Role of the Fiberoptic Bronchoscope in Lung Lavage of Patients with Cystic Fibrosis

Charles W. Ewing, M.D., F.C.C.P.*

Cystic fibrosis is a hereditary disease of children, adolescents and adults that is transmitted by a Mendelian recessive gene and affects approximately 1 in 3,000 Caucasian and 1 in 17,000 blacks. It is characterized by an increased loss of sweat electrolytes, pancreatic and pulmonary insufficiency. All manifestations of the disease are secondary to the production of a thickened, sometimes mucoid, secretion which involves all exocrine glands. These increased secretions produce the symptoms of disease through obstruction of the various channels in their vicinity.

Cystic fibrosis is particularly devastating to the tracheobronchial tree. These secretions cause or lead to obstructive irritation, tissue breakdown and subsequent scarring of the lung tissue. They are responsible for the atelectasis, infections, emphysema, chronic bronchitis, bronchiectasis, pulmonary fibrosis, cor pulmonale, subsequent cardiopulmonary insufficiency and subsequent death of 90 percent of these patients.

Various methods have been devised to remove the secretions before the disease can progress. Inhalation therapy and physical therapy are the mainstays of present therapy. There has been a significant change in the mortality and morbidity of CF patients since the introduction of these methods. Attempts have been made to augment this intermittent therapy through bronchial washing or lavage. Several techniques have been reported.

Kline and Winternitz suggested, in 1915, that endobronchial lavage therapy for pneumonia could be performed using saline solution introduced directly into the lungs. These investigators and Winternitz and Smith noted no deleterious effects from the introduction of saline solutions and were able to remove previously instilled nonpathogenic bacteria, starch, and pneumococci from dog lungs by washing. Vicente described a technique in 1928 whereby a catheter was placed in the dependent lung of an awake patient and saline solution was flushed into that lung to aid in removal of excess secretions found in bronchiectasis, chronic bronchitis, asthma and lung abscess. Thompson et al. and later, Lefemine and colleagues injected saline solution through a bronchoscope into the lungs of asthmatic patients under anesthesia and improved their ventilatory insufficiency.

In 1965, Hackett and Lees suggested a (then) radical approach to therapy for the pulmonary complications of cystic fibrosis. They instilled 10 ml of 20 percent acetylcysteine through the endotracheal tube during general anesthesia. This was followed by tracheobronchial aspiration and postural drainage to remove secretions. They felt that any child with cystic fibrosis who required anesthesia for surgery should undergo the described procedure to prevent serious postoperative pulmonary complications. Ramirez, Kieffer and Ball introduced repeated pulmonary segmental flooding as a method of bronchial alveolar debridement in the treatment of six cases of alveolar proteinosis. These patients were treated initially by using segmental irrigation four times a day with 50 to 100 ml of saline solution containing heparin, acetylcysteine and sodium iodide. Subsequently, in 1964 and 1965, Ramirez suggested that segmental bronchopulmonary lavage was inefficient and reported four lavages performed using general anesthesia with a Carlens bronchosoratory tube during which they filled the dependent lung with 1,300 to 1,800 ml of solution.

Cezeaux et al. in a report comparing agents for bronchial lavage, reported segmental lavage under general anesthesia. The patients were placed in five different positions in succession for lavage of the dependent lobe. In these positions, either 10 ml of 10 percent acetylcysteine or 20 ml sodium chloride were injected and followed by manual hyperventilation. The total volume of this procedure was between 80 and 190 ml.

Kylstra et al. washed and drained the lungs of ten cystic fibrosis patients using a similar procedure. They used an average of 10 liters of saline solution over a one-hour period. The only complication noted was a temperature rise within 24 hours after lavage.

The rigid bronchoscope also has been used in

*Associate Clinical Professor of Pediatrics and Rehabilitation, Baylor College of Medicine, Houston.
Reprint requests: Dr. Ewing, 6634 Fannin Street, Houston 77030

750 CHARLES W. EWING

CHEST 73: 5, MAY, 1978 SUPPLEMENT
conjunction with general anesthesia. Alterman et al.12 lavaged 100 patients with cystic fibrosis; 50 patients were operated electively, and 50 on an emergency basis. The rigid bronchoscope was used to localize the administration of 2 to 20 ml of 5 percent acetylcysteine. This was repeated 8 to 12 times until a total of 60 to 200 ml of fluid was delivered to one side. Transient cardiac arrhythmias were reported during some procedures. All of the 50 elective cases had improved respiratory rates and white blood cell counts after the procedure. Pulmonary function tests were not recorded.

