A Technique of Bronchography in Children
with Evaluation of Contrast Media

SOMCHAI BOVORKITTI, M.D., F.C.C.P. and JOHN ZABRISKIE, M.D.
New York, New York

Since 1947 an intensive study of endobronchial tuberculosis in children has been undertaken in the Chest Clinic of the Children's Medical Service of Bellevue Hospital. An attempt was made to determine by means of bronchography the incidence and types of residual bronchial and pulmonary disease in children previously found to have tuberculous endobronchial lesions on bronchoscopy. During 1955-56, 117 bronchograms were made in children with apparently healed endobronchial disease; in addition, seven bronchograms were carried out in children with non-tuberculous pulmonary disease, making a total of 124 bronchograms.

This investigation has provided an unusual opportunity to evaluate methods of bronchography in children, also three commonly used contrast media.

In recent years, bronchography has been used with greater frequency as an aid in the diagnosis and localization of pulmonary disease. However, its use in children has been limited, due to certain technical difficulties. Various methods for the introduction of the contrast medium have been used, such as supraglottic, transglottic and subglottic routes. Different techniques of anesthesia have been tried, using local anesthetics, general anesthetics or a combination of both. Our satisfactory results in 110 out of 124 bronchograms (88 per cent) compare favorably with the other accurately reported series of bronchograms in children, namely that of Bates and his associates, who obtained good bronchograms in 41 out of 50 cases (82 per cent) in 1950.

We attribute our good results particularly to the following factors: a) anesthesia, b) type and amount of contrast medium used, c) careful and systematic positioning of the patient following fractional instillation of the contrast medium, and d) radiographic technique.

Technique: The technique of bronchography described by Bates and his co-workers, slightly modified by one of us (S.B.), has been used throughout the entire study.

Patients are admitted to the hospital on the day before bronchography and discharged on the following day. They are allowed a light breakfast but no lunch as the procedure is always performed between 1 and 3 p.m. When auscultation of the chest on admission reveals rales and rhonchi, the quality of the bronchograms is improved if postural drainage is performed for 10 minutes on the evening of admission and repeated the following morning.

From the Chest Clinic of the Children's Medical Service of Bellevue Hospital and the Department of Pediatrics, New York University College of Medicine.
Scopolamine is given subcutaneously 30 to 60 minutes before the procedure. The dosage is 0.0002 Gm. for children up to six years of age and 0.0003 Gm. for older children. Occasionally Nembutal® by mouth is given to apprehensive or over-excited children.

Because the patients are in an age range of two to 13 years in this series, with one exception, a boy of 16 years (Table I), general anesthesia in the form of open-drop ether is used in all cases. When the patient reaches the second plane of anesthesia, direct laryngoscopy is performed and the largest possible endotracheal tube inserted and taped to the corner of the mouth opposite the side of the lung to be studied; secretions are aspirated through the lumen of the tube. Just prior to insertion of the endotracheal tube, its length is measured off on the fine rubber catheter (8-10 F.) which will be used for instillation of the contrast medium, and marked with a small strip of adhesive tape.

The patient is then taken to the radiographic room by the anesthetist.

Occasionally Cyclaine® solution has been sprayed directly into the endotracheal tube. Though it was obvious that this helped suppress the cough reflex better than general anesthetics alone, we feel that the danger of aspiration after the procedure is much greater than the benefit obtained from its use.

The catheter is introduced inside the endotracheal tube to the distance previously marked off, so that the contrast medium will be delivered at the end of the tube. The contrast medium is injected into the catheter with a 20 ml. syringe.

