Recent Advances in Bronchography*

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Recent advances in bronchography have occurred as a result of new bronchographic media and technique. These advances have improved the quality of bronchography to such an extent that small bronchial lesions are more readily seen. A method of correlating these bronchographic defects with their histological appearance has increased our knowledge of the significance of these defects. The first part of this paper will discuss the recent advances in bronchographic media and technique and the second portion will describe the finer bronchographic defects and their histological appearance.

PART I

Bronchographic Media and Technique

There are two schools of thought in regard to the type of bronchogram which is considered the most valuable from a diagnostic viewpoint. The first school maintains that a good bronchogram should demonstrate patency between the trachea and the alveoli of each segment; that is, they seek alveolar filling to demonstrate this patency. Those belonging to the second group prefer to have the bronchial tree well outlined with a uniform coating from the trachea to the bronchioles without alveolar filling. Residues remaining in the lung after bronchography, whether opaque or non-opaque, can produce foreign body reactions. Foreign body reaction has been demonstrated due to the non-opaque peanut oil in Dionosil Oily,† to carboxymethyl cellulose in Dionosil Aqueous‡ and to the residual oil following instillations of Iodochlorol,§ as well as Lipiodol.¶ This reaction is much greater in areas where there are larger amounts of alveolar filling. To avoid foreign body reaction in the lungs of patients, a technique of bronchography and a type of bronchographic medium must be used which do not produce alveolar filling. Alveolar filling is not essential for a thorough examination of the bronchial tree by bronchography.

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Figure 1: Filling Beyond Areas of Obstruction. A benign tumor in the common basal stem bronchus produced sufficient obstruction to cause intermittent basilar pneumonitis and acute recurring bronchitis.—Figure 2: Metras Catheter Used in Routine Bronchography. To facilitate filling of apical cavities or spaces, the Metras catheter is used to fill the space before the catheter is withdrawn to allow completion of the unilateral bronchogram. This patient has a persistent apical space following a previous pulmonary resection for pulmonary tuberculosis.—Figure 3: Residual Oil Remaining in the Lungs After Dionosil Oily Bronchogram. Plain peanut oil in Dionosil Oily was substituted with iodinated peanut oil (Iodochlorol) for a right bronchogram so that after absorption of propyldone, the oil remaining in the lungs can be seen on the roentgenogram. (A) Notice the residual oil on the roentgenogram taken twelve days later. (B) This residue is greater than is usually seen after Visciodol. Presence of oil remaining in the lungs after the use of Dionosil Oily has also been confirmed histologically.
Alterations in the viscosity and surface tension of Lipiodol produced by the addition of sulfanilamide powder, that is Visciodol, permits a continuous and uniform coating of the entire bronchial tree with minimal alveolar filling. These outlines show good contrast in areas of pulmonary disease and usually produce a double contrast effect which permits small bronchial lesions to be readily seen. We have had no great difficulty in peripheral filling of diseased bronchi or filling beyond areas of partial obstruction (Figure 1) unless these bronchi are filled with mucopurulent secretions. Visciodol, being a more viscous medium than the Dionosils or ordinary iodized oils, flows slower through the small bronchi; therefore sufficient time must be allowed for adequate bronchial filling.

Allergic reactions in the form of uticaria by sulfanilamide powder occurred in only two patients after 500 bronchograms and these have responded well to antihistaminic therapy. Other types of postbronchographic reactions were less frequent with Visciodol than with Dionosil Oily. Bronchograms of diagnostic quality with outlining of all segments in each lung were obtained in 78 per cent of examinations with Dionosil Oily as compared to 89 per cent with Visciodol. This increase of approximately 10 per cent in the incidence of bronchograms with greater diagnostic value warrants the continued use of Visciodol. Bronchography at our hospital is used in the preoperative work-up in a large percentage of the patients prior to pulmonary resection. Experience with Visciodol now exceeds 500 examinations with excellent results.

