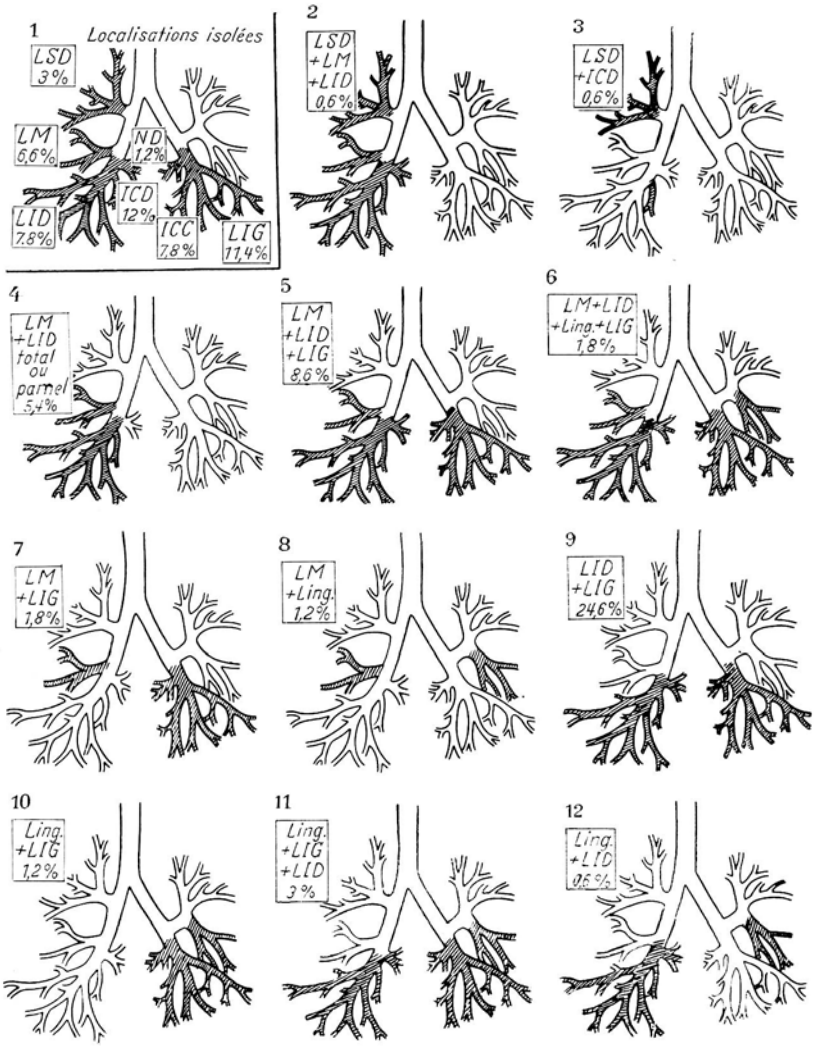

Fig. 23. Percentual localization of bronchiectasis (SOULAS and MOUNIER KUHN)

The localization and cause of our first 126 surgical cases of bronchiectasis have been collected by SWINNEN in the tables 4 and 5. The figures refer to operative material.

When establishing the cause of a given case of bronchiectasis, it should always be kept in mind that the cause mentioned in the above table may also be the result of an already existing bronchiectasis as well as of a condition underlying both affections (see the chapters on aetiology and pathogenesis).

Idiopathic bronchiectasis in one of the upper lobes alone is of a relatively very rare occurrence. In these cases one should always think of a tuberculous process that may be secondarily infected.

The solitary middle lobe localization should also be mentioned. GRAHAM, BUFFORD & MAYER (1948) were the first to describe the "middle lobe syndrome" as a separate clinical entity. PAULSON & SHAW (1949) reported 32 similar cases. SEBESTENY observed the syndrome 18 times. Further publications to be mentioned are those of BROCK (1950), RUBIN and HEKKING. The essentially pathological process of the affection consists of an obstruction of the middle lobe bronchus resulting in atelectasis, pneumonitis and fibrosis of the middle lobe. In 15 of PAULSON's 32 cases the bronchial obstruction had been caused by swollen, later often calcified, hilar glands. The affection is not exclusively confined to the middle lobe, but various mechanical factors, dependent on the anatomy

of the bronchial tree, promote the localization of bronchiectasis in the middle lobe. Compared with the other lobar bronchi, the lumen of this particular bronchus is narrow (on an average 6—8 mm. in an adult).

According to BROCK, the lymph nodes of the middle lobe hilus are highly important in the development of the middle lobe syndrome. These lymph glands are not only localized on both sides of the bronchus underneath the artery, but also in the angle directed towards the lower lobe.

The swelling of the lymph nodes may have been caused by unspecific as well as by specific inflammation. In view of the rare occurrence of bronchiectasis in sarcoidosis (BOECK), the pressure exerted by unspecifically swollen glands should not be emphasized too much. Oedematous swelling of the bronchial mucosa may also cause severe changes in the middle lobe.

GØRGENYI et al. found atelectasis of the middle lobe, caused by swollen and probably infiltrating lymph nodes, in 198 (17,1 %) of 727 children with epituberculosis.

In SOULAS-MOUNIER-KUHN's series of 200 cases, the percentual localization of the bronchiectasis was as shown in Fig. 23.

E. Classification of Bronchiectasis Based on the Morbid Anatomy; Pathological Physiology

From a morbid anatomical point of view bronchiectasis is usually divided into cylindrical and saccular forms. The production of sputum and the severity of coughing are not in proportion to the degree of bronchial dilatation. Saccular bronchiectasis is sometimes asymptomatic, while large amounts of purulent sputum may be produced in a case of cylindrical bronchiectasis. Some cystic-saccular forms (Fig. 24) may show a striking resemblance to congenital cystic lungs, as described on p. 240.

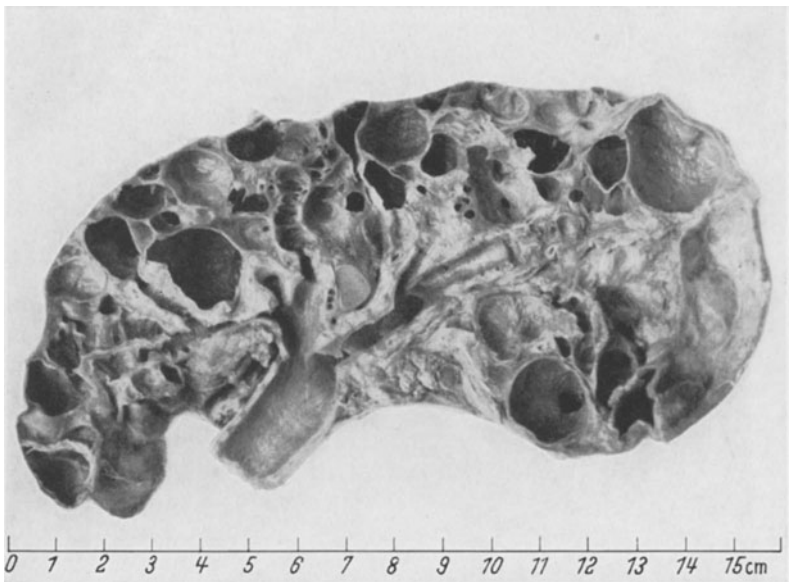

Fig. 24. 21-year-old male, HM 23. 6. 49. Congenital sacculated cystic bronchiectasis of left lung

The macroscopic picture depends on the degree of atelectasis, fibrosis and inflammation of the pulmonary tissue. Some degree of shrinkage is usually present, also due to repeated infection. There are parts with pneumonic consolidation and extensive fibrosis. The dilated bronchi are pressed close together and contain a mucopurulent substance. The mucosa is swollen, with scattered ulcerations in rare cases. There are also cases in which the dilated bronchi are surrounded by practically normal pulmonary tissue (Figs. 25 and 26). Purulent foci may be present in the pulmonary tissue. The pleura above the diseased lobe is usually thickened, but there are also numerous cases with no pleural adhesions at all, even when there are extensive areas of bronchiectasis (LANDER & DAVIDSON). As a matter of course the regional lymph nodes are very often swollen, due to unspecific inflammation.

Broncholiths are occasionally found in association with bronchiectasis (Schmidt; Clagett & McDonald). These concretions may enter the lumen from the wall of a bronchus, from the surrounding pulmonary tissue or they may be formed in situ within a bronchiectatic sac. Most broncholiths are calcareous, and appear to be derived from remnants of calcified bronchial lymph nodes, presumably of tuberculous origin.

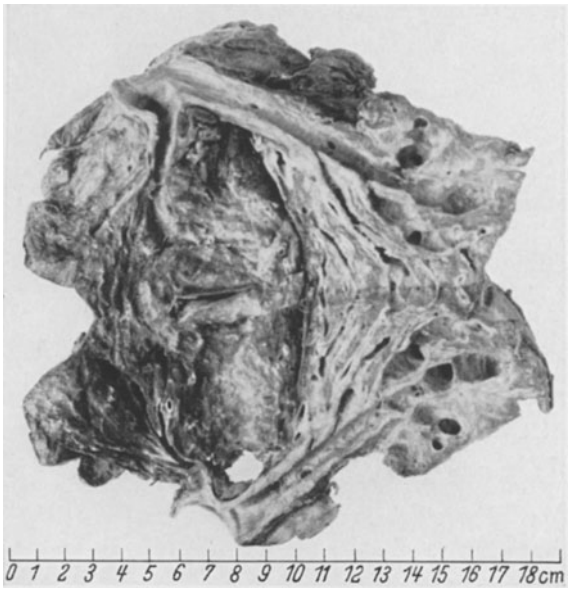

Fig. 25. Marked induration with bronchiectasis of the right lower lobe. Normal air-containing tissue, but still ampullary bronchiectasis in the right upper lobe

In long-standing cases, bronchi, blood vessels and glands in the hilar region of the lobe or lung may have grown together into one mass, the so-called frozen hilus. Dissection may be greatly impeded by these adhesions.

Atelectasis affects the mediastinum and the contralateral lung; this results in a displacement towards the affected side and a compensatory stretching of pulmonary tissue. The following schema summarizes the findings of Whitwell, Dijkstra, Duprez and Reid (table 6); our clinical experiences and the valuable clinical data of Whitwell are elaborated in it.

It is not so strange that the "atelectasis" group is not mentioned in the material of Duprez and Reid. Reid emphatically excludes "secondary" forms. Duprez does distinguish the tuberculous group in his discussion, but later mentions only one case of it. The descriptions of others (Dijkstra; Magnin et al.; Whitwell), however, make it probable, and quite in agreement with clinical experience, that dilatations of a different type may be formed following tuberculous bronchial obstruction, in which the infection factor is only of minor importance and bronchiolar obstruction is absent. These forms constitute only the minority in surgical statistics on "bronchiectasis operations". Sometimes (as in the middle lobe syndrome) it is conceivable that the infection arising later (see the average high age of Brock's group, for example) still causes bronchiolitis with obstruction of the bronchioli. In a number of these cases, tuberculous changes in the periphery will of course give rise to occlusion of the bronchioli. It is moreover understandable that, after a protracted and anatomically fixated collapse of an atelectatic lung, the bronchioli no longer open up if the obstruction is abolished. A proper understanding of this can only be provided by further study of a group with secondary bronchiectasis of tuberculous origin. Finally, it should be kept in mind that in a number of cases attention will be drawn to bronchiectasis of a tuberculous nature, by the simultaneously present local or general inclination to bronchitis (Alexander). These latter forms of bronchiectasis, therefore, are not distinguishable from the idiopathic types. The differences are insufficiently shown by the X-ray picture, because this is

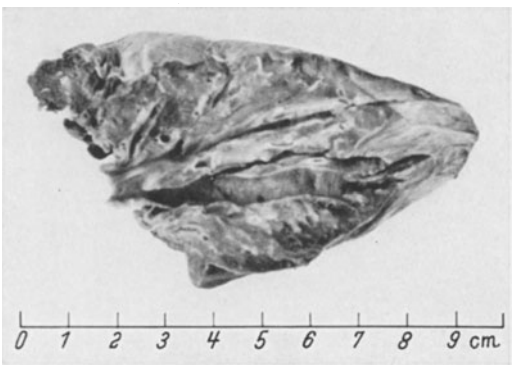

Fig. 26. Cylindrical bronchiectasis in normal pulmonary tissue

mainly determined by the presence or absence of collapse of the most peripheral parts, and by the collapse of the lobe or the segment.

The difference (as described by GORDON & PRATT) between "idiopathic" bronchiectasis in which the dilatations would appear to continue as far as the periphery and the vascular pattern is normal, and the bronchial dilatations after tuberculosis in which the dilatation fills only partially and the vascular pattern shows marked changes, corresponds only partially with the preceding anatomical observations. In idiopathic bronchiectasis marked disturbances in vascularization are frequently observed, as shown by the observations of KOCH, LIEBOW, MARCHAND, GILROY & WILSON, and ROOZENBURG, even though some features of the above mentioned basic pattern are also recognized.

Table 6

	Idiopathic bronchiectasis		Bronchiectasis on tuberculous basis
WHITWELL	follicular	saccular	atelectatic
DUPREZ	preterminal	terminal	sporadic terminal ?
REID	cylindrical	varicose	sporadic saccular ?
Bronchiolitis	moderate	marked	none
Infection	++	++	slight
Epithelium	intact	intact	intact
Destruction bronchial wall	varying	varying	slight
Number of branches	8 and 16	4—8	normal ?
Lymphoid proliferations	present	present	usually absent

It therefore seems probable that in principle there is a difference between the idiopathic and the post-tuberculous forms of bronchiectasis, but there are indications that this difference is levelled out by secondary infection and peripheral tuberculous processes. This needs further investigation, however.

Roentgenologically, the atelectatic bronchiectatic lower lobes give rise to the typical triangular shadows beside the heart.

Attention should also be directed to the condition of the blood vessels in bronchiectatic lungs. *Pneumo-angiography* has provided very important data on this subject. Bronchiectatic pulmonary areas show a retarded and reduced blood flow. The vessels that are visible are thinner than normal, somewhat irregular, they lie closely together and are distorted owing to fibrosis with retraction of lung tissue. AMEUILLE et al. reported these findings in 1938, but their investigation concerned extremely diseased lungs. WEISS, WITZ & KOEBELE observed in less advanced pulmonary changes that there was an incongruence between the slight blood flow on the angiocardiogram and the relatively mild abnormalities of the pulmonary arteries found in their resection specimens. Some authors think in this respect of a pressure on the vessels exerted by swollen glands and periadenitis, others rather of vasomotor reflexes, for the blood flow is sometimes strikingly reduced in the healthy part of the lung as well. The flow of blood is restored after resection of the affected part of the lung. HEEMSTRA's phenomenon affords a better explanation, as emphasized by J. W. KOCH. This phenomenon is a reduced pulmonary flow in the parts of the lung with a low alveolar oxygen tension due to deficient ventilation.

It is common knowledge that the alveolar ventilation is bad in bronchiectatic areas. The bronchioli are more or less obstructed, which greatly impedes ventilation, or limits it to collateral ventilation. The bronchi moreover contain much secretion, and the dead space is larger, while the elasticity of the lung is decreased by the peribronchial fibrosis, and many alveoli are destroyed. The bronchogram therefore shows that only small amounts of lipiodol reach the periphery of these areas; the small bronchi do not fill. The decreased ventilation causes a low alveolar oxygen pressure, and little blood will flow even through the healthy arteries.

Lindskog's observations might give rise to the deduction that there is also interference with ventilation in the adjacent healthy parts of the lung, and that in these areas the pulmonary flow is also considerably reduced, according to Heemstra's phenomenon. This hypothesis cannot explain the fact, however, that sometimes no filled vessels at all are found in a lung with local bronchiectatic changes of moderate degree, unless this be attributed to the marked development of the bronchial circulation (Liebow et al.; Marchand et al.; Roozenburg).

Study of a bronchiectatic lobe makes it conceivable why the respiration is impeded: the dilated bronchi are usually filled with secretion. The bronchiectatic spaces are separated from the alveolar parenchyma by obliteration of the distal bronchial ramifications. The ventilation of the pulmonary parenchyma must therefore take place via the so-called collateral ventilation. In the lower lobes the basal segments are very often bronchiectatic, and the ventilation is collateral, starting from the apical segment, because this is usually normal.

If all segments of a lobe are involved, as is the case in severe bronchiectasis, the pulmonary tissue is atelectatic. Nevertheless, undersaturation of the blood is only seldom observed in an atelectatic lung. This implies that only a small amount of oxygen-poor blood, or none at all, flows through the pulmonary parenchyma that does not participate in the respiration.

Various causes can be indicated to account for this fact. In the first place, the diseased rigid pulmonary tissue is not subject to the changes of form of the thorax during respiration which contribute to the circulation of the blood. A further cause is that the bronchial arteries are markedly hypertrophic in bronchiectasis, extensive anastomoses existing between the bronchial arteries and branches of the pulmonary artery (Wood & Miller; Liebow, Hales & Lindskog). The higher pressure in the first-mentioned vessels prevents the blood from the region with low pressure flowing towards the diseased pulmonary parenchyma. These two mechanisms cooperate in directing the blood flow towards healthy and functioning pulmonary tissue.

The conclusion is that, if there is much diseased pulmonary tissue as a result of bronchiectasis and its sequelae, a great strain is imposed on the right heart, due to the hypoxia and the shunt from the bronchial towards the pulmonary circulation. This fact makes the prognosis worse if the myocardium has already been damaged by other causes. There are occasional observations of improved pulmonary function after exstirpation of the diseased pulmonary tissue.

The Sequestrated Lower Lobe

In this abnormality, an arterial branch originates in the abdominal or thoracic aorta and runs to the right or left lower lobe. According to Holmes Sellors, Cole, Alley and Russell this malformation occurs in about 1—2 % of all pulmonary resections. The area supplied by this arterial branch is not regarded as an extrapulmonary lobe, but as an interlobar sequestration or bronchopulmonary dissociation (Pryce; Holmes Sellors & Blair), i.e., an amputation of a bronchial bud from the growing bronchial tree in the early embryonic period, caused within the lobe by a persistent artery. The bronchial system of such a lobe may be connected with the bronchial tree, or it may have no communication at all with it. The artery with its branches follows the course of the dissociated bronchi, or it ramifies in the usually cystically degenerated sequestrated lobe. The cysts may become infected via possible bronchial communications, and also haematogenically or directly; thus attention may be directed to the affection.

This abnormality should be kept in mind in the event of all purulent, recurrent processes of the lower lobe. The dissociated mass usually lies in the posteromedial part of the lower lobe. The only correct treatment is resection of the lower lobe, in which the surgeon

should be on the alert for abnormal vessels; no vessel should be divided without ligation. If this is omitted, haemorrhage from the abnormal vessel difficult to check may be the result.

Four cases have been reported in which the patient was lost owing to uncontrollable bleeding (HARRIS & LEWIS 1940; MOORE 1940; BUTLER 1947; DOUGLAS 1948).

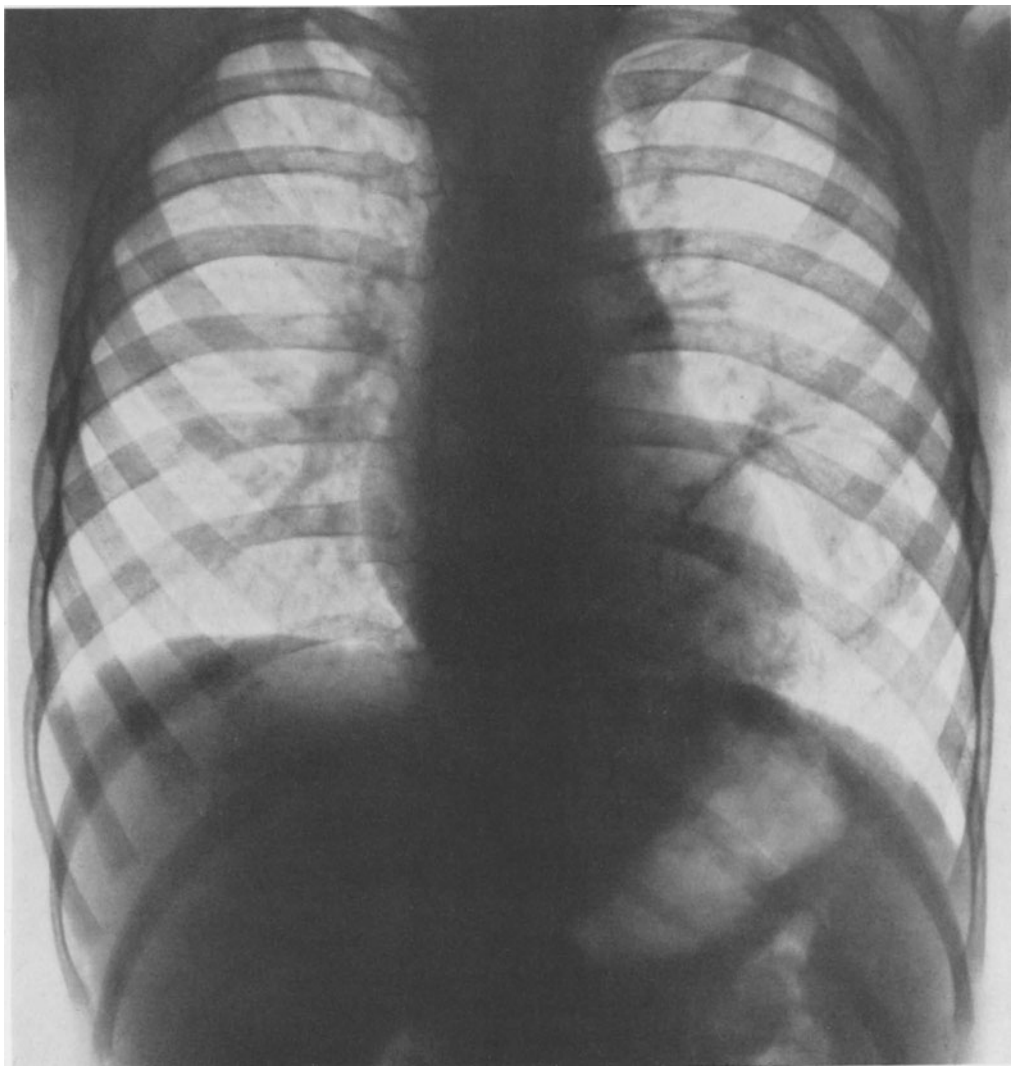

Fig. 27. 2-year-old girl. Three cysts are visible in the left lower region. HM 2. 6. 1954

A good example of a sequestrated lower lobe was the observation described on p. 239, concerning a 33-year-old woman (HM April 29th, 1949). Another example is the case history of a 2-year-old child:

G. L., female, age 2. HM June 2nd, 1954.

In January 1953 the girl had had a pneumonia on the left side with fever and cough. In the autumn of that year there was a relapse. She was admitted with the diagnosis of cystic disease of the lower lobe, the latter showing three cysts on the X-ray (Fig. 27). The PIRQUET was negative, the blood picture normal. Bronchography did not reveal any abnormalities.. The whole left lower lobe was displaced somewhat in an upward direction. On June 9th, 1954 the left lower lobe was resected (EERLAND). The operation was difficult because of adhesions. A thick abnormal blood vessel ran

— from the aorta through the diaphragm—towards the lower pole of the lobe in the region of the cysts. This blood vessel was divided after ligation. Recovery was uneventful.

