Diagnosis of Tracheal Injury in Mechanically Ventilated Premature Infants by Flexible Bronchoscopy*
A Pilot Study

Dennis E. Schellhase, M.D.; Leroy M. Graham, M.D.; Elizabeth J. Fix, C.R.T.; Loretta M. Sparks, R.R.T., R.C.P.T.; and Leland L. Fan, M.D.

Flexible bronchoscopy (FB) is uniquely suited for the study of large airway lesions in the ventilated premature infant. However, no standardized clinical scoring system of distal tracheal injury exists and the adverse consequences of FB in ventilated premature infants are not well described. Using a prototype Olympus fiberoptic ultrathin bronchoscope with a directable tip and an outer diameter of 2.2 mm, we serially scored distal tracheal injury in conventionally ventilated premature infants on the basis of mucosal and obstructive changes observed at bronchoscopy. In addition, we prospectively evaluated the incidence of adverse cardiovascular and pulmonary effects during, immediately after, and within 1 h of FB. We performed 21 FBs in eight conventionally ventilated premature infants with birth weight of 1,239 ± 438 g and gestational age of 30 ± 3 weeks. The carina and mainstem bronchi were easily visualized in all infants using the prototype bronchoscope. During the first several days of life, moderate-to-severe distal tracheal mucosal injury occurred frequently, while moderate-to-severe obstructive injury occurred infrequently. Distal mucosal injury appeared to improve during the fourth week of life. Mild distal obstructive injury began to appear during the second week of life. Adverse consequences of FB observed in our patient population included transient hypoxemia and bradycardia during FB, changes in systolic blood pressure immediately and within 1 h after FB, and emesis immediately after FB. Serious adverse cardiovascular or pulmonary effects were not observed. We conclude that FB can be performed safely with appropriate monitoring and is a useful tool in the clinical assessment and serial evaluation of distal tracheal injury in ventilated premature infants. We speculate that moderate-to-severe distal tracheal mucosal injury may be associated with the development of later obstructive injury. On the basis of this preliminary study, further prospective investigations of tracheal injury in ventilated premature infants appear to be warranted. (Chest 1990; 98:1219-25)

**FB** = flexible bronchoscopy; **NTB** = necrotizing tracheobronchitis; **RDS** = respiratory distress syndrome; **ETT** = endotracheal tube

Tracheal injury has been described by a number of investigators as a consequence of intubation and mechanical ventilation.1–4 Both severe, acute tracheal injury (NTB)5–10 and less severe, occasionally unsuspected tracheal injury11–15 have been reported in ventilated premature infants. Although NTB has been associated with inadequate humidification of inspired gases, severity of illness, duration of mechanical ventilation, need for high mean airway pressures and mode of ventilation,1 the incidence of NTB in ventilated premature infants is unknown. Recently, less severe tracheal injury has been associated with duration of mechanical ventilation;16 however, the incidence of less severe tracheal injury and its immediate and late sequelae remain speculative.

Prior to the development of pediatric ultrathin flexible bronchoscopes, the study of tracheobronchial injury and long-term large airway sequelae in premature infants could not be accomplished easily. Rigid bronchoscopy allows excellent visualization of the large airways, but is limited by the necessity of general anesthesia and extubation. Flexible bronchoscopy has several advantages: ability to be performed at the bedside, ability to pass the instrument through an existing ETT, and no need for general anesthesia. The adverse consequences of flexible bronchoscopy in ventilated premature infants have been reported to be minimal.14,15 Thus, FB is uniquely suited for the study of large airway lesions in ventilated premature infants.

Recently, tracheobronchial histopathologic scoring systems have been developed to grade the extent and severity of tracheal injury.16,17 One of the problems with the several studies using FB to assess tracheal...
changes in ventilated premature infants is the lack of a standardized clinical scoring system of tracheal injury. Further, prospective serial evaluation of tracheal injury has yet to be attempted in ventilated premature infants. In this study, we report preliminary results of a prospective serial evaluation of tracheal injury in mechanically ventilated premature infants using a prototype fiberoptic directable tip bronchoscope clinically to score tracheal mucosal and obstructive changes. In addition, we report a prospective evaluation of the adverse consequences of FB in this patient population. Preliminary reports of these investigations have been presented previously.18,19

**METHODS**

Infants who required conventional mechanical ventilation for RDS in the neonatal intensive care at the Children's Hospital, Denver, were enrolled in this investigation if they met the following criteria: birth weight less than 2,000 g, age of not more than 3 days and no congenital abnormalities. Informed consent was obtained from the parents of each infant and the study protocol was approved by the Institutional Review Board of the Children's Hospital. Flexible bronchoscopy was performed within 24 to 36 h of admission, at 3 to 5 days of age, at 10 to 12 days of age and then at 4 weeks of age.