Millis et al.13 reported the clinical and pulmonary function test results of six CF patients following use of the rigid bronchoscope under light fluothane (Halothane) anesthesia. They instilled up to 300 ml of 5 percent acetylcysteine in 5 ml increments and found improved Gw/VL values in three patients and decreases in PaO2 in “four or five.” No consistent changes in trapped gas, minute ventilation or depth of respiration were observed after the procedure.

The use of the fiberoptic bronchoscope for segmental lavage was first suggested by Sackner and associates in 1972.14,15 The results of 73 lavages in 33 patients under local anesthesia was reported by Dahm et al.16 This study compared the use of the fiberoptic bronchoscope with other lavage techniques under general anesthesia, and of techniques using the rigid bronchoscope. The technique described herein is basically that previously reported with some modifications of location and patient evaluation.

**Material and Methods**

The fiberoptic bronchoscope has the advantage of providing direct visualization, as does the rigid bronchoscope. It also allows greater flexibility and the safety of local analgesia. We have previously reported 73 lavages of 36 patients performed between 1973 and 1977 under local analgesia. The procedure used is similar to the rigid bronchoscopic washouts under general anesthesia described by Altman and colleagues12 and Millis et al.13 However, we did not have the advantage of controlled hyperventilation and depended primarily on the patient’s cough and local or oral suction to clear the loosened secretions.

**Indications**

The patients varied in age from 8 to 30 years. The primary determinant for lavage was not the patient’s size or chronologic age as much as it was cooperation. The 5.8 mm Olympus BF-5 fiberoptic bronchoscope was used in all procedures so that patency of the airway was not a major consideration.3 The inability or immaturity to follow directions was a greater deterrent. Characteristically, the CF patient is cooperative. When the procedure is explained to them, they usually can be expected to assist.

The other indications for bronchoscopic procedures are noted in Table 1. All patients should be moderately to severely affected and have loose secretions which are evident to auscultation or by obvious sputum production. The severely affected patient with multiple cysts, abscesses, dry bronchitis and excessive fibrosis is less likely to respond favorably to the procedure.

All patients should have received prolonged courses of antibiotics, inhalation and physical therapy and show persistent deterioration of pulmonary function values, poor exercise tolerance, weight loss or sputum production. The criterion of frequent hospitalizations is listed, but is much more subjective. Many of our patients had reached the point in their disease in which they were more comfortable not only emotionally, but physically, when hospitalized and receiving frequent inhalation therapy and dual antibiotics intravenously.

The characteristic patient for a lavage is an adolescent with moderate disease (Shwachman score 50 to 75) who has received antibiotics intravenously twice in the preceding six months and has a chronic and progressively productive cough. He would be placed in the ASA class 3.

**Contraindications**

Jackson is reported to have said “When you think of a bronchoscopy, it should be done.” This statement may fit flexible bronchoscopy as well. However, the use of the flexible bronchoscope has both real and relative contraindications. Respiratory insufficiency and cardiac arrhythmias would delay the procedure. We would not perform a lavage on a child who had an arrhythmia, was in congestive heart failure, had a PaO2 level below 50, or a Pco2 level above 80. The relative contraindications would be those of immaturity, inability or lack of desire to follow demands, ASA class 5 (severely affected moribund patient), and the patient with a dry chest or nonproductive cough.

The presence of hemoptysis or pneumothorax also could be considered contraindications. If the patient has a controlled pneumothorax and a mild pneumomediastinum which has not extended, the procedure could be performed. Although the presence of gross blood and certainly massive bleeding, as defined by Holsclaw et al.,11 would delay the procedure, the slight streaking or occasional clots of blood in the sputum would not.