Operation specimen (No. 82,336, Prof. Vos). Cross section revealed three cavities, varying in size from that of a marble to that of a pigeon's egg, with moderately thick walls, and with a smooth surface. The pulmonary tissue in the apical part was emphysematous. The thickened wall of the cysts was

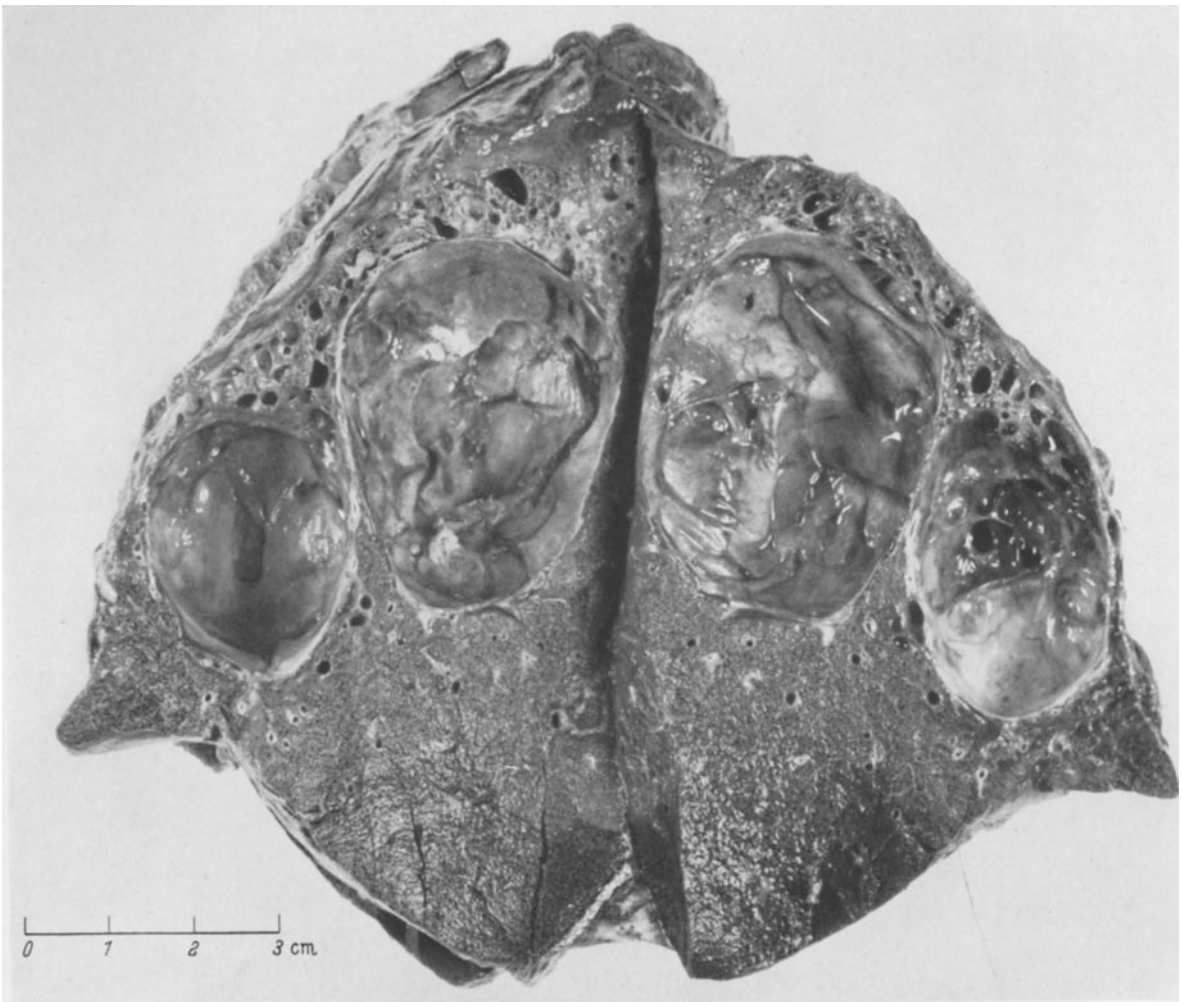

Fig. 28. Operation specimen of sequestrated left lower lobe with cysts and compensatory emphysema. Mild bronchiectasis. There is a thick artery with an abnormal course towards the lower pole of the lobe

not lined with epithelium but with non-specific granulation tissue. Small bronchial branches and pulmonary lobuli in the apical segment were distended.

Diagnosis: Cysts with compensatory emphysema and chronic oedema in the left lower lobe; minimal bronchiectasis (Fig. 28).

F. Signs and Symptoms: Diagnosis of Bronchiectasis (Ordinary X-ray Findings, Bronchography, Bronchoscopy, Sputum Examination, Pulmonary Function Tests)

History. The symptoms are very probably largely dependent on the pathogenesis of bronchiectasis. It is a generally accepted fact that bronchiectasis with a tuberculous background usually gives rise to but few symptoms. Symptoms, if present, are mostly coughing, expectoration of sputum, and repeated febrile infections, but these are considerably less severe than in "idiopathic" bronchi-

ectasis. Haemoptysis constitutes an exception to this rule. Although we do not possess sufficient statistical data about this, we still have the impression that in dry, asymptomatic bronchiectasis haemoptysis is scarcely less rare than in the forms with bronchitis. Severe stenosis of the lobular bronchi is often still demonstrable in cases of strictly localized bronchiectasis of tuberculous origin, which show serious signs of recurrent or continued infection[1].

The signs and symptoms occurring in idiopathic bronchiectasis are usually of a mixed nature; a fairly good impression of the relative frequency is probably given by the following survey of 100 patients from our personal series.

Symptoms (100 personal cases).

Coughing	98	"Spastic" manifestations	42	Haemoptysis	26
Dyspnoea	55	Pain	32		
Pneumonia	50	Fatigue	32		

SOUDERS mentions as main symptoms.

Coughing	267	Dyspnoea	149
Sputum	254	Pain	113
Pneumonia	154		

When comparing these figures with the symptomatology of tuberculosis, one is especially struck by the high incidence of dyspnoea.

The *local physical signs* are often not very marked. Occasionally a squeaking or buzzing rhonchus is heard in the lung, either diffused or in the affected region. Sometimes, but certainly not always, more or less finely sibilant rhonchi are heard in the basal lobes. If the affected areas are more extensive, a lagging behind of the diseased part of the lung during respiration, and a less good mobility of the borders, are demonstrable. These cases fairly frequently show pleural involvement. A more or less severe degree of emphysema is not rare, and is probably associated with the asthmatic factor. In our opinion, however, emphysema is certainly not always present.

General manifestations are usually absent; cyanosis is only rarely observed, mainly in very extensive and diffuse affections, usually accompanied by marked emphysema. These are also the cases frequently accompanied by overstressing of the right heart. This arises especially readily in this group of cases, because of the severe hypoxia due to the bronchial infection. It should be regarded as a complication of the bronchiectasis rather than as a symptom. We have no very exact knowledge of the clubbed fingers which are often present in cases of bronchiectasis. Their presence is not quite in proportion to the severity of the affection, but they are especially found in advanced cases. It is not known under what circumstances the very rare syndrome of PIERRE-MARIE—"ostéopathie hypertrophiante pneumique"—arises.

Anaemias of the secondary type are sometimes observed, especially in extensive bronchiectasis accompanied by severe infection. In spite of the occasionally present hypoxia, polyglobuly is a fairly rare manifestation.

X-ray picture. In bronchiectasis of tuberculous origin the X-ray picture usually clearly shows stripey changes in the apices, although the pattern shown by these areas may be practically normal. A picture still showing marked characteristics of previous atelectasis is less frequent, while calcified glands—indicative of a previous bronchial stenosis—are also observed only in a minority of cases.

The idiopathic forms may have quite normal X-ray pictures. Symptoms sometimes consist of a somewhat stripey pattern of the lower areas, which may be recognizable as such both on the normal X-ray and on the tomogram.

The localization in the middle lobe or lingula can sometimes only be verified by radiological examination in the lordotic position. If one is searching for bronchiectasis,

[1] Tuberculous bronchiectasis does, of course, also occur in patients who are already chronic coughers owing to other causes.

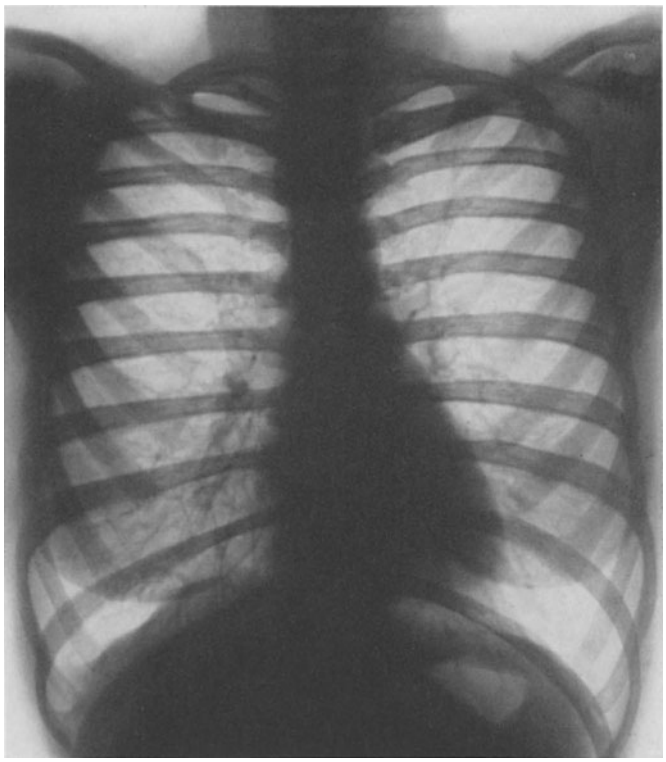

Fig. 29

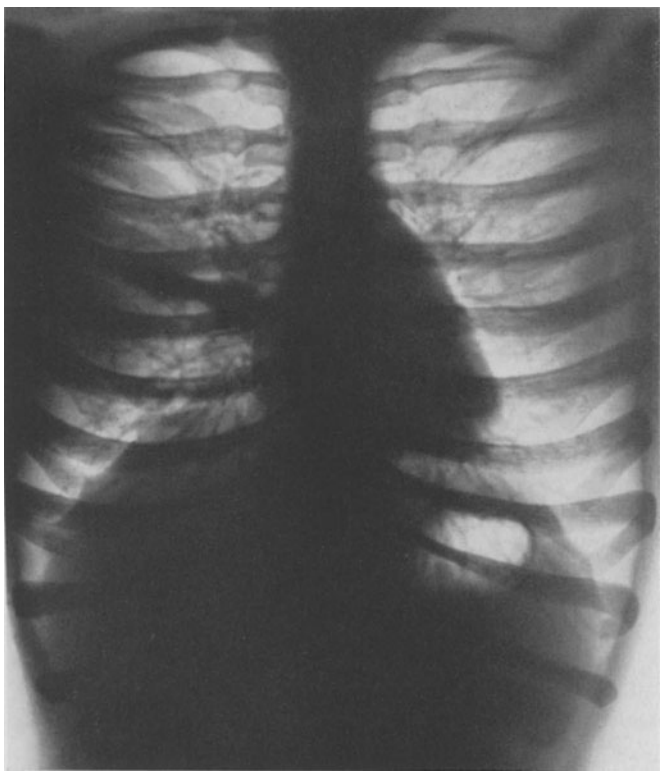

Fig. 30

examination in lordosis (Figs. 29 and 30), as well as fluoroscopy in other positions, should certainly not be omitted.

The only radiological indications are not rarely adhesions of the phrenico-costal sinus or elsewhere; pericardial adhesions in particular occur fairly frequently. Apart from pleural adhesions, a less good or even unsatisfactory mobility of the diaphragm is a not uncommon occurrence, but it should presumably be attributed rather to the associated emphysema. A local emphysema posterior to or in the neighbourhood of bronchiectatic areas is frequently observed, and occasionally marked atelectasis is visible, especially in the basal branches next to or in the shadow of the heart.

This is the picture formerly often described as mediastinal pleuritis.

Tomography. This method of examination sometimes reveals the dilatation even without lipiodol or demonstrates bronchial stenoses or deposits of calcium in the bronchial walls. Particularly in processes (usually of tuberculous origin) in the apical segments of the lower lobes, sagittal tomography is an important aid in the interpretation of shadows of doubtful nature.

Bronchography. The facts described above have demonstrated the great, and indeed

Fig. 29 and 30. H. M. de V., female, age 23. Irritative cough, attacks of dyspnoea, abundant glassy sputum. The antero-posterior photo does not show evident abnormalities, but the lordotic position clearly demonstrates the reduced middle lobe which is intrinsic to bronchiectasis. Sputum was purulent, mucous, and infected with *Haemophilus influenzae*

invaluable significance of bronchography in the study of the extent, severity and localization of the affection. HUIZINGA emphasized the importance of the "rest photo"; this is illustrated by Figs. 31, 32 and 33.

The technique employed may be that of SICARD & FORESTIER with lipiodol, or water-soluble preparations may be used, in which, as we believe, there is scarcely any sense at

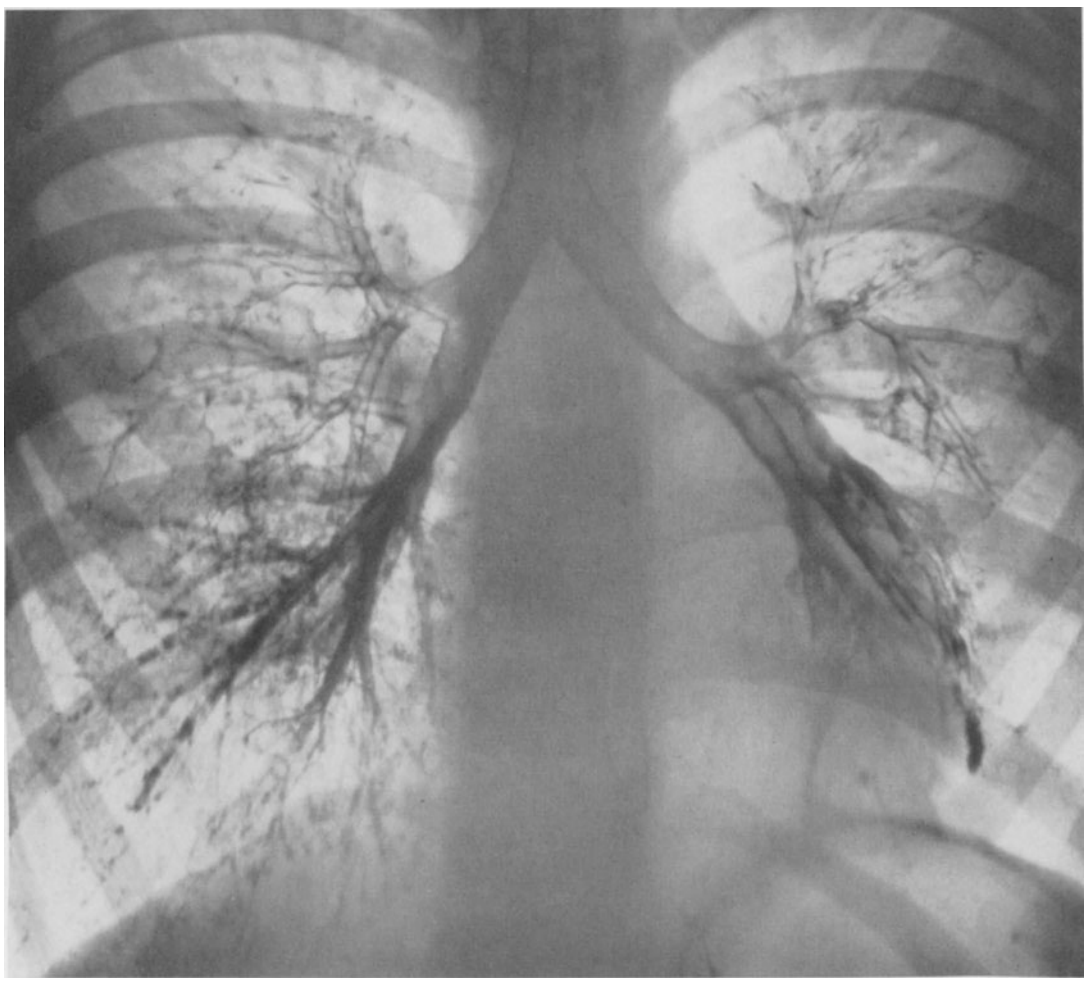

Fig. 31. "Restphoto". Dorsoventral photo of 7-year-old boy. Cylindrical bronchiectasis of left lower lobe and lingula. The right side is normal

present, although in particular cases these are to be preferred to the classical lipiodol method (J. MCKECHNIE). On the other hand, damage to the pulmonary tissue, especially by preparations containing carboxymethylcellulose, has been reported (VISSCHER). The use of lipiodol combined with sulphonamides, however, has proved to be an important step forward (BARIETY; HOUGHTON & RAMSAY). The addition of other substances to increase the viscosity has also proved of value, even though a faultless technique will remain a sine qua non if good results are to be obtained (DIRIENZO; HUIZINGA & SMELT; LEMOINE). Great difficulties may still be met in the correct interpretation of the picture, in spite of perfect filling, especially due to the incredible adaptability of the bronchial tree in the available thoracic space. These difficulties are most manifest in post-operative efforts to study the remaining segments on the bronchogram. This is sometimes scarcely possible, because the branches left, are displaced and thus fill the open space after the resection.

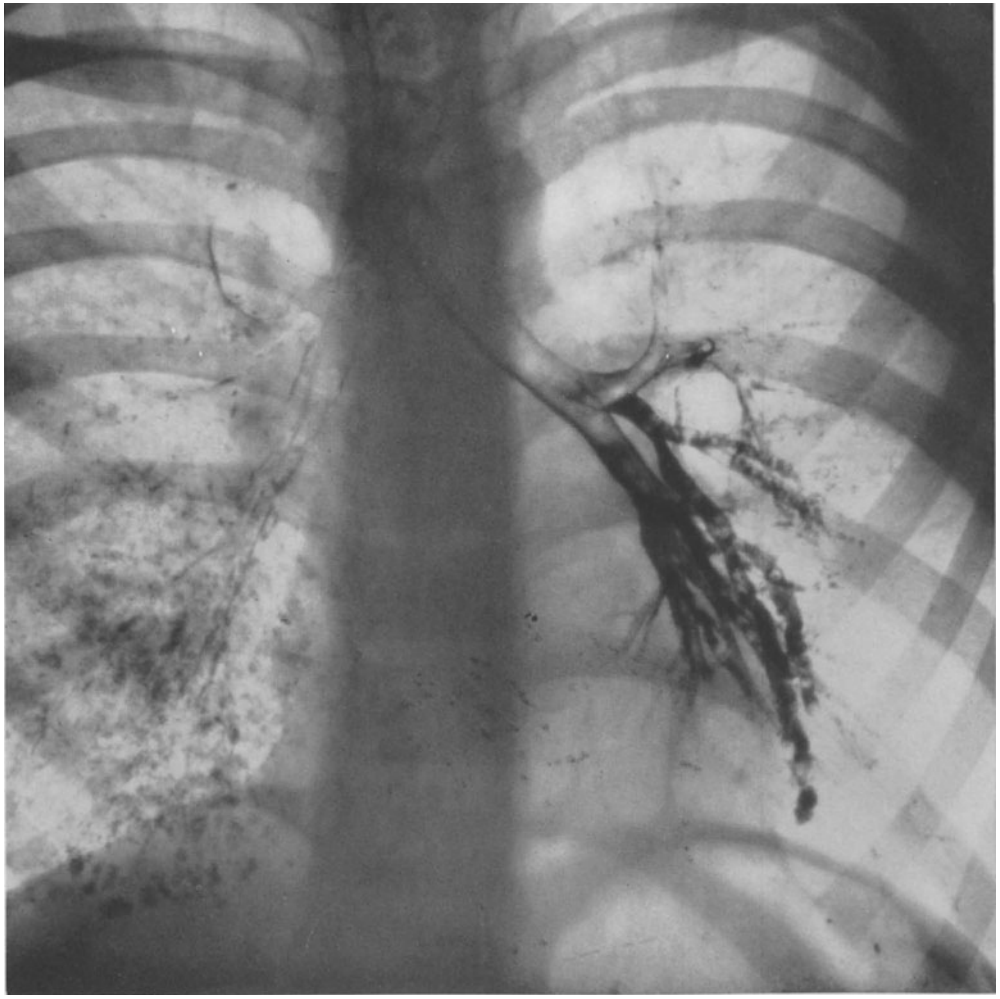

Fig. 32 "Restphoto". 7-year-old boy. After lying on his left side the left bronchiectasis shows up much clearer. This is the so-called rest photo, important for the diagnosis: a well-known "trick" of the Groningen Centre. The lipiodol has flown over

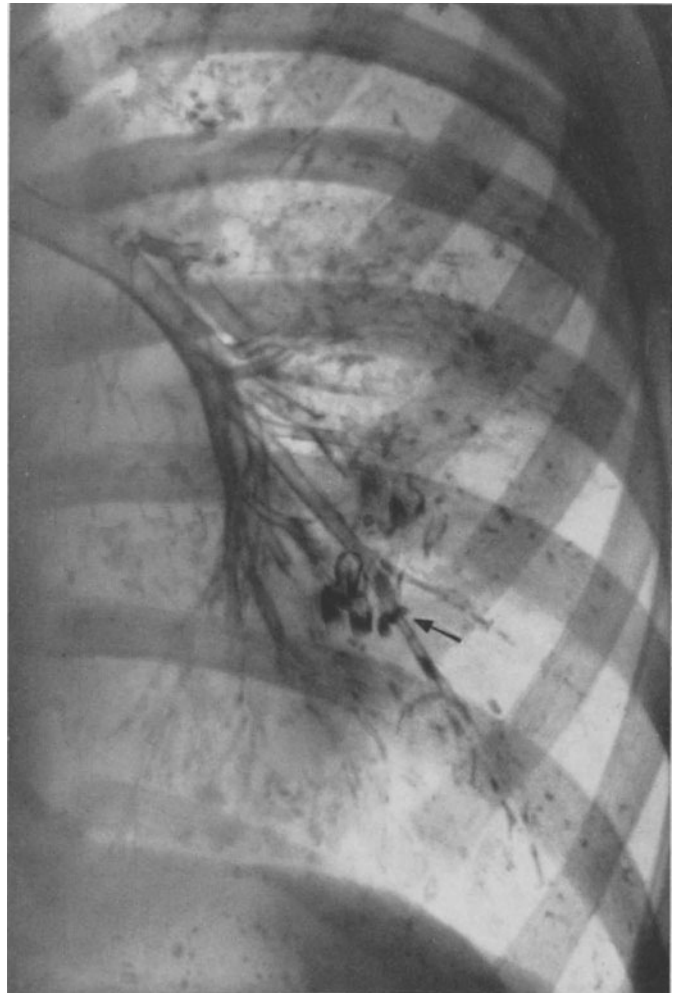

Fig. 33. "Restphoto". As in Fig. 32, after the child had been lying in such a position for 30 minutes that the left posterior part of the thorax formed the lowest point. The bronchiectasis in the left lower lobe is now evident. This is an advantage of the rest photo

An adequate knowledge of the manifold and rare variations is also among the strict requirements to be fulfilled by those who have to interpret bronchograms.