The technique of selective bronchography using the Metras or Thompson catheters5 to fill specific segmental bronchi is of value in the occasional case where a segment was not outlined on a previous examination. When difficulty in filling a small apical space, cavity or diseased bronchus is anticipated, the selective technique is suggested in which an appropriate Metras or Thompson catheter is used to fill this defect. The catheter is then withdrawn sufficiently to permit completion of the routine unilateral bronchogram (Figure 2) thus obviating the need for a repeated examination. Since this technique may be associated with an increase in alveolar filling, it is essential that a medium be used, such as Visciodol, which has little tendency to flow into the alveoli.

Following bronchography an aerosol using a bronchodilator drug, such as Vaponefrin,* prior to postural drainage was studied to determine its effect on the elimination of bronchographic media. Postural drainage was routinely performed three times on the day of bronchography and again the following morning. Residual oil remaining in the lungs after 72 hours following bronchograms with Dionosil Oily was determined roentgenographically by substituting iodinated peanut oil for the plain peanut oil in this medium. The use of the bronchodilator drugs after installations of Visciodol produce an 18 per cent reduction in the number of patients having significant amounts of residual oil in the lungs. The bronchodilator

*Vaponefrin used in this study was donated by the Vaponefrin Company, Upper Darby, Pennsylvania.
drugs had a similar reducing effect on the residual oil following Dionosil Oily installations. Of further interest is the fact that the opaque oil remaining in the lungs after Visciodol is less than the non-opaque oil following bronchography with Dionosil Oily (Figure 3).

**PART II**

*Interpretation of Bronchographic Lesions*

The fact that the findings on histological examination are not always consistent with the clinical opinion has necessitated a better method of clinico-pathologic correlation of areas with bronchial disease. Bronchiectasis has been studied previously by obtaining corrosion specimens; however, this prevents histological examination of the same areas. Others have studied bronchographic lesions by injecting the surgical specimen with opaque media and have taken roentgenograms of the injected specimens. This method allows the correlation of a bronchogram with the surgical specimen but it is often difficult to accurately localize a bronchial lesion for histological examination. If the surgical specimen is injected under controlled pressure with an opaque medium which solidifies during formalin fixation of the specimen, the segmental planes can then be dissected prior to roentgenographic study. The bronchus more nearly maintains its original size so the roentgenograms can be correlated segment by segment with the bronchogram for accurate localization of bronchial lesions (Figure 4). A medium now used for injection studies of this type

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**FIGURE 4A**

*Figure 4: Bronchogram and Injected Surgical Specimen.* After left lower lobectomy, each segment is injected with an opaque medium which solidifies during formalin fixation. The segments are then separated and a roentgenogram made. This allows localization of bronchial defects for histological examination. The anteromedial basal segment (A) is compared with the lateral view of the preoperative bronchogram (B). The numbers on the bronchial branches correspond in each of the two illustrations. Only by this method could the location of such a defect be positively identified.
Figure 5: Inspiration and Expiration Bronchoograms Showing Variation in Size of Saccular Tuberculous Bronchiectasis. Variation in size of saccular bronchiectasis in the right upper lobe is seen on lateral bronchogram in (A) inspiration and (B) expiration. A histological section from the posterior segmental bronchi is seen in Figure 6.

FIGURE 6: Histology of Saccular Bronchiectasis Which Changes in Size During Respiration. A thin layer of fibrous tissue and smooth muscle surrounds the dilated bronchi. Blood vessels are surrounded by greater amount of fibrosis. No active inflammatory reaction is seen. Masson Stain, 4x.
is made by mixing Lipiodol, egg yolk and acacia in appropriate amounts for the desired consistency. Studies of this nature increase the diagnostic potentialities of bronchial defects so adequate treatment can be made more effective.