In all instances, FB was done through a bronchosopic adapter (Bodai bronch-safe double swivel airway connector, Sontek Medical Inc, Hingham, MA) attached to the ETT to allow continuous mechanical ventilation and oxygen delivery during the procedure. Infants were held NPO for 2 to 4 h prior to FB. Sedation was not used. All infants were stable and preoxygenated to maintain SaO2 levels greater than or equal to a minimum of 90 percent prior to FB. Ventilator settings (except for FiO2) were not changed prior to the procedure. Heart rate by cardiac monitor (Hewlett-Packard model No. 78834 A, Hewlett-Packard, West Germany), SaO2 by pulse oximeter (Nellcor N-100 pulse oximeter, Nellcor Inc. Hayward, CA) and clinical status were continually monitored immediately prior to, during and up to 1 h after FB. Systolic blood pressure was serially determined (Dinamap vital signs monitor No. 1846 SX, Systolic Blood Pressure Monitor, model No. 1846 SX, Dinamap, Critikon Inc. Tampa, FL). Changes in SaO2 and heart rate were monitored as well.

**Table 1—Tracheal Injury Clinical Scoring System: Mucosal Changes**

<table>
<thead>
<tr>
<th>Level</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>Absence of erythema, edema, hemorrhage, and ulceration of the tracheal mucosa; Absence of secretions</td>
</tr>
<tr>
<td>Mild</td>
<td>1 to 3 of the following: Noncircumferential erythema, Edema that results in blunting of the tracheal rings, Patchy (1 to 3 isolated small lesions) hemorrhage, Thin, clear secretions</td>
</tr>
<tr>
<td>Moderate</td>
<td>Greater than 3 mild changes and/or any 1 of the following: Circumferential erythema, Edema that abolishes the tracheal rings, Diffuse (&gt;3 confluent large lesions) areas of hemorrhage, Thick cloudy secretions</td>
</tr>
<tr>
<td>Severe</td>
<td>2 or more of the following: Circumferential erythema, Edema that abolishes the tracheal rings, Diffuse (&gt;3 confluent large lesions) areas of hemorrhage, Thick cloudy secretions</td>
</tr>
</tbody>
</table>

*All changes were classified on the basis of evaluation of the tracheal and carinal mucosa.*
Table 2—Tracheal Injury Clinical Scoring System: Obstructive Changes*

<table>
<thead>
<tr>
<th>Normal</th>
<th>Absence of obstructing edema, pseudomembranes, granulations, mucus, tracheobronchial stenosis or tracheobronchomalacia</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mild</td>
<td>Any 1 lesion (edema, mucus, granulation, pseudomembrane, tracheobronchial stenosis, tracheobronchomalacia) that results in less than 25% narrowing of the airway lumen diameter</td>
</tr>
<tr>
<td></td>
<td>1 to 3 pseudomembranes or granulations that result in less than 25% narrowing of the airway lumen diameter</td>
</tr>
<tr>
<td>Moderate</td>
<td>Any 1 lesion (edema, mucus, granulation, pseudomembrane, tracheobronchial stenosis, tracheobronchomalacia) that results in 25 to 50% narrowing of the airway lumen diameter</td>
</tr>
<tr>
<td></td>
<td>4 to 5 pseudomembranes or granulations that result in less than 50% narrowing of the airway lumen diameter</td>
</tr>
<tr>
<td>Severe</td>
<td>Any 1 lesion (edema, mucus, granulation, pseudomembrane, tracheobronchial stenosis, tracheobronchomalacia) that results in greater than 50% narrowing of the airway lumen diameter</td>
</tr>
<tr>
<td></td>
<td>Greater than 5 pseudomembranes or granulations</td>
</tr>
</tbody>
</table>

*Obstructive changes were classified on the basis of evaluation of the tracheal airway lumen and mainstem bronchial openings.