Fig. 35. 23-year-old male. Bronchography for better localization of foreign body near arrow in branch of left lower lobe bronchus. Bronchiectasis of left lower lobe. Foreign body was removed bronchoscopically

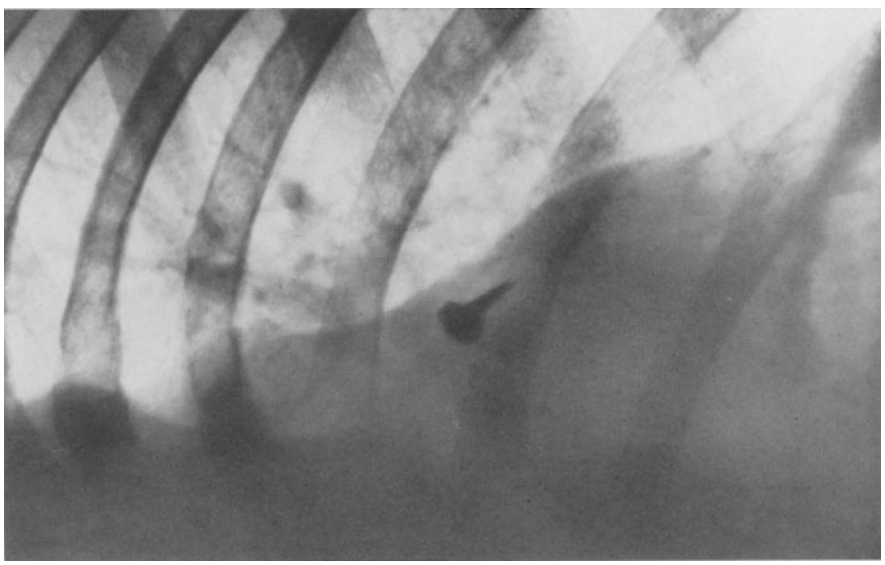

Fig. 34. 23-year-old male, with a tack in the left lung for many years

Figs. 34—37 give some examples of bronchiectasis caused by aspirated foreign bodies. The pictures do not need further comment.

Bronchoscopy. Bronchoscopy usually contributes only slightly to the establishment of the diagnosis of bronchiectasis. Redness of the bronchial ostia and traces of secretion or larger amounts in the branches may be indications of a higher or lower degree of inflammation in particular areas. This method of examination may however yield important data, because unexpected causes of the dilatations are often only found on bronchoscopy.

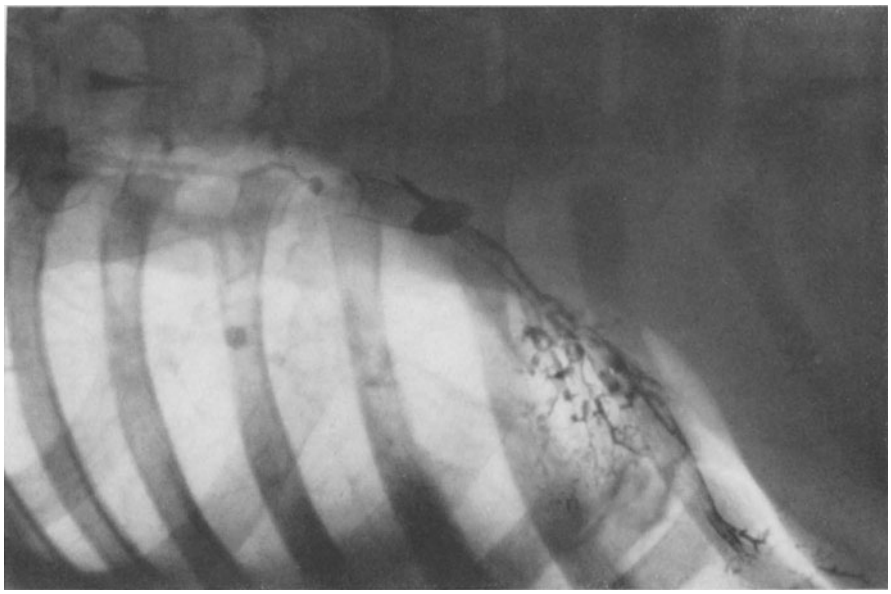

Fig. 37. 5-year-old girl, with a tack in the main bronchus for three months. A little lipiodol was used for localization. Collapsed middle lobe. Bronchiectasis of lower lobe

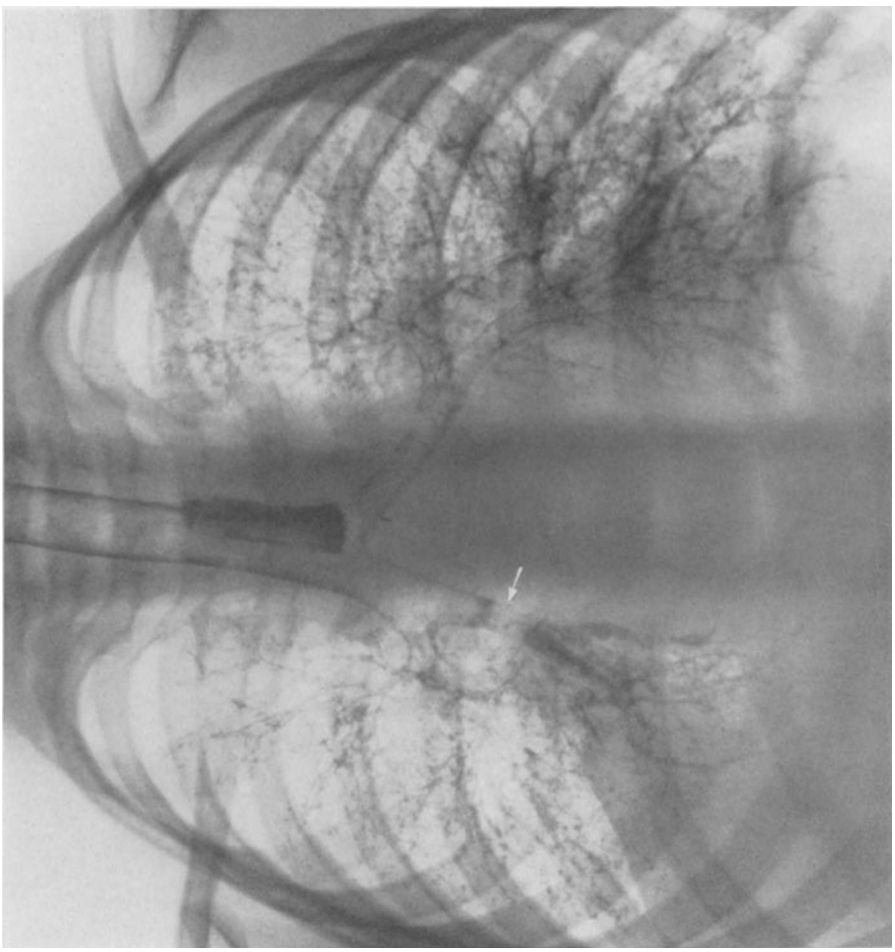

Fig. 36. 2-year-old girl, with a peanut in the right main bronchus for ten days. The bronchogram shows this clearly as an open space near arrow. Bronchiectasis has already developed in the right lower lobe

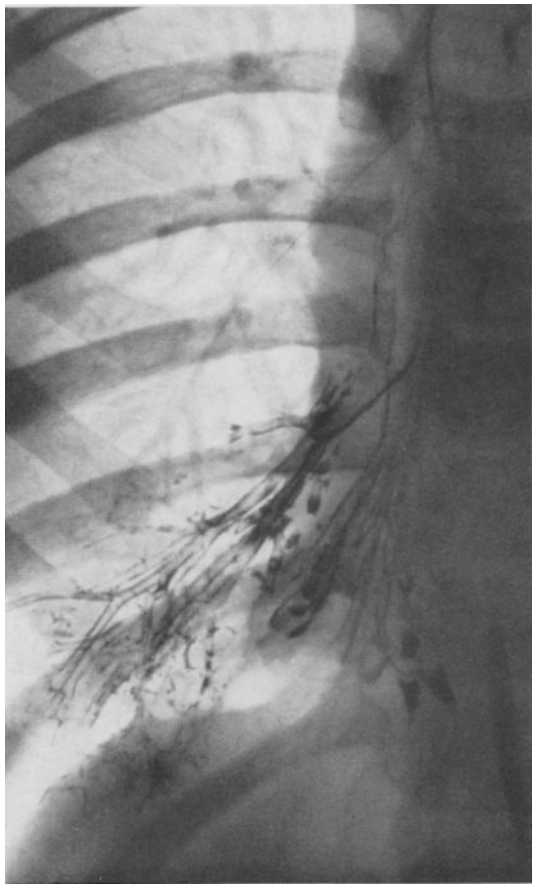

Fig. 38. 5-year-old girl. Bronchography six months after removal of tack. Expansion of middle lobe has improved. Bronchiectasis of right lower lobe

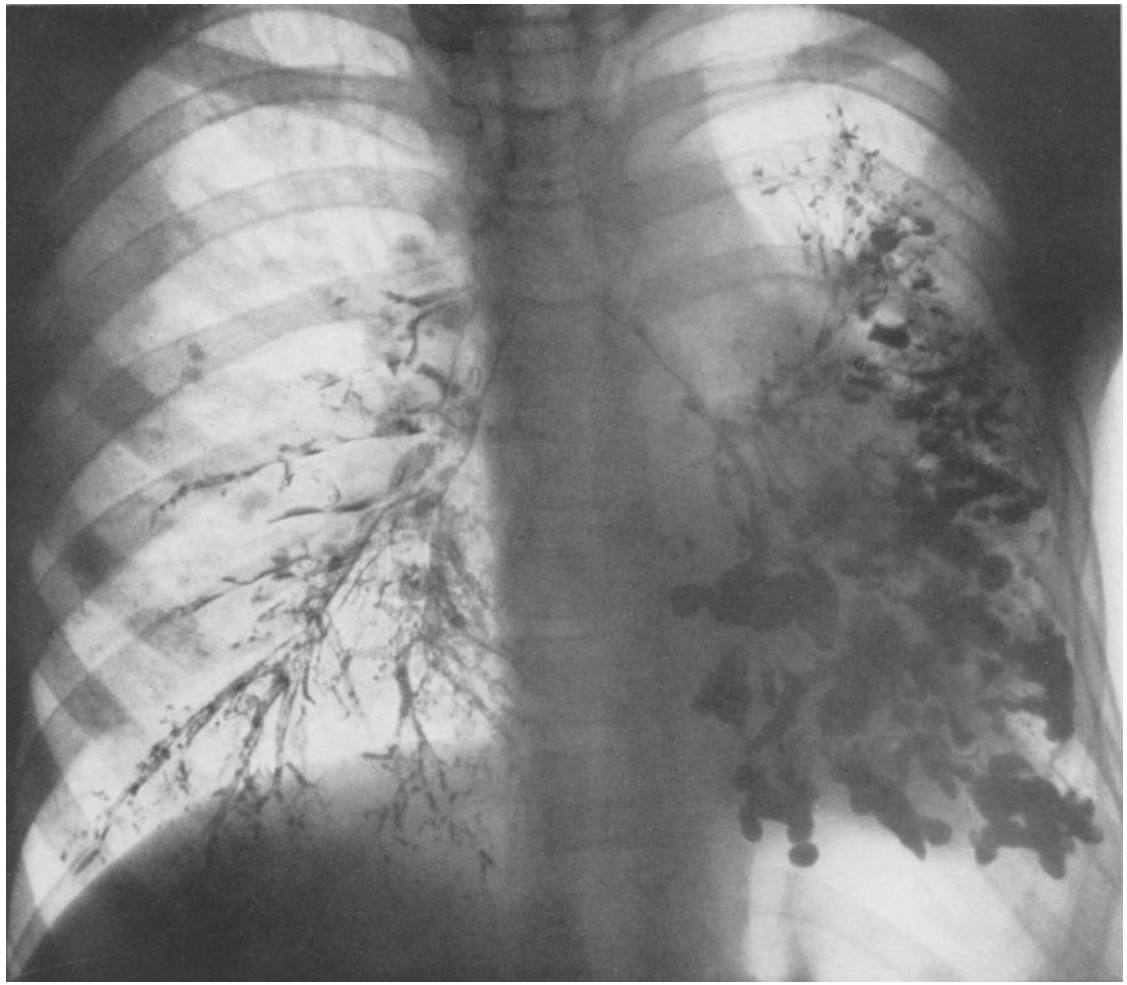

Fig. 39. Dorsoventral photo of 9-year-old boy. Bronchiectasis of the whole left lung due to foreign body. Large ampullae. Right side is normal; recovery after pneumonectomy

Bronchial adenoma, and may be even more frequently a *foreign body*, are not rarely recognized as the cause of bronchiectasis on bronchoscopy.

Case report. J. E., male, age 64. The patient had suffered from recurrent bronchitis with dyspnoea since 1950. His father had a chronic cough; his son suffered from hayfever. The vital capacity was 2,465 ml. (normal value 3,455 ml.). The one-second value of the vital capacity was 41 %. Residual volume/total capacity × 100 = 41 %. Functional residual volume/total capacity × 100 = 63,9 %. Functional residual volume/total capacity × 100 on exertion = 70 %. On auscultation, bilateral squeaking rhonchi were heard.

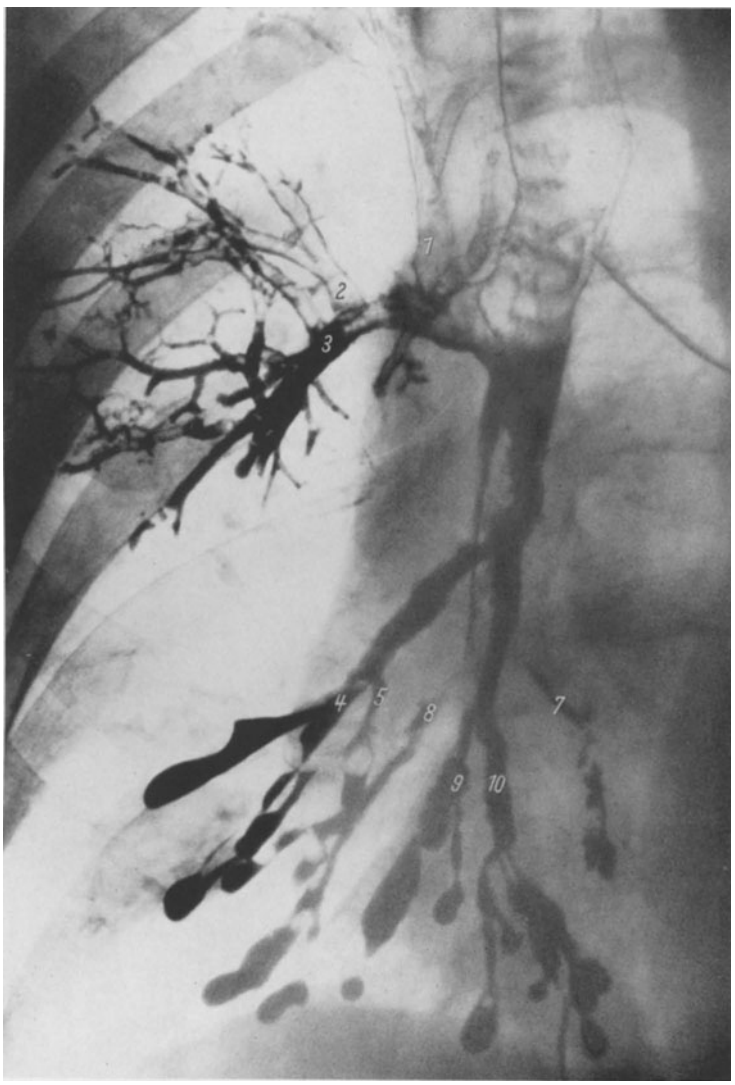

Fig. 40. 64-year-old male with aspirated piece of duck bone in right lower lobe

Although there were numerous signs pointing to a diffuse affection, and although this was presumably present as well, the lipiodol photo (Fig. 40) indicated a local process in the right lower region. This was due to the aspiration of a piece of duck bone in 1951. It was removed bronchoscopically in 1954.

Laboratory examination. This usually also contributes but little to the diagnosis of bronchiectasis, although occasionally it is of value in the recognition of complications.

Blood eosinophilia (although often absent—see ISRAELS) may in given cases favour a probable diagnosis of bronchiectasis of asthmatic origin, especially if the number of eosinophil cells markedly increases after successful treatment. Laboratory examinations should never be omitted, however, because sometimes their results are both diagnostically and therapeutically of importance. *Examination of the sputum*, if carried out with care, usually demonstrates two species of bacteriae: *Haemophilus influenzae* in the chronic cases, and a pneumococcal infection super imposed on it in the cases with an acute exacerbation of the symptoms. J. MULDER emphasized the importance of these micro-organisms, in a great number of publications. Acute infections will usually readily yield to sulphonamides and antibiotics. The resistant *Haemophilus influenzae* (PFEIFFER), however, is often difficult to deal with, due to its slight sensitivity as well as to its localization in badly accessible tissues. Even if an apparent success has been obtained, the treatment still proves to have been not radical enough in the course of time.

The characteristic *Haemophilus* flora—especially if this is found in the typical autolytic sputum—will not only be of value for choosing the correct treatment of the infection,

but will also favour the establishment of the diagnosis of bronchiectasis. This flora generally shows marked differences from that in pulmonary abscesses, for instance, while often no non-tuberculous infection at all is found in tuberculosis or sarcoidosis.

The alternate occurrence of purulent and eosinophil sputum is often also a strong indication of bronchiectasis.

Pulmonary function tests. On the one hand the pulmonary function examination may be of high importance because its results can also be regarded as a criterion of the severity of the affection, on the other hand it may be an aid in the determination of the type of bronchiectasis. It should not be forgotten that the functional disturbances may be partly due to complicating fibrosis or emphysema.

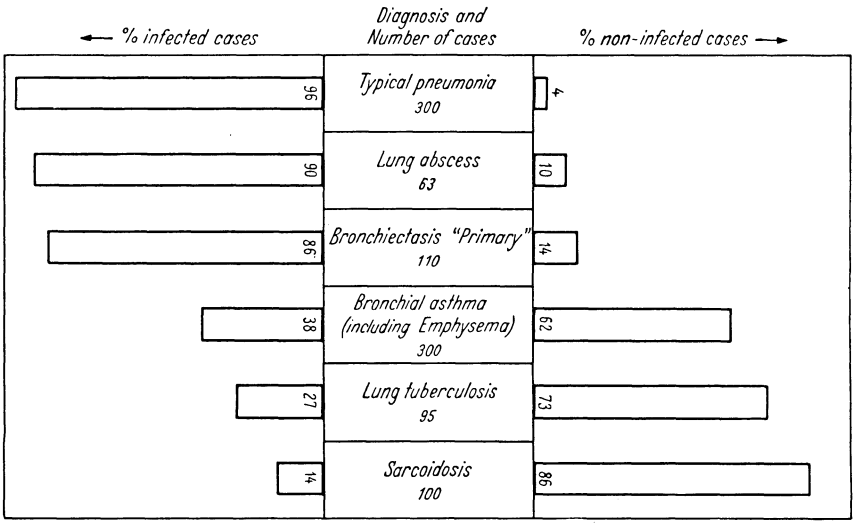

Fig. 41. Non-tuberculous infections in different pulmonary diseases

The finding of changes in the functional pattern after administration of adrenaline and histamine, and the presence of an unsatisfactory expiratory rate TIFFENEAU; GAENSLER (1950)], and a considerable residue or functional residue, are indications of an asthmatic pathogenesis, of great importance in estimating the indications for operation.

It is therefore a matter of course that no operation should be carried out without previous extensive and accurate pulmonary function tests, because thus the functional severity of the process and the functional results of a resection are clearly expressed in figures, and because it moreover enables us exactly to find out with which form of bronchiectasis we are dealing. The latter knowledge is of high significance in view of the post-operative complications, as it is well recognized that the chronic cougher with a tendency to bronchospasm seldom shows a completely uneventful post-operative course. The results of the function tests will only rarely decide whether an operation can be tolerated. An operation is seldom indicated if there is already a considerable loss of function, or if this is to be feared due to the operation. The transformation of the often young bronchiectasis patients into "respiratory cripples" should be avoided as far as possible. In the case of carcinoma and sometimes also in tuberculosis, one is earlier inclined to take this risk.

The schema printed below may serve as an example of a form for a routine examination of a patient about to undergo pulmonary resection. Some determinations may of course be omitted, if the results can be forecasted with certainty. In older bronchiectasis patients, however, it is particularly desirable to adhere to the complete schema: a) to limit the risks for these patients as much as possible; b) to know what post-operative complications are to be expected; c) to avoid turning patients into "respiratory cripples"; d) to contribute to a more precise determination of the causes of operative failure, a comparison with the post-operative function tests then being possible.

Name: No.

Diagnosis:

Length in standing position: Department:

No.

Weight:

Age:

Date			Normal Value			
F. (= respiratory frequency)						
Vital capacity						
V.C. after adrenaline-histamine						
C.U.S.	Utilisable—part of the V.C./sec. and, $^1/_2$ sec. idem after adrenaline		> 70 %			
Utilisable part of the V.C. on exertion						
Expiratory reserve volume						
R.M.V. (= respiratory minute volume)						
M.R.M.V. (freq. 30 or more)						
(Maximum R.M.V.) = Maximum breathing capacity						
M.R.M.V./V.C.			> 20			
Residual volume		% T.C.	< 25 %			
Funct. resid. capacity in rest		% T.C.	< 40 %			
on exertion		% T.C.	< 40 %			
Broncho-spirometry	V.C. ri lung	% of V.C.	55 %			
	V.C. le lung	% of V.C.	45 %			
	O_2 upt. ri lung	% of V.C.	55 %			
	O_2 upt. le lung	% of V.C.	45 %			
Arterial blood		Norm.	Rest	Exertion	After 15 % O_2	After 99 % O_2
	O_2 sat.	> 94				
	p_H	7.40				
	Alk. res. (vol. %)	45—55				
	p. CO_2 (mm. Hg)	36—40				
Pulm. art. pressure	p. art. pulm. syst. diast. mm. Hg					
	p. art. pulm. average cm. H_2O					
Elasticity	cm. H_2O/500 ml. oesophagus					
	v. cava sup.					
Circulation time						
E.C.G.						
X-ray						
Conclusion						

Fig. 42

The following four determinations should be carried out in every case:

a) Vital capacity + adrenaline effect, b) one-second value of the vital capacity (TIFFENEAU, GAENSLER) + adrenaline effect. c) Maximum breathing capacity, d) Residue or functional residue during rest and exertion.