Normal variation in the caliber of the bronchi can be observed on bronchograms taken during inspiration and expiration. Bronchi which show saccular dilatation (Figure 5) on inspiration but are markedly reduced in size during expiration usually show little or no evidence of inflammatory

**Figure 7:** Outline of Bronchi in Areas of Bronchiectasis on 24-Hour Roentgenogram. (A) Bronchiectasis in left lower lobe is seen on bronchogram. (B) An outline of the bronchiectatic bronchi still present on the 24-hour roentgenogram shows evidence of poor bronchial cleansing.—**Figure 8:** Normal Left Bronchogram with 24-Hour Bronchial Outline. (A) Bronchogram left lower lobe shows normal outlines of bronchi. (B) Roentgenogram in 24 hours shows outline of two basal segments. Histological sections of one of these bronchi are seen in Figure 9.
reaction or fibrosis on histological examination (Figure 6). Bronchi which do not vary in size during the two phases of respiration more frequently show inflammatory changes or significant amounts of fibrous tissue in the bronchial wall. Roentgenograms are routinely taken in one view during the two respiratory phases in order to correlate these findings with histological sections.

Histological findings in early chronic bronchitis consist of hypertrophy of the mucous-secreting elements which is corroborated by an excess of

Figure 9: Histology of Bronchus Showing 24-Hour Outline. The basal bronchus outlined on the 24-hour roentgenogram in Figure 8B shows numerous goblet cells in the epithelium. (A) Hematoxylin and Eosin stain. (B) Periodic acid-Schiff stain is more specific for mucus. (67x)
Figure 10: Bronchographic Changes in Early Chronic Bronchitis. (A) Wavy outlines of lingular bronchi; (B) Rippled appearance of the right upper lobe bronchi and (C) Transverse striations in the right middle lobe and basal segmental bronchi.
mucus in the air passages. These changes consist of an increase in the number of goblet cells in the epithelial surface and hypertrophy of the mucous glands with marked dilatation of their ducts. When an excess of mucus is present in the bronchi, the cilia exert little more than a churning action on the mucus which steadily accumulates in the lungs requiring cough for evacuation. The resistance-lowering action of mucus together with purulent bronchiolitis and its sequela lead to progressive obliteration of pulmonary tissue thus setting the stage for production of emphysema. In order to treat chronic bronchitis and prevent the progressive changes in the lungs, a definite diagnosis must be made in the early stage of this disease.

Outlines of the bronchial tree with bronchographic medium as seen on a subsequent roentgenogram (Figure 7) have been observed in the areas of bronchiectasis since the early days of bronchography. This has been attributed to a poor cleansing mechanism of the diseased bronchi. In chronic bronchitis one of the earliest changes which occurs in the bronchus is an impaired cleansing ability. This is apparent in a bronchus which appears normal on the bronchogram (Figure 8) but remains outlined on a roentgenogram in 24 hours. The only changes on histological examination of this bronchus (Figure 9) is an increase in goblet cells in the epithelium and a few inflammatory cells in the submucosa. A roentgenogram taken 24 hours after bronchography is extremely valuable to observe this cleansing mechanism. When bronchial outlines are observed, a closer examination of the bronchogram will frequently reveal less obvious structural changes in the walls of these bronchi.

In 1949 DiRienzo and in 1953 Simon and Galbraith have described
some of the bronchographic findings in patients having chronic bronchitis. The use of Visciodol permits a more detailed study of these lesions so that a diagnosis can be made before more advanced changes occur. Bronchographic changes in early chronic bronchitis may consist either of wavy

FIGURE 12A

FIGURE 12B

Figure 12: Bronchographic Changes in Chronic Bronchitis Producing Diverticula. (A) Bronchial diverticulae seen in patients with chronic bronchitis may present a "saw-toothed" appearance, or (B) they may be so numerous that they produce "feathering" of the bronchial outline.

FIGURE 13: Histology of Diverticula. Two large dilated ducts of mucous glands are seen containing blood. Portions of three other ducts are seen with less evidence of dilatation. Hypertrophy of the mucous glands is evident.
Figure 14: Bronchographic Changes in Advanced Chronic Bronchitis. (A) Cylindrical bronchiolectasis is evident in the right upper lobe when dilated bronchi approach the lung periphery; (B) Cystic bronchiolectasis is present in the left anterior segment; (C) Cylindrical and cystic bronchiectasis is present in a right upper lobe bronchus; (D) Diverticula are seen in a right upper lobe bronchus; (E) Areas of constriction and dilatation are seen in the right basal segments of a patient with secondary emphysema, and (F) "Pipe-stem" deformity of a right basal segmental bronchus is characterized by very little diminution in size of the bronchus.
outlines of the bronchi showing alternate areas of dilatation and constriction or of a rippled appearance (Figure 10). These areas of constriction and dilatation may vary in length and diameter. When the interval between them is small, transverse striations in the bronchial mucosa are prominent (Figures 10 and 11).