Figure 3. Mild distal tracheal obstructive injury. This is a representative photograph of the distal tracheas of a conventionally ventilated premature infant with mild distal tracheal obstructive changes. Note the small single granuloma (G) on the lateral wall of the bronchial orifice. This lesion narrows the airway lumen diameter less than 25 percent.

Figure 4. Severe distal tracheal obstructive injury. This is a representative photograph of the distal tracheas of a conventionally ventilated term infant with severe distal tracheal obstructive changes (patient not included in current study). Note the large granuloma (LG) on the carina, the multiple small granulomas (SG) on the posterior tracheal wall, and the marked (>50 percent) stenosis of the left mainstem bronchus.

Critikon Inc, Tampa, FL) immediately prior to (baseline), immediately after and every 15 to 20 min thereafter as clinically indicated for up to 1 h after FB. Duration of FB and ETT size also were noted. Adverse consequences of FB were defined as bradycardia (HR less than 100 beats per minute), tachycardia (HR greater than 180 beats per minute), hypoxemia (SaO2, less than 90 percent), change in baseline SBP (increase or decrease in baseline SBP of greater than 10 mm Hg), increases in ventilatory requirements, air leak, tracheal bleeding, emesis and accidental extubation. The occurrence of adverse consequences was compared with the size of the ETT, the duration of FB and postnatal age by the Fisher exact test with significance accepted at p<0.05.

Flexible bronchoscopy was performed with a prototype fiberoptic ultrathin bronchoscope with a directable tip and an outer diameter of 2.2 mm (Model BF 22, Olympus Corporation of America, New Hyde Park, NY). This instrument is immersible, has an insertion tube length of 53 cm, a radius of flexion/anti-flexion of 2.8 cm, an angle of flexion of 130°, an angle of anti-flexion of 65° and no suction channel. All airway studies were video-recorded and 35-mm color slides (Kodak Ektachrome color slides, ASA 200, Eastman Kodak Co, Rochester, NY) also were obtained with the majority of procedures. Scoring of tracheal injury was done at the bedside by the endoscopist primarily upon the basis of direct visual inspection of the distal trachea and carina during bronchoscopy and partly upon the basis of brief review of the video-recording immediately after bronchoscopy. Mucosal changes were classified as normal, mild, moderate or severe by evaluation of the tracheal and carinal mucosa for erythema, edema, hemorrhage, ulceration and character of secretions (Table 1, Fig 1 and 2). Obstructive changes were classified as normal, mild, moderate or severe by evaluation of the tracheal airway lumen and mainstem bronchial openings for pseudomembranes, granulations, stenosis, malacia and inspissated mucus (Table 2, Fig 3 and 4).

Results

We performed 21 FB procedures in eight conventionally ventilated premature infants with birth weights less than 2,000 g between September 9, 1988, and January 18, 1989. All eight infants were intubated and receiving conventional mechanical ventilation at the time of study. Six infants underwent serial FB with
Table 3—Tracheal Mucosal Injury*  

<table>
<thead>
<tr>
<th>Age (days)</th>
<th>2 ± 1</th>
<th>4 ± 1</th>
<th>11 ± 1</th>
<th>25 ± 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mucosal changes</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>0/6</td>
<td>0/6</td>
<td>0/4</td>
<td>0/3</td>
</tr>
<tr>
<td>Mild</td>
<td>4/6</td>
<td>1/6</td>
<td>1/4</td>
<td>1/3</td>
</tr>
<tr>
<td>Moderate</td>
<td>2/6</td>
<td>4/6</td>
<td>3/4</td>
<td>1/3</td>
</tr>
<tr>
<td>Severe</td>
<td>2/8</td>
<td>1/6</td>
<td>0/4</td>
<td>0/3</td>
</tr>
<tr>
<td>No. patients studied</td>
<td>8</td>
<td>6</td>
<td>4</td>
<td>3</td>
</tr>
</tbody>
</table>

*Data is presented as the fraction of patients with a particular degree of mucosal injury at each age studied.

