Introduction. Anesthesia for rigid bronchoscopy in infants and children is a challenging procedure since it is often difficult to maintain airways for adequate ventilation. Over the last decade, Hopkins type glass rod telescopes have been introduced and their use through the bronchoscope lumen have further compromised the airway patency. For the optimal anesthetic management of infants and children undergoing bronchoscopy, it is highly desirable to know the flow-pressure characteristics of different bronchoscopes combined with the telescope. Such data, however, is lacking in the literature. The purpose of the present study was to obtain such information in order to evaluate rationally the different anesthetic techniques such as spontaneous breathing, assisted or controlled ventilation, and high frequency ventilation (HFV).

Methods. We evaluated Storz bronchoscopes with a Hopkins glass rod telescope, with and without an anti-fog sheath for the telescope, since this combination is used in over 75% of pediatric centers in the United States. A Fleisch pneumotachograph was connected to the proximal end of a bronchoscope and alternatively to the breathing side port. The pressure gradient across the bronchoscope was measured with a differential transducer (HP267B).

Varying rates of air flow were directed through the pneumotachograph and bronchoscope while all other proximal openings were properly sealed. All measurements were made twice on different occasions to insure the accuracy of measurements.

Results and Discussion. As anticipated, there was a large increase in flow resistance through the ventilating side-arm (Rsa) as compared with that through the main passage of the same bronchoscope. At the flow rate of 0.4 L/sec, the resistance increased seven fold in the size 5.0 and 6.0 bronchosopes, while the increase was 2 to 4 fold for the smaller bronchoscopes. With the insertion of a telescope (4mm OD), Rsa increased only moderately in large bronchoscopes (+14% in size 6.0 scope) while the increase was extreme in smaller ones (+600% in size 3.5 scope). Insertion of the anti-fog sheath was associated with an additional increase in Rsa by 12% to 300%.

To evaluate the clinical significance of flow-pressure characteristics of these bronchoscopes with accessories, we estimated the flow rate necessary for adequate tidal ventilation for various age groups when appropriate bronchoscopes were used as recommended (1). We assumed the tidal volume of 10 ml/kg, inspiratory to expiratory time ratio of 1:2, square-wave flow pattern, and respiratory frequency from available physiological data (2). The values for Rsa with and without accessories were compared with the predicted values of airway resistance (Raw) for each representative age (2).

From Table I, it is apparent that spontaneous breathing is not possible in any age group when the telescope with anti-fog sheath is in use, since flow resistance of the bronchoscope system alone exceeds patient's total airway resistance (Raw) by 3105 to 700%. In particular, the obstruction seems worst in infants between the ages of 3 months and 12 months when the size 3.5 (30 cm length) scope is used as recommended. In these patients the added inspiratory pressure for the bronchoscope alone is estimated to be 12-18 cmH₂O.

Even when the ventilation is controlled, the problem of inadequate gas exchange is not eliminated. The driving pressure for the deflation of the lungs after each inflation is the static recoil pressure of the total respiratory system which may range between 6 cmH₂O in the newborn and 12 cmH₂O in the adolescent (3). This pressure is not sufficient to deflate the lungs to functional residual capacity (FRC) because of the prolonged time constant of the respiratory system including the bronchoscope and telescope. This would result in hyperinflation of the lungs and hyperventilation, as reported by Rah et al., in the animal model (4). The problem of air trapping in the lungs would be far greater with the use of HFV if the proximal end of the bronchoscope is occluded by a telescope. Based on the data obtained, we conclude that neither spontaneous nor controlled breathing may be adequate for pediatric bronchoscopy with telescope particularly for the patient below one year of age.

One satisfactory technique to maintain adequate ventilation during bronchoscopy is to remove the telescope periodically (i.e. every 30-60 seconds) during the procedure while the bronchoscope is left in place and to hyperventilate the patient through the sidearm with the proximal end of the bronchoscope occluded.

**Table I: Predicted Raw vs. computed Rsa cmH₂O L/sec**

<table>
<thead>
<tr>
<th>Age</th>
<th>Raw</th>
<th>B'scope</th>
<th>Rsa¹</th>
<th>Rsa²</th>
<th>Rsa³</th>
<th>Rna³/Raw</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 wk</td>
<td>29</td>
<td>3.0</td>
<td>17</td>
<td>31</td>
<td>119</td>
<td>4.1</td>
</tr>
<tr>
<td>6 mo</td>
<td>19</td>
<td>3.5</td>
<td>12</td>
<td>134</td>
<td>NA</td>
<td>7.0</td>
</tr>
<tr>
<td>3 yr</td>
<td>10</td>
<td>4.0</td>
<td>14</td>
<td>37</td>
<td>59</td>
<td>5.7</td>
</tr>
<tr>
<td>5 yr</td>
<td>8</td>
<td>5.0</td>
<td>10</td>
<td>17</td>
<td>25</td>
<td>3.1</td>
</tr>
<tr>
<td>10 yr</td>
<td>5</td>
<td>6.0</td>
<td>16</td>
<td>19</td>
<td>22</td>
<td>4.3</td>
</tr>
</tbody>
</table>

Rsa¹: Empty bronchoscope
Rsa²: With telescope
Rna³: With telescope and anti-fog sheath

References.