

BRONCHOGRAPHY

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FOREWORD

In contemplating the publication of a monograph, the first question that should be asked is whether a publication of this sort would be justified and advisable. This will primarily depend on whether it fills a particular need and also on the question whether any views are advanced, which have not yet sufficiently become a matter of common knowledge. These two questions, the answers to which are decided by the readers for whom the publication is intended, are intimately connected. As several studies written in a foreign language have appeared during the last decade, – commencing with Huizinga's standard work which was published in the Netherlands in 1948 and has now become a classic –, it might be assumed that to-day there is no longer any need for a book of this kind. This might be true in the case of chest physicians permanently engaged in clinical work, but it certainly does not hold true to an equal extent for those pulmonary specialists who, before the advent of resection therapy as a method of treatment in pulmonary disease, were employed at dispensaries and similar establishments, which usually have to deal with out-patients only. This also applies to internists and roentgenologists who are often, if not constantly, concerned in establishing the tentative diagnosis and deciding which particular forms of subsequent treatment are indicated in cases of pulmonary disease. These physicians, who are requested to establish a preliminary diagnosis and to offer advice, cannot do so on the basis of the limited data provided by ordinary X-raying, the data supplied by tomography frequently also being inadequate for this purpose. This has had as a result that, though 10 years ago bronchography was still regarded as a very special examination which was the sole concern of the oto-rhino-laryngologist, in recent years bronchograms are not only being frequently made by chest physicians who meanwhile have become highly skilled in this procedure, but also by internists and roentgenologists. Several physicians employed at dispensaries also show inclination to adopt this form of examination, since hospitalization has been found to be by no means necessary or even advisable in every case and bronchography may just well be performed in the out-patient department.

From various quarters we gained the impression that the opportunity to consult a simple manual dealing with the technique as well as the interpretation of the results obtained in bronchography is a commonly felt wish.

The standard text-books which tend to be very detailed and written solely from the specialist's point of view, fail to comply with these requirements, as they offer too many details and do not lay sufficient stress on essentials, so that

the main facts do not stand out clearly. As a result, these books are not consulted often enough or are not consulted at all. In the present monograph, an attempt has been made to avoid this drawback by describing the essentials of the technique of bronchography as well as those relating to the interpretation of results in the briefest possible text, supplemented, however, by a large number of illustrative plates. The form chosen in doing so was similar to that which previously met with appreciation when an earlier textbook on bronchial lesions in tuberculosis, written by the present author, was published. The method adopted was to insert the figures in a text which also included a report on the clinical findings in certain patients affected with particular forms of pulmonary disease. Accordingly, the monograph has come to include a number of clinical lectures concerned with the various subjects which are discussed in succession.

A short bibliography has been added, listing the papers written by authors referred to in the text, which papers are frequently concerned with special topics of a theoretical nature, and also listing the best-known comprehensive standard works on bronchography. Consequently, the book as a whole is mainly designed for readers among internists and roentgenologists, i.e. its primary object is to provide information for those whose professional activities are not constantly confined to the diagnosis and treatment of pulmonary disease. However, this does by no means imply that this monograph is incomplete. It covers the entire field of bronchial lesions in pulmonary diseases confronting the chest physician in his daily medical practice. Only very uncommon conditions and those pulmonary lesions in which the bronchograms fail to show any characteristic changes, are not accompanied by illustrations. In addition to details of a purely clinical nature, the text includes a brief review of the more theoretical problems, e.g., a number of problems involved in the pathogenesis of bronchiectasis. In doing so, particular attention is paid to symptoms indicative of the reversible or irreversible character of these lesions, as these are essential in deciding whether or not surgical treatment is indicated. The bronchographic features appearing in chronic bronchitis, bronchial asthma and/or emphysema, which may present a markedly varied and complex picture, are analysed into their different components, among which bronchial spasm is an outstanding phenomenon.

In the chapter concerned with changes of the bronchi in tuberculosis, reference is only made to a number of common and typical bronchial lesions, as there would be no point in repeating what had previously been stated on the subject in the earlier monograph published in 1955, which included a larger number of data relating to this matter.

