Bronchography in Pulmonary Tuberculosis

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The recognition of tuberculous bronchitis as a clinical entity has been of practical importance to the chest man. The presence of this complication in the main or lobar bronchi is known to be associated with interference with the normal physiological function and may be aggravated by any form of collapse therapy. Thus bronchoscopy is being extensively used in sanatoria. One of the most important lessons learned from this complication is that once tuberculous bronchitis has been established, particularly as an extensive lesion, it may be a source of positive sputum. This is of particular significance in cases where there are no demonstrable lesions in the pulmonary parenchyma and also in cases where the lesions appear controlled but sputum remains positive. The following case illustrates this point:

H.E., male, aged 31 years, was admitted to Mountain Sanatorium in August, 1936 because of positive sputum. His history of illness dated back to 1920 when he was a patient in a California Sanatorium for 10 months for an upper lobe lesion. He was treated by bed rest only. In 1934 a specimen of sputum was found positive but because of doubtful activity in the right upper lobe, he was discharged after five months, with a negative sputum. On his admission to the Mountain Sanatorium in 1936 the lesion in the upper lobe remained unchanged and was considered inactive, but because of persistently positive sputum, right pneumothorax was started soon after admission and right pneumolysis carried out in February, 1937. Shortly after the latter procedure he developed a persistent wheeze. During the night of March 8, 1937 he had a fatal hemorrhage. Postmortem examination showed tuberculous ulceration of the lower part of the trachea, of the right main and right upper lobe bronchi. The ulceration in the upper bronchus led to perforation of the right pulmonary artery. Sections of the upper lobe showed partially calcified nodules but no active disease.

In the past we have concerned ourselves chiefly with the findings in the bronchi as seen through the bronchoscope, but in some of the cases with negative findings in the major bronchi we felt the need of studying the segmental branches. We have, therefore, added bronchography to our investigations. The cases studied were those who have had medical or surgical treatment and in whom usually a positive sputum persisted. Of particular interest to us were the

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post thoracoplasty cases who obviously had a satisfactory collapse, negative bronchoscopic findings and positive sputa. Also, in view of the increasing number of resections done in our institution, the opportunity presented itself to study the whole bronchial tree clinically and pathologically. In addition to post thoracoplasty cases with positive sputum, we made bronchograms on the cases who had to have some major surgical procedure.

Bronchography in tuberculosis has not been used extensively (1) because of the fear of spread of disease in the process of coughing up of lipiodol. (2) because of the presence of residual lipiodol in the lung which may interfere with the interpretation of the x-ray films for months, and (3) because of the fear of the effect of Iodine on the patient. As will be mentioned later these reasons were found to be of no importance in our experience.

This group of 100 patients studied by bronchography consisted of 53 females and 47 males. The majority (88 per cent) were between 20 and 50 years of age. The youngest was a girl of 17 and the oldest a man of 65. In this group 11 per cent were of minimal extent, 58 per cent moderately advanced, and 31 per cent far advanced. The majority as seen were in the moderately advanced group probably because this is a group more likely to require surgery than the minimal group and better able to tolerate surgery than the far advanced group. The method of bronchography used is the one practiced in Groningen University Hospital and shown to us by Dr. G. Smelt. It chiefly consists in posturing the patient according to position of the ostium to each lobar bronchus, filling it with an assigned quantity of lipiodol and then posturing the patient again according to the course of the segmental branches of the lobar bronchus. No fluoroscope and no tracheal catheter is used for this method. The procedure of filling one lung at a time should take a little over one minute and the x-ray films are taken immediately afterwards. Ten to 12 cc. of lipiodol at room temperature are used for one side. After the posterior-anterior, lateral and oblique films are taken, the patient is again placed in a position corresponding to the disease area studied. He remains in this position until the films are developed and studied. If the films are satisfactory he is immediately put in a position to drain the lipiodol. Should more information be required, more films are taken.