Four infants undergoing three or more studies. Birth weight of the eight infants was 1,239 ± 438 g (mean ± SD) and gestational age was 30 ± 3 weeks. Fifteen FB studies were done through 3.0 ETTs, five FB studies were done through 2.5 ETTs and one FB study was done through a 3.5 ETT. FB was performed in the majority of infants in less than 120 s (12 of 21 procedures; range, 32 to 209 s). The majority of the procedures (15 of 21) were scored by the same individual (D.E.S.). Two infants were excluded from the study after the initial FB study. One was changed from conventional to high-frequency ventilation and the other was extubated at 5 days of age. Two infants were excluded from the study after the second FB study. One remained ventilated but was transferred to another institution and the other was extubated at 9 days of age. One infant was excluded from the study after the third FB procedure. This infant was extubated at 12 days of age.

Distal tracheal mucosal injury occurred frequently and appeared to progress during the first several days of life in our study population (Table 3). Four of eight infants were noted to have moderate to severe mucosal changes at two days of age. At four days of age five of six infants had moderate to severe mucosal changes and at 11 days of age three of four infants had moderate to severe mucosal changes. By 25 days of age, one of three infants was noted to have moderate to severe mucosal changes and two of three infants were noted to have mild mucosal changes.

Moderate to severe distal tracheal obstructive injury occurred infrequently in our study population (Table 4). Only one of eight infants was noted to have early moderate to severe obstructive changes at 2 days of age and this consisted primarily of thick tenacious mucus plugging of the ETT. By 4 days of age no infant had moderate to severe obstructive changes and only one infant developed moderate to severe obstructive changes during the remainder of the study. However, mild distal tracheal obstructive injury occurred in the majority of infants by the second week of life and tended to persist in the majority of infants into the fourth week of life.

Transient hypoxemia during FB occurred in five of 21 procedures. The lowest SaO₂ noted during FB was 82 percent, with a range of 82 to 89 percent. After cessation of FB, hypoxemia resolved in less than 1 min and treatment was not required. Hypoxemia did not occur immediately after or within 1 h of FB. In addition, no procedure resulted in sustained increases in oxygen requirement or in increases in ventilatory requirements. A partially plugged ETT was identified during one procedure. After vigorous suctioning, the ETT was cleared and ventilatory and oxygen requirements decreased from pre-FB settings.

Transient bradycardia during FB occurred in four of 21 procedures. The lowest HR noted during FB was 60 beats per minute with a range of 60 to 87 beats per minute. After cessation of FB, bradycardia resolved in less than 30 s and treatment was not required. Bradycardia did not occur immediately after or within 1 h of FB. In addition, no other arrhythmias were noted during, immediately after, or within 1 h of FB.

Changes in SBP of greater than 10 mm Hg from baseline occurred in six of 21 procedures immediately after FB and in two of 21 procedures for up to 1 h after FB. Four of 21 procedures resulted in an increase in SBP of greater than 10 mm Hg from baseline immediately after FB. A sustained increase in SBP of greater than 10 mm Hg from baseline occurred for up to 1 h after FB in one of four procedures in which there was an immediate increase in SBP after FB. Two of 21 procedures resulted in a decrease in SBP of greater than 10 mm Hg from baseline immediately after FB. A sustained decrease in SBP of greater than 10 mm Hg from baseline occurred for up to 1 h after FB in one of two procedures in which there was an immediate decrease in SBP after FB. Despite these changes in SBP noted immediately and for up to 1 h after FB, the infants remained clinically stable with no change in HR, SaO₂ or peripheral perfusion.

Other adverse consequences of FB in our study population were uncommon. Emesis occurred immediately after FB in one of 21 procedures. Emesis did not occur during FB. Except for the immediate period after FB, emesis did not occur within 1 h of FB. After one of 21 procedures, during movement of an infant from an open warmer to an isolette, accidental extubation occurred within 1 h of FB. The infant did not require reintubation.

The occurrence of adverse consequences was not
associated with the size of the ETT or the duration of FB. The occurrence of adverse consequences did not correlate with postnatal age.

**Discussion**

In this prospective pilot study of tracheal injury in conventionally ventilated premature infants, we have shown that tracheal mucosal and obstructive injury can be detected and clinically scored in a standardized manner by FB. Moderate to severe distal tracheal mucosal injury occurred frequently in our patient population, while moderate to severe distal tracheal obstructive injury occurred infrequently. We also have shown that with appropriate monitoring FB in stable conventionally ventilated premature infants can be performed without serious adverse consequences.