Associated with chronic bronchitis, one will occasionally notice small diverticula along the surface of the larger bronchi measuring up to three millimeters in diameter. These diverticula may be few or numerous. They may have the appearance of feathering along the edge of the bronchial wall or may have a saw-toothed appearance (Figure 12). Bronchial diverticulosis was first described by Morlock and Pinchin\(^\text{10}\) in 1933, but it was not until 1953 that Duprez and Mampuys\(^\text{11}\) showed that these diverticula were dilated ducts of the bronchial mucous glands (Figure 13). Irregularity of the transverse striations will occasionally show filling defects which simulate diverticula in the bronchogram.

Bronchographic lesions become more prominent (Figure 14) in later stages of chronic bronchitis. Bronchioles in the periphery of the lung

**FIGURE 15:** Bronchographic Changes in Bronchitis Which Simulate Bronchiectasis. An acute respiratory infection in a patient with chronic bronchitis produces changes in the basal segments of the left lower lobe which simulate bronchiectasis. Histological section of the posterior basal bronchus is seen in Figure 16.
may become dilated and show cylindrical or cystic bronchiolectasis. Medium sized bronchi may also show similar cylindrical and cystic dilations. Cystic dilatations are due to destruction of the wall by localized areas of acute inflammation. Diverticula may appear along the walls of the medium sized bronchi. After the clinical symptoms of emphysema begin to appear, the basal bronchi may show areas having marked constriction of the lumen with distal dilatations or they may extend some distance without variation in the caliber of the lumen.

Bronchitis following an acute respiratory infection may produce such severe changes that a diagnosis of bronchiectasis is frequently made. This change was demonstrated by Blades in patients with so-called atypical pneumonia. More often this is seen in patients with chronic bronchitis due to superimposed acute infection (Figure 15). On histological examination the bronchi show acute suppurrative bronchitis (Figure 16). Broncho- graphic changes in acute bronchitis may be differentiated from those seen in true bronchiectasis by their symmetrical areas of dilatation and constriction, by relatively slight variation in the diameter of the bronchi and frequently by changes in other bronchi consistent with chronic bronchitis. Bronchial deformity produced primarily by atelectasis gives a similar appearance except the lumen decreases in diameter more rapidly due to relaxation and relative shortening of the bronchus. The nature of sputum

**FIGURE 16A**  
**FIGURE 16B**

*Figure 16: Histology of Acute Bronchitis.* Histological section of the posterior basal bronchus of the left lower lobe seen in Figure 15 shows acute suppurrative bronchitis without fibrosis. (A) Acute and chronic inflammatory cells are seen in the bronchial wall and lumen. A lymph follicle is also seen (80x). (B) The epithelial layer is infiltrated with similar inflammatory cells. The smooth muscle fibers are separated by edema. There is no evidence of fibrosis or destruction of the bronchial wall to suggest bronchiectasis.
and the bronchoscopic findings are often helpful in differentiating these bronchial lesions.

A poor prognosis can be anticipated if we attempt to cure patients with chronic bronchitis by surgical excision of the more involved areas, unless we use intensive medical therapy during the immediate preoperative and postoperative periods. Following surgery these patients must continue indefinitely under good medical management. Some patients who receive adequate medical treatment may not require surgery (Figure 17). It is imperative that a bronchogram be inspected closely especially to observe the less obvious changes which are consistent with chronic bronchitis prior to surgical treatment.

CONCLUSIONS

1. Since all bronchographic media remaining in the alveoli may produce foreign body reaction, it is recommended that a technique of bronchography and a type of bronchographic medium be used in which alveolar filling is not seen. There is less alveolar retention after Visciodol than after other bronchographic media.