On the other hand, the appearance of severe bronchial lesions in Boeck's sarcoid, a little known fact, was discussed in greater detail.

The chapter on malignant tumours of the bronchi comprises every stage in changes of the bronchi observed in this type of lesion.

Finally, the chapter concerned with foreign bodies offers some comment on

a number of cases in which the history of the patient was misleading and a sufficiently positive roentgen-diagnosis was difficult.

This has resulted in a conveniently and systematically arranged account in which the figures rapidly supply complete information regarding the possible help offered by bronchography in establishing a diagnosis, the clinical as well as the more theoretical and scientific problems involved being discussed in the accompanying text. In addition to a complete description of the lesions, the legends beneath the figures state the clinical diagnosis for the benefit of those who mainly wish to use this book as an atlas. Those interested in clinical details will be able to consult the text and those interested in the problematical aspect of the subject-matter discussed will also be able to become acquainted with the facts which may be regarded as universally established to-day.

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TECHNIQUE AND HAZARDS OF BRONCHOGRAPHY;
GENERAL CLASSIFICATION
OF FORMS OF BRONCHIAL DISEASE

I. HAZARDS OF BRONCHOGRAPHY

As early as 1921, when this technique was introduced by SICARD and FORESTIER, it was obvious that bronchography was destined to become a method of great value in the clinical diagnosis of various forms of pulmonary disease. Previously (viz., from about 1915), there had been no lack of efforts to visualize the outlines of the bronchi in the X-ray film by powdered barium or bismuth. This method, however, was found to be useful for experimental purposes only and could not be employed in clinical studies. Only iodized oils (lipiodol) were found to enable adequate visualization of the large as well as the small, and even the smallest, bronchi.

Although various subsequent attempts were made to avoid certain drawbacks attaching to the use of lipiodol by substituting other, especially water-soluble, contrast media (such as dionosyl) for this substance, the latter cannot be claimed to have superseded the original lipiodol.

There are two drawbacks or objections to the use of lipiodol, viz.:

1. the retention of remnants of lipiodol within the pulmonary parenchyma,
2. the risk of toxic manifestations due to the liberation of iodine, which may give rise to urticaria, oedema and (in exceptional cases) a general state of poisoning associated with symptoms of anaphylaxis or anaphylactic shock in certain hypersensitive individuals.

To avoid these two drawbacks wherever possible, efforts were made to prepare water-soluble contrast fluids which might be expectorated more readily than oily media following their introduction into the bronchial tree. When these substances are used, the disadvantage of the retention of contrast medium in the peripheral bronchi (and in the lung tissues themselves) may indeed be almost entirely avoided. This does not hold equally true, however, for toxic manifestations, as water-soluble contrast media are much more readily absorbed by the mucous membranes of the bronchi than is the oily lipiodol. In addition, the fact should be borne in mind that the drawbacks to the use of lipiodol may in large part be avoided by adopting a suitable technique in filling the bronchi. A simple method by which excessive filling of the peripheral bronchi and pulmonary parenchyma may be largely, if not entirely, avoided, consists in ensuring optimum anaesthesia of the upper respiratory tract prior to bronchography. This will prevent coughing during the filling of the bronchial tree.

As a result, one of the chief factors causing penetration of the contrast medium to the alveolar region, is eliminated. Another very simple method by which to avoid excessive peripheral filling, is to add powdered sulphonamide to the contrast medium (e.g., 1 gr. of sulphonamide to 4 ml. of lipiodol). This will increase the viscosity of the contrast medium, so that too rapid and excessive a filling of the peripheral regions of the lung may be avoided in almost every case. Moreover, using a mixture of sulphonamide and lipiodol offers the advantage that bronchography may be carried out without haste and that, if need be, additional exposures of details may be made without the interpretation of the bronchogram being rendered unnecessarily difficult by too many details and overlapping of shadows.

The bronchographies carried out by this method in several thousands of cases in the course of a large number of years, have shown that the drawbacks to the use of lipiodol may be almost completely avoided and that this technique results in entirely satisfactory filling of the small and very small bronchi. There is a minimum absorption of the mixture of sulphonamide and lipiodol by the bronchial mucosa, which also considerably reduces the risk of toxic manifestations.