The BF-5 Olympus fiberoptic bronchoscope or the newer models of Olympus or Machida should be used. The primary criterion for selection of the instrument is that of a 2 to 3 mm suction channel. This suction channel is necessary not only for

---

**Table 1—Indications and Contraindications for Bronchial Lavage**

<table>
<thead>
<tr>
<th>Indications for lavage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unresponsive to outpatient treatment</td>
</tr>
<tr>
<td>Unresponsive to IV outpatient therapy for over 7 days</td>
</tr>
<tr>
<td>Unresponsive to inpatient therapy for less than 7 days</td>
</tr>
<tr>
<td>Two hospitalizations in less than 6 months or 2 IV antibiotic trials in less than 6 months</td>
</tr>
<tr>
<td>Over 8 years of age</td>
</tr>
<tr>
<td>Cooperative patient</td>
</tr>
<tr>
<td>Productive chest by auscultation or sputum</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Contraindications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cardiac arrhythmia</td>
</tr>
<tr>
<td>Massive hemoptysis</td>
</tr>
<tr>
<td>Congestive heart failure</td>
</tr>
<tr>
<td>ASA class</td>
</tr>
</tbody>
</table>

---

**CHEST 73: 5, MAY, 1978 SUPPLEMENT**

---

LUNG LAVAGE IN PATIENTS WITH CYSTIC FIBROSIS 751
local suction at the time of lavage, but also to aid in the
instillation of local analgesics. This is frequently necessary,
not only at the beginning of the procedure, but as it pro-
gresses. These patients cough forcibly and unmask una-
esthesitized areas of the lung which were initially covered
with thick secretions. It is not unusual to add additional analgesia,
particularly to the left lower bronchi, as the procedure
progresses.
All procedures should be performed in an operating suite
or in an area with capabilities for cardiorespiratory resuscita-
tion. All patients should have functioning cardiac monitors
and intravenous lines in place. A preoperative x-ray exami-
nation, pulmonary function test results, and arterial blood gas
values should be available in addition to the usual surgical
requirements of complete blood counts and urinalysis. Arter-
ial blood gas levels may be obtained during the procedure
by installing a radial line or by intermittent arterial puncture.
The patients should be in a supine or sitting position. Even
though the cough may be more forceful if the patient is
partially erect, the supine position makes it possible to suction
from the mouth, as well as to maintain better control of the
patient’s head.
All patients have oxygen catheters with humidified oxygen
placed in the nasopharynx. We use 100 percent oxygen at a 2
liter flow in our procedures. Although it has been reported
that patients undergoing fiberoptic bronchoscopic examina-
tion will suffer hypoxia during fiberoptic bronchoscopy, the
oxygen nasal catheter will increase the degree of oxygenation
through the procedure.18-20 (Table 2).
We have not had any indication of loss of respiratory drive
secondary to this increased oxygen concentration, although it
should be remembered that these patients are receiving
assisted inhalation. Postoperatively, the oxygen is removed,
and the patient receives only a maximum of 40 percent FIO2
by IPPB in order to reduce the possibility of loss of the
oxygen respiratory drive.