**Bronchoscopic Examination**

All patients with the exception of two were bronchosceded before the bronchograms were done. The interval of time between bronchoscopy and bronchography varies considerably as bronchography was not necessarily a planned procedure at the time of
bronchoscopy. A few patients had lipiodol introduced at the time of bronchoscopy, but on the whole, this method was found less satisfactory than the one used on the rest of the patients and described above. Of the 98 patients bronchoscoped, 54 cases were found to have no pathology. The rest showed such pathology as stenosis of a lobar bronchus (16), some localized infiltration (21), some tuberculous infiltration with stenosis (6), and one case showed extra bronchial pressure stenosis. No cases of extensive ulceration was found in this group. The presence of a red and generally thickened mucosa was not considered pathognomonic of tuberculosis. From these figures it is apparent that a small majority of the patients under investigation had no pathology of the bronchial tree as diagnosable by the bronchoscope.

Diagnosis of stenosis of a main or lobar bronchus is much more accurate by bronchoscopic examination than bronchography as in only three bronchograms was this noted. It is of note that of the 54 cases with negative bronchoscopic findings there were 51 who had satisfactory bronchograms and of these, 41 or 80 per cent, were abnormal. It is obvious, therefore, that a negative bronchoscopic finding does not rule out the possibility of disease in the segmental bronchi. The remaining 10 cases (20 per cent) with negative bronchoscopic findings and satisfactory bronchograms had normal bronchial trees.

It might also be pointed out here that of the 51 cases with negative bronchoscopic examination, 25 (50 per cent) showed beading on the bronchograms. As this beading (a form of bronchiectasis) is most likely due to present or past tuberculous bronchitis, it is apparent that many cases of tuberculous bronchitis are not being diagnosed by the bronchoscope. This would appear to be a most important observation in view of the beneficial effect streptomycin has on most cases of tuberculous bronchitis.

Conversely, one may now consider those cases with normal bronchograms to see what the bronchoscopic examination showed. Of the 12 normal bronchograms, one showed tuberculous bronchitis six months prior to bronchography which had improved on later bronchoscopy and might have been healed by the time bronchography was done. One case was not bronchoscoped and the other 10 showed no abnormality on bronchoscopic examination.

There are various terminologies available for the naming of the segmental bronchi, and the nomenclature we have adopted is that proposed by the International Congress of Otolaryngology, July 1949.

Of the 100 bronchograms done (Table I), there were 12 normal, 83 abnormal and five unsatisfactory. The small number of normal and the large number of abnormal bronchograms indicates how
much more frequently the bronchial tree is involved in pulmonary tuberculosis than might be suspected, and this difference may also be indicative of the usefulness of bronchography in the study of particular cases of pulmonary tuberculosis. The unsatisfactory bronchograms included those where there was poor filling of the bronchial tree as a whole, or where there was some other complicating factor that made the interpretation of the x-ray films too difficult to be sufficiently reliable to be of use. Those bronchograms done through the bronchoscope were the least reliable and as there are many factors intrinsic and extrinsic contributing to good bronchograms, a rate of 5 per cent unsatisfactory films is not considered high.

Table II lists the various abnormal findings on bronchography and the number of cases in which each appeared. In some cases there was obviously more than one type of abnormality present, for instance, stenosis and beading of two different bronchi might be present in the same patient.

TABLE I
BRONCHOGrams

<table>
<thead>
<tr>
<th></th>
<th>RIGHT</th>
<th>LEFT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>64</td>
<td>7</td>
</tr>
<tr>
<td>Abnormal</td>
<td>55</td>
<td>28</td>
</tr>
<tr>
<td>Unsatisfactory</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

TABLE II
ABNORMALITIES IN THE BRONCHOGrams

_Bronchiectasis:_
- Beading: 48
- Saccular: 3
- Fusiform: 12
- Cylindrical: 6

_Other Findings:_
- Cavity: 4
- Broncho-pleural fistula: 2
- Stenosis: 3
- Contraction of Lobe or Segment (bunching of the bronchi): 16
- Poor filling of one or more bronchi: 22
- Stump of a bronchus: 1
In four cases lipiodol was demonstrated in cavities but bronchography is not recommended as a means of diagnosing the presence of cavities. However, in rare instances it may be useful in segmental localization of a cavity. Neuhof found bronchography useful in diagnosis of obscure cavities by indirect evidence, i.e., in the disposition of the bronchi around the site of a cavity.

The diagnosis of broncho-pleural fistula by bronchography may be a most important procedure, particularly if the fistula follows lobectomy or segmental resection and the fistula leads into a small empyema pocket.

