Role of Bronchopulmonary Lavage in the Treatment of Respiratory Failure: A Review*

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A large part of our therapeutic effort in the treatment of respiratory failure is directed at enhancing the clearance of secretions from the lung. Such procedures as nasotracheal suctioning, tracheostomy, bronchoscopy, chest physiotherapy and postural drainage are used with varying degrees of success.

Over the last few years, we have gained experience with the technique of volume controlled bronchopulmonary lavage which can remove large quantities of material from the airways and alveoli in a short period of time. Although the procedure was first reported in 1965,1 published clinical experience remains limited. In view of the potential applications of this procedure in the treatment of respiratory failure, it seems appropriate to review the technical, physiologic and clinical aspects of bronchopulmonary lavage at this time.

BACKGROUND AND TECHNICAL CONSIDERATIONS

Endobronchial therapy for pneumonia was suggested in 1915 by Kline and Winternitz2 following claims by earlier investigators3,4 that the introduction of saline solution into the lungs of dogs produced no deleterious effects. Winternitz and Smith5 were able to remove from the lungs of dogs with lavage more than 90 percent of previously instilled nonpathogenic bacteria or starch. Virulent pneumococci instilled into dog lungs could also be removed in the same large quantities, but the development of pneumonia was not prevented, and the authors suggested the use of endobronchial antiseptics in the future. Vicente,6 in 1928, was the first to describe a technique whereby a catheter was placed into the dependent lung of an awake human patient breathing room air in the lateral decubitus position. Saline solution was flushed into the dependent lung through the catheter to aid in removal of secretions (Fig 1). Figure 1 pictures the dependent lung filled with fluid, but this is obviously not accurate since degassing was not employed and numerous bubbles would be present. Vicente treated such conditions as bronchiecctasis, chronic bronchitis, asthma, and lung abscesses, publishing extensively on his experience with this technique between 1928-36. No similar reports of lavage in humans (other than bronchoscopic7,8) were reported until 1963 when Ramirez-R and colleagues9,10 introduced the technique of “segmental flooding” for the treatment of alveolar

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Figure 1. Diagram of a patient during lavage with the technique of Garcia Vicente. (From Rev Prog de la Clinica, julio, 1928).
proteinosis. This technique involves the introduction of 50 to 100 ml saline solution into various lung segments via a transtracheal polyethylene catheter (Fig 2). Both segmental lavage and bronchoscopic lavage remove some secretions directly, but depend primarily on the patient's vigorous coughing and expectoration.

Kylstra,15-18 interested in the lung as an exchange surface for dialysis, demonstrated that prolonged survival in dogs was possible following lavage of one lobe. Subsequently, Finley19 performed segmental lavage in man for diagnostic and research purposes using a cuffed radiopaque catheter. With this work as a background, Ramirez-R20 developed a technique whereby an entire lung could be lavaged while the other lung was ventilated. Kylstra and co-workers21 subsequently utilized a similar technique for lavage in human disease which represents a modification of the technique he perfected in dogs. We will limit our discussion in this paper to volume controlled bronchopulmonary lavage, also called "massive bronchopulmonary lavage" and "total bronchopulmonary lavage." This procedure has two major advantages over those previously mentioned:

1) adequate alveolar ventilation can be maintained by ventilating the non-lavaged lung; 2) it can be assumed that the fluid reaches essentially all areas of the lung since the lavaged lung is gas free and filled with fluid.

**Technique**

In all our lavages, we have utilized the volume controlled technique of Kylstra and colleagues,21 and our description will be limited to this approach. Their technique differs slightly from that of Ramirez-R, which has been described in detail elsewhere.20 We perform all lavages using general anesthesia with supplemental topical anesthesia of the larynx and trachea. A high inspired oxygen level (FIO2), preferably 95 to 98 percent, is used. The hazard of the repeated use of halothane is considered in choosing an anesthetic. Patients are carefully monitored throughout the procedure. The use of an esophageal stethoscope, electrocardiographic monitor, and frequent arterial blood gas determinations is routine. A Carlen catheter is placed isolating the two lungs, and proper positioning is verified by auscultation and bronchospirometry. During spontaneous breathing, after placement of the Carlen catheter, bronchospirometric measurements of oxygen consumption of each lung are made. Following these measurements, ventilation is controlled to maintain normal Paco2 level.