In addition, the danger of toxic manifestations in bronchography may be reduced by using a tracheal catheter rather than a nasal catheter. This is due to the fact that a portion of the contrast medium will be much more likely to be swallowed and find its way into the stomach (where it disintegrates, resulting in the absorption of iodine) using a nasal catheter than when a catheter is inserted into the trachea beyond the vocal cords.

Personal experience has shown that the risks of iodine poisoning do not differ appreciably in using the water-soluble dionosyl and the lipiodol-sulphonamide mixture, when an identical method of filling is employed.

The fact should be stressed, however, that these are real hazards which may occasionally give rise to conditions involving danger to the life of the patient. Milder toxic manifestations such as urticaria or local oedema (especially of the face) are fairly common; nor, unfortunately, are mild shock-like conditions an unusual complication of bronchography. This state of shock failed to respond to any therapeutic agent in one case (out of about 12,000 patients), so that the patient died within 3 days after examination. However, patients tend to make a fairly rapid and spontaneous recovery in almost every case of hypersensitivity to iodine, though the impression was gained that administration of a physiologic saline solution by intravenous drip has a favourable effect in these cases¹.

This also was the reason why a few grams of sodium chloride dissolved in water were administered to the patient shortly prior to bronchography; this was done in view of the fact that some of the contrast medium might enter the stomach during the examination.

Before describing the technique of bronchography, however, attention

¹ This treatment is assumed to promote the "elimination" of potassium and thereby of the iodine bound to the potassium; administration of the physiologic saline solution is assumed to prevent dissociation of the potassium iodide.

should be drawn to another hazard involved in this examination, viz., that of toxic symptoms caused by the anaesthetic employed. Hypersensitivity to "pantocain" is at least as dangerous as idiosyncrasy to iodine, but it is much less common, provided at any rate that a small dose is carefully administered, i.e. that a minimum quantity of anaesthetic is used. In addition, using higher concentrations of the anaesthetic should be avoided. Therefore, it is not advisable to use a 2 per cent solution of pantocain (which was widely recommended previously), but only to employ a 0.5 per cent solution. Experience has shown that a physician skilled in bronchography will always be able to produce an adequate degree of anaesthesia, both of the pharynx and the vocal cords, provided a few drops of adrenaline are added to this solution.

Although cases of pantocain poisoning hardly ever occur when this method is adopted, this hazard cannot be entirely avoided, and even then fatal complications may result. Death occurred in two personal cases in which the patients lapsed into a state of shock following anaesthesia of the oropharynx and subsequently failed to respond to the administration of analeptics or treatment with cortisone and transfusion(s). We do not know whether the hazard of intoxication from other anaesthetics such as xylocaine and bronchiocaine is less great than that involved in the use of pantocain.

Certain authors claim that the risk of shock during bronchography might be reduced by administering 50-100 mgr. of phenobarbital (luminal) to the patients about one hour prior to examination. So far, we have only used this drug in more or less restless and anxious children.

2. TECHNIQUE OF BRONCHOGRAPHY

a. *Anaesthesia*

A vaporizer is used in producing anaesthesia of the pharynx (including the lower portions of this cavity). The proximal part of the trachea (including the posterior surface of the epiglottis) is then painted with the pantocain solution, using a curved cotton-wool carrier. This is followed by anaesthesia of the vocal cords and bifurcation by instillation of a few ml. of the 0.5 per cent pantocain solution into the postero-inferior portion of the fauces, the patient having been ordered to put out his tongue. In doing so, the pantocain should be given slowly, drop by drop, to prevent the patient's having to inhale too large a quantity of anaesthetic at a time, as the latter will give rise to a sense of oppression and anxiety.