The total amount of contrast medium injected into each lung is approximately 1 ml. per year of age up to five years. A maximum of 8 ml. per lung is used for older children. The amount of contrast medium for each lung is divided as follows: for the right lung twice as much material is required for the lower lobe (first fraction) as for the middle (second fraction) and upper (third fraction) lobes together. In the case of the left lung, the amount for the lower lobe (first fraction) is the same, and half of this amount is divided between the lingula (second fraction) and the upper lobe proper (third fraction). For example, for a six year old child the total amount of material used for each lung is 6 ml.; 3 ml. are instilled into the lower lobe and 1.5 ml. each into the middle and upper lobes respectively on the right; on the left side, 3 ml. are instilled into

### TABLE I

<table>
<thead>
<tr>
<th>Age in Years</th>
<th>Number of Patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 - 5</td>
<td>33</td>
</tr>
<tr>
<td>6 - 9</td>
<td>44</td>
</tr>
<tr>
<td>10 - 13</td>
<td>22</td>
</tr>
<tr>
<td>16 -</td>
<td>1</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>
the lower lobe and 1.5 ml. each into the lingula and the left upper lobe proper. Each lobe is filled in turn after appropriate positioning of the patient.

Positioning of the Patient: A clear idea of the segmental anatomy of the lung is essential for satisfactory positioning. The segments of the lung are shown diagrammatically in Figure 1 (segment 7 is not visualized on the right lateral view), numbered according to the scheme adopted by the International Committee in 1949.

The order in which the segments are filled has been worked out with a view to minimizing the labor of moving the unconscious patient. Also it has been our experience that the quality of the bronchograms is better when the lower lobe bronchi are filled first, and those to the upper lobes just prior to radiography.

Good team-work is important. The assistant holds the child's head elevated, slightly hyperextended, and turned to the side opposite the lung to be studied. This helps to maintain the airway and to direct the flow of contrast medium to the side under study.

To outline each of the segments of the lung, the operator manipulates the patient successively in each of the six positions shown in Figure 2, all the while keeping the patient inclined (not rotated) towards the right side.

For outlining the bronchi to the right middle lobe (segments 4 and 5), the patient is placed in position 3; fraction 2 of the contrast medium is now instilled.

Fraction 3 of the contrast medium is instilled just after placing the patient in position 4; he is then turned to positions 5 and 6 respectively, leaving him 15 seconds in each position. This ensures complete filling of the apical, posterior and anterior segments of the right upper lobe (1, 2 and 3).

The above procedure ensures visualization of the right lung. For the left lung the entire sequence of positions is repeated as above, following instillation of fractions 1 and 2 of the contrast medium, the only difference
being that the patient is kept inclined (not rotated) towards the left. However, for fraction 3 he is placed on his left side (position 7) prior to instillation of the contrast medium, then rotated to the Trendelenburg positions 8 and 9.

**Radiography:** As soon as the contrast medium has been instilled and the child placed in the six positions, chest radiographs are taken in the following order:

- **Unilateral Bronchograms:**
  - Lateral view.
  - Posterior oblique view.
  - Antero-posterior view.

- **Bilateral Bronchograms:**
  - **Right Lung—**
    - Right lateral view.
    - Right posterior oblique view.
    - Antero-posterior view.
  - **Left Lung—**
    - Left posterior oblique view.
    - Antero-posterior view.

Ideally, respiratory movements should be eliminated when the radiographs are taken. However our experience has shown that the slight respiratory movements of the well-anesthetized child are compatible with excellent bronchograms. On several occasions, the endotracheal tube has been attached to a respiratory bag with a closed circuit so that the respira-

![Diagram of the positions](image-url)
tions of the child could be controlled by the anesthetist during radiography; in this case radiographs are taken when the chest is inflated into the position of deep inspiration.

Recovery: After the radiographs are taken, the contrast medium is aspirated through the endotracheal tube. The child is then put in the position of postural drainage and returned to the ward as soon as he regains consciousness.

Complications: In this series of 124 bronchograms there was no case in which the underlying disease, tuberculous or non-tuberculous, appeared to be in any way aggravated by bronchography.

Two patients developed irritative conjunctivitis from ether anesthesia, with clearing within 48 hours.