Procedure
The nose is anesthetized with 2 percent lidocaine viscous
administered with a 6 ml syringe. The patient is encouraged
to gargle while the anesthetic is administered in both the
right and left nostrils. The most open nasal channel is
determined by passage of a cotton tipped applicator. This
channel is used for the bronchofiberscope and the oxygen
catheter is placed in the other side. After placement of the
oxygen catheter, the bronchoscope is inserted through the
nostril and the larynx is visualized. An additional 2 ml of 4
percent lidocaine topical is injected through the suction
channel of the instrument directly on the larynx. When
analgesia is obtained, the instrument is inserted into the
trachea and advanced to the level of the carina. An additional
2 ml of 4 percent lidocaine topical is injected at this site. The
bronchoscope then is advanced into the right main stem
bronchus and each orifice of the bronchus examined. It is
withdrawn to the carina and the left bronchus examined in
the same manner. The bronchoscope is then again placed in
the right main stem bronchus in the position opposite the
orifices of the right upper lobe and 30 ml of 5 percent
acetylcysteine forcefully injected into this area. The area is
suctioned through the suction channel. The material coughed
by the patient is removed from the mouth with an additional
suction tube. The bronchoscope is removed from this area
and placed adjacent to the orifice of the right middle lobe. A
similar 20 ml aliquot of acetylcysteine is injected at this point
and subsequently at the right lower lobe in the same manner.
The upper lobe and left lower lobe orifices are irrigated and
suctioned in the same manner. All orifices are then re-
examined. Additional acetylcysteine is instilled as necessary
to assure removal of visible plugs and thickened mucous.
After completion of the bronchoscopic procedure, the patient
is placed prone in a Trendelenburg position. He is transferred
to the recovery room where he receives one hour of seg-
mental postural drainage, clapping, and IPPB. Supplemental
oxygen is given only if cyanosis is present or arterial blood
gas levels are unsatisfactory. Following one hour of this
intensive therapy, the patient will return to routine inhalation
therapy. Most patients can be fed within one hour following
this procedure. Preoperative antibiotics are resumed. A chest
x-ray film is obtained immediately following the procedure,
at three days and at five to seven days postoperatively.
Pulmonary function tests are ordered in five to seven days.
Arterial blood gas levels are obtained as needed to evaluate
the clinical status. However, the values obtained after five
days and at one month are of greater prognostic value than
those found immediately postoperatively. Chest x-ray films
and arterial blood gas values will deteriorate within the first
three days due to mobilization of secretions.
The patient may cough throughout the procedure. Spas-
modic coughing is not desirable, but each patient is encour-
gaged to cough forcefully following the instillation of acetyl-
cysteine to the lung segments. If coughing becomes spas-
modic, there is evidence of fatigue, or an indication of
arrhythmia, the procedure is held until either additional
lidocaine or oxygen can be administered. The fiberoptic
bronchoscope is not removed from the trachea.

Table 2—Blood Gas Levels Before, During and
After Procedure

<table>
<thead>
<tr>
<th>Changes in Blood Gas Levels from Baseline Levels</th>
<th>Mid Procedure (9 Studies)</th>
<th>Post Procedure (16 Studies)</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>0.0±1.0</td>
<td>0.0±1.0</td>
</tr>
<tr>
<td>Pco2</td>
<td>32±7</td>
<td>32±7</td>
</tr>
<tr>
<td>PaO2</td>
<td>102±10</td>
<td>102±10</td>
</tr>
</tbody>
</table>

Arterial Gas Levels before Procedure

<table>
<thead>
<tr>
<th></th>
<th>14 Studies</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>7.40</td>
</tr>
<tr>
<td>Pco2</td>
<td>42</td>
</tr>
<tr>
<td>PaO2</td>
<td>56</td>
</tr>
</tbody>
</table>

Table 3—Patient Characteristics

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patients</td>
<td>39</td>
</tr>
<tr>
<td>Procedures</td>
<td>77</td>
</tr>
<tr>
<td>Sex—Male</td>
<td>21</td>
</tr>
<tr>
<td>Female</td>
<td>18</td>
</tr>
<tr>
<td>Age</td>
<td>8-30 years</td>
</tr>
<tr>
<td>Weight</td>
<td>14.3 kg-62.3 kg</td>
</tr>
</tbody>
</table>
Table 4—Results

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Arterial Blood Gas Levels</th>
<th>Pulmonary Function Tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>77</td>
<td>Improved 14 (42%)</td>
<td>Improved 46 (61%)</td>
</tr>
<tr>
<td>33</td>
<td>Equivocal 6 (18%)</td>
<td>Equivocal 17 (23%)</td>
</tr>
<tr>
<td></td>
<td>Deteriorated 3 (8%)</td>
<td>Deteriorated 12 (17%)</td>
</tr>
</tbody>
</table>

There is not a “good” objective comparison between the methods because the same evaluations were not performed. A number of investigators did pulmonary function tests which recorded vital capacities. Of the 96 procedures, 56 patients (58 percent) showed improvement, 21 of 96 (22 percent) had equivocal results (pre- and post-values within 10 percent) and 19 of the 96 (20 percent) showed deterioration. The same authors recorded similar ABG results: 18 of 53 (34 percent) improved; 19 of 53 (36 percent) equivocal; and 19 of 53 (36 percent) deterioration. Hackett et al. described improvement in VC and ERV/FVC by percentage. Altman and colleagues noted improved white blood cell counts and respiratory rates. Subjective clinical improvement, ie feeling of well-being, clearing of secretions and increased exercise tolerance were reported by other authors.