2. The technique of selective bronchography using the Metras catheters is of value when there is insufficient outlining of a particular segment during a previous bronchographic examination. Routine bronchography in selected cases using an appropriate Metras catheter prevents the necessity of repeated bronchograms.

3. A method for correlating bronchiographic defects with their histo-
logical appearance has been described. We believe that this study will increase our knowledge of the significance of these defects.

4. A roentgenogram made 24 hours after bronchography should become a part of the routine bronchographic procedure so that our attention can be directed to less obviously involved areas of bronchial disease. Roentgenologists should be encouraged to include this in the total cost of the bronchogram.

5. Bronchography using Visciodol has made possible a more detailed study of bronchial defects. Bronchographic findings in acute as well as various stages of chronic bronchitis are described. In order to give proper treatment to patients with acute or chronic bronchitis, these less obvious lesions must be recognized on bronchography.

RESUMEN

1. Puesto que todos los medios de contraste para broncografía producen reacción de cuerpo extraño cuando permanecen en los alvéolos, se recomienda que se adopte una técnica de broncografía con un medio que no permita el llenado alveolar. Hay menos retención alveolar después de usar Visciodol que después de otros medios.

2. La técnica de la broncografía selectiva con las sondas de Metras es de valor cuando hay insuficiente delimitación de algún segmento en particular según se haya visto en broncografía previa. La broncografía de rutina en casos adecuados usando una sonda de Metras evita la necesidad de repetir los broncogramas.

3. Se describe un método para correlacionar los defectos broncográficos con su apariencia histológica. Creemos que este estudio aumentará nuestro conocimiento de la significación de estos defectos.

4. Un roentgenograma hecho 24 horas después de br'oncografía debe formar parte del procedimiento broncográfico de modo que nuestra atención se enfocque a las áreas menos comprometidas por la enfermedad bronquial. Los radiólogos deben animarse a incluir esto en el costo total del broncograma.

5. La broncografía con Visciodol hace posible un estudio más detallado de los defectos bronquiales. Se describen los hallazgos broncográficos en casos agudos o de bronquitis crónica. Para dar tratamiento adecuado a los enfermos con bronquitis aguda estas lesiones menos aparentes deben ser reconocidas por la broncografía.

RESUME

1. Puisque tous les produits utilisés pour la bronchographie qui stagnent dans les alvéoles peuvent se comporter comme des corps étrangers, les auteurs recommandent d'employer une technique de bronchographie et un type de produit avec lesquels on ne voit pas le remplissage alvéolaire. La rétention alvéolaire est moindre après usage de "Visciodol" qu'après tout autre produit à usage bronchographique.

2. La technique de bronchographie sélective utilisant les cathéters de Metras est de grande valeur quand le dessin d'un segment particulier s'est
montré insuffisant au cours d'un examen bronchographique préliminaire. Une bronchographie de routine, dans des cas choisis, utilisant le cathéter de Metras, évite la nécessité de bronchogrammes répétés.

3. Les auteurs décrivent une méthode qui met en parallèle les altérations bronchographiques à leur traduction histologique. Ils pensent que cette étude augmentera nos connaissances sur la signification de ces altérations.

4. Un cliché radiologique 24 heures après la bronchographie devrait faire partie de la technique bronchographique de routine, de telle sorte que l'attention puisse être dirigée sur des zones bronchiques dont l'atteinte est moins évidente. Les radiologistes devraient être encouragés à faire entrer cet examen dans le montant des frais de la bronchographie.

5. La bronchographie utilisant le visciodol a rendu possible une étude plus détaillée des altérations bronchiques. Les auteurs rapportent leurs constatations bronchographiques dans les bronchites aiguës et dans les différents stades des bronchites chroniques. Pour traiter comme il convient les malades atteints de bronchite chronique ou aiguë, il est nécessaire de reconnaître sur la bronchographie des altérations qui apparaissent de façon moins évidente.

REFERENCES