Marked cyanosis developed in two patients as the contrast medium (Visciol®) began to enter the second lung, although they had been asymptomatic throughout the first part of the procedure. Prompt recovery followed withdrawal of the material, suction, oxygen and postural drainage. The first patient was a six year old girl who had generalized pulmonary emphysema as well as extensive bilateral calcification of old tuberculous foci. The second patient was a five year old boy who previously had had active primary pulmonary tuberculosis and endobronchial lesions leaving him with bronchiectasis in the shrunken right middle lobe.

Enlargement of the thyroid gland occurred in a three year old boy, in whom three successive bronchograms were done at intervals of one to two months (September 22, 1955, November 27, 1955, and December 29, 1955). Lipiodol® was used on each occasion. The thyroid gland was noted to be enlarged on December 31, 1955 and the level of protein-bound iodine on January 31, 1956 was 27.6 gamma per cent (normal = 4-8 gamma per cent). By April 6, 1956 the thyroid gland had returned to almost normal size. The level of protein-bound iodine on September 2, 1956 was 10.4 gamma per cent.

Analysis of Bronchographic Results

A total of 124 bronchograms in 100 patients have been performed during the past year.

<table>
<thead>
<tr>
<th>ALVEOLAR FILLING</th>
<th>Lipiodol</th>
<th>Dionosil</th>
<th>Visciol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Absent</td>
<td>10</td>
<td>12</td>
<td>22</td>
</tr>
<tr>
<td>Minimal</td>
<td>17</td>
<td>13</td>
<td>14</td>
</tr>
<tr>
<td>Moderate</td>
<td>10</td>
<td>14</td>
<td>4</td>
</tr>
<tr>
<td>Excessive</td>
<td>4</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>TOTAL</td>
<td>41</td>
<td>43</td>
<td>40</td>
</tr>
</tbody>
</table>
Three different contrast media have been used:
1. Lipiodol® (iodized oil, U.S.P.).
2. Dionosil® (propyliodone) aqueous suspension.
3. Visciiodol® (lipiodol-sulfanilamide).

Criteria for Evaluation of Results of Bronchograms: Excellent Bronchograms: All segmental bronchi are well outlined; secondary and tertiary bronchi are well visualized; absence of or minimal alveolar filling, and good radiologic contrast.

Good Bronchograms: All segmental bronchi are adequately outlined; most of the secondary and tertiary bronchi are visualized; minimal to moderate alveolar filling; and adequate or fair contrast.

Adequate Bronchograms: Poor filling of the segmental bronchi which can, however, be traced; secondary and tertiary bronchi are poorly visualized; moderate to excessive alveolar filling without, however, obscuring the bronchial outline completely, and poor contrast.

Unsatisfactory Bronchograms: Incomplete filling of segmental bronchi which cannot be traced; excessive alveolar filling interfering with visualization of the bronchial outline, and poor contrast.

The details of our results with regard to alveolar filling and radiologic contrast can be seen in Tables II and III.

---

**TABLE III**

<table>
<thead>
<tr>
<th>RADIOLOGIC CONTRAST</th>
<th>Lipiodol</th>
<th>Dionosil</th>
<th>Visciiodol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good</td>
<td>20</td>
<td>13</td>
<td>37</td>
</tr>
<tr>
<td>Fair</td>
<td>16</td>
<td>14</td>
<td>3</td>
</tr>
<tr>
<td>Poor</td>
<td>5</td>
<td>16</td>
<td>0</td>
</tr>
<tr>
<td>TOTAL</td>
<td>41</td>
<td>43</td>
<td>40</td>
</tr>
</tbody>
</table>

---

**TABLE IV**

<table>
<thead>
<tr>
<th>OVERALL RESULTS IN 124 BRONCHOGAMS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quality</td>
</tr>
<tr>
<td>---------</td>
</tr>
<tr>
<td>Satisfactory</td>
</tr>
<tr>
<td>Excellent</td>
</tr>
<tr>
<td>Good</td>
</tr>
<tr>
<td>Adequate</td>
</tr>
<tr>
<td>Unsatisfactory</td>
</tr>
<tr>
<td>Total Number of Bronchograms</td>
</tr>
<tr>
<td>Total Number of Satisfactory</td>
</tr>
</tbody>
</table>
Discussion

We attribute the satisfactory results obtained in our bronchograms principally to: (a) the type of anesthesia; (b) the contrast medium, and (c) the careful and systematic positioning of the patient, and (d) radiographic technique.