Contraction of a lobe, often the right upper, was easily demonstrated by the bunching together of the bronchi of a lobe and poor filling of the small branches. Although collapse of a lobe is often evident by other more frequently used procedures, in some cases bronchography demonstrated whether the collapse involved one or more than one lobe or segment. In 22 cases there was poor filling of one or more of the bronchi. There were various reasons for this, some pathological such as stenosis, or the presence of secretions, and some mechanical causes such as improper positioning of the patient and insufficient lipiodol. Taking into account the bronchoscopic findings and other investigations, it was usually possible, in these cases of poor filling of a bronchus, to decide if it was due to a local pathological process.

**Lobar and Segmental Distribution of Bronchographic Abnormalities**

Tabulation of the various lobes affected shows that it is the upper lobes where bronchographic abnormalities were more frequently found. Forty-three of the 55 abnormal right bronchograms showed involvement of the upper lobe and in the left lung 26 of the 28 abnormal left bronchograms showed involvement of the upper lobe.

By a slight majority only one lobe of either lung was involved and in only nine cases was the right middle lobe bronchi abnormal either alone or in combination with the remainder of the right lung.

The segmental branches of the upper lobe bronchi most frequently involved were the posterior and the apical in that order, and the anterior branch of the upper lobe bronchus was seldom involved. In the lower lobe, in either lung, it is the apical segmental bronchus tha tis involved in the majority of cases. In 45 cases where the lower lobe bronchi were abnormal the apical segmental branch was abnormal in 30 alone, and in association with the basal branches in seven cases. In only eight cases were there abnormalities of the basal branch bronchi alone.
Residual Lipiodol

The presence of residual lipiodol in the lungs is often given as a contra-indication to bronchography in the presence of pulmonary tuberculosis, as the lipiodol may remain for months or years and causes mottled shadows on the x-ray film. Admittedly this does happen in a small percentage of cases as shall be shown by our figures but it happened so seldom, and since the shadow of lipiodol is quite characteristic on the x-ray film, we do not consider it a contra-indication if bronchography will help in the investigation of a case. It should be mentioned that those patients showing the slowest clearing of lipiodol were those who had had pleurisy in the past.

In no case has there been any harmful effect on the patient and no spread of disease was noticed. In one patient only, early in this series, was some lipiodol found in the opposite lung. This is explained by the fact that he drained the lipiodol by lying on the opposite side.

In 50 cases there was good follow-up with x-ray films to determine the time required to eliminate the lipiodol. The following figures are of interest.

<table>
<thead>
<tr>
<th>Clearing of Lipiodol in less than</th>
<th>1 week</th>
<th>2 weeks</th>
<th>3 weeks</th>
<th>4 weeks</th>
<th>8 weeks</th>
<th>12 weeks</th>
<th>16 weeks</th>
<th>20 weeks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cases</td>
<td>13</td>
<td>2</td>
<td>3</td>
<td>13</td>
<td>12</td>
<td>3</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Percentage</td>
<td></td>
<td>43</td>
<td>62%</td>
<td>86%</td>
<td></td>
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</tbody>
</table>

Reactions to Lipiodol

Iodism was no encountered in any case in this series.

Relationship of Bronchography to Surgery

Bronchography was carried out on 10 post thoracoplasty cases and four post lobectomy cases. This was done because of persistent positive sputum. As further surgical procedures were conducted on some of them only recently, the follow-up of these cases will be of interest. Altogether during this study, 23 cases of thoracoplasty, six pneumonectomies and 16 lobectomies were done. Although the usual indications for thoracoplasty or resection were applied, the presence of gross bronchiectatic dilations or occlusion of a segmental branch helped to tip the scales in favor of resection. Fine beading of one or several branches were not considered a contra-indication to thoracoplasty. These cases of thoracoplasty will be followed up and will constitute the subject for another study. Of particular interest to us was a case of a broncho-pleural...
fistula that developed following a right lower lobectomy and led to formation of an encapsulated empyema. The usual signs of a broncho-pleural fistula were absent and the diagnosis was made only when a bronchogram was done. Thoracotomy confirmed the diagnosis and further resection was necessary.

We have had little luck in demonstration of tuberculomas. This is probably because these lesions are located between the bronchi and interfere little with the lumen of them. In some of them fine beading was present and in some a small branch was obstructed. In general, bronchography was of help only in the exact localization of the lesion.