b. *Inserting the catheter*

It is advisable to use rubber catheters opaque to X-rays (Charrière 9-12). The catheter is inserted into one of the nostrils (previously anaesthetized by a few drops of pantocain) and pushed down as far as a few cm. beyond the vocal cords under fluoroscopic control. In our opinion, the use of the so-called Métras catheter which is introduced into one of the lobar or segmental bronchi, should be confined to exceptional cases in bronchography. There hardly ever

is any advantage in directing the initial bronchography solely towards a particular portion of the lung or in electively filling the area where the lesion is localized. This often interferes with the correct localization of the site of the lesion and also is liable to result in changes of the bronchi adjacent to the lesion passing unnoticed. Moreover, filling of a particular region, at least when Métras' catheter is inserted into one of the smaller bronchi, tends to give rise to excessive filling of the peripheral bronchi or bronchioles and thereby of the pulmonary parenchyma, so that a correct interpretation of the condition and form of the larger bronchial branches becomes extremely difficult. Therefore, we believe that this method of so-called "gezielte Bronchographie" (guided bronchography), which is frequently used by certain roentgenologists, reflects an overrating of the value of technical know-how and is a demonstration of the German saying: "nur nicht einfach, weil es auch kompliziert geht" (why do things in a simple way, when a complicated method is available?), rather than that it offers any actual advantages.

c. *Introducing the contrast medium*

Prior to introduction of the contrast medium (lipiodol and sulphonamide, or dionosyl), the patient is placed in lateral decubitus on a narrow table resting on a trestle (or "see-saw").¹ This board which can be moved about a horizontal axis, contains an opening into which the lower arm can be inserted, enabling the patient comfortably to rest with his shoulder on the board (Fig. 1).

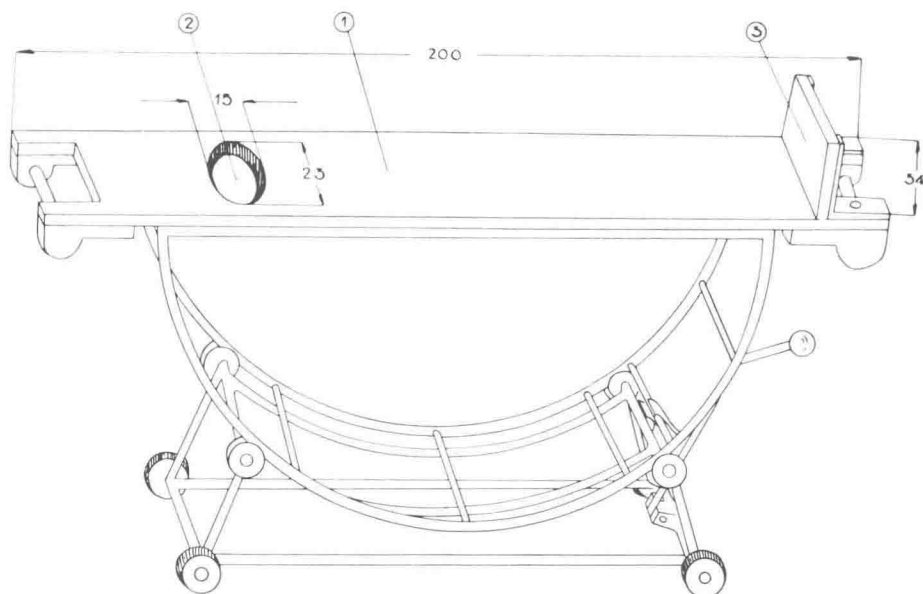


FIG. 1. Apparatus for use in bronchography. (For a description of the apparatus, the reader is referred to the text).

¹ This apparatus was initially designed by A. E. V. Hillebrand, a specialist in internal medicine, and has come to be widely used in the Netherlands to-day.

Depending on whether the right or left lung is to be filled, the patient lies on the right or left side. The board and the trestle on which it rests are so narrow that the entire apparatus may be placed between the X-ray apparatus and the screen, so that filling can be effected under fluoroscopic control if need be. In actual practice, however, this is hardly ever necessary (or advantageous). In almost every case, filling without fluoroscopic control will suffice. In our opinion, the rule that the simplest method yields the best results also holds true as regards this part of the examination. Usually, filling starts with the postero-inferior portion of the lung. For this purpose, the patient is rotated approximately 45° about the long axis (so that he is inclined backwards), the board making an angle of about 45° with the horizontal axis (foot of board down, head up).