There have been no previous prospective studies of the natural history of distal tracheal injury in mechanically ventilated premature infants. The appearance of early distal tracheal mucosal injury in our patient population was unexpected and previously has not been reported. In our patient population, the majority of these early mucosal lesions appeared to heal and did not prevent extubation. Unlike our study, recent clinical studies have utilized bronchoscopy to examine the large central airways in older infants with bronchopulmonary dysplasia.8,11–15,20 In these infants a significant incidence of distal tracheal lesions, mostly obstructive in nature, was observed. Many of these lesions were unsuspected14 and many were thought to contribute to persistent pulmonary complications in the infants studied.11,12 Since distal tracheal obstructive lesions appear to be common in older infants with bronchopulmonary dysplasia, we speculate that early severe distal tracheal mucosal injury in conventionally ventilated premature infants may predispose to development of later distal tracheal obstructive injury.

In contrast to the results of recent studies,11,12,14 we found that moderate to severe distal tracheal obstructive injury occurred rarely during the first several weeks of life in our patient population. The reasons for the lack of moderate to severe distal tracheal injury in our patient population are unclear. A recent preliminary investigation suggested that premature infants who undergo mechanical ventilation greater than seven days were at increased risk of distal tracheal obstructive abnormalities. Unfortunately, the severity of these abnormalities was not reported.13 If the majority of these abnormalities were mild, then our results may not be dissimilar. We found that during the second week of life the majority of our patient population had mild distal tracheal obstructive injury and that this injury tended to persist into the fourth week of life. Thus, we speculate that duration of mechanical ventilation may be an important risk factor for development of distal obstructive injury.

Although several studies of FB in premature infants have reported few adverse consequences,12,14,15 there have been no previous attempts to prospectively and systematically determine the frequency of adverse consequences in conventionally ventilated premature infants. Adverse consequences of FB in clinically stable conventionally ventilated premature infants observed in our study included transient hypoxemia and bradycardia during FB, changes in SBP immediately and within 1 h after FB and emesis immediately after FB. The one occurrence of accidental extubation observed within 1 h after FB was not directly related to FB but to movement of the infant from an open warmer to an isolette. Factors associated with the development of adverse consequences during or after FB in our study did not include the size of the ETT, duration of FB or postnatal age.

In our study, bradycardia occurred relatively infrequently and resolved in less than 30 s after cessation of FB. This rapid recovery in HR after FB is similar to the rapid recovery in HR after endotracheal suctioning in preterm conventionally ventilated infants noted in a recent study.21 We also observed that hypoxemia occurred relatively infrequently and resolved in less than 1 min after cessation of FB. Hypoxemia may actually persist for up to 4 min after endotracheal suctioning in preterm conventionally ventilated infants, although these changes were reported not to be statistically significant when compared with baseline values.21 Thus, the occurrence of transient hypoxemia and bradycardia during FB in clinically stable, conventionally ventilated premature infants is similar to the occurrence of these same adverse consequences during endotracheal suctioning. We conclude that transient hypoxemia and bradycardia during FB in clinically stable, conventionally ventilated premature infants are not serious adverse consequences if FB is terminated as soon as hypoxemia and bradycardia are detected. Because undetected hypoxemia and bradycardia may have serious adverse consequences, we recommend pulse oximetry and cardiac monitoring during and immediately after FB.

In our study, increases and decreases in SBP of greater than 10 mm Hg were observed relatively frequently immediately after FB and tended to persist in some infants for up to 1 h after FB. Our results differ from the results of a recent study of blood pressure and intracranial pressure changes associated with endotracheal suctioning in preterm conventionally ventilated infants.21 These investigators showed that significant increases in SBP and associated increases in intracranial pressure occurred during but not immediately after endotracheal suctioning in their patient population. Unfortunately, SBP was only determined during the first 5 min after endotracheal suctioning.21 The reasons for these differences remain
unclear. Since we did not measure SBP during FB in our patient population, we were unable to detect an increase in SBP during FB. In addition, the clinical significance of changes in SBP observed in our patient population remains unclear. We did not observe changes in HR, SaO₂ or peripheral perfusion in infants who had changes in SBP of greater than 10 mm Hg. Thus, the significance of changes in SBP after FB in clinically stable conventionally ventilated premature infants remains to be defined. Because we remain uncertain as to the frequency and importance of changes in SBP after FB, we recommend blood pressure monitoring immediately and for at least 1 h after FB.