Correlation of Bronchographic to Pathological Findings

In all cases of resection the pathologist found gross lesions in the form of small or large cavities, small or large areas of caseation and in some tuberculomas. In no case was the lesion entirely limited to disease in the bronchi but was always associated with some findings in the parenchyma. Fibrosis was not an outstanding feature in most of the cases. In 14 out of the 22 cases of resection the bronchographic findings were shown to exist on biopsy. In some of the cases examination of the affected bronchi was not carried out so that there is no correlation between the bronchographic and pathological report. Another factor which may influence the rate of accuracy in reading bronchograms is the experience of the interpreter, as the largest number of cases where there was a discrepancy occurred early in the series and later on, with more experience, the reading became more accurate.

The following cases are presented as examples of the usefulness of bronchography in pre-surgical investigation:

Case 1: Mr. W.M., aged 35, was admitted to the Mountain Sanatorium in January 1947, with a diagnosis of pulmonary tuberculosis, far advanced, bacillary, and diabetes mellitus. The pulmonary disease was confined to the right lung and there was cavitation in the apex. During the next 22 months he was treated with bed rest and two courses of streptomycin totalling 107 grams. As his diabetes was difficult to control he was never considered suitable for surgery until October 1948, when pre-operative bronchogram showed bronchiectasis of all segmental bronchi of the right lung. Because of this a right pneumonectomy was done on November 3, 1948. Pathological examination of the removed lung showed (1) pulmonary tuberculosis with cavitation, (2) fibrosis, (3) bronchiectasis. Before operation his sputum had been persistently positive for tubercle bacilli by culture, and since operation there have been four negative cultures to date, and no positives. Without the bronchographic evidence of widespread bronchiectasis a right thoracoplasty would probably have been the treatment prescribed. Figure 1 is a reproduction of the bronchogram in this case.
Case 2: Mrs. G.G., aged 28, was first admitted to a sanatorium in May 1941, following severe hemoptysis. Left pneumothorax was unsuccessfully attempted in May 1941, and left phrenic crush was done in December 1941, and repeated in November 1943. She was discharged in December 1943, and had regular check-ups until November 1945, when she had another severe hemoptysis and was re-admitted in December 1945. In June 1946, she had a repeat phrenic crush and in March 1947 pneumoperitoneum was initiated. In August 1948, a positive sputum was obtained for the first time in eight months. In November 1948, she was transferred to the Mountain Sanatorium for consideration of surgery. A left bronchogram revealed beading of the apico-posterior segmental branch and cylindrical dilatation of the peripheral portions of the lingula bronchus. Left upper lobectomy was done in February 1949, and the pathological examination of the lobe showed a small (1 cm.) tuberculoma, well walled off with a fibrous capsule, at the apex, and bronchiectatic dilatation of the apico-posterior and lingula segmental branch bronchi. One positive sputum was obtained the month previous to operation, and two negative since. As the patient was transferred back to her home sanatorium two months after operation a longer follow-up has not been done. Figure 2 shows a right oblique view of the left bronchogram.

Discussion

The incidence of tuberculous bronchitis in the major bronchi as seen in postmortem has been reported by different writers. Salkin, Cadden and Edson found an incidence of 40 per cent; Bougher, Littig and Culp in 41 per cent and Silverman saw it in 60 per cent where large cavities were present an incidence of 70 per cent. The most frequent lesions found were tubercles beneath the epithelium and in the submucosa. Gross ulcerations were infrequent. In view of these findings it is easy to understand why these lesions are frequently missed on bronchoscopic examination. The segmental branches which cannot be outlined and observed through the bronchoscope have been studied by bronchography. In our series of 100 cases we found 83 abnormal bronchograms. Dormer, Friedlander and Wiles in their extensive study of bronchography in pulmonary tuberculosis feel that in the majority of cases the basic disease is bronchial block. Murphy found bronchial dilatation in 60 per cent of his cases. Mitchel and Thornton state that in a recent review of 52 lobectomies for pulmonary tuberculosis, 12 patients had bronchiectasis.