About 6-8 ml. of the contrast medium are introduced in this position. The patient is then rotated forwards about the long axis of his body (the foot of the board continuing to be directed downwards) and the anterior branches of the lower-lobe bronchus as well as the middle-lobe bronchus are filled (about 4 ml.). The board is then placed in an almost horizontal position, the patient being in the middle position (i.e., inclined neither forwards nor backwards). About 6-8 ml. of the contrast medium are introduced in this position. Some of the contrast medium directly makes its way to the upper lobe; another part, however, passes on to the stem bronchus or finds its way into the lower-lobe bronchus, a quantity of the contrast medium also being retained within the upper respiratory tract when the patient is in this position. Therefore, the board is again placed foot downwards for a few moments after all the contrast medium has been introduced, so that the quantity retained within the upper respiratory tract will flow into the stem bronchus. Immediately after, the patient is placed head down, so that the contrast medium present in the stem bronchus or lower-lobe bronchus will flow back to the orifice of the upper-lobe bronchus, resulting in complete filling of the upper-lobe region. This method will almost always enable uniform filling of all portions of the bronchial tree, even without fluoroscopic control.

When filling has been completed, the patient rises and walks to the X-ray apparatus. At least three exposures (antero-posterior, semi-sagittal and sagittal) are made. If need be, viz., when this is justified by the fluoroscopic findings, supplementary exposures of details may be taken.

d. *X-ray technique*

Preferably, a not too sensitive X-ray film (size 24×30 cm.) is used; tube at a distance of 80 cm. Rotating 2 mm. focus tube. When a quadrivalvular apparatus is used, X-rays in adults of average height and girth are taken in the following conditions:

1. antero-posterior X-ray: about 90 KV; 0.03-0.04 sec.; 14-19 Ma.S.
2. semisagittal X-ray: about 88-92 KV; 0.06-0.08 sec.; about 30-35 Ma.S.
3. sagittal X-ray: about 90-96 KV; 0.08 sec.; about 35-40 Ma.S.