With the patient in the lateral decubitus position (Fig 3), the lung to be lavaged is isolated from the anesthesia-oxygen supply by clamping the tubing and connecting it to the saline delivery system. At one minute intervals, a volume of saline solution equal to the measured oxygen consumption of that lung is allowed to flow into the lung by gravity. It is assumed that in this manner, complete degassing of the lung can be accomplished without significant creation of air pockets or turbulence such as might occur if saline were added at a rate exceeding the measured oxygen consumption. It is also hoped...
that this will prevent extensive atelectasis, since ideally, the end result will be a lung "distended" by fluid which has replaced the gas without atelectasis intervening. When the volume of saline in the lung is equal to the functional residual capacity (FRC) of that lung, volumes of 300 to 500 ml of saline solution are allowed to flow rapidly into the lung, after which a similar volume is drained into the bottle by gravity (Fig 3). Total volumes of fluid have ranged from 5 to 25 liters. Following the last instillation, as much fluid as possible is drained from the lung. The Trendelenburg position and endotracheal suctioning through the Carlens catheter are used to augment drainage. In every case, an amount of saline solution at least equal to the residual volume of the lavaged lung has remained in that lung following the procedure and is absorbed or expectorated over the next 24 to 48 hours.

The patient is taken to the recovery room receiving supplemental oxygen which is continued for 24 hours, the need being determined by serial PaO2 measurements. Elective mechanical ventilation is continued in cases where the patient was in respiratory failure before lavage. Asthmatics who have had severe bronchospasm following lavage have also been ventilated for up to 48 hours. For these cases, the Carlens tube is replaced with an endotracheal tube.

**Effects of Saline Solution on Lung Histology**

Winternitz and Smith,5,22 interested in war gas poisoning, demonstrated that the pathologic changes following introduction of isotonic saline into dog lungs were minimal and had resolved by four days. Kylstra5-18 has confirmed the paucity of histologic changes following lavage in dogs. A report of minor light and electron microscopic changes in the dog lung following lavage with saline solution, at room temperature and without degassing,23 is difficult to evaluate because the technique is so different from volume controlled bronchopulmonary lavage. A more detailed report24 of minor light and electron microscopic changes in the dog lung following saline solution lavage has also been published. These same investigators, however, also stated that no such histologic changes were found in dog lungs examined after segmental saline solution lavage if the volume of solution was 300 ml or less,19 and on the basis of these observations they have performed segmental lavages in man. It seems reasonable, therefore, to conclude that minor transient histologic changes are present immediately post lavage, although no confirmatory histologic studies in humans are available for obvious reasons.

**Physiologic Considerations**

We are unaware of any systematic evaluation of the effects of lavage containing medications, and therefore will limit our discussion to saline solution. Saline might conceivably be harmful in one or several ways: 1) if rapid absorption of the solution occurs, the circulating intravascular volume would be increased and this could lead to cardiac failure; 2) significant hypoxia might result because the blood perfusing the saline solution filled lung is not exposed to oxygen; 3) surfactant might be removed by lavage, causing a decrease in compliance; 4) other pulmonary function tests might be impaired by the saline solution remaining in the lung at the completion of lavage, irritation of the airway by the catheters, or removal or displacement of surfactant.

**Absorption of Saline**

The quantity of saline solution absorbed during lavage appears to be insignificant in man1 and animals.15-18,25 Figure 4 illustrates the amount of fluid which is recoverable from dog lungs after instillation of 100 ml of distilled water, isotonic saline solution, serum, and sea water. Saline solution has a half-life of one hour, while distilled water is instantaneously absorbed, 90 percent of dog serum is absorbed in 20 minutes, and sea water actually draws additional water into the lungs. This slow absorption can probably be attributed to the inherent resistance of the alveolar capillary membrane to the absorption of ionic solutions26-27 and the diminished pulmonary blood flow to the lung being lavaged (see below).

We have carefully observed pre- and post lavage electrolytes, hematocrit, weight, intake, and output, in our patients and have concluded that there is little fluid or electrolyte absorption other than the residual saline solution left in the lung at the completion of lavage (200 ml to 1500 ml). The absorption of this small amount of saline solution has caused no significant clinical problem.