A more extensive survey of the methods used is given by the following—mostly comprehensive—articles: CARA et al.; TIFFENEAU; GAENSLER; GEELEN; HIRDES; ROSSIER; SIMONIN; DONALD; COURNAND et al. (1941); VAN DER STRAETEN & VERBEKE; COURNAND & RILEY; BOLT gives a very good review of the most important literature from the German school; KNIPPING and his collaborators have made a special study of this subject. BUYTENDIJK surveys the work carried out by the Groningen Institute of Physiology (DIRKEN) on the elasticity, a factor which—together with the viscosity—will be of great importance in future years, especially when evaluating the severity of bronchiectasis cases. ZIJLSTRA gives an extensive report on the methods of oxygen determination, and describes extensively his personal experiences with the BRINKMAN apparatus. The oxygen and carbon dioxide saturation of the blood is an important factor, especially when emphysema is present (COMROE; SEGAL and DULFANO).

G. Complications of Bronchiectasis

There are various complications, almost exclusively in the idiopathic type.

a) *Local complications*, in the form of bronchopneumonia and pleuritis (or empyema) are very frequent. These may, in turn, give rise to fibrosis and pleural thickening. They are often of great importance in the disablement resulting from the bronchiectasis. These complications sometimes also cause bronchopleural—or pleurocutaneous—fistulae, a rare but serious occurrence. Emphysema is also frequently encountered in greater or lesser degree, and should probably be regarded as a manifestation associated with the asthmatic diathesis rather than as a complication of the bronchiectasis. This idea is supported by the fact that emphysema is only rarely observed in bronchiectasis of tuberculous origin. Independent of this form, more localized bullous emphysema sometimes occurs as well. Both complications may lead to a third one: overstressing of the right heart. Ideal conditions for this complication are formed by a combination of fibrosis, emphysema and chronic diffuse infection [COURNAND; MCMICHAEL; DENOLIN et al. (1952)]. An acute infection is then often sufficient to provoke the decompensation. It should still be kept in mind that it is particularly the infection factor which is of decisive importance, while the circulation is usually only slightly impeded by fibrosis plus emphysema in the absence of infection (ORIE et al.). An imminent decompensation of the right heart can therefore not always be determined from the X-ray picture and the ECG [LENÈGRE (1950); ORIE et al. (1952)]. Chronic decompensation of the right heart on a pulmonary basis in bronchiectatic patients frequently arises following acute infections.

b) *General complications.* Amyloidosis of the kidneys and liver usually only occurs in cases producing large amounts of purulent sputum, particularly in the event of empyema or fistulae. Although it is sometimes difficult to establish the diagnosis with certainty (RIST), this is usually possible with the help of urinalysis and functional examination of the liver and kidneys, together with the absorption pattern of Congo red and the examination of biopsies (liver). Compared with the high incidence of the disease, the complication is rare. The same holds true for cerebral abscess. During the past ten years we have observed this complication only twice out of a total of about 1,000 cases of bronchiectasis, both in hospital and the out-patient department. Progression of a bronchiectasis by "spilling over" from one bronchus to another, if present, should be regarded as a very rare occurrence.

H. Bronchiectasis and Infections of the Nasopharynx

Two facts may be considered established: a) the frequent concurrence of both affections, and b) the absence of an adequate explanation of this fact. Different figures are

given for the frequency by different authors. Some of them regard the presence of sinusitis as a primary cause, and consider the bronchiectasis to be the result of constant aspiration, for example during sleep. Although the latter possibility cannot be denied in view of the results of lipiodol experiments, it is still strange that the overflowing of pus from the sinus would lead to bronchial dilatations, while in the lung no new dilatations arise from the spilling over that must take place far more frequently and in much greater amounts. This explanation is therefore not satisfactory at all. There are moreover a large number of patients suffering from sinusitis, without—probably—bronchiectasis. The explanation of the frequent concurrence of the two affections as a "sensitive mucosa", or "susceptibility to infection", etc., is no more than another expression to describe the observation, but does not give an essential explanation. The concomitance is perhaps conceivable from the allergic point of view (Watson & Kibler). It is known that allergic nasal symptoms frequently also involve the deeper parts of the respiratory tract. Because sinusitis may be caused by obstructions due to mucosal swellings, the same factor is encountered here which might be assumed to cause bronchiectasis at a youthful age, and pulmonary abscess and pneumonia in later years [Watson & Kibler; Mulder (1953); Israels (1952); Orie (1954)]. The very frequent occurrence of sinusitis in cases of asthma not complicated by bronchiectasis (Wissler), is of importance in this respect. This is confirmed by the interesting observations of Graham in a case of bronchial fistula, in which he observed changes of the bronchial mucosa simultaneously with alterations of the nasal mucous membranes. The fact that the secretion was first *mucous*, and did not become purulent until after a few days, agrees with this idea. Still there are many open questions, and although we would like to correlate Kartageners observations on the agenesis of the sinus with the above facts, this does not seem possible with the present extent of our knowledge.

Table 7. *Some figures on the frequency of sinusitis in bronchiectasis*

Souders	(1949)	33 %
Watson & Kibler	(1939)	67.3 %
Goodale	(1938)	69 %
Clerf	(1927—1934)	82.4 %
Kourilsky . . .	(1949)	87 %
Mullin		100 %

(P. v. d. Calseyde).

I. Therapy

1. Prophylaxis

Bronchial dilatations in children sometimes develop in early youth. Cases have been reported in which the ventilation of the lower lobes was incomplete during the first two post-natal weeks, following which bronchiectasis arose. A short time ago F. L. Mendez et al. reported two such cases, a $2^1/_2$-month-old baby and an 18-month-old child, in whom pulmonary resection was successfully carried out. This author cites the investigations of Wasson in this field.

It might be desirable in newborn children to investigate radiologically whether the lungs have expanded completely, in order to resort to rational measures (suction drainage) in the case of disturbances in this expansion. This also applied to victims of traffic accidents, which may lead to bronchiectasis as sequelae, in addition to pneumonia. The same holds true for patients recovering from an anaesthetic. Apart from prevention of aspiration, breathing exercises may contribute considerably to adequate clearance of the bronchial tree. The coughing up of secretions is insufficient particularly in children; it should be taught to them. A stay in hospital of long duration is not always necessary for this purpose, because much can be done in the out-patient department, especially if the parents are sensible and willing to cooperate. Prophylaxis also comprises measures against infections of the upper respiratory tract and bronchial tree.

The possibility of unnoticed aspiration of foreign bodies (e.g. peanuts) in children with pulmonary symptoms should be borne in mind, and as soon as possible this should be

ascertained by bronchoscopy. Such an occurrence has been overlooked fairly frequently. The bronchopneumonia so often observed after measles, whooping cough, diphtheria and other diseases of childhood, should be treated with due care. Vaccination against these diseases is very important. These considerations are probably also true for poliomylitis. The treatment of infections in the nasopharynx and accessory sinuses should also be included among the prophylactic measures.

2. Conservative Treatment

Some considerations on conservative treatment are also of surgical importance. These are: 1. the treatment of infections, 2. the treatment of the asthmatic factors and emphysema; 3. the treatment of the residual conditions after infections of the respiratory tract, and their complications.

a) Treatment of Infections

Great advances have been made in this field during the past few decades. The discovery of the sulphonamides and their derivatives, as well as of the antibiotics obtained from fungi and the synthetic products equivalent to them, have brought about a true revolution in the battle both against chronic infection in bronchial dilatations and against the acute infections often superimposed on these.

As described before—and shown in Fig. 43 the flora of the chronically infected bronchial tree is rather unvarying, just as that of most other infections in various organs.

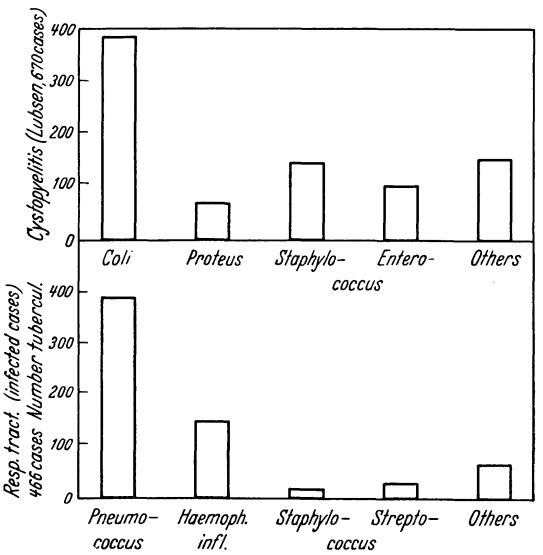

Fig. 43. Incidence of different species of micro-organism in acute and chronic bronchopulmonary infections as compared with bacterial findings in infections of the uro-genital tract (LUBSEN)

Antibacterial treatment, therefore, mainly consists in combating *Haemophilus influenzae* (PFEIFFER), which is the infectious organism in a very high percentage (about 80%) of the cases of bronchiectasis with bronchitis, at any rate in the "idiopathic" cases (MULDER 1939). *Klebsiella pneumoniae* is occasionally found, while other bacteria are sometimes observed in a small proportion in a mixed flora—often with anaerobes. In most cases, however, identification of the flora [MULDER (1953)] with determination of the resistance will have to precede treatment. If this is impossible, the line of conduct should be as if we were dealing with *Haemophilus influenzae*. This bacterium is not very sensitive to penicillin (inhibition of growth at 0.18—1.5 U./ml. in non-encapsulated strains (HERWITT & PITTMAN 1946). J. MULDER found a sensitivity of 0.5—7.5 U./ml. in 187 strains; in 75% of cases the sensitivity was between 1 and 2.5 U./ml. The sensitivity to (dihydro) streptomycin (95%: 0.5—2 U./ml.; J. MULDER) is better, but the well-known drawback is the early developing resistance.

Chloramphenicol (chloromycetin) is highly active (sensitivity 90%: 0.25—1 U./ml.; J. MULDER), while the literature usually mentions a reasonable sensitivity for oxytetracycline (terramycin) and chlortetracycline (aureomycin). This is also true, even to a higher degree, for polymyxin, and presumably for erythromycin as well. The hydro-iodide of the diethyl-amino-ethyl ester of penicillin[1] (JENSEN et al. 1950) is characterized by a higher concentration in the lung than is the case after administration of ordinary penicillin

[1] Commercially available as Bronchocillin, Deripan, Estopan, Leocillin, Neopenil, Pulmo 500.

or preparations with delayed excretion (JENSEN et al.; CHRISTENSEN). Although these observations were confirmed (GOSLINGS et al.) and the clinical results were satisfactory (PATIALA & SAROLAIM), the question still remains to be answered whether this is a more efficient therapeutic agent. The same holds true for the use of preparations with prolonged action (procaine penicillin, penicillin in wax, or in oil).

Although the sulphonamides give very good inhibition in vitro, the clinical results in chronic cases are disappointing. Treatment with massive doses of penicillin (4 millions U. daily) or chloramphenicol (2 g. daily) for 5—10 days is usually sufficient to completely inhibit the production of purulent sputum with bacteria.

The same results can also be obtained by combination of, for example, penicillin (2.5—4 mill. U. daily) and streptomycin (2 g. daily), the chances of adequate sterilization of course being better the higher the dosage and the longer the period of administration. It is still subject to discussion whether the addition of a penicillin or a streptomycin aerosol is of advantage (v. d. PLAS). We use these aerosols in our clinic. Chloramphenicol seems to be indicated as a second choice in treating *Haemophilus* infection, in spite of the fact that the risk of aplastic anaemia must always be borne in mind.

Administration of penicillin exclusively by aerosol or intratracheally is not very effective; this is due to the rather low blood titres that can be obtained (GAENSLER et al. 1949); ROOTH) and the presence of the micro-organisms deep in the bronchial tissues. The consideration that deficient blood flow in the diseased tissues might be an argument in favour of the local application of drugs, has been abandoned now it has appeared that, although the perfusion of the pulmonary arteries in the diseased area has often decreased considerably, the supply of blood from the bronchial arteries may be increased to an important degree (LIEBOW; ROOZENBURG).

Although treatment of the bronchitis in the manner described above usually gives highly satisfactory results, pneumococci or *Klebsiella pneumoniae* (which may be present simultaneously or superimposed) also being eliminated of course, the effect is only rarely lasting.

It is not known with certainty whether relapse is brought about by endogenous (inaccessible, closed foci) or exogenous causes, but many arguments can be advanced to support the first opinion.

There is much controversy as regards the desirability of continuous treatment with sulphonamides or antibiotics for the prevention of relapses. We do not know whether continuous oral or inhalation treatment is effective. We know of 15 cases out of a series of about 600 bronchiectasis patients, in whom continuous spray treatment with 100,000 U. penicillin daily or every other day, although accompanied by expectoration of sputum containing micro-organisms, led to suppression of the clinical manifestations to a great extent for several years in succession. The latter was most clearly shown if the treatment was discontinued, which was tried repeatedly in each of these patients. Apart from this limited number of successes—which are difficult to understand, in our opinion—there are many failures, and we agree with J. MULDER (1953) and v. d. PLAS that this treatment usually *fails*, and that, so far, it is impossible to *prevent* relapses in a satisfactory manner. As a rule they may be *treated* without difficulty.

Bronchoscopic aspiration of the secretions and instillation of antibiotics only rarely has a favourable influence in bronchiectasis. The same is true for similar manipulations with MÉTRAS tubes. It is occasionally possible to cure very localized processes in this way, provided the treatment is combined with parenteral treatment. Conservative antibiotic treatment should be combined with adequate *postural drainage.*

For a description of the best drainage posture for the various bronchi—of course a highly important factor—we refer to the paragraphs on pre-operative care.

b) Treatment of the Asthmatic Factors and Emphysema

We cannot give here an extensive discussion of the asthmatic aspects of bronchiectasis. This factor—irrespective of whether it is regarded as primary or secondary— should never

be neglected, particularly in the pre- and post-operative phases. Both the inhalation of sympathicomimetics (isopropyl, noradrenaline, adrenaline) and the administration of ACTH may be highly important in this period for a smooth post-operative course. It must be emphasized, however, that although asthma, if present, may be improved by the treatment of infections of the respiratory tract, measures against chronic respiratory infection may also lead to marked exacerbations and even to severe asthma, especially in elderly patients (ISRAELS). The sometimes favourable effect of climatological treatment is presumably to be attributed mainly to the influence on the asthmatic factor. The symptomatic usefulness of expectorants must also be ascribed mainly to the effect of potassium iodide and ephedrine. The significance of both mucolytic and exsiccating agents (oil of eucalyptus) in bronchiectasis, is largely unknown to us, and the exact mechanism is beyond our understanding (HOWELL). SEGAL & BARACH describe the principles of the treatment of the emphysema, often concomitant with bronchiectasis (i.e. breathing exercises, abdominal belt, pneumoperitoneum, bronchodilator drugs and ACTH after treatment of possible infections).

c) Treatment of the Residual Conditions after Infections of the Respiratory Tract and their Complications

The treatment of the residual conditions of chronic infections in bronchiectasis and their complications, should, of course, be primarily aimed at the cause, i.e., the infecting agent. Additional useful measures may be: adequate or supplementary nutrition, administration of vitamins, and transfusions of blood or plasma. These measures have fully been discussed in the pre-operative programme.

We can only deal very briefly with the treatment of the complications.

Cerebral abscess (only twice observed in our series) belongs, naturally, to the field of the neurosurgeon.

Empyema can usually be treated conservatively, if it is associated with a pneumonia developing on the basis of bronchiectasis. Cure is sometimes strikingly rapid by means of drainage and adequate local and general antibiotic treatment. The same is true for *bronchopleural fistula.*

In both conditions, surgical treatment will be more often resorted to, the greater the number of clinical and extensive fibrotic pulmonary abnormalities. But especially in these cases, however, the less favourable functional condition will constitute a serious objection. We are in an identical position with the complication: *pulmonary abscess* or suppurative pneumonia.

As soon as there are indications of the development of *amyloidosis*, operative measures should be considered without delay, and, if possible, carried out. Conservative treatment will as a rule no longer be justified in these cases. In incipient cases, removal of the purulent focus—also in marked amyloidosis—may still lead to recovery as we observed very satisfactorily in tuberculosis with secondary empyema.

The problems created by the overloading of the right heart in bronchiectasis [COURNAND et al.; ORIE et al. (1952)], are scarcely of importance in this respect, because patients in this condition, if examined properly, will never be considered for operation.

3. Operative Treatment and Technical Details in Bronchiectasis

So long as resection therapy had not developed into the safe procedure of nowadays, the cure of bronchiectasis patients was tried via other operative means. There were of course pioneers who carried out lobectomies and even pneumonectomies, but the imperfect anaesthesia and the shortcomings of the pulmonary resection technique led to such a high mortality that the operations were mainly confined to collapses, which did not take such a high toll. These collapses have become obsolete by now. The only technique to be taken into consideration is pulmonary resection, in which at present the dissecting

technique is generally employed, both in lobectomy and pneumonectomy, and in segmental resection. It is a one-stage operation in the free pleural space.

Anaesthesia was a difficult matter, especially in bronchiectatic patients producing much sputum. The use of the intratracheal tube and the modern anaesthetic technique have contributed considerably to the better results of pulmonary resection.

To counteract the overflowing of secretions to other pulmonary areas, in the Groningen clinic the bronchi of the diseased lung or lobe are tamponaded according to the technique of FRENCKNER; the BJÖRK-CARLENS tube has also been used in recent years.

We have not had a very favourable experience with the "blockers" and they were given up by our anaesthesists after some failures.

In our clinic anaesthesia is preferably given with intermittent pressure according to the method of CRAFOORD with the Aga spiropulsator of GIERTZ-CRAFOORD. An N_2O—O_2 mixture is usually chosen; curarizing agents being used in addition. In general, shallow anaesthesia is aimed at, in which we are warned against hypoxaemia and too high a CO_2 content of the blood by means of the cyclope oxymetry of BRINKMAN and a carbovisor, which records the percentage of CO_2 in the expired air.

The patient is operated on with an intravenous drip into an arm vein. We usually replace a quantity of blood corresponding to the amount lost by the patient during the operation. The blood loss during a thoracotomy is greater than is often realized, as repeatedly confirmed by measurements. When the patient is anaesthetized, thoracotomy is carried out in the lateral position, a postero-lateral incision or the modification of CRAFOORD being used. We always resect a piece of rib subperiosteally: the fifth rib in resections in the upper areas, and in the other cases the sixth rib. In a CRAFOORD incision the scapula is kept raised by means of a piece of umbilical tape, drawn through the musculature round the point of the scapula and fixed to a metal clamp placed on the top of the operating table.

After protection of the soft parts with wet gauze compresses and after detachment of any adhesions between lung and thoracic wall, a FINOCHIETTO speculum is used; we have found this the most satisfactory of any thoracic specula.

The lobe or lung to be removed is now completely freed from its surroundings, following which the dissection work at the hilus can be begun. We only give some, in our opinion valuable particulars, because the dissection technique for the various lobes and segments has been described in detail elsewhere.

The instrument used throughout the resection is a rectangularly bent KELLY clamp, such as is sometimes used in gallbladder surgery. We have completely abandoned the ligation needles of DESCHAMPS. If the blood vessel to be ligated is isolated, the first assistant inserts a linen thread centrally and distally into the KELLY clamp. The threads are drawn through and tied, following which the vessel is divided. The central ligature is tied as an interlocking ligature, because otherwise there is danger of slipping, especially if one is dealing with the main branch of the pulmonary artery and the major pulmonary veins in a pneumonectomy.

The pulmonary artery branch is usually tied off first, and then the vein, following which the bronchus is dealt with. The freed bronchus is taken into one bronchial clamp at about 1 cm. distally of the place chosen for amputation. The bronchus is severed in stages, and also closed in stages by knotted sutures of thin linen, silk or nylon, so that, when the last few millimetres are cut through, only the last suture must be made in order to obtain a completely closed bronchial stump.

During the dividing of the bronchus, care should be taken to avoid aspiration of blood and secretions and contamination of the thoracic cavity. The bronchus is always amputated as close to its bifurcation as possible, to obviate stagnation of secretions in the stump on the suture line.

We have abandoned all intricate techniques of closure of the bronchial stump in favour of the above method, which is simple and efficient.

Care should be taken not to damage the tiny bronchial branches, and the sutures should not be tied too tightly, the rule being "tight but not too tight". The final bronchial closure is a cure by second intention because a lid is formed from adjacent connective tissue, organs or pleura.

To promote satisfactory closure of the stump, the latter is always buried as deep as possible in the mediastinum; then this is closed or covered with parietal pleura. The pleural tissue necessary is taken from the surroundings and is mobilized from the mediastinal or aortic lining, either by displacement or by the formation of a pedicled pleural flap. If it has been impossible to spare the parietal pleura close to the stump, a pleural flap of the thoracic lining is mobilized at some distance, turned over and sutured in situ on the bronchial stump and its surroundings.

In a resection of an upper lobe it is often possible to place the bronchial stump behind the pleura by means of one purse-string suture, taking the surrounding pleura and the base of the middle and lower lobe in its grip; a satisfactory pleuralization is thus guaranteed.

On the right side the azygos vein is sometimes included in the suture. The needle curves around it, and when tying the thread, the azygos vein which is thus covered with pleura is used as cover for the stump.

In a lower lobe resection the threads which draw together the end of the bronchial stump, are kept long. They are doubly armed with a bent needle and drawn pairwise through the pleura after undermining the parietal pleura in a lateral direction. If the threads are tied once more, the pleura is on the suture line. The free edge of the pleura is now attached round the hilus of the upper lobe, or upper and middle lobe, so that the stump is well buried.

If we do not trust the closure in the mediastinum after a pneumonectomy, the hilar region is covered with spongostan patches. We always see to it that the region of the bronchial stump is kept dry for the first 48 or 72 hours, by means of drainage with the patient in the semi-sitting position.

Should this measure be unsatisfactory, the mediastinal zone can be brought into contact with the parietal pleura by means of a thoracoplasty; following this, adhesions form soon. After a pneumonectomy the operation is terminated by the insertion of a rubber drain at the lowest lateral point of the thorax, opening under the fluid level into a bottle filled with some disinfectant.

After a lobectomy or segmental resection we always institute suction drainage with one drain on the lateral side or with an additional drain on the front side. It is our impression that this is a better guarantee for the expansion of the spared parts of the lung. After pneumonectomy the drain is usually removed after two or three days, because we believe that it is better that the hilar region is not flooded during this period. After lobectomy or segmental resection we are guided by the X-rays, which give a picture of the expansion. We try to keep the drain open by certain measures, for example by massage of it or by syringing it with some sterile fluid. We usually insert a drain through which liquid paraffin has been squired, in order to counteract obstruction by blood and fibrin, at any rate in the beginning. So far the use of drains of which the inner surface is coated with a mixture of silicones has been an absolute failure. After lobectomy the drainage can usually be discontinued after 5—7 days.