The prototype 2.2-mm fiberoptic ultrathin bronchoscope was a useful instrument to investigate tracheal injury in intubated premature infants. Infants intubated with a 3.0-mm ETT were studied easily. Although technically more difficult, infants intubated with a 2.5-mm ETT also were studied without an increase in adverse consequences. The carina and mainstem bronchi were visualized easily in all the infants studied. The image obtained with this instrument was similar in quality to the image obtained with the 2.7-mm fiberoptic ultrathin bronchoscope currently available (model PF 27 M, Olympus Corporation of America, New Hyde Park, NY). We believe that the 2.2-mm fiberoptic, directable-tip bronchoscope is superior to nondirectable-tip fiberoptic bronchoscopes, since nondirectable-tip bronchoscopes tend to wedge up against the tracheal wall making visualization of the carina and mainstem bronchi difficult. On the other hand, the prototype 2.2-mm bronchoscope could be improved by shortening the radius of flexion/anti-flexion, by increasing the angle of flexion and anti-flexion and possibly by adding a small suction channel.

One of the problems with any clinical scoring system is the issue of inter-observer variability. Prior to the initiation of this study, we attempted to limit inter-observer variability by establishing a relatively strict clinical scoring system based on findings that were agreed upon after review of a number of procedures done in our neonatal intensive care unit. Comparison between investigators was difficult because clinical scores were assigned at the time of FB primarily upon the basis of direct visual inspection of the distal trachea and carina. Comparison of clinical scores would thus have required airway endoscopy by each of the investigators at or near the same time for each infant. We considered this potentially harmful. In addition, comparison between investigators based upon scores taken from the video-recordings may be misleading secondary to color distortion and limitations of resolution of the image from the ultrathin bronchoscope. This method of scoring may miss significant areas of edema, hemorrhage or ulceration that would only be apparent to the observer directly visualizing the airway through the bronchoscope. One possible solution to these difficulties would be to assess inter-observer variability in an animal model of tracheal injury using a similar clinical scoring system and ultrathin bronchoscope.

In this pilot study, we have shown that diagnosis and assessment of tracheal injury in mechanically ventilated premature infants can be accomplished by FB using a standardized clinical scoring system and a prototype ultrathin directable-tip bronchoscope. Moderate to severe distal tracheal mucosal injury appeared to be common early in our patient population and may be associated with the development of later obstructive injury. Moderate to severe distal tracheal obstructive injury appeared to be uncommon early in our patient population; however, mild distal tracheal obstructive injury appeared commonly during the second week of life. Adverse consequences of FB in our population of conventionally ventilated premature infants appeared to be minimal. From a primarily clinical viewpoint, FB may be indicated in those conventionally ventilated premature infants with unexplained increases in ventilatory or oxygen requirements, duration of mechanical ventilation of greater than seven days and in those infants unresponsive to changes in ventilator management or other pulmonary therapies. Further prospective investigations using standardized clinical scoring systems are necessary to delineate the incidence of tracheal injury, the risk factors for the development of tracheal injury and the natural history of tracheal injury in mechanically ventilated premature infants. Correlation of tracheal injury clinical scoring systems with pathologic findings also would be useful. Hopefully, such investigations will lead to improved strategies to prevent and treat tracheal injury in mechanically ventilated premature infants.

ACKNOWLEDGMENTS. We appreciate the support of the neonatal care nurses of The Children's Hospital, Denver; the statistical assistance of Mark Riggs, Ph. D. of Texas A & M University College of Medicine, Temple, TX; and the assistance of Frank Klosterman, Product Engineer (Olympus Corporation of America).

REFERENCES
6 Kirkpalani H, Higa T,Perlman M, Friedberg J, Cutz E. Diagnosis and therapy of necrotizing tracheobronchitis in ven-

Tracheal injury in Mechanically Ventilated Premature Infants (Scheithauer et al.)
8 Garvey PA, Masters IB, Davis GM, Mitchell I, Cooper DR, McMillan DD. Acquired tracheobronchial lesions in the mechanically ventilated neonate [abstract]. Pediatr Res 1987; 21:452A
17 Hwang WS, Boras V, Trevensen CL, McMillan DD, Garvey P. The histopathology of the upper airway in the neonate following mechanical ventilation. J Pathol 1988; 156:189-95

Plan to Attend ACCP's
57th Annual Scientific Assembly
San Francisco
November 4-8, 1991