**Hemodynamic Effects**

We found, as did others,28-30 that venous admixture varied during lavage. It was clear that the percentage of venous admixture was largest when the lung was partially filled with saline solution and least when the lung was filled to total lung capacity (TLC). In a series of patients, we were able to demonstrate that when the hydrostatic pressure in the airway of the lavaged lung exceeded pulmonary artery pressure, perfusion of that lung approached zero, and when the airway pressure of the fluid filled lung fell below pulmonary artery pressure, perfusion returned and venous admixture increased.31 This is a situation analogous to the zone 1 lung of West28 and consistent with earlier observations on the relationship between alveolar pressure and blood flow in dogs.33,34 It is clear from these findings that shunting can be minimized by extending the time periods when the fluid...
volume is close to TLC, and decreasing the time for drainage, at which time lung volume is close to FRC. Thus, with the use of 99 percent oxygen to ventilate the nonlavaged lung and careful monitoring of arterial blood gases, lavage can be safely performed in the severely ill respiratory patient.

Recovery of Surfactant in Lavage Effluent

It has been shown in dogs that the introduction of saline solution into the alveolar spaces causes a reduction in lung compliance which is due to increased surface forces.⁴⁵ In these studies, the surface tension of lung extracts was higher in fluid instilled lobes than in nonfluid instilled lobes, suggesting that the fluid inactivated or displaced pulmonary surfactant. These findings were consistent with the observation that a stable foam can be obtained in fluid that has been instilled and withdrawn from the alveoli.⁵⁶ Subsequently, several investigators²⁴⁻³⁰ have been able to obtain minimum surface tension values of less than 13 dynes/cm, indicating the presence of surfactant in the lavage effluent of animals. Both instillation of saline solution⁵⁶ and saline lavage²⁴,³⁶ in dogs have produced an acute shift to the right of the pressure-volume curves of the lavaged lung, a finding consistent with decreased surfactant.

Studies of lavage effluent in humans, however, have been less clear. Kylstra and colleagues²¹ studied the surface tension of lavage effluents from a normal volunteer and four patients with asthma and found minimal surface tensions in excess of 12 dynes/cm in the mixed effluent of lavage fluid. In alveolar proteinosis, Ramírez-R has been unable to find surface active material in nine of ten washings. We have examined the lavage effluent of 14 lavages in ten patients forty (seven with asthma and three with alveolar proteinosis). Our technique differed from Kylstra’s in that we collected the effluent serially in 1500 ml bottles and centrifuged a 500 ml aliquot of each bottle. The centrifugate was resuspended in 40 ml of saline solution and placed in a modified Wilhelmy balance. In every patient’s effluent, we found minimum surface tension below 13 dynes/cm in at least one bottle, and in two to five bottles in seven patients. In order to simulate the mixed effluent examined by Kylstra, we combined all 1500 ml bottles into a large container and examined a 500 ml centrifuged specimen on the Wilhelmy balance. Minimum surface tension values were similar to those reported by Kylstra.²¹ We concluded that since in animal work only 100 to 500 ml of lavage effluent is utilized while 6 to 27 liters is used in humans, the latter volume so dilutes the surfactant present that it cannot be measured in the mixed effluent.

We have also noted a shift in the pressure-volume curve down and to the right immediately post-lavage. However, this returned to normal by 24 to 72 hours.⁴¹ This acute shift of the curve down and to the right has also been reported in a normal human volunteer²¹ and is consistent with increased surface forces.

Effect of Lavage on Pulmonary Function

We have measured vital capacity (VC) and maximum mid-expiratory flow rate (MMEFR) dur-
ing the immediate 72 hours post lavage in eight instances. The VC decreased in the first ten hours (range of change 0 to 1.5 L), and this decrease tended to last up to 24 hours. Between 24 and 48 hours postlavage, all patients had attained or exceeded their prelavage values. Similar changes were noted in MMEFR. In patients with alveolar proteinosis, the decrease in VC and MMEFR was less than in patients with asthma and the return to normal occurred earlier.

One patient had severe, persistent hypoxemia throughout one lavage, but had nine additional lavages with no oxygenation problem. In all our other patients, adequate oxygenation during lavage was easily accomplished. Hypercarbia occurred during lavage more frequently in the asthma patients and usually could be easily corrected by increasing the ventilation to the non-lavaged lung. During the immediate postlavage period, most patients required only high inspired oxygen concentration. However, two asthmatics and one alveolar proteinosis patient required mechanical ventilation for 6-12 hours postlavage.