Although at present segmental resection is also an important operation in other pulmonary diseases [tuberculosis, pulmonary abscess, pulmonary cyst, benign tumours (BRUNNER)], this new technique was used for the first time in bronchiectasis. In 1939 CHURCHILL & BELSEY published an important paper on this subject. Their "clamping method", however, has been completely superseded by operation on the dissecting principle. Nothing was known, however, about the significance of the intersegmental veins at that time. The dissection as described by CLAGETT & DETERLING in 1946, proved

to be the solution: a retrograde removal of the segment by traction on the bronchus. OVERHOLT c. s. (1951) use the same procedure. While pulling on the bronchus, a blunt dissection is carried out with the help of thumb and index finger. RAMSAY pointed to the significance of the segmental veins as guides to the intersegmental plane. These intersegmental veins are clearly visible after a successful segmental resection.

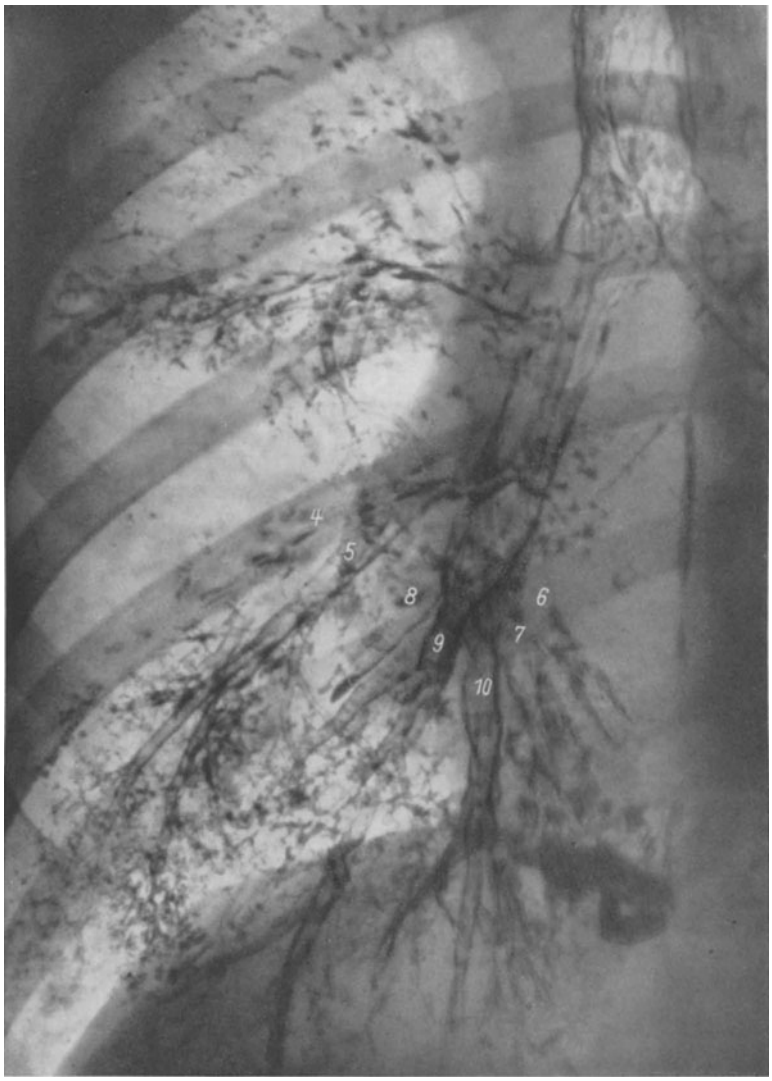

Fig. 44. 12-year-old girl. Oblique photo of right side. Segmental bronchiectasis on the right in the apical segment (6) and cardial segment (7) of the left lower lobe. Recovery after segmental resection

Figs. 44 and 45 represent a typical bronchogram and a morbid anatomical picture of a segmental spread.

In order to obtain an uncomplicated post-operative course, it is necessary to close all blowing bronchial openings, even very small ones, after the segmental resection, and to secure expansion of the spared parts of the lungs by efficient suction drainage. We always close the plane of resection by finely knotted sutures. OVERHOLT et al. leave this plane open, but we have objections to this, because, even if closure implies sacrificing of a small part of the pulmonary volume, it gives rise to less oozing of blood; this oozing may have an unfavourable influence on the pulmonary function.

Study of the anatomical relationships showed that in 10—30% of cases the intersegmental planes are crossed by blood vessels. This was especially studied, and verified by BOYDEN (see ZENKER, HEBERER & LÖHR: *Die Lungenresektionen*, pp. 89—90).

OVERHOLT is of the opinion that isolated resection of every bronchopulmonary segment is possible, without the development of circulatory disturbances in the adjoining segments. ZENKER rightly remarks that this is subject to doubt, due to the anatomical variations of the vascular tree. In pure segmental resections, only the following segments are to be considered for isolated removal: a) the apicodorsal segment of the two upper lobes, b) the anterior segment of the two upper lobes, c) the apicodorsal + anterior segments combined of the left upper lobe, d) the lingula, e) the apical segment of the two lober lowes, f) the basal segments combined of the two lower lobes.

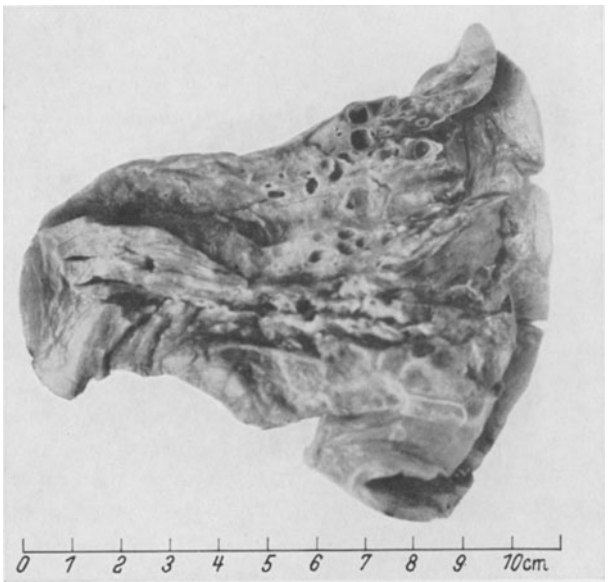

Fig. 45. Bronchiectasis of basal branches. Apical segment normal

The mediobasal, anterobasal and the latero- + posterobasal segments combined of the lower lobes can only be removed if there are certain favourable vascular relationships. These are not always clear, which may cause failure of the segmental resection. In such a case the residual pulmonary tissue proved later to serve as "filling" tissue only; it did not take part in the oxygen exchange.

In segmental resection we generally only ligate the artery and the bronchus of the segment, and only attend to the venous branches if they stretch on pulling on the segment. Wedge resections are only to be recommended if the focus is small and superficially situated. In other cases subsegmental resection or removal of the segment involved are to be preferred.

K. Pre- and Postoperative Treatment in Resection Therapy of Bronchiectasis

Pre-treatment comprises the following measures:

A. Treatment of possibly present, chronic sinusitis or chronic suppurating processes of tonsils and adenoids and of carious teeth is urgently required. Major operations had better be postponed (CALDWELL-LUC) until after pulmonary resection, as they are less well tolerated. Treatment of accessory sinuses by puncture and irrigation is to be recommended (D'ABREU).

B. The restoration of normal values of haemoglobin content and erythrocyte count. Before operation the haemoglobin content should be at least 75%.

C. Improvement of a bad nutritional condition (hypoproteinaemia, vitamin deficiencies), if necessary. The protein content and the albumin-globulin ratio of the blood must be determined. Normally the ratio $\frac{\text{albumin}}{\text{globulin}} = \frac{4.2—6.2 \text{ g. per } 100 \text{ ml.}}{1.3—3 \text{ g. per } 100 \text{ ml.}}$ In hypoproteinaemia the albumin content especially is lowered; the globulin fraction is as a rule not much reduced.

These patients are given a high protein and high carbohydrate diet and a low fat diet. Protein can still best be given by mouth, because protein synthesis is then approximately three times better than on parenteral administration, when in general 0.25—0.33% of

the nitrogen supplied is immediately excreted by the kidneys. Formerly, insufficient quantites of protein were usually given. In affections in which protoplasm is destroyed and catabolism is accelerated, and particularly in cases with loss of blood or plasma from ulcerating wounds, extensive inflammation and exudation in the body cavities, amounts of even up to 200—300—500 g. of protein daily are required.

Protein may also be given intravenously in the form of a proteolysate containing the ten essential amino-acids.

A good dosage is: 2—3 g. protein and 50—60 cal. per kg. body-weight. This means 150 g. of protein and 3,000 cal. daily for a patient of 75 kg. ELMANs nutritional formula is often used in our clinic in cases of hypoproteinaemia.

R/ Milk . . . . . 250 g.
Sugar . . . . . 50 mg.
Milk powder. . . . . 135 g.
Pure casein . . . . . 70 g.
Cocoa . . . . . 20 g.
Make up to . . . . . 750 ml.

This contains 136 g. protein and 1,670 calories.

Other foodstuffs to produce the necessary calories are: yoghourt, curds, milk and eggs, custard and sugar, and fruit juices.

In the meantime it should be realized that hypoproteinaemia is not always caused by a deficient protein supply or protein breakdown. Damage to the blood-protein regenerating mechanism may also be a factor, e.g. in cases of severe liver diseases. In acute infections the deficiency may arise rapidly, even if there is plenty of protein available. Finally, the problem has also an endocrinological aspect. Administration of testosterone is said to be protein-saving. Patients who have to undergo major surgery are routinely given the following amounts of vitamins in our clinic:

1. Vitamin A in oil (20,000 U. daily),
2. Vitamin C 1—1.5 g. daily,
3. Vitamin B complex 2 ml./day in an aqueous solution of sodium salicylate, containing:

vitamin B^1 . . . . . 10 mg.
vitamin B^2 . . . . . 4 mg.
nicotinic acid amide . . 40 mg.
pyridoxine HCl . . . . 4 mg.
pantothenic acid . . . 6 mg.

4. Vitamin K_3 10 mg. daily.

The question is raised whether vitamin K (K_1) does not involve the risk of causing a tendency to thrombosis. If the patient is fed parenterally, vitamin B complex must be injected separately and not in the infusion.

D. Measures against the infection factor by administration of chemotherapeutics and antibiotics, which are intended to sterilize the sputum and secretions and to reduce their quantities. The operative risk is much greater for a very toxic patient than when the infection has largely subsided due to medical treatment. The infection factor is mainly combated by chemotherapy, in which sulphonamides and antibiotics are very important nowadays. In a number of cases a "wet" case can be made completely "dry". Penicillin, streptomycin or other antibiotics are given parenterally; if necessary, they are also applied locally in the bronchial tree, either as an aerosol or via a MÉTRAS tube, according to the method described in the chapter on conservative therapy. In sulphonamide treatment the urine is generally made alkaline by means of a so-called "alkaline beverage." In the Groningen clinic the following preparation is used:

R/ sodium citrate
sodium bicarbonate àà . 50
syrup of orange 100
water 1000
1 tablespoonful three times daily.

In cases with much very viscid sputum, repeated bronchoscopy with suction drainage may be helpful, although effective "postural drainage", supported by the administration of the above-mentioned drugs, is usually also successful in changing a wet into a dry case. The patient's posture for emptying the bronchial tree is dependent on the localization

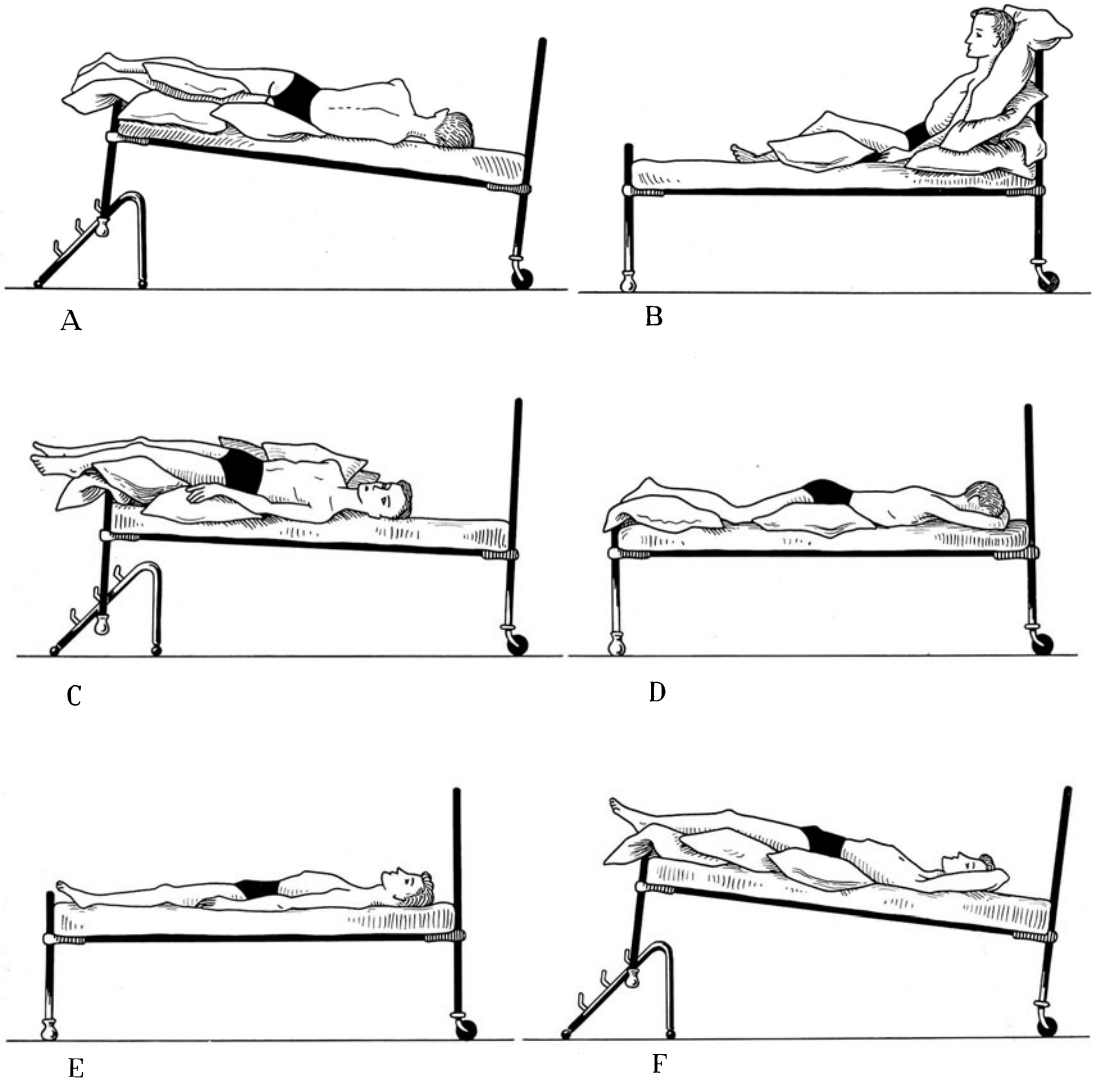

Fig. 46 A—F. Positions for postural drainage of individual segments. From D'ABREU, *A Practice of Thoracic Surgery*. Courtesy of E. ARNOLD, London. A Left lateral and posterior basal segment; B Apical segments of upper lobes; C Right middle lobe; D Apical segments of lower lobes; E Anterior (pectoral) segments of both upper lobes; F Anterior parts of both lower lobes.

of the bronchiectasis. Fig. 46 shows which position of the patient promotes the drainage of a particular lobe most efficiently.

The above-mentioned measures are not always completely successful, but it is generally possible to make the sputum more innocuous.

Overflowing of secretion during the operation with the risks of atelectasis or infection of other parts of the lung may be prevented by various measures. The choice of the position for operation is of importance here. Some surgeons strongly advocate pulmonary resection with the patient in the prone position, whereas others, including ourselves, have stuck to operating in the lateral position. However, even when using the first method the bronchus is dealt with as soon as possible in order to clamp it provisionally. Great

skill is required on the part of the anaesthetist when dealing with a case of bronchiectasis. In pneumonectomy in a wet case we like to use an intrabronchial tamponade according to FRENCKNER. When the main bronchus is divided the thick silk thread to which the tampon is attached, is cut and so the tampon, which is situated in the lung, is left in situ.

We have not made use of "blockers". BJÖRK CARLENS' tracheal tube was often employed with good results. In wet cases suction drainage of the bronchial tree with the bronchoscope has also been recommended, as soon as anaesthesia is deep enough and before the patient is turned on his side.

E. Breathing exercises under guidance are considered to be of very great importance. Many patients do not breathe efficiently, and by paying attention to this point post-operative complications may be prevented.

F. Psychic reassurance of the operation patient. Words of comfort from the surgeon are generally necessary for patients selected for operation and certainly in the case of such a serious operation as pulmonary resection. The possibility that the patient considers himself as a mere cipher is prevented, and the time given to this detail of the treatment programme is anything but lost.

G. Pre-operative institution of a pneumothorax in bronchiectasis patients is not practised any more by us.

H. Measures against thrombosis and embolism. The legs of patients with varices are tightly bandaged from the toes as far as high into the inguinal region; despite these measures thrombosis could not be completely banished from our series.

Anticoagulants are only given after resection for bronchiectasis if thrombosis or embolism is suspected, especially in elderly patients and particularly in those in whom the disease is of a hereditary nature.

I. The high frequency of postoperative collapse and infections, particularly in cases of bronchiectasis, which in our opinion is partly due to residual bronchitic, bronchiolitic, and also bronchiectatic processes in spared parts of the lung, and partly to the allergic astmathic constitution of many of these patients, has induced us to give ACTH to some of them, especially to those in whom the results of the respiratory function tests were not optimal. A suitable dosage is 10 mg. 6—8 times on the day before operation and on the day itself, 7 mg. 6 times on the third and 4 mg. 6 times on the fourth post-operative day. Doses of 25, 25, 15 and 10 mg., respectively, may also be added to the infusion. The duration of the drip should be 8—10 hours per day at least. Up to now the results are encouraging. Summarizing, it may be said that adequate pre-operative treatment will be followed by a decrease in the number of per-operative and post-operative complications.

Postoperative Treatment

Four factors are of great importance in the after-treatment of bronchiectasis cases who have undergone pulmonary resection:

1. measures against anoxaemia,
2. prevention of accumulation of secretions in the bronchial tree,
3. prevention of intrapleural infection and
4. promotion of early re-expansion of the residual lobe or lobes.

During the first six hours after operation the patient is nursed in bed, in the supine position, only the head being supported by a small cushion. For the first two or three days oxygen is administered through a special apparatus with nasal intubation, designed by BOSMAN. The oxygen is first bubbled through water.

It was determined by MAIER & COURNAND that hypoxaemia may be more severe and of longer duration after lobectomy than after pneumonectomy. This can be explained by the fact that in the immediate post-operative period, the residual lobe on the side

operated upon is badly ventilated, while during the early stages the circulation of this lobe changes but little. Because of this the oxygen saturation of the arterial blood is below normal. Oxygen is especially required if the patient's respiratory reserve is low and of course in evident cyanosis, shock or tachycardia. In prolonged postoperative coma, in addition to the oxygen saturation, the carbon dioxide tension of the arterial blood should be determined, especially if oxygen is supplied.

For patients who have undergone a resection and who are still unconscious, the supine or the TRENDELENBURG position has several advantages. The venous return of the blood is promoted and bronchopulmonary and pharyngeal secretions as well as the vomit flow to the mouth.

A pressure of 12—16 to —18 cm. H_2O in the thoracic cavity is guaranteed by suction-drainage, which is practised in every pulmonary resection, except after pneumonectomy. The drain may be removed if the amount of serohaemorrhagic fluid flowing through it has become less than 50 ml. daily. This usually happens between three and six days after operation.

From the moment that the patient has completely recovered consciousness, he is encouraged to expectorate. As a first sedative and analgesic, the patient is given 600 mg. of procaine intravenously via the intravenous drip. The advantages over opiates are that a less depressant effect is exerted on the respiratory centre and the heart reflexes. However it is usually impossible to do without pantopon, morphine and dilaudid. If the oxygen saturation is poor, one should be careful with these drugs. The daily thorax X-rays, which during the first ten days are made with the patient in bed, provide the necessary information about the condition of the lungs (atelectasis), the position of the mediastinum and the presence of fluid retention in the pleural cavity.

To prevent infections complications a dose of 200,000 to 1,000,000 U. penicillin and 0.5 to 1 g. streptomycin per 24 hours is given, the amounts varying according to age, weight and special condition of every patient. In cases of bilateral bronchiectasis and cases accompanied by expectoration of large quantities of sputum or prolonged collapse of the residual lobe, part of the dose is given by spray or in the form of an aerosol. If infectious complications occur, the doses of the antibiotics are increased and for a period of 4—6 days 6 g. sulphadiazine daily may be added, or one may change to one of the broad-spectrum antibiotics according to the nature and resistance of the flora found (see page 275).

As a rule the intravenous drip is stopped after 24 hours, because most patients are able to take fluids orally after this period, and can thus be treated efficiently with regard to proteins.

Besides a sufficient supply of proteins, ample provision of vitamins is necessary to increase the resistance against infections and tissue trauma, and to promote good wound healing.

The course of vitamin injections which is started before operation is continued for another 10—14 days after operation.

Once or twice daily breathing exercises are carried out under skilful guidance, because the posterolateral incision has more or less seriously damaged the muscles involved in movements of the arm and shoulder. The marked fall in the number of post-operative complications which follows early mobilization is also seen in cases of pulmonary resection. The patient is encouraged to perform active movements during the first 24 hours and to move the lower extremities frequently.

With the exception of cases in which early mobilization is contra-indicated (heart diseases, danger of haemorrhage, dyspnoea, low oxygen saturation, marked weakness) patients are allowed to sit for a moment on the edge of the bed or for ten minutes in a chair as early as during the first two days. In uncomplicated cases patients are allowed to walk freely about the room after a week.

L. Operative and Postoperative Complications

The *early* complications are discussed first and then the *late* ones. Apart from disturbances connected with the anaesthesia, *haemorrhages* should be regarded as one of the primary post-operative complications. Acute haemorrhage may originate from one of the greater or smaller vessels of the hilar stump, from an intercostal artery or from the subclavian artery and vein. In the course of years we have lost three patients due to this complication. A 19-year-old boy and a 12-year-old girl, in whom resection of the right middle and lower lobe, and a right pneumonectomy had been carried out, respectively. The first patient developed severe *shock* immediately after the operation, and the second one after five hours. Autopsy revealed the cause of the haemothorax: haemorrhage from an intercostal artery. The third patient, a 39-year-old man, had a "frozen hilus", so that during the pneumonectomy we switched over to a "cutting" resection. A very brittle pulmonary vein ruptured, and all attempts to stop the bleeding were unsuccessful.