(a) Anesthesia: Good anesthesia is the first essential for success in securing satisfactory bronchograms. In our series, open-drop ether anesthesia has proved to be the method of choice because of its simplicity and efficiency.

Inadequate anesthesia can be troublesome, giving rise to jerky respirations, coughing or even bronchospasm during instillation of the contrast medium. It may result in overfilling of the alveoli, motion during radiography and incomplete filling of the segmental bronchi.

(b) Contrast Medium: The contrast medium is important in obtaining successful bronchograms.

Lipiodol, an iodized oil, has been successfully used ever since its introduction by Sicard and Forestier in 1922. We have performed 41 bronchograms in children using Lipiodol and find the main disadvantage to its use to be the delay in elimination of the material from the lung. As a result, the radiographic pictures remain obscured for many weeks or even months and repetition of bronchography becomes impossible. Another disadvantage is the ease of alveolar flooding, which can, however, be successfully prevented by proper manipulation. Postbronchographic collapse of portions of the lung reported by others did not occur in our series. Clinical iodism, although rare, has been noted. One of our children developed enlargement of the thyroid gland with significantly prolonged eleva-

![FIGURE 3A](http://journal.publications.chestnet.org/pdfaccess.ashx?url=/data/journals/chest/21299/)  
![FIGURE 3B](http://journal.publications.chestnet.org/pdfaccess.ashx?url=/data/journals/chest/21299/)

**Figure 3A:** P-A view: Good normal bronchogram of right lung obtained with Visciodol.—**Figure 3B:** Right oblique view.
tion of the protein-bound iodine after three consecutive bronchograms. Hyde and Hyde\textsuperscript{14} studied the blood iodine levels after administration of iodized oil and noticed high levels lasting many months after broncho-
graphy.

More recently, Dionosil, an organic iodine compound, suspended in water or peanut oil has been widely acclaimed as a more satisfactory contrast medium for bronchography.\textsuperscript{15,16} The advantage of using the aqueous suspension of Dionosil as the contrast medium has been demonstrated in 43 bronchograms. The main advantage over Lipiodol is the rapid absorption of the material which usually disappears from the lung within one week. This permits subsequent radiologic examination without interference by the contrast medium. We agree with others that, with the use of Dionosil, radiography can be unhurried, as the medium is slower in penetrating into the alveoli. The chief drawback to its use is the lack of sharp radiologic contrast. Furthermore, when alveolar filling does occur, it gives rise to blurring of the lung fields, thus enhancing the poor radiologic contrast produced by Dionosil. Dionosil will, however, give adequate results if the respiratory movements can be entirely eliminated during radiography, as in cooperative adults under local anesthesia, or in children when the respirations can be completely controlled by the anesthetist. Toxic reactions with Dionosil have been described,\textsuperscript{15,16} but did not appear in any of our patients.

A third contrast medium used in this study, Visciodol, is a suspension of sulfanilamide in iodized oil. This was accidentally discovered by Dormer, Friedlander, and Wiles\textsuperscript{7} in 1945, and has been extensively used for bronchography especially in adults.\textsuperscript{18} Visciodol in our experience has given the