**Clinical Indications**

Currently, this procedure has been utilized in humans for the treatment of alveolar proteinosis, bronchial asthma, cystic fibrosis, chronic bronchitis, desquamative interstitial pneumonitis, unresolved pneumonia, Goodpasture's syndrome and inhalation of radioactive particles. Table 1 tabulates the clinical experience with bronchopulmonary lavage reported to date. There has been only one death reported during or postlavage and this patient died of a pulmonary embolism which is difficult to relate to the procedure per se. Lavage has been suggested, but not performed in other clinical conditions such as aspiration pneumonia, alveolar microlithiasis, allergic bronchopulmonary aspergillosis, *Pneumocystis carinii* infection, and bronchiectasis. Removal of excessive secretions or abnormal material in these diseases might be expected to lead to at least temporary improvement in lung function and, in many cases, provide valuable time for the employment of other therapeutic measures. It is to be expected that the transient adverse effects of lavage will be offset by the substantial improvement in pulmonary function that will result from the removal of significant quantities of secretions. We will review our own experience and the published experience with lavage in the diseases for which it has been used. In addition, we will review some of the theoretic and pathophysiologic reasons to consider it in other diseases.

**Table 1—Bronchopulmonary Lavage Performed in Man**

<table>
<thead>
<tr>
<th>Disease</th>
<th>No. of Patients</th>
<th>No. of Lavages</th>
<th>Investigator</th>
</tr>
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<tbody>
<tr>
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<td>4</td>
<td>9</td>
<td>Ramirez-R, et al</td>
</tr>
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<td>3</td>
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<td>26</td>
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<td>2</td>
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</tr>
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<td>1</td>
<td>Smith, et al</td>
</tr>
<tr>
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<td>7</td>
<td>27</td>
<td>Rogers, et al</td>
</tr>
<tr>
<td></td>
<td>27</td>
<td>103</td>
<td></td>
</tr>
<tr>
<td>Asthma</td>
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<td>2</td>
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<tr>
<td>Asthma</td>
<td>1</td>
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</tr>
<tr>
<td>Asthma and chronic bronchitis</td>
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<td>Asthma and bronchitis</td>
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<td>Kylntra, et al</td>
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<tr>
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</tr>
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<td>Unresolved pneumonia</td>
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<td>Goodpasture’s syndrome</td>
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<tr>
<td>Accidental inhalation of radioactive particles</td>
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<td>3</td>
<td>Muggenbury</td>
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*current report
Pulmonary Alveolar Proteinosis

The first "volume controlled" bronchopulmonary lavage was performed on a patient who had alveolar proteinosis. Alveolar proteinosis is a rare pulmonary disease of unknown etiology which has a unique pathologic picture—i.e., alveolar spaces filled with a PAS-positive, lipid rich "proteinaceous" material, and no abnormality of the alveolar wall, interstitial spaces, conducting airways, or pleural surfaces (Fig 5). The most common symptom experienced by all our patients has been dyspnea on exertion. Other symptoms, such as productive or nonproductive cough, chest pain, and hemoptysis, are less frequent and often seem to be related to superimposed infections. The degree of symptomatology ranges from minimal or none to severe respiratory failure which can be fatal. Physical findings are nonspecific and include cyanosis and fine inspiratory rales with some dullness to percussion. Mild to severe hypoxemia with reduction in carbon monoxide single breath diffusing capacity and minimal decrease in lung volumes are the consistent abnormalities in pulmonary function. Removal of the "proteinaceous" material from the alveolar spaces is the goal of lavage and the large amount of sediment in the effluent makes it clear that one can accomplish this (Fig 6A and B).

Clinical improvement has been consistently reported. Improvement in the chest roentgenogram is also common, but did not occur in all of our patients despite significant clinical improvement. We have performed 28 lavages on six patients which brings the total number of patients to 27 and the number of lavages to 103. Each of our patients showed clinical improvement accompanied by a rise in resting arterial partial pressure of oxygen on room air and 100 percent oxygen. A typical patient’s results are summarized in Figure 7. She had dramatic clinical, roentgenographic and physiologic improvement after four lavages.

Since the symptoms in patients with alveolar proteinosis range from minimum to severe, not all patients with the disease are candidates for lavage, especially since spontaneous remissions have been noted. We have reserved lavage for those patients with moderate to severe dyspnea on exertion. We feel that lavage is the treatment of choice in these patients, and nebulized enzymes, etc, are not indicated.