Shock after pulmonary resection is not always caused by loss of blood. It was observed particularly in technically difficult operation cases with marked adhesions between lung and thoracic wall; blood transfusions were usually sufficient to overcome it. The use of noradrenaline is recommended in combating shok in patients with only slight loss of blood.

In some cases early changes of the heart rhythm were observed, tachycardia as well as atrial fibrillation with a completely irregular pulse, especially after pneumonectomy. They usually disappeared again after adequate medical treatment. Pericardial irritation is often a factor in the development of the arrhythmias, while a transient overloading of the right heart is also observed on the second and third days after operation.

1. Atelectasis

This is an important post-operative complication; it may arise in an early or late stage. The incidence has become lower since the abandonment of the cutting technique, but it is still frequent in sufferers from bronchiectasis.

The percentage of cases of post-operative atelectasis is associated with the care in the examination of operation patients. If regular X-rays are taken of the thorax during the first few days, as is done in our clinic, more cases will be recorded. Table 8 lists our findings.

Table 8

	Duration						
	Atelectasis		1—5 d.	6—10 d.	11—15 d.	15 d.	permanent
"Cutting" resection mortality 13 (28%) .	45	20	2	5	1	11	1
"Dissecting" resection mortality 2 (1.7%) .	116	26	3	6	6	9	1
Total	161	46 (28.5%)	5	11	7	20	2

The percentages reported in the literature vary between 10 (Mayer) and 33 (Gowar). In spite of a relatively high percentage of cases of atelectasis, the final results of pulmonary resection carried out for bronchiectasis have been reasonably good, as the atelectasis persisted in only two patients. All the other cases recovered under adequate treatment.

Compared with pulmonary resection for tuberculosis, the bronchiectatic patients show a greater incidence of atelectasis. This is also manifest in segmental resection, as shown by the findings of Seghers[1].

In other words, the number of cases of atelectasis following segmental resection for bronchiectasis is almost 3 times as high as in tuberculosis.

[1] Up to Jan. 1st. 1955 we have performed 512 segmental resections for tuberculosis. The incidence of atelectasis p. o. was 7.4% (38:512).

The following factors are usually mentioned as causes of atelectasis:

1. Insufficient coughing and expectoration after the operation.
2. Reduction of the calibre of the bronchi due to spasm.
3. Qualitative and quantitative changes in the bronchial secretions.

The retained secretions occlude the smaller bronchi, and the air is absorbed distal to the occlusion. The cough reflex is suppressed by the pain, and the coughing is inefficient due to the recumbent or semi-recumbent position of the patient or to disturbed movements of the diaphragm. Injury to the phrenic nerve during pulmonary resection is by no means an insignificant factor in this respect.

VAN DIJK carried out a follow-up investigation of 277 pulmonary resection cases, operated upon by us for tuberculosis in the Beatrix-oord Sanatorium at Appelscha in the period July 22nd, 1948—March 19th, 1952; in 28 of the patients an elevated diaphragm was found as a manifestation of the atelectasis. Fortunately this does not persist permanently, and sometimes it is observed after several months that the diaphragm begins to move again and that its position is lowered. In 11 of these 28 cases in which the elevation occurred directly following operation, it was cured by draining of the intrabronchial secretion responsible for the atelectasis, via the bronchoscope or a MÉTRAS tube. The harmful influence of a permanent phrenic paralysis on the pulmonary function need not be discussed here.

Table 9

Duration	Segmental resection			
	Bronchiectasis		Pulmonary tuberculosis	
	Atelectasis	Segmental resection	Atelectasis	Segmental resection
1—5 d.	2		10	
6—10 d.	5		2	
11—15 d.	2		1	
15 d.	4		2	
permanent	—		1	
Total	13 29.5 %	44	16 10 %	167

Anything affecting the activity of the ciliary epithelium (anaesthesia, oxygen deficiency, excess of carbon dioxide, increased viscosity of the sputum) causes retention of sputum.

Swelling of the bronchial mucosa and spasm reduce the calibre of the smaller bronchi. The occurrence of such an edema or spasm is promoted by the introduction of the intratracheal tube at the beginning of anaesthesia, especially when cyclopropane is chosen as the anaesthetic. For this reason this drug is contraindicated in cases which already show signs and symptoms of chronic bronchitis. These patients have a special tendency to post-operative bronchospasm.

The bronchial secretion is increased by infection and irritation of the bronchial mucosa and stimulation of the glands in the bronchial wall, which is effected by a reflex mechanism via the vagus nerve (FLOREY, DE TAKATS et al.).

Infections of the upper respiratory tract should be treated before the operation, because they increase the risk of post-operative atelectasis. Increased viscosity of the sputum due to the use of atropine and scopolamine and in a dry climate constitute a factor predisposing to atelectasis.

Inhalation of steam from a croup kettle is therefore recommended, to render the sputum more liquid.

The atelectasis sometimes involves the whole lung, on other occasions one or more lobes and often only a segment. Atelectasis is not only a sequel of pulmonary resection. Abdominal operations, especially gastric resection and gallbladder operations, are often followed by atelectasis. Segmental atelectasis is also fairly frequently found after herniotomy, if it is looked for.

The diagnosis may usually be established clinically with a considerable degree of probability and radiologically practically always with certainty.

When all cases of atelectasis are taken into consideration—including those affecting only a segment or part a of segment—their number proves to be fairly large, and the

development of post-operative pneumonia must in many cases be regarded as a consequence of the atelectasis.

If an X-ray of the side on which the pulmonary resection is carried out shows a shadow, this need not always be based on atelectasis due to retained bronchial secretion, but it may also indicate a compression atelectasis caused by accumulation of fluid or a reflex collapse. A few aspirations in case of an excess of fluid are usually sufficient. Sometimes there is a fairly spontaneous resorption of the fluid.

When discussing the treatment of atelectasis, the question of prophylaxis should not be neglected. In patients with chronic bronchitis, who are, as it were, predisposed to it, a bronchodilator and decongesting (vasoconstrictor) drug is given, following which the bronchial tree should be cleared by means of vibromassage and topical treatment. PALMER showed that the inhalation of 1 ml. 1 % isopropyl-noradrenaline 3—4 times daily in combination with physiotherapy in general markedly reduced the number of cases of post-operative atelectasis. His results were better than those of ARONOVITCH and SCURR, who used bronchodilator agents only. This prophylactic treatment of PALMER, in which physio-therapy is started 20—30 minutes after the inhalation of isopropyl-noradrenaline, is continued after the operation.

Respiratory exercises are also important, but during the topical treatment the spasmolytic allows the bronchial secretions to flow into the larger bronchi (postural drainage), following which they can be expectorated.

In case of highly viscid sputum, according to BAKER et al., the intravenous administration of 1—2 g. sodium iodide twice daily improves the condition. Here also the patient must be encouraged to cough 15—30 minutes after the injection. SIMONART recommends 15 drops of spiritus ammonii anisatus three times daily.

If atelectasis is diagnosed, we perform drainage of the bronchial tree, either via the bronchoscope or with a MÉTRAS tube. This does not help much, however, when the secretions block the smaller bronchi, although a cough stimulus may sometimes suddenly clear up the X-ray picture.

We also give inhalations of carbon dioxide, and SINNINGHE DAMSTÉ elaborated a method in which he tried to re-expand the atelectatic lobe by means of active hyperventilation in a closed system with a mixture of 5 % oxygen, 5 % carbon dioxide and 90 % nitrogen. Inhalation of carbon dioxide and low oxygen mixtures cause hyperventilation and a better liquefaction of the secretions blocking the smaller bronchi. A good result was obtained by this method in some cases (SWINNEN, cases No. 106 and 123).

As regards the inhalation of carbon dioxide, the experiments of EINTHOVEN deserve to be recalled to mind. In 1892 he found that inhalation of high concentrations of carbon dioxide caused bronchoconstriction in a dog, which could be prevented by severing the vagus nerve. On the other hand, HERXHEIMER thinks hypocapnia induces bronchoconstriction in the clinical experiment.

Sixty years later DALY et al. proved that the tonus of the bronchial musculature is controlled by the brain. In 1953 these authors once more proved this in interesting animal experiments. Bronchoconstriction arose when during perfusion of the brain a change was made from arterial to mixed venous blood. Severing the vagus nerve or atropinization prevented it.

Perfusion with anoxic and hypercapnic blood (5 % oxygen and 10 % carbon dioxide) caused bronchoconstriction, as did perfusion with anoxic (5 % oxygen + 5 or 6 % carbon dioxide) or hypercapnic (90 % oxygen + 10 % carbon dioxide) blood. In other words, blood with a low oxygen and high carbon dioxide content stimulates the vagal centres, resulting in bronchoconstriction and often bradycardia. Perfusion with hypocapnic blood causes bronchodilatation. These experiments once more stress the desirability that the carbon dioxide content be kept within normal limits by good ventilation during anaesthesia. This is the anaesthetist's duty. A check on it by a carbovisor seems indicated. Hyperventilation however is undesirable because hypocapnia promotes the tendency to shock (DIRKEN).

We must also mention the investigations of GOMAR who drew attention to the change of the direction of the upper lobe bronchi after resection of the lower lobe. Due to the re-expansion of the upper lobe and its tendency to fill up the thoracic cavity, the upper lobe bronchus is pressed downwards, so that it becomes parallel to the stump of the lower lobe. When the stump fills with secretion it is easily diffused, with a greater risk of atelectasis.

A rare cause of atelectasis is the aspiration of part of the bronchial tumour for which the resection is carried out. This possibility must therefore also be kept in mind when atelectasis has arisen. We saw a case with fatal outcome, in which during a lobectomy part of an adenoma broke off during manipulation of the pulmonary tissue and was aspirated into the other lung. The patient died in anoxia because too great a proportion of pulmonary tissue had become atelectatic.

2. Granulation or Ulceration of the Bronchial Stump

The technique of closure of the bronchus, cut off as short as possible (flush), in pulmonary resection is not directed at healing by first intention of the cut surfaces. A kind of lid is formed by the pleura used in the pleuralization of the stump, or by the surrounding connective tissue of the mediastinum. Granulation is therefore not a rare occurrence. The patient will show few symptoms as long as it remains within normal limits, but when a larger granulation plug has formed the cough stimulus and the expectoration of blood-stained sputum will reveal the condition.

In case of excessive granulation the bronchial lumen is in danger of being narrowed or occluded, with a risk of atelectasis and later formation of a constriction. Bronchoscopy reveals the situation, in so far as cases of pneumonectomy or lobectomy are concerned. It is difficult to bring the stump into the visual field after a segmental resection. The suture material of the stump, for which after many experiments we have been using thin linen thread of recent years, is often observed in situ. The sutures still present maintain the granulation. The bronchial sutures are usually coughed up by the patient or removed bronchoscopically. It is advisable to carry out the latter procedure only when the linen sutures lie practically loose, because too active measures enhance the risk of a fistula. On the other hand, uneventful healing of the granulating stump is observed when all the sutures have disappeared. Sometimes local treatment with trichloracetic acid or 40 % silver nitrate is necessary.

Table 10

1939 up to Sept. 1st, 1954 Pulmonary resection for: (cutting + dissecting technique)	Number	Number of empyemata	Number of bronchial fistulae
Bronchiectasis	206	21	19
Cystic disease	20	—	—
Chronic pulmonary abscess	19	2	1
Carcinoma	153	7	7
Sarcoma	8	—	—
Adenoma	13	—	—
Neurogenic tumor	4	—	—
Hamartochondroma	2	—	—
Arteriovenous aneurysm	5	—	—
Synovioma	1	—	—
Fibrosarcoma	1	—	—
Total	432	30	27

We will confine ourselves to the bronchial stump granulations in non-tuberculous pulmonary affections. In segmental resections for bronchiectasis a bronchial stump granulation was observed only once; it healed spontaneously. There were presumably more. Bronchopleural fistula occurred six times. Fourteen stump granulations were observed out of 117 lobectomies and pneumonectomies in the same category of patients (bronchiectasis). Most of them date from the early period when the "cutting" technique was still in use.

When the healing process of the bronchial stump is not satisfactory, a bronchopleural fistula may form, usually leading of contamination of the possibly present dead space

in the thorax. Post-operative empyemata are therefore usually accompanied by a fistula, even though this need not always be the case. In our opinion, however, some authors go too far when they contend that the empyema breaks through towards the site of least resistance. i.e., the bronchial stump, so that the bronchial fistula is secondary. In resections for tuberculosis we are dealing with tuberculous empyemata, which may easily be infected secondarily, especially when there is a bronchial fistula. The number of empyemata observed by us was 30, 27 times with a bronchial fistula. Table 10 gives particulars.

When analysing these figures it should be realized that "cutting" resections for bronchiectasis alone account for 15 empyemas. When only the "dissecting" technique cases are considered, the percentage of post-resection empyemata is much lower, namely 15:387 = 3.8%. Our complete material of 1026 pulmonary resections for tuberculosis showed 21 cases of bronchial fistula and 25 of empyema, e.i., an incidence of 2,4%.

3. Spread of the Morbid Process over the Remaining Parts of the Lung

As regards resection for bronchiectasis, spread of the infection (reactivation of minimal bronchiectasis) in the spared pulmonary tissue occurred in 9 of the first 161 cases; six times in patients operated upon by the "cutting" technique, and 3 times in the 116 "dissecting" technique cases. Re-operation was necessary in two cases of the latter series; the third refused operation for the time being. Of the 6 other patients, 2 died, one as a result of empyema and pericardistis, and the other from bronchial-fistula, empyema and amyloidosis.

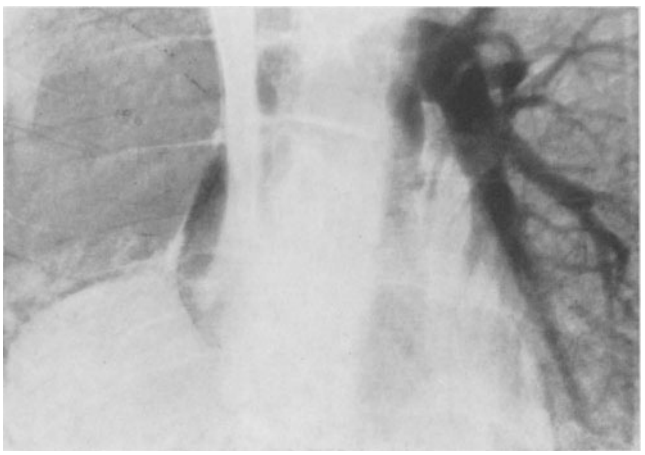

Fig. 47. Angiography. Thrombosis of pulmonary artery after resection of right upper lobe. Post-operative oxygen uptake of right lung = nil

Apart from the better operative technique and anaesthesia, the modern antibiotics and sulphonamides are now a very important factor in combating spread of the process over the spared parts of the lung. We have already referred to the harmful influence of atelectasis. Prophylaxis is of primary importance in this respect.

We do not deal in detail with the complication pneumothorax (or tension pneumo-thorax) after pulmonary resection, because the treatment does not need further comment. We have now dealt with the three main bronchopulmonary complications after resection for non-tuberculous affections of the lung. We have not discussed the pulmonary blood vessels as a possible cause, but they should be mentioned as such. During resection a wrong branch of the pulmonary artery or vein is sometimes ligated, with an adverse influence on the oxygen uptake of the part of the lung concerned. Angiocardiography may record this complication on the film. It should be kept in mind that the post-operative functional loss is greater than one would associate with the amount of lung tissue removed.

Case report. Patient M. Z., female, age 30 (H. M. 25.10. 1949). In 1949 she underwent resection of the right upper lobe for tuberculosis. Dissection was difficult, due to the many partially calcified glands.

Thirty months post-operatively there was diaphragmatic elevation on the right side and paradoxic movements. The ventilation of the right lung was 29% of total (before operation 49%). Oxygen uptake of right lung was nil (before operation 44%). The right pulmonary artery was occluded (by thrombosis?) Angiography (Fig. 47).

The operator is not always to blame. Thrombosis may have the same effect. Injury to the pulmonary artery in lobectomy or resection of segments of the left upper lobe is a dreaded accident and not always to be avoided under difficult conditions.

We finally mention oedema of the remaining parts of the lung when injudicious amounts of fluid are infused post-operatively. Critical situations may readily occur with the usual 0.9 % saline solution; there is less risk in the use of protein hydrolysate. A special warning is, however, still necessary. Small children in particular who have undergone a resection may be brought to the brink of the grave through acute pulmonary oedema when too great quantities of fluid are given.

M. Results and Prognosis in Patients Treated Conservatively and in Patients Undergoing Pulmonary Resection

In order to understand properly the surgical indications, the following points have still to be discussed: the short-term results of a) conservative and b) surgical treatment, as well as the long-term prognosis of a) conservative treatment and b) of surgical treatment.

1. Results

a) Short-term Results of Conservative Therapy

Immediate results are good after treatment with adequate doses of the antibiotic to which the patient is susceptible (cf. the chapter on conservative therapy). The sputum can almost always be made sterile, although the possibility that foci of infection persist in the bronchial tree in certain cases, cannot be excluded. A few months after treatment, however, the results are not satisfactory, as explained by M. C. VAN DER PLAS. After a short time there is usually a relapse. According to our experience, the more diffuse the affection and the more it is complicated by asthmatic reactions, the more often does this relapse occur. The presence of anatomical changes in the minor bronchi might also be a factor. More continuous treatment does not improve these results very much, although there are some favourable exceptions. The prognosis of acute complications of bronchiectasis (abscess, empyema) has become much better, while their incidence has decreased.

b) Short-term Results of Surgical Therapy

The results of pulmonary resection for bronchiectasis are determined by the primary operative mortality and according to whether the symptoms disappear completely, partly or not at all.

Sometimes considerable improvement occurs, but certain signs and symptoms may persist or new ones may arise.

Of the less serious, but for the patient still troublesome symptoms, those of pain in the thorax after thoracotomy must be mentioned. The pain is usually situated in the line of the incision. It is often due to a traumatic stimulation of an intercostal nerve and can be treated effectively by a series of infiltrations with procaine. It may be necessary to divide this nerve posteriorly. It has been recommended prophylactically to infiltrate a few intercostal nerves with efocaine during thoracotomy. This has proved to be not without danger (BRITTINGHAM et al.), even if it is performed intercostally (BOERÉE). In a number of thoracotomies we severed the nerves; at present this is no longer the fashion, however. The effect seems to be better if the ribs are not too widely separated by the speculum. Traumatic arthritis in the small joints between ribs and vertebrae is thus obviated. Scoliosis and thoracic deformities, especially after pneumonectomy, are seen much more rarely nowadays, because of the great attention paid to the patient's

post-operative posture and to regular remedial gymnastics. The condition is more serious if the patient goes on coughing and expectorating in spite of pulmonary resection. This may be partly due to bilaterality of the affection or to incomplete removal of the diseased lung tissue. In the early days, when bronchography was in its initial stages, this occurred more frequently. It is therefore absolutely necessary to have perfect bronchograms prior to the resection, if good results are to be obtained. The radiological technique used at Groningen in antero-posterior, lateral and oblique directions may be recommended (HUIZINGA & SMELT). A second cause of persistent excessive sputum production is associated with possible bad expansion of the spared lung tissue. We try to combat this condition by means of suitable suction drainage, respiratory exercises and maintenance of an active cough stimulus. In parts of the lung which remain atelectatic, pneumonitis with formation of areas of bronchiectasis may develop. The finding of GINSBERG et al. that residual bronchial abnormalities (especially ipsilateral) may play a role in the development of post-operative complications, corresponds with our personal observations.

Table 11

Author	Number of resections	Post-operatively	Died %
D'ABREU	210	8	3.8[1]
ADAMS	80	2	2.5
BUCKLESS	300	9	3
KERGIN	58	4	6.8
LAIRD	80	1	1.2
LAMBERT	28	3	10.7
MEADE et al.	161	1	0.62
SAMSON	66	1	1.5
DERRA (1949)	174	22	12.7[2]
T. H. SELLORS	100	6	6
CHESTERMAN	114	2	1.75
PRICE THOMAS et al.	111	4	3.6
EERLAND	206	15	7.5[3]
GROSS	72	7	10
SANTY & BÉRARD	136	6	4.4
MATHEY & GALEY	120	4	3.3
WENSE	40	4	10
OCHSNER, DEBAKEY	96	11	11.4
Total	2152	110	about 5.5

[1] In 100 consecutive operations there has been only one death.

[2] In pure uncomplicated bronchiectasis the post-operative mortality was 7.4 %; in bronchiectasis with pulmonary abscesses 24.5 %.

[3] In 161 cases in which the dissecting technique was used, the post-operative mortality was 1.2 %. In 54 successive lobectomies post-operative mortality was nil.

Thirdly, the expectoration of pus must be mentioned, when an empyema has formed after operation. This is generally the result of a primary bronchial fistula. The formation of a stump empyema, usually perforating into the bronchial tree, is also possible; the patient then expectorates blood-stained pus. Finally, bronchiectasis patients often appear to have a generally diffuse catarrhal (eosinophilic), but sometimes also purulent bronchitis. This does not always disappear immediately after excision of the diseased areas; sometimes after-treatment in a mild climate may be advisable. This diffuse bronchitis is in turn the cause of some of the many post-operative complications.

Apart from the cause of the dilatations, the operative result also depends on the patient's general condition before operation, particularly of his cardiovascular system, and on whether the affection is bilateral or not. These factors are of more importance than the age of the patient selected for resection, although it must be remarked that results are as a rule better in children than in adults. Due to new advances made in the field of anaesthesia and chemotherapy, older patients can nowadays also be operated upon successfully. Generally speaking, an age of over forty is no longer a contraindication to pulmonary resection. Excellent results can still be obtained, especially in localized bronchiectasis.

The great drawback of operating on very young children, is the rather high percentage of cases of atelectasis, owing to the fact that they are usually not very cooperative during the postoperative stage. However, even babies have been successfully operated upon. F. L. MENDEZ reports the cases of two babies, aged $2^1/_2$ and 18 months respectively, in

whom pulmonary resection was successful. The age-group from 6—12 years is the most suitable, however.

Most authors give low mortality figures for resection in children. DERRA (1949 to 1953) lost only one girl among 31 resections in children. Later on, another patient died from pneumonia in the other lung, also bronchiectatic. GROSS reported no mortality in a series of 54 consecutive lobectomies in children with bronchiectasis. Of a total of 88 children, aged 1—12 years operated on in our series, only one died after a pneumonectomy. There were no fatal cases in the 60 in whom resection was carried out according to the "dissecting" technique.

In our total group of 206 patients (1939—September 1st, 1954) the primary mortality was 15 (*7.5%*). Of 128 lobectomies 6 died, of 43 pneumonectomies 8, of the 9 lobectomies combined with segmental resection 1 and of 26 pure segmental resections none died. During the first period when the "cutting" technique was used, 13 of 45 patients died (mortality *28%*). Of 161 cases operated upon according to the modern "dissecting" technique 2 died (*1.2%*). Of the 159 survivors one died one year after operation due to tuberculous meningitis; another operated upon in 1949 died in 1952: cause epistaxis? For comparison with a few other operative results reported in the literature (dissecting technique) table 11 should be consulted.