\begin{figure}
\centering
\begin{tabular}{cc}
\includegraphics[width=0.4\textwidth]{fig4a.png} & \includegraphics[width=0.4\textwidth]{fig4b.png} \\
\textbf{FIGURE 4A} & \textbf{FIGURE 4B} \\
\end{tabular}
\caption{\textbf{Figure 4A:} P-A view: Bronchogram obtained by instillation of Visciodol on August 29, 1956.\textsuperscript{-}\textbf{Figure 4B:} P-A view of same patient on September 6, 1956 showing complete disappearance of contrast media.}
\end{figure}
most satisfactory results of the three contrast media employed. The bronchograms obtained are technically excellent (Figure 3A, B). Because of its high viscosity there is less tendency for the material to enter into the alveoli, thus allowing ample time for positioning of the patient and for unhurried radiography. Perhaps also because of its high viscosity, the material is more readily eliminated by the ciliary section of the bronchial mucosa and is not retained in the lung. We have taken follow-up radiographs within a week after bronchography and found no evidence of retained material (Figure 4A, B). Visciodol provided excellent radiologic contrast. Finally, in our own experience it lacks clinical toxicity from the iodized oil although we did find the protein-bound iodine fraction elevated in all cases studied to above 100 gamma per cent. The only unfortunate drawback of Visciodol is that the thickness of the material makes it troublesome to prepare: it needs constant warming and vigorous stirring up to the moment of use and even then it must be forcibly ejected from the syringe. Dangers from the use of too viscous a medium in outlining the bronchial tree have been stressed, and from our experience with two patients described above, we believe it inadvisable to perform bilateral bronchograms simultaneously with Visciodol in children, unless the material is aspirated from the first side studied before proceeding to the second side.

(c) Careful and Systematic Positioning of Patient: Positioning of the patient is of utmost importance in obtaining complete filling of all of the segmental bronchi of the lung. It is also important to instill the contrast medium by the fractional method described above. This technique assures the proper distribution of the opaque material in all segments of the lung.

(d) Radiographic Technique: The final success of bronchography really depends upon the radiographic pictures obtained. Naturally, the best possible technique will give the best results.

SUMMARY

One hundred and twenty-four bronchograms were performed in 100 children; 110 of these bronchograms were satisfactory. Our experience leads us to believe that successful bronchography in children depends upon the anesthesia, the choice of contrast material, careful positioning of the patient to ensure complete filling of all segmental bronchi and finally upon the radiographic technique. Our exact technique is described in detail, as well as the advantages and disadvantages of three contrast media, namely, Lipiodol, Dionosil and Visciodol.

The patient is admitted to the hospital for the procedure; postural drainage is instituted prior to anesthesia if physical examination reveals presence of rales. Scopolamine followed by open drop ether is the method used. Direct laryngoscopy permits insertion of an endotracheal tube, and the contrast material is inserted through a catheter of known length. Most satisfactory results have been obtained using Visciodol (sulfanilamide in iodized oil). For best results it is advised that this material be warmed and vigorously stirred up to the moment of instillation. Exact amounts of contrast material and sequence of positions are described in the text.
Better than 85 per cent satisfactory bronchograms have been obtained using this method.

Untoward reactions have been noted: cyanosis may occur if both lungs are done simultaneously with Visciodol; aspiration of the first side before proceeding to the second side is therefore recommended. High iodine levels and enlargement of the thyroid following the use of Lipiodol and Visciodol have been noted by others as well as by ourselves.

ACKNOWLEDGMENTS

We should like to thank the members of the Staff of the Anesthesiology Department: Mr. Fred Sheinkopf and Mr. Joseph McGowan, radiographers, without whose skill and cooperation this work would not have been possible.

We should also like to thank Dr. Edith M. Lincoln for her help in the evaluation of the bronchograms and valuable criticism; Dr. Margaret H. D. Smith and Dr. Samuel Stone for their constant advice and encouragement.

Dr. Herbert Kupperman of New York University College of Medicine has kindly determined the protein-bound iodine levels.

One of us (S. B.) is indebted to Parke, Davis and Company for a financial grant enabling him to complete the study.

We are grateful to E. Fougera and Company, Incorporated, for supplying the Visciodol used in this study.

RESUMEN

Se hicieron ciento veinticuatro broncogramas en 100 niños; 110 de ellos fueron satisfactorios. Nuestra experiencia nos lleva a creer que la bronco- grafía bien lograda depende en los niños, de la anestesia, la elección del medio de contraste, la posición cuidadosa del enfermo para asegurar el llenado completo de todos los bronquios segmentarios y por último también depende de la técnica radiográfica. Se describe nuestra técnica con exactitud en detalle así como las ventajas y desventajas de los medios de contraste como son: lipiodol, dionsil y visciiodol.