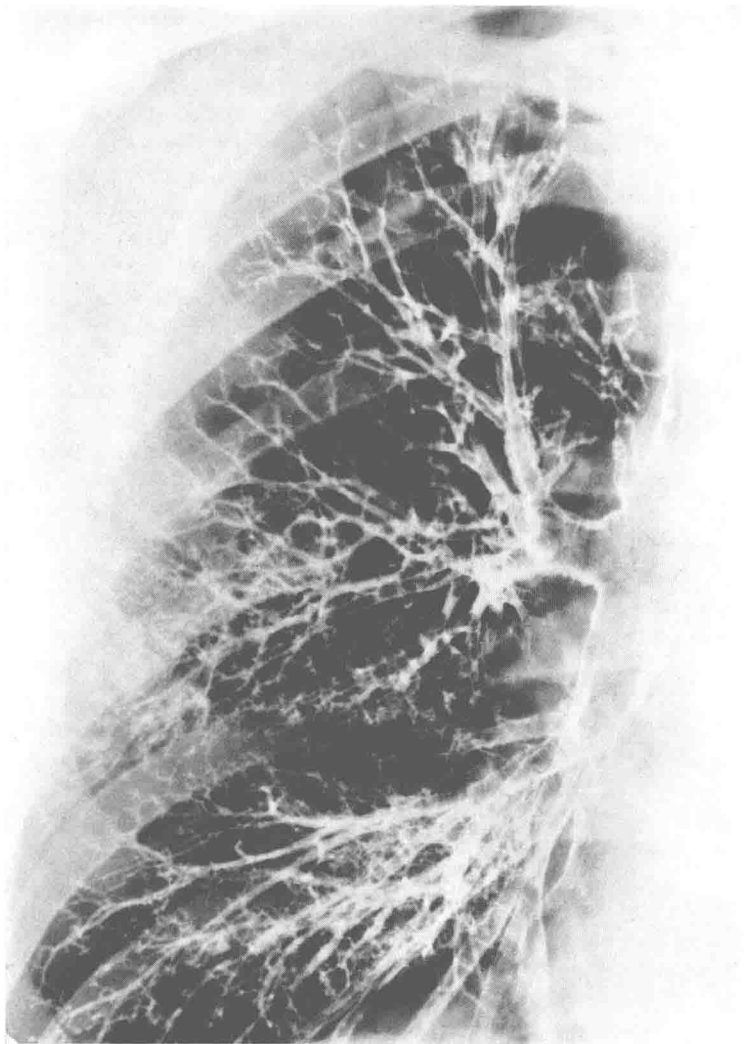


FIG. 2, case 1426. *Bronchogram of right lung: April 2, 1937.*

Almost normal bronchial tree without any marked evidence of bronchial spasm. Slight changes in form of certain apical branches of the upper-lobe bronchus, resulting from the presence of tuberculous lesions in this region.

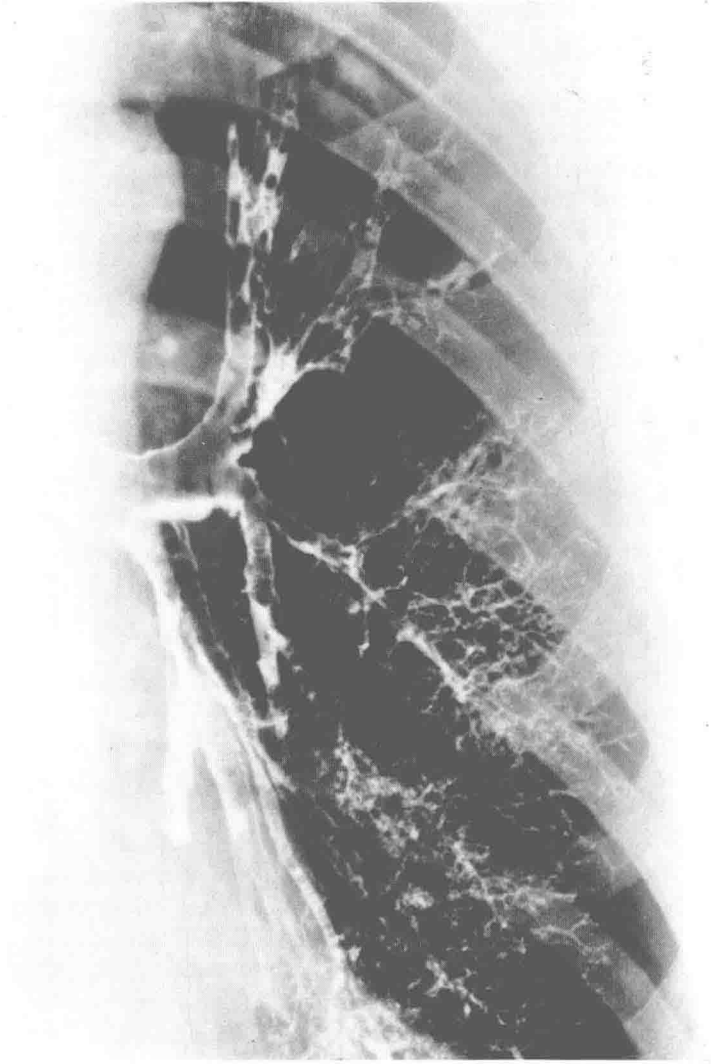


FIG. 3, case 1426. *Bronchogram of left lung: April 2, 1957.*

Marked spasm of the segmental and subsegmental bronchi in the middle and lower regions. Severe spasm of one of the medial branches of the lower-lobe bronchus, resulting in obstruction of the latter. The dilatation of a number of upper-lobe branches and the almost complete absence of filling of the peripheral bronchi in the upper lobe in this case may be indicative of the presence of (long-standing) tuberculous inflammatory lesions on the one hand, or spasm on the other.

As a rule, it is not advisable to fill both lungs during a single examination.