These figures are in agreement with recent extensive statistics of GINSBERG et al. In a series dealing with 221 cases from the Mayo Clinic over a period of twelve years the mortality was 4.7%.

The immediate results may, therefore, be called satisfactory, considering that the average mortality since the introduction of the dissecting technique and with the newer antibiotics is about 1—2%. R. EDWARDS reported more than 800 pulmonary resections for bronchiectasis from the Thoracic Centre, Liverpool; after the first 100 cases the operative mortality was less than 1%.

2. Prognosis

a) Long-term Prognosis of Conservatively Treated Cases

On the strength of the material available at present, it is rather difficult to give an opinion on the prognosis of conservatively treated cases, because two factors have profoundly altered it especially as regards the chances of life:

1. The progress of conservative, particularly antibiotic, treatment; 2. X-ray examination with lipiodol, which is carried out much more frequently and with greater experience, and which has considerably changed the character of the group known as bronchiectasis patients.

Formerly this group consisted exclusively or almost exclusively of patients with serious and usually extensive abnormalities; at present, however, this category also comprises patients with mild subjective symptoms but distinct changes, and many cases formserly regarded as chronic bronchitis in which lipiodol examination has revealed more or les manifest changes.

In the period before World War II, the prognosis in cases of bronchiectasis was anything but good. This is obviously demonstrated by statistics published on the subject. BRADSHAW, PUTNEY & CLERF report a mortality of 34.5% in a group of 171 cases, observed from 1925—1935. The percentages published by PERRY & KING are still more unfavourable. Of 144 patients 41% died within five years from the onset of the disease and only 10% survived for 20 years or longer.

The picture that COOPE gives of bronchiectasis and the passage quoted from the novel *Clochemerle* by GABRIEL CHEVALIER are not very cheerful either. The sword of Damocles is always seen hovering even above the head of the non-infected bronchiectasis patient, and the opinion is advanced that only a few of those who acquire the disease before the age of ten will survive their fortieth birthday. However, the uncertainty existing about this at the moment is also mentioned.

The bad prognosis of former cases and the uncertainty about the future of our present series of patients might be illustrated by other examples.

New data, indispensable to compare the risks of surgical and conservative therapy can only be obtained in the course of time, but it is probably an established fact that the prognosis is worse, the more extensive the areas involved and the more persistent and serious the infection in these regions. In our opinion, haemoptysis is not an important prognostic factor. Since 1945 none of our cases of bronchiectasis has died from haemoptysis, although our series of patients examined approaches 1000.

KISSLING (loc. cit. SYLLA) gives a mortality of 5% due to haemoptysis, but we have not found this confirmed in the literature. In our experience the number of cases which change permanently from a "dry" into an infected bronchiectasis is not high either.

b) Long-term Prognosis of Surgically Treated Cases

SWINNEN re-examined 139 bronchiectasis patients operated upon in the period 1939 to 1952. Seven could not be traced in this follow-up (longest time of observation, over eleven years). On January 1st, 1952 five patients appeared to have died in the course of time, and, taking fifteen fatal post-operative cases into account, it was possible to evaluate the condition of 112 patients. It should be noted that the "cutting cases" from the first period are also included in this series.

Cured or marked improvement . 91 (81.2%)
Little improvement 13 (11.6%)
Unsatisfactory . . . . . 8 (7.2%).

The comparatively rarely published statistics from the world literature are given here for comparison, arranged in the same way.

Table 12

	Number of patients followed-up	Cured %	Little improvement %	Unsatisfactory %
ADAMS & FICARRA	50	44 = 88	4 = 8	2 = 4
LAMBERT	78	56 = 71.8	11 = 14.1	11 = 14.1
LINDSKOG (bilateral cases)	20	15 = 75	4 = 20	1 = 5
MATHEY	49	35 = 71.4	6 = 12.2	8 = 16.4
MOODY	41	40 = 97.2		1 = 2.8
OCHSNER & DEBAKEY . .	86	69 = 79.3	12 = 13.8	5 = 6.9
CHESTERMAN	95	77 = 80.5		
Groningen Clinic	112	91 = 81.2	13 = 11.6	8 = 7
SANTY & BÉRARD	115	80 = 67	20 = 17	15 = 13
ROSMAND & BURNETT . .	161	118 = 73.2	36 = 22.3	7 = 4.5

The percentage attained in our series gives too optimistic a picture of pulmonary resection for bronchiectasis.

Out of a total of 139 patients, seven were not followed-up; of the remaining 132 only 91 (68.9%) were cured by pulmonary resection.

Table 13. *The influence of residual bronchiectasis on the significance of post-operative secretion retention*

Secretion retention	Total	Good results	%	Without secretion retention	Total	Good results	%
Some residual.	25	15	60	Some residual	60	50	83
Ipsilateral residual . .	8	2	25	Ipsilateral residual . .	20	19	95
No residual	31	20	66	No residual	88	77	88

The figures of GINSBERG et al. (Mayo Clinic), which were kindly given to us by A. M. OLSEN, show a similar distribution. Of 221 cases, results were good in 75%, fair in 16%

and bad in 5%; 4.7% died after operation. They again stress the fact that especially patients with ipsilateral residual abnormalities have post-operative secretion retention. In this category results are particularly bad.

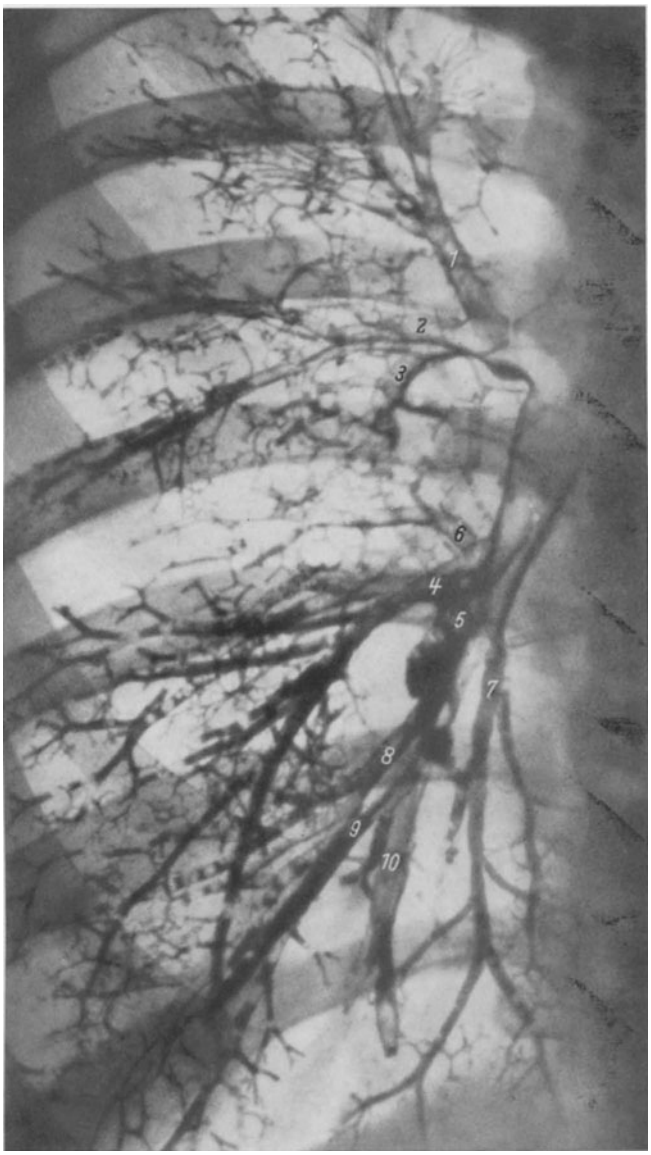

Fig. 48. Dorsoventral bronchogram of 26-year-old female, H. M. 24. 2. 1941. Bronchiectasis of medial branch of middle lobe (5); the postero-basal branch is also dilated (10). The history revealed frequent bronchitis during childhood. At present expectoration of purulent blood-stained sputum

Whatever the relationship between these two symptoms—in our opinion the unremoved diseased (although not always dilated) bronchi are the cause both of secretion retention and post-operative dilatations—it is certain that existing abnormalities in spared parts of the lungs have an unfavourable influence on post-operative complications and the ultimate result. Even a small lesion in the postero-basal segment (10) (Fig. 48 and 49) probably caused a less optimal result of an in itself very successful resection of the middle lobe in a woman of 26.

The results in *children* of our personal series are as follows: of 44 children (aged 1—12 years) who could be followed-up 39 (88.6%) are cured; if the total number of children

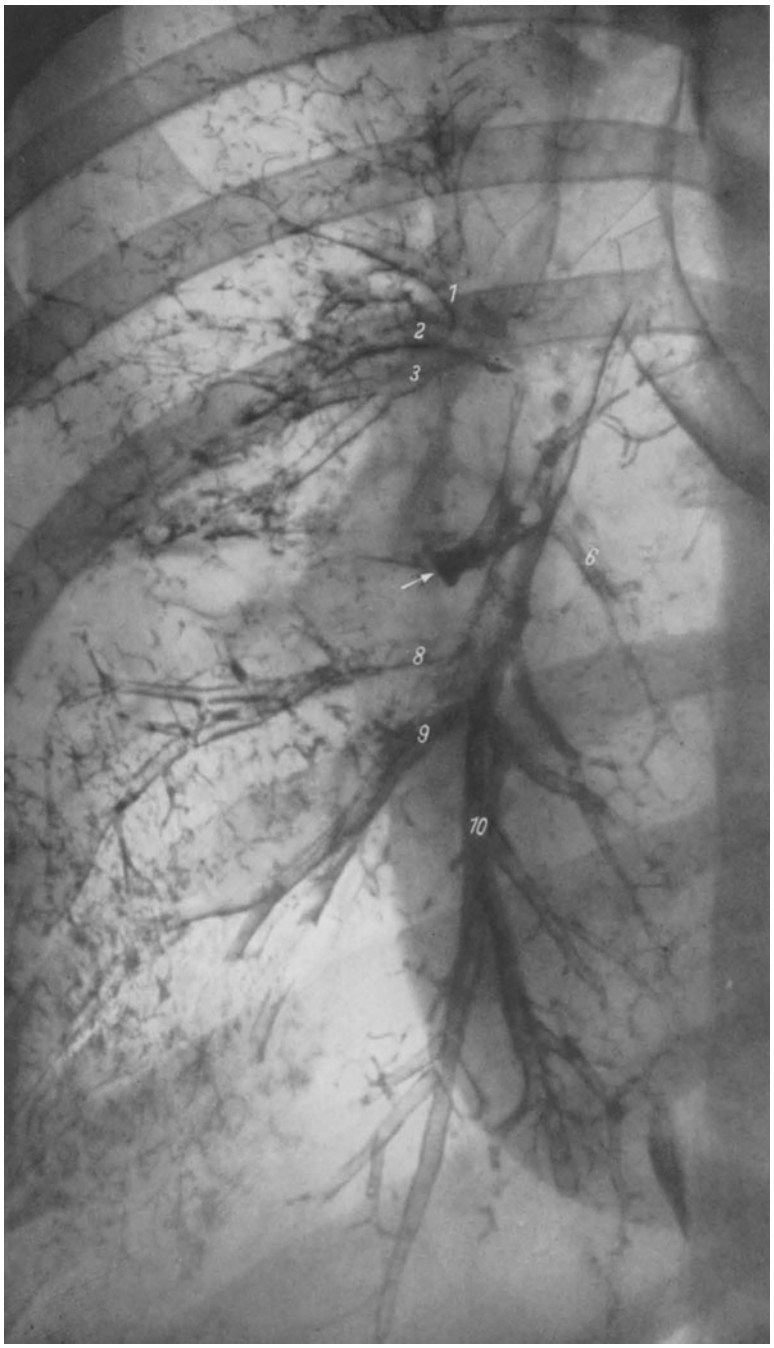

Fig. 49. Same patient of Fig. 48. Left anterior oblique photo of right side one year after resection of middle lobe (1947). The arrow indicates the stump of the middle lobe bronchus. Postero-basal branch (10) stationary. In 1954 again frequent complaints of coughing and bringing up of sputum

who came for treatment are considered, this percentage becomes lower, viz. 39:49 = 79.6%. The results of R. Edwards show that one must be prepared for a renewed occurrence of symptoms in the course of post-operative years. Because of these very important figures, the ultimate results of surgical treatment cannot yet be regarded as established.

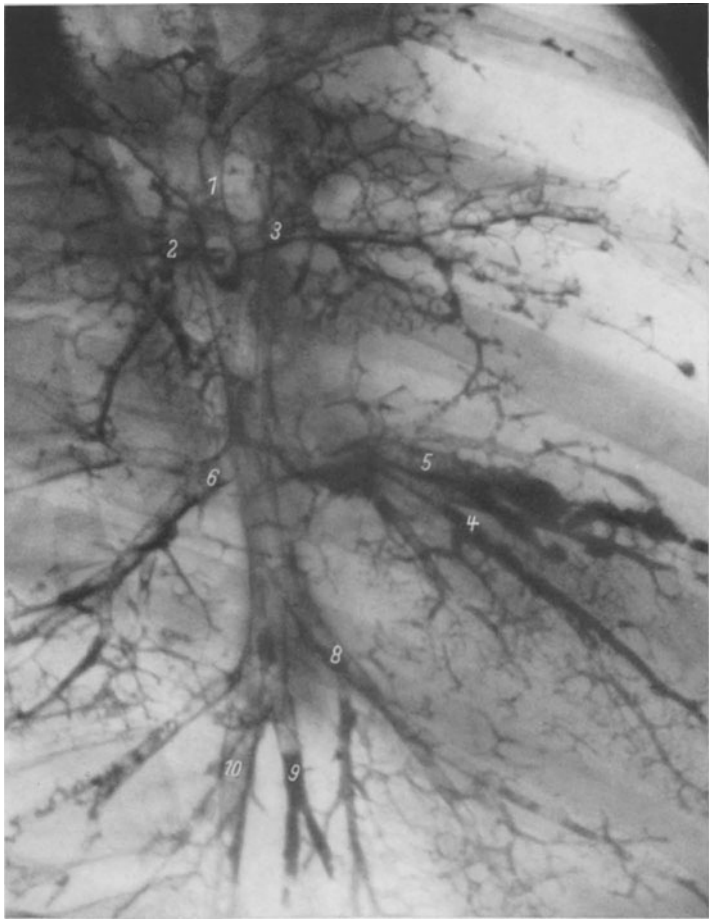

Fig. 50. Lateral bronchogram of patient of Figs. 48 and 49

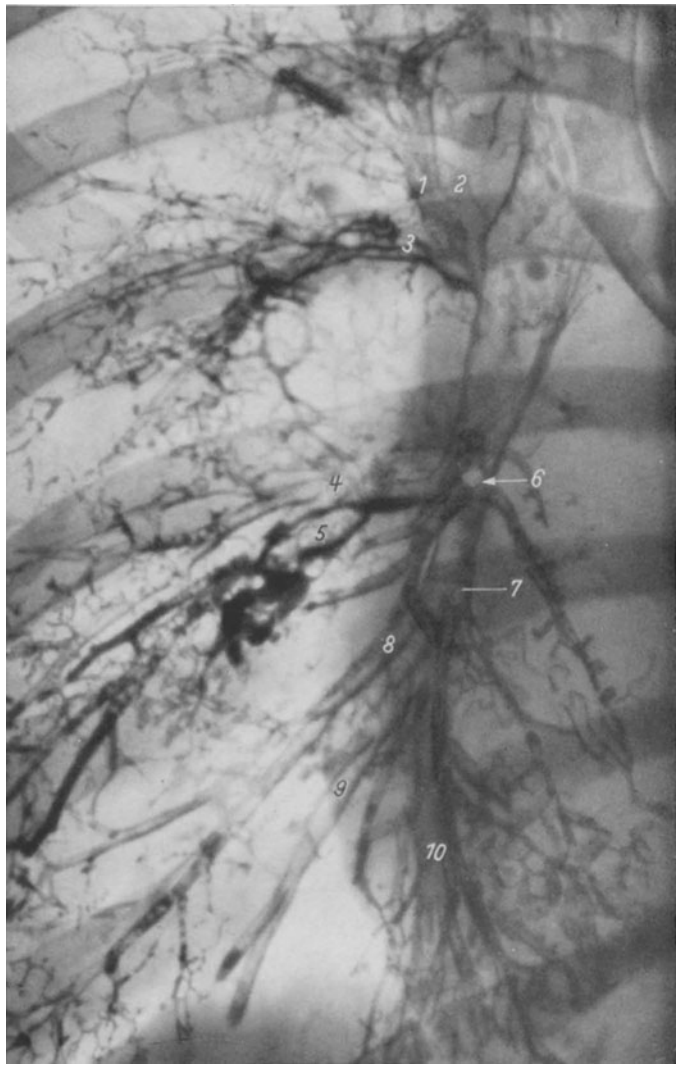

Fig. 51. Same patient as in previous photos. Left anterior oblique photo of right side

N. Indications for Surgical or Conservative Therapy

In view of the preceding data we have tried to list the indications. The decision to treat bronchiectasis surgically or conservatively depends on:

a) The risk of the treatment, b) the severity of the patient's symptoms, c) the results to be expected.

If it is realized that only the first point mentioned leaves no doubt about the answer, it is evident that the indications are not so simple.

a) Conservative therapy hardly involves any risks. The possibility that the drugs administered may cause toxic damage is very small, and can be fairly accurately estimated. The great advances made in the field of pulmonary resection and anaesthesia have also considerably improved the prognosis of surgical therapy, although, of course, some risk is still present.

b) An answer to the second question seems easy. Yet this is not the case because, especially in the group in which operation is usually considered, viz. bronchiectasis with many typical symptoms in the age-group 6—20 years, these symptoms are anything but constant. Various authors agree that, particularly in this age-group, symptoms often considerably diminish as the patient grows up. This can be easily understood in view of the identical course of the asthma often underlying these symptoms. This spontaneous tendency to improvement is probably the reason why surgeons operate so readily, especially in the group aged 6—20 years.

c) However, the ultimate result of treatment is the most important factor. The spontaneous course of the affection, which influences the results of both conservative and surgical therapy, should be taken into account. In the discussion on conservative therapy we have argued extensively that in many cases the result will not be permanent, although a passable condition will often be obtained.

So far little can be said about the ultimate prognosis of cases treated conservatively. It may probably be assumed that the prognosis as regards life has much improved, whereas symptomatically more can be achieved than formerly, without really satisfactory results being obtained.

In the surgical literature one is struck on the one hand by the fact that a large series of authors report favourable figures (75—90 % good results) and on the other by less optimistic communications.

Table 14. *Difference in some lung functions after resection for tuberculosis and bronchiectasis*

	Mean age	VC in % of normal values of remaining lung tissue	RES. V./TC	FRC/TC	MBC in L.	1-sec. value of VC
Lobectomy t.b.c.	28.5 (39)	103 (39)	24.5 (19)	41 (19)	60.6 (36)	70.3 (33)
Lobectomy bronch. . . .	25.3 (28)	100.5 (26)	33.2 (26)	51.9 (26)	49.5 (28)	64.3 (26)
Significance			P 0.0026	P 0.0026	P 0.0026	P 0.0026
Pneumonectomy t.b.c. . .	29.9 (45)	108 (45)	30.3 (40)	46.8 (40)	43.9 (43)	69 (43)
Pneumonectomy bronch. .	28.7 (14)	100.4 (13)	37.1 (14)	57.2 (14)	37.4 (14)	67 (14)
Significance			P 0.013	P 0.0026		

(Number of cases in parenthesis).

A survey of the series of MANNIX et al., PATERSON, CRELLIN et al., R. EDWARDS and our personal experiences does not leave any doubt about this. This therefore concerns residual bronchitis—dilatation—and in the course of time a decrease in the percentage of favourable results. These results may also indicate a transient favourable influence of age and operative stress itself. This is particularly true for the data of EDWARDS. The difference between the results of a pulmonary function test after resection for bronchiectasis and after resection for tuberculosis points in the same direction (GEELEN).

While GEELEN's figures lead one to accept a real difference between the results of resection in tuberculosis and bronchiectasis from a functional point of view, EDWARD's results make it plausible that the clinical results are not only not optimal, but also that

these results become less favourable in the course of years. This is true for both younger and older age groups.

See further tables 15, 16, 17 and 18 given by R. EDWARDS.

Optimistic reports of OVERHOLT, SWIERINGA et al. indeed raise the question whether careful resection might give better results, or whether there are considerable qualitative differences between the groups operated upon. However, an extensive, complete account of a large series of patients observed for a long period of time will have to prove the constancy of the satisfactory effects reported.

Table 15

Age group 0—19 years; Period 3—5 years

Res. lung.	Living	Symptoms					
		mild or none	moderate	marked	severe	dead	unknown
Left lower lobe	27	16	8	—	—	—	3
Left lower lobe + lingula	25	20	5	—	—	—	—
Left-pneum.	7	5	1	—	—	—	1
Right-sided resection + miscellaneous	17	11	3	—	—	—	3
Bilateral	8	6	1	1	—	—	—
Total	84	58	18	1	—	—	7
Percentage		69	21	1	—	—	9

Table 16

Age group 0—19 years; Period 5—9 years

Res. lung.	Living	Symptoms					
		mild or none	moderate	marked	severe	dead	unknown
Left lower lobe	43	27	6	2	2	3	3
Left lower lobe + lingula	8	3	1	2	—	1 (tbc)	1
Left-pneum.	9	4	2	—	1	1	1
Right-sided resection + miscellaneous	14	9	2	—	—	1	2
Total	74	43	11	4	3	6	7
Percentage		58	15	5	4	8	10

Table 17

Bronchiectasis — Surg. treatment — Resection

Age group over 20 years; Period 3—5 years

Res. lung.	Living	Symptoms					
		mild or none	moderate	marked	severe	dead	unknown
Left lower lobe	20	13	3	1	—	—	3
Left lower lobe + lingula	14	6	5	1	—	—	2
Left pneum.	5	1	1	1	—	—	2
Right-sided resection + miscellaneous	26	9	9	5	1	—	2
Total	65	29	18	8	1	—	9
Percentage		44	27	12	1.5	—	14

Table 18

Age group over 20 years; Period 5—9 years

	Living	Symptoms					
		mild or none	moderate	marked	severe	dead	unknown
Left lower lobe	24	7	12	3	—	1	1
Left lower lobe + lingula	14	4	5	1	1	1	2
Left pneum.	9	6	1	—	—	—	2
Right lower lobe	9	—	2	3	1	2	1
Right-sided resection + miscellaneous	19	12	4	2	—	—	1
Total	75	29	24	9	1	4	8
Percentage		39	32	12	1	5	11

It must be stressed that the increase in expiratory rate (TIFFENEAU, GAENSLER) after resection therapy does not necessarily mean that the function has much improved.