The results obtained from segmental lavage with the fiberoptic bronchoscope appear better than those of controlled volume lavage reported by Klystra et al and segmental lavage under general anesthesia reported by Cezeaux et al, and use of the rigid bronchoscope as reported by Millis et al and Altman and coauthors. Improvement in pulmonary function values was primarily in the large airways and not apparently affecting the small airways. This was to be expected because the areas that were lavaged were in the larger bronchi and did not reach the small bronchi or the alveoli. Our studies evaluating the reduction of a number of hospitalizations and improvement exercise of tolerance are inconsistent. Most patients will report that they feel better, their chests are clearer, and that they cough less. However, our objective evaluations of the results of pulmonary function tests and arterial blood gas values show only 63 percent improvement in pulmonary function and 58 percent improvement in arterial blood gases after one week. The overall 64 percent is a melding of these improved patients.

A prospective study is needed which incorporates the values of pre- and postoperative MMEV, RV/TLC (determined by body plethysmography), flow volume curves and arterial blood gas values. These values appear to have the greatest acceptance for determining small airway involvement and prognosis. Although alterations are seen in the studies reporting VC, peak flow and FEV1, these are late pulmonary function changes. They are not only effort-dependent, but reflect large airway disease and are less valuable in assessing longterm benefits or in developing a prognosis for the individual patient.

An evaluation of the complications and ease of operation may be of greater value. Controlled volume lavages have resulted in arrhythmias, pneumo-

on both the pulmonary function test and arterial blood gas determinations, the criterion for improvement was a change of greater than 10 percent in either direction from the preoperative value. Table 4 examines the pulmonary function and arterial blood gas results. There were 75 determinations of pulmonary function. Forty-two of the 75 procedures showed improvement, 17 were equivocal, and 12 procedures showed deterioration. Thirty-three pre- and postoperative arterial blood gas values were obtained. Fourteen had improved, 6 had equivocal results and 13 showed deterioration postoperatively. Twelve of the patients showed improvement on pulmonary function testing and had improved arterial blood gas results giving an overall improvement rate of approximately 64 percent. A breakdown of classifications indicated a 64 percent improvement of class 3 pulmonary function tests, but only a 53 percent improvement in blood gas values. Class 4 had 48 percent and 47 percent improvement, respectively; all class 5 patients showed deterioration.

DISCUSSION

Seventy-seven procedures were performed on 39 patients. Their vital capacities were improved in 46 (61 percent) of the 75 valid measurements. There were 17 (23 percent) equivocal results. Only one of the 17 patients who had neutral pulmonary function tests (PFT) had an improvement of his arterial blood gases (ABC). Therefore, 83 percent had either definite improvement or did not show deterioration from the standpoint of this parameter. Arterial blood gas levels showed improvements in 14 (42 percent) of the 33 values obtained. There were six equivocal results and five of the seven patients that had neutral ABGs showed improvement of their PFTs. Therefore, 19 (58 percent) had either definite improvement or did not deteriorate from this parameter of measurement.
nitis and death. Elevated temperatures have been noted within eight hours of lavage. We have also seen this following local analgesia. It is probably due to the distribution of the bacteria by the lavage rather than a true complication. Bronchoscopic evaluations with the rigid bronchoscope under general anesthesia reported not only arrhythmias but deaths. It should be emphasized that most of the procedures with the rigid bronchoscope were performed on class 4 or class 5 patients in emergency situations, so these data are skewed and do not accurately reflect the overall safety of the procedure when handled electively with small volumes of lavage fluid. Fiberoptic bronchoscopic evaluations in general have had few complications. The mortality rate is less than 0.02 percent. We have seen only an extension of a pneumomediastinum following our procedures. Arrhythmias have not been a problem nor have we had an exacerbation of hemoptysis. We have not seen a reaction to local analgesia, although this has been reported.

I, therefore, cannot conclude with a statement as to whether a lavage procedure should be done on patients with cystic fibrosis, but can suggest that if a lavage is going to be done, it can be done segmentally under local analgesia with the fiberoptic bronchoscope with great efficiency and safety.

REFERENCES

4. Vicente C: Sobre una tecnica simplificada en la terapeutica intrapulmonar. Rev Progr de la Clinica, July, 1928