As a matter of fact, one of the drawbacks to this method is that in this case a sagittal X-ray can be taken of one lung only, the roentgenologist having to be content with merely making an antero-posterior and one or two semi-sagittal exposures of the lung filled last. However, there are considerable disadvantages in not taking a sagittal X-ray when the object is accurately to localize all changes of the bronchial tree, as this is a strict requirement in cases in which treatment by resection may be indicated. Another drawback to filling both lungs at one session, consists in the fact that filling of one lung is frequently followed by the secretion of mucus into the bronchi of the lung which has yet to be examined, and that this is often accompanied by spasms of the (segmental) bronchi of the lung still to be examined. The result of this naturally is that the X-rays of the two lungs are not entirely comparable and that certain portions of the last-filled lung are incompletely filled in the event of more marked symptoms of spasm. In addition, spastic changes in a particular portion of the lung may result in an incorrect interpretation of the actual bronchogram, as a bronchial spasm may create the impression of obstruction by a foreign body or tumour or the, frequently bizarre, spastic changes in shape of certain bronchi may suggest a bronchitis deformans which actually is not present.

For all these reasons, it is usually considered preferable to fill only one lung per session.

The plates (Figs. 2 and 3) may serve as instances of the appearance of a (not very severe) spasm during filling of the other lung (the *left* lung in this case). These X-rays were taken in a patient in whom bronchography was done with a view to deciding whether resection for bilateral tuberculous lesions in the apical regions of both lungs was indicated.

Comparison of the two figures clearly shows that, on the whole, the bronchi in the middle portion of the left lung are narrower than those in the corresponding region of the right lung. In addition, filling of the lower region of the left lung is incomplete (a check showed this to be due to bronchial spasm). The upper region of the left lung also shows only slight filling of the peripheral bronchi. However, there are reasons for assuming that this phenomenon is not, or at any rate not merely, due to bronchial spasm, as the large bronchi in this region are wider than normal. Rather, the malformations and dilatations observed in these bronchi should be attributed to earlier tuberculous inflammatory lesions, the failure of the peripheral bronchi in this region to become filled probably being mainly, if not entirely, due to diminished ventilation of the segments having undergone pathological changes caused by tuberculosis.

A bronchographic follow-up showed that these were constant changes.

Diagnosis: Tuberculosis of the apices of both lungs; also, symptoms of bronchial spasm (Fig. 3) during the filling of the second lung, although the patient did not have an allergic constitution.

e. *Nomenclature of the bronchi*

Before proceeding to a description of the bronchial changes in various forms of pulmonary disease, it is advisable to review the current bronchographic nomenclature. Although there continue to be slight variations in the nomenclature of the different bronchial regions, an almost universally accepted and adopted terminology may be stated to have developed.

Broadly, this terminology is as follows:

1. *Main bronchus*, i.e., that portion of the bronchial tree, which extends from the bifurcation of the trachea as far as the site of origin of the upper-lobe bronchus.
2. *Stem bronchus* (only in the right lung); this is the portion of the central bronchus extending from the orifice of the upper-lobe bronchus as far as the site of origin of the middle-lobe bronchus from the central bronchus.
3. *The central lower-lobe bronchus* which becomes continuous with the postero-basal branch of the lower lobe, is that portion of the bronchial tree which follows the stem bronchus (right lung) or is connected with the main bronchus (left lung).

Segmental branches:

1. of the upper-lobe bronchus
 - a. apical branch (
 - b. dorsal branch (or apico-dorsal branch
 - c. axillary branch
 - d. pectoral branch (= anterior branch)
 - e. only in left lung: lateral and medial lingula branches
2. of the middle-lobe bronchus
 - a. upper (lateral) branch
 - b. lower (medial) branch
3. of the lower-lobe bronchus
 - a. postero-basal branch (from which the apical branch of the lower lobe arises)
 - b. antero-basal branch
 - c. latero-basal branch
 - d. cardiac branch (only in right lung)

Figures 4, 5 and 6, taken from "Bronchography" by Huizenga and Smelt, schematically represent the relative positions and expanse of the segmental regions.