GEELEN's figures give an indication which may be helpful in the selection of cases for operation: if the results obtained are divided into two groups, there appears to be an obvious difference in function. One group comprises patients actually reacting to adrenaline during the function test, and the other group consists of patients in which this reaction is absent (at least at the time of examination). From a functional point of view the results in the second group are practically identical to those of tuberculosis patients who had undergone a resection (Table 14).

Fig. 52. H. D., male, age 29. Seborrhoea, asthma, emphysema, nasal polyps, bronchiectasis. Bronchography in 1949. Bronchiectasis in anterior segment of right upper lobe, right middle lobe and antero-basal segment of right lower lobe

The presence of asthmatic factors in the personal or family history also gives some indication whether to operate or not. The more asthmatic symptoms are predominant in the picture and the more marked emphysema is, the more this will hold true. GINSBERG's figures strongly suggest that the presence of lesions outside the area to be resected also diminishes the chance of favourable results. For the rest, even with all these data available, it remains difficult to decide with certainty whether patients will belong to the favourably or to the unfavourably responding group. The improvement even in cases of the "asthmatic" group is often quite apparent and—even if not altogether permanent—must not be disregarded [SWIERINGA, OVERHOLT (1953)]. Therefore, a line of conduct must be accepted which takes both factors into account. In our opinion however this attitude has to be a conservative one, with one exception, viz. the group of the strictly localized processes, e. g. those which are associated with a tuberculous bronchial stenosis, a bronchial adenoma or a foreign body. If these patients show symptoms, they form the group in which functional and clinical results should be optimal after resection. It must be accepted, therefore, that some of the differences in result which have been published must be attributed to this selection of cases. Yet, as was shown earlier, the results of R. EDWARDS indicate that there is a great risk of taking too optimistic a view of the results if the follow-up period is too short.

Progression of the bronchial dilatations cannot be used as an argument in favour of operative therapy (WAMSTEKER). Some authors state that bronchiectasis is a progressive disease, but no pertinent facts are known to support this statement. Repeated long-term (bronchographic) observations on a number of cases never showed clearcut progress. We give two examples (Figs. 52, 53, 54, 55) in which no change occurred in the bronchogram after three and five years respectively.

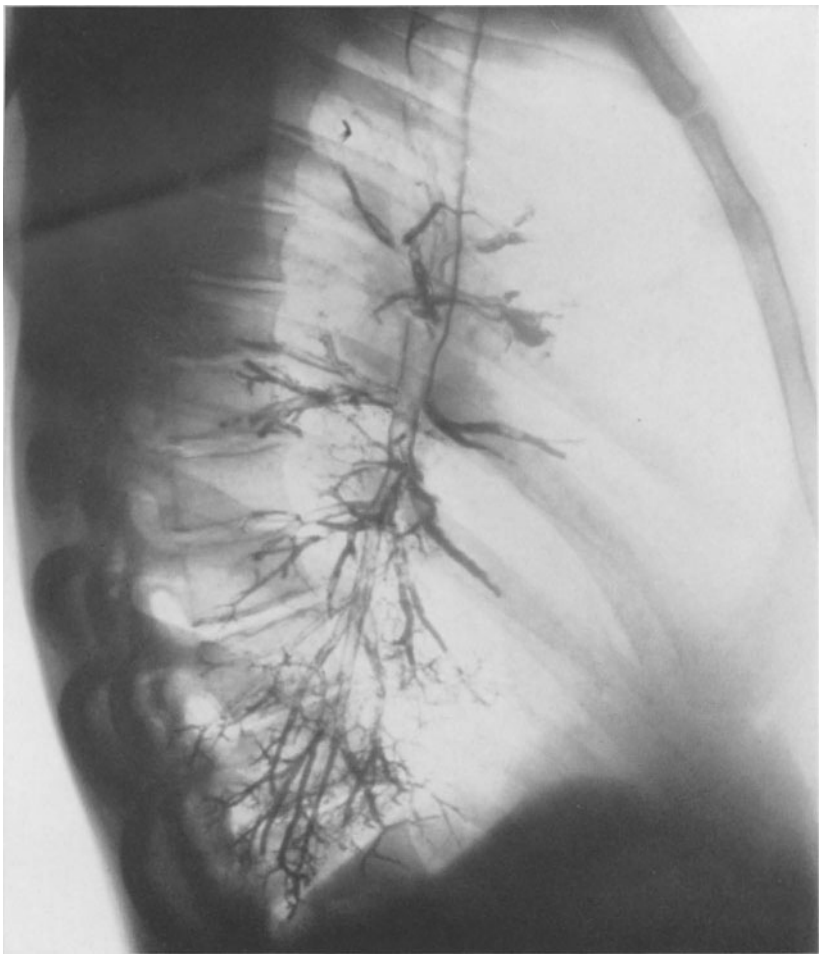

Fig. 53. Same patient as in Fig. 52. Bronchography in 1952. The condition has remained practically identical as regards bronchiectasis in anterior segment of right upper lobe, right middle lobe and antero-basal segment of right lower lobe

Table 19. *Comparison of pulmonary function of adrenaline-positive and negative cases after resection for bronchiectasis.*

		Number	VC in % of normal values of remaining lung tissue	Res. V/TC	FRC/TC	FRC/TC exercise	MBC in L.	MBC/VC	1-sec value of VC	
									before adrenaline	after adrenaline
Lobectomy . .	adr. +	18	93	37.1	54.9	60.2	46.2	18.3	59.4	67.4
	adr. −	7	108.5	28.4	43	48	62.1	21.6	76.2	
Significance . .				P = 0.05	P = 0.05	P = 0.05			P = 0.0028	
Pneumonectomy	adr. +	7	92.1	38.6	57.9	61.7	35.3	18.7	60	67.6
	adr. −	7	109.7	35.7	56.7	54.8	39.4	21.5	74.3	

The apical segment especially (6) of Figs. 54 and 55 must have been exposed to continuous overflowing of secretion.

We therefore support the opinion of Rubin and of Whitwell in this respect, that bronchiectasis is not a progressive disease. This does not imply that minor bronchial

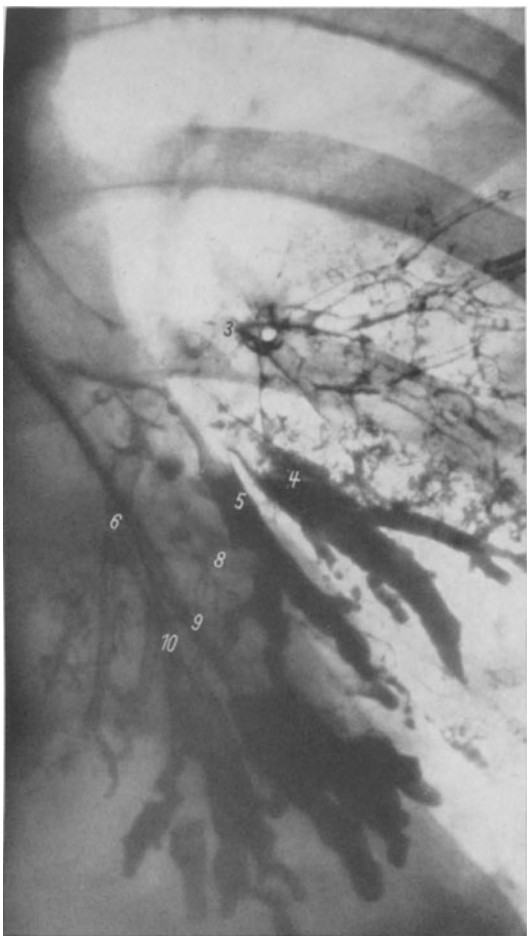

Fig. 54

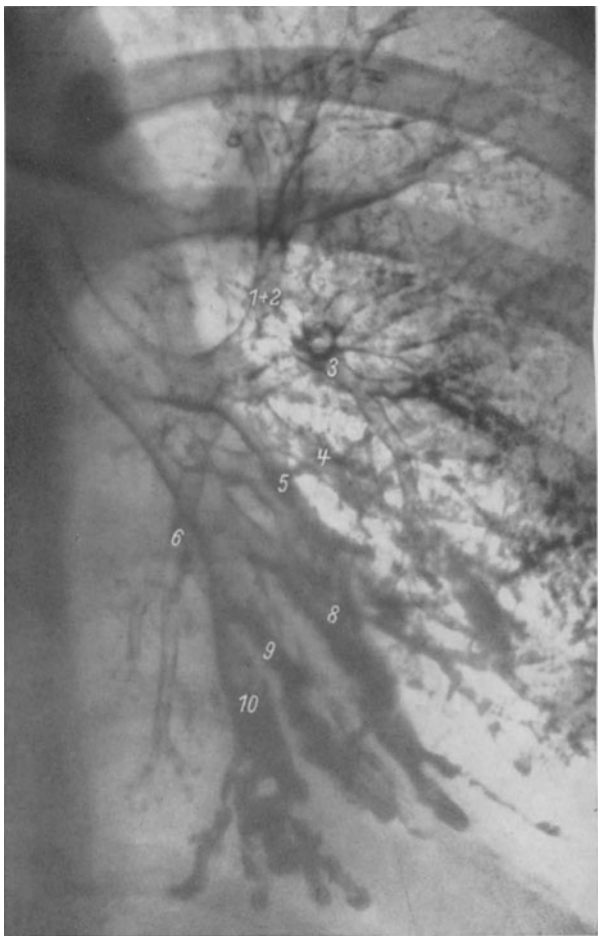

Fig. 55

Fig. 54. H. S., male, age 19. Bronchiectasis, left chronic maxillary sinusitis, right chronic otitis media. Bronchography in 1946. Bronchiectasis in anterior segment of right upper lobe, medial branch of right middle lobe, medio-, latero- and postero-basal branches of right lower lobe. Left lingula and all basal branches dilated. Apical branch of left lower lobe seemingly normal in 1946 and 1952 (see Fig. 55)

Fig. 55. Same patient as in Fig. 54. Bronchography in 1952. Bronchiectasis has remained practically unchanged

lesions may not become more severe and markedly bronchiectatic after distension caused by resection of other parts of the lung.

In our opinion so-called post-operative spread of the disease is usually a manifestation of this phenomenon. It is not at all rare and may sometimes be anticipated from minimal abnormal patterns in other parts of the lung on the pre-operative bronchogram. It most often occurs in cases of diffuse (asthmatic) disease.

This does not alter the fact that with the above-mentioned restrictions, excellent results may sometimes be obtained by resection therapy. Moreover, it must not be forgotten that the prospects of conservatively treated cases are not certain either, although it may be accepted on good grounds that at present the prognosis is no longer as bad as might be concluded from former observations.

As a rule conservative treatment should precede surgery. Adequate use of antibiotics and postural drainage are necessary in conservative treatment. If this is unsuccessful or the results inadequate, resection should be carried out without hesitation, especially in the younger age-groups, at any rate if the symptoms are so serious that they justify

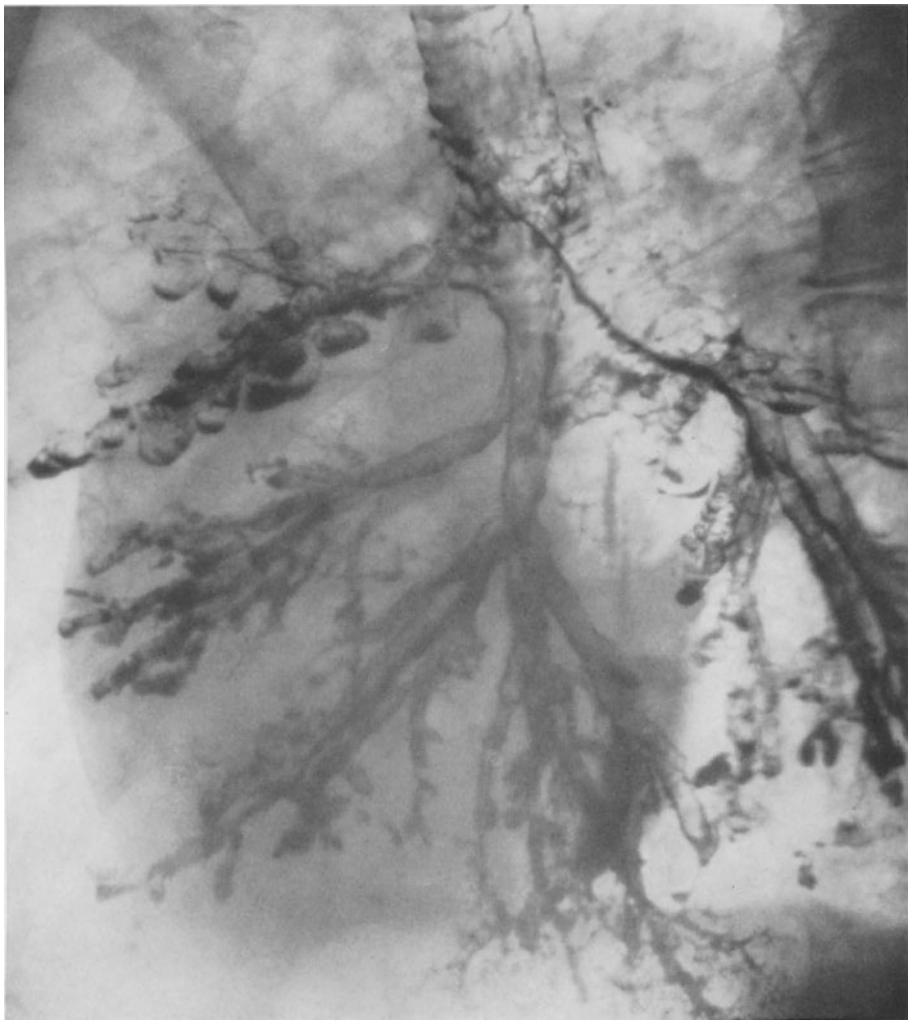

Fig. 56. 56-year-old female. Very long history of coughing and expectoration. Very diffuse bronchiectasis in all lobes, also on the left side. Oblique photo of right side. Case unsuitable for operation

a small operative risk. Asymptomatic bronchiectasis without haemoptysis is as a rule not an indication for surgical therapy. Contra-indications are:

a) Too great an extent of the area to be resected (Fig. 56), b) especially if the abnormalities are not sharply localized, c) restrictions in the pulmonary function, particularly if these are asthmatic or emphysematous in nature, d) serious amyloidosis of long duration; an incipient amyloidosis may be an indication for operation if the pulmonary changes are sharply defined; e) right heart failure past or present.

Of course only a bad general condition, hypertension, malformations of heart, kidneys or liver constitute serious contra-indications to operation. In every case they should be judged individually. Although no definite line can be drawn as regards age, as a rule (except in the case of very serious symptoms and sharply localized abnormalities) about

50 years should be the limit. Particularly because the condition is usually not critical, one should be more careful in taking risks than in bronchial carcinoma or pulmonary tuberculosis. In those cases in which life is jeopardized by the disease, the deficient pulmonary function or the spread of the process will also contra-indicate operative treatment.

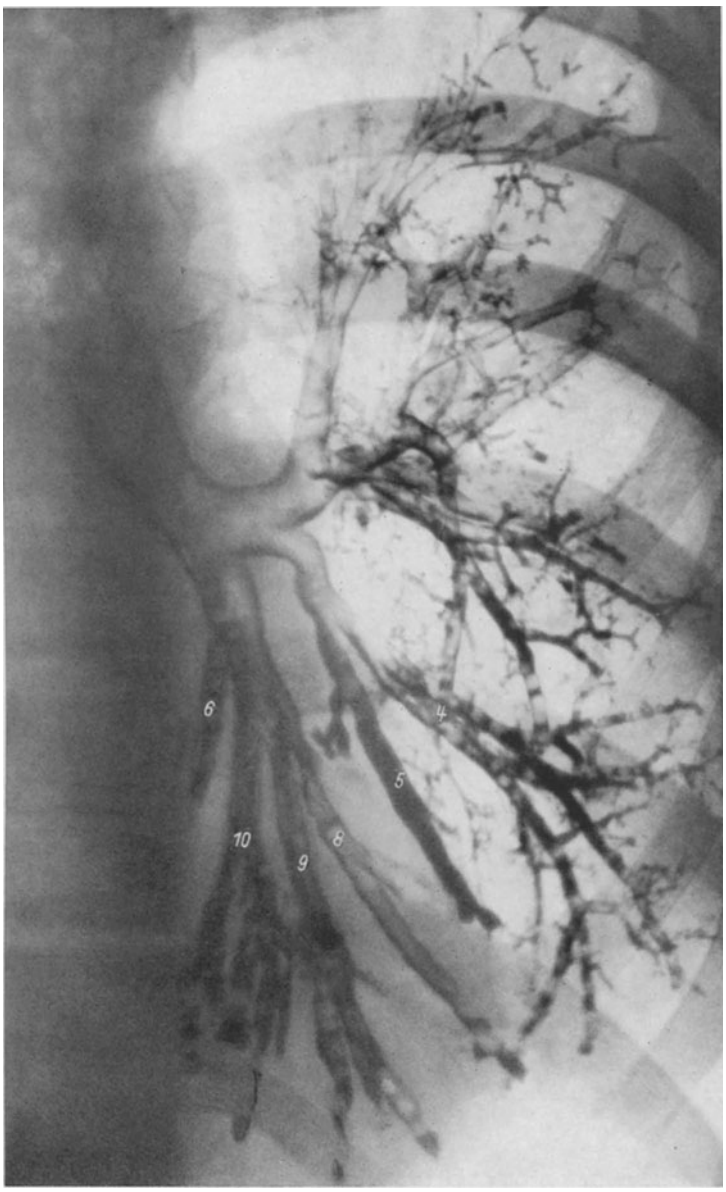

Fig. 57. Dorsoventral photo of 33-year-old female. Bronchiectasis of all branches of the left lower lobe (6—10) and the inferior segment of the lingula (5). Resection of left lower lobe + lingulectomy led to recovery

Figs. 57 and 58 represent two patients with almost identical bronchiectasis. The case shown in Fig. 58 was not operated upon, because of his unfavourable general condition.

Resection Therapy in bilateral Bronchiectasis

The development of segmental resection techniques has made it possible to operate even on cases of bilateral bronchiectasis without causing too great a loss of pulmonary function. Many cases have thus come within the scope of pulmonary surgery. In bronchi-

ectasis, just as in bilateral resection for pulmonary tuberculosis, the difficulty is which side to attack first.

Overholt is of opinion that this should be the most diseased side. Chamberlain shares this viewpoint, because great difficulties are to be expected in the expectoration of secretion, if the less diseased side is dealt with first. Most investigators (Kergin, Santy & Bérard, Mathey & Galey, Swieringa and Shaw) consider that the less

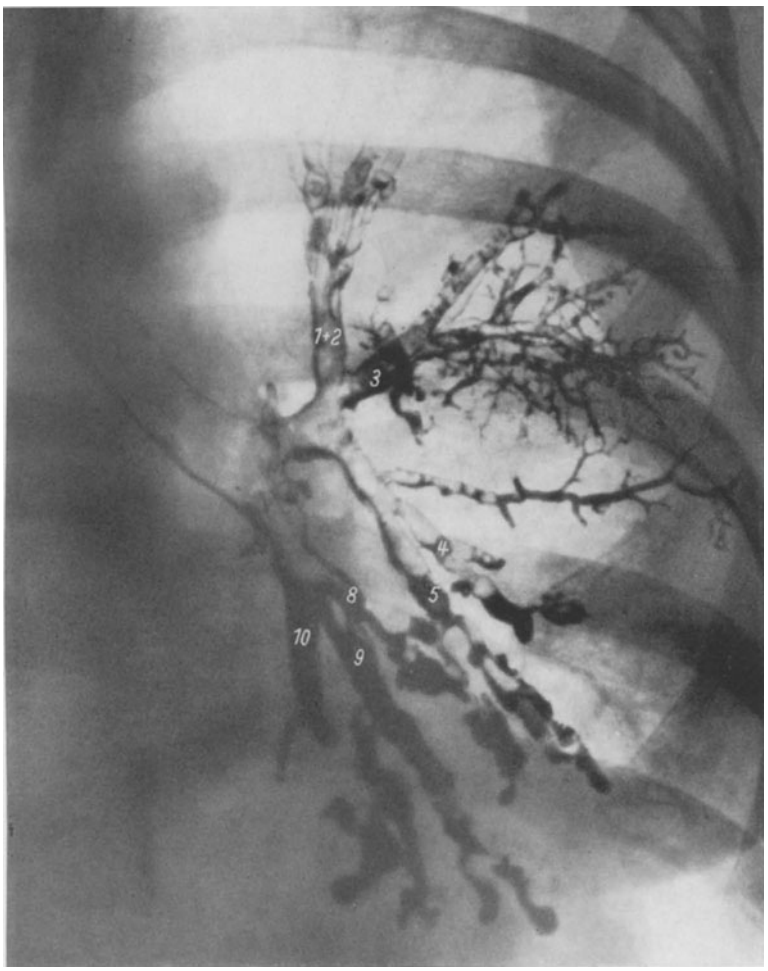

Fig. 58. Dorsoventral photo of 46-year-old woman. Bronchiectasis, varying from cylindrical to ampullary forms in left lower lobe and lingula. Resection of left lower lobe + lingulectomy was impossible due to the bad general condition

diseased side should preferably be resected first, in which case the operated lung has a larger respiratory surface than the non-operated one. When the second lung is operated upon, the patient has to live on the other lung, which has healed in the meantime.

Kergin lost four patients in whom resection was first carried out on the most diseased side, death being due to anoxaemia.

A series of 20 patients with bilateral bronchial dilatations was operated upon by Klinkenbergh. One patient died from a pulmonary embolism after the second operation, and in another case pulmonary tuberculosis developed after bilateral resection. The interval between the two pulmonary resections must be judged individually and according to the literature, varies from 3 months to several years. Restoration of the pulmonary function after the first resection is an important factor in this respect. We believe that

too many risks are involved by performing bilateral resection in one stage, as advised by OVERHOLT (EERLAND). In OVERHOLT's series of 220 patients, bilateral resection was carried out in 70. The values of the pulmonary function were generally satisfactory after the second operation in the series of SWIERINGA-KLINKENBERGH. However, they only report partial functional results and these are not quite consistent with the data of ROOS et al. and the clinical findings of OLSEN & CLAGETT. Extensive bilateral bronchiectasis can only be treated conservatively. Our personal experiences in 36 bilateral resections for pulmonary tuberculosis were very favourable (EERLAND & KRAAN). All the cases recovered, with a 100% sputum conversion. No bronchopleural fistulae were formed and the loss of pulmonary function, which was determined at least six months after operation, corresponded in all cases approximately with the volume of the resected lung tissue.

Although evidently bilateral resection as such is tolerated well, one is again struck by the difference with tuberculosis, at any rate in the publications of a number of authors (ROOS, OLSEN, CLAGETT).

Because constitutional factors are so frequently found, particularly in bilateral bronchiectasis, they should be given due attention in considering the indications.

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