El enfermo ingresa al hospital para el procedimiento; se hace primero drenaje postural, antes de la anestesia si la auscultación revela estertores. Se usa la escopolamina seguida de la anestesia al éter por goteo abierto. La laringoscopía permite la inserción del tubo endotraqueal y el medio de contraste se inyecta a través de un cateter de longitud conocida. Los mejores resultados se obtienen con visciiodol (sulfanilamida en aceite yodado). Para obtener mejores resultados se aconseja que este material se caliente y se agite vigorosamente hasta el momento de la instilación.

Se describen las posiciones que deben usarse y las cantidades exactas de medios de contraste. Más del 85 por ciento de resultados satisfactorios se logran por este método.

Reacciones desagradables que se han observando: cianosis puede ocurrir si los dos pulmones se instilan con visciiodol; la aspiración del primer lado antes de emprender el segundo se recomienda.

Elevadas concentraciones de yodo y crecimiento de la glándula tiroides después del lipiodol o del visciiodol se han notado por otros así como por nosotros.
RESUME

124 bronchogrammes ont été obtenus chez 100 enfants. 110 de ces bronchogrammes furent satisfaisants. L'expérience des auteurs les conduit à penser qu'une bronchographie satisfaisante chez les enfants dépend de l'anesthésie, du choix de la substance de contraste, de la position convenable du malade pour obtenir la pénétration complète de toutes les bronches segmentaires, et finalement de la technique radiographique. La technique précise des auteurs est décrite en détail, ainsi que les avantages et les inconvénients de trois substances de contraste, à savoir: le lipiodol, le dionisol, et le visciiodol.

Le malade est admis à l'Hôpital pour cet examen; un drainage de posture est institué avant anesthésie si l'examen physique révèle la présence de râles. Les auteurs utilisent la méthode d'anesthésie par la "scopalamine" suivie par l'administration d'éther. La laryngoscopie directe permet l'insertion du tube endotrachéal, et la substance de contraste est instillée par un cathéter de longueur connue. La plupart des résultats satisfaits ont été obtenus par la visciiodol (sulfanilamide dissous dans de l'huile iodée). Pour obtenir les meilleurs résultats, il est conseillé de chauffer cette substance et de l'agiter vigoureusement au moment de l'instillation. Les quantités exactes de substance de contraste et les positions sont décrites dans le texte. Plus de 85% des bronchogrammes satisfaits ont été obtenus par cette méthode.

Des réactions secondaires ont été notées: de la cyanose peut survenir si les deux poumons sont instillés en même temps par le visciiodol; l'aspiration du premier côté avant de procéder à l'instillation du deuxième est dés lors recommandée. Les auteurs comme d'autres l'avaient déjà signalé, ont noté un taux élevé d'iode, et l'augmentation de la thyroïde après emploi du lipiodol et du visciiodol.

ZUSAMMENFASSUNG


Der Patient wird für den Eingriff im Krankenhaus stationär aufgenommen; eine Lagendrainage wird durchgeführt vor der Anaesthesie, sofern die physikalische Untersuchung des Bestehen von Rasselgeräuschen ergibt. Scopalamin mit anschliessendem Tropf-Aether ist das angewandte Verfahren. Direkte Laryngoskopie ermöglicht die Einführung eines endotrachaealen Tubus, und das Kontrastmittel wird durch einen Katheder bekannter Länge eingeführt. Das am meisten befriedigende Resultat wurde erzielt bei der Verwendung von Visciodol (Sulfanilamid in Jod-
Um die besten Resultate zu gewinnen, wird empfohlen, dieses Material zu erwärmen und kräftig zu schütteln bis zu dem Augenblick der Einfüllung. Exakte Mengenangaben des Kontrast materials und die Reihenfolge der Lagerung werden im Text beschrieben. Mehr als 85% befriedigende Bronchogramme wurden unter Verwendung dieser Methode erzielt.


REFERENCES