Meissner in his study of 60 resection cases found that 31 had tuberculosis of the major bronchi and in this latter group all the segmental bronchi were involved. These latter findings prompted Overholt to make the statement that tuberculous involvement of the segmental bronchi is almost universally associated with parenchymal tuberculosis.

Of interest is the fact that most of the lesions found in our study were in the dorsal branches of the upper and lower lobes, a fact
which corroborates R. C. Brock's hypothesis of bronchial embolism and posture which he so convincingly defends in his excellent book.

We, however, have not found in our series a single case where the subapical branch of the lower lobe was involved, while Brock found that "abscesses of the apical and subapical segments often co-exist."

That tuberculous bronchitis may heal spontaneously without leaving permanent changes in the bronchus is a well known fact, particularly this is the case where the submucosa is not destroyed. In cases where there is extensive ulceration with blocking of the bronchus conditions are created for permanent changes with formation of bronchiectasis which may act as a source of positive sputum. In other words, in most of the cases, even in the presence of bronchial disease, good drainage of the bronchus and resistance of the patient will facilitate healing, while in some the extensive destruction of the bronchus will result in creation of a source of positive sputum. As 50 per cent of our cases showed beading, a type of not too extensive bronchiectasis, and as thoracoplasty was carried out on most of them, it will be of interest to follow them with reference to sputum conversion.

Further bronchographic investigations with more detailed pathological studies of the resection cases may in time add considerably to our present indications for major thoracic surgery. Tuberculosis, as Murphy stated, is a broncho-pulmonary disease and should be treated as such.

SUMMARY

1) One hundred cases of pulmonary tuberculosis studied by bronchography are reviewed.
2) Bronchography supplements bronchoscopy and is a practical procedure in pulmonary tuberculosis.
3) The usual contraindications to bronchography in pulmonary tuberculosis, (1) spread of disease, (2) residual lipiodol, (3) iodism, are not important.
4) As a pre-operative procedure bronchography may be as important as bronchoscopy.
5) Bronchography is particularly useful in localization of lesions; demonstration of tuberculous bronchiectasis of segmental bronchi; demonstration of some broncho-pleural fistulae; and in differential diagnosis between a contracted and atelectatic lobe.
6) Negative bronchoscopic examination does not rule out segmental bronchial disease.
7) The majority of lesions occur in the posterior segment of the upper lobe and the apical segment of the lower lobe.
RESUMEN

1) Se revisan cien casos de tuberculosis pulmonar estudiados por broncografía.

2) La broncografía auxilia a la broncoscopía y es un procedimiento práctico en tuberculosis pulmonar.

3) Las contraindicaciones habituales para la broncografía en tuberculosis: (1) diseminación de la enfermedad, (2) lipiodol residual y (3) yodismo, no son importantes.

4) Como medida preoperatoria la broncografía puede ser tan importante como la broncoscopía.

5) La broncografía es particularmente útil para localizar las lesiones, la demostración de bronquectasia tuberculosa de los bronquios segmentarios; demostración de algunas fistulas broncopleurales y en la diferenciación entre lóbulo retraido y lóbulo atelec-tático.

6) La mayoría de las lesiones ocurren en el segmento posterior del lóbulo superior y en el segmento apical del lóbulo inferior.

RESUME

1) L'auteur étudie une centaine de cas de tuberculose pulmonaire examinés par bronchographie.

2) La bronchographie complete la bronchoscopie et constitue un procédé pratique en tuberculose pulmonaire.

3) Les contrindications habituelles a la bronchographie dans la tuberculose pulmonaire ne sont pas importantes: diffusion de la maladie, lipiodol résiduel, iodisme.

4) Comme mesure pré-opératoire, la bronchographie peut être aussi importante que la bronchoscopie.

5) La bronchographie est particulièremen utile dans la localisation des lésions, dans la mise en évidence de dilatations tuberculeuses des bronches segmentaires et de quelques fistulas broncho-pleurales; et pour distinguer l'un de l'autre le lobe rétracté et le lobe atélectasie.

6) L'examen bronchoscopique négatif n'élimine pas la bronchite segmentaire.

7) La majorité des lésions atteint le segment postérieur du lobe supérieur et le segment apical du lobe inférieur.

REFERENCES

3 Dormer, B. A., Friedlander, J. and Wiles, F. J.: “Bronchography in Pul-