Bronchial Asthma

Status Asthmaticus. When death occurs in status asthmaticus, one usually finds at postmortem ex-
ROLE OF BRONCHOPELUMARY LAVAGE

FIGURE 7. Results of blood gas studies and vital capacity measurements on a patient with alveolar proteinosis before and after lavage. Note the rise in arterial $P_{O_2}$ on room air, exercise and 100 percent oxygen and the increase in vital capacity. The improvement in pulmonary function was accompanied by a marked clinical improvement. (From Med Clin NA 54:755, 1970.

amination thick, tenacious mucus plugs obstructing airways that vary in size from lobar bronchi to bronchioles.6-10 These mucus plugs are felt to contribute to the severe hypoxemia and hypercarbia which is noted prior to death. Bronchoscopists have removed these plugs by suctioning through the bronchoscope, usually after instillation of saline solution.6-10 Drawbacks of the bronchoscopic approach include: 1) limited access to peripheral airways because of rigidity of the instrument, and 2) inability to assist ventilation mechanically during the procedure. On the other hand, with bronchopulmonary lavage, the lung is filled with saline solution; hence, all affected airways are lavaged and adequate ventilation can be maintained by the other lung. This conclusion, of course, is valid only if one is able to control the bronchospasm.

Figure 8 pictures bronchial casts from the lavage fluid of a severe asthmatic. The large casts were present in the first effluent (Fig 8A), while subsequent effluent contained the very small mucus plugs noted in Figure 8B. These smaller plugs appear to represent Curschmann spirals (Fig 8C and D). The cells noted in these specimens proved to be predominantly eosinophils, although macrophages were also noted when the specimens were examined under higher power magnification in fixed stain section. We have not identified bacteria or fungus in this material to date.

Subacute or Chronic Asthma. The rationale for the use of bronchopulmonary lavage in subacute or chronic asthma is less certain. The approach is

![Figure 8](http://journal.publications.chestnet.org/pdfaccess.ashx?url=/data/journals/chest/21550/ on 04/28/2017)
reasonable if one assumes that antigenic material has been deposited deep in the lungs, where it cannot be removed because of increased viscosity of mucus, impaired mucociliary movement, or decreased effectiveness of cough. Its presence might be causing continued release of a bronchoconstrictive material such as histamine, and therefore be responsible for the chronic, persistent symptoms of the patient. This, of course, is all supposition, and one should not embark upon treatment of patients in this situation without a clear-cut protocol from which information can be gained regarding effectiveness, indications for treatment, etc.

**Clinical Experience**

We have performed 12 volume controlled lavages on seven patients with bronchial asthma. Five of these patients were treated during a period of severe status asthmaticus which was unresponsive to the usual measures, including bronchodilators and high dose steroids. Casts of large and small airways were present in the effluent, and there were usually several hundred smaller ones which measured as small as respiratory bronchioles. Each patient showed clinical improvement, although in some it was not apparent for 4 to 12 hours postlavage, and two patients required mechanical ventilation for 4 to 12 hours postlavage. The long-term effects of lavage in this group, as well as in the three other asthmatics (lavaged because of chronic moderate wheezing requiring high doses of steroids, is uncertain. One patient was able to stop all medication for one year, but then had a severe attack which was not reversible by lavage and required a high dose of steroids to reverse. In several others, the amount of medications and the number of hospital admissions per year were reduced; however, the group was too small to draw any firm conclusions. Kylstra has reported pulmonary function studies on 18 patients with asthma and chronic asthmatic bronchitis before and after lavage. "Substantial" improvement occurred in ten patients, and mean data indicated significant increases in vital capacity, FEV₁ and Pao₂. Ramírez-R and Obenour have also lavaged patients with moderately severe asthma and felt that the procedure had promise.

It should be noted that in the severely ill patient, lavage is frequently very difficult. Degassing is often incomplete, as indicated by bubbles present in the lavage effluent. Bronchospasm may be severe and adequate ventilation with one lung may not be feasible. Most patients, in fact, require intensive intravenous bronchodilator therapy (usually with aminophylline) and steroids before, during and immediately after lavage. Because of the above factors, we recommend that lavage be reserved primarily for the intractable asthmatic when other measures have not succeeded and mucus plugging is felt to be an important factor threatening survival of the patient. Careful monitoring during the procedure is imperative, and a positive pressure machine may be necessary to ventilate the nonlavaged lung during the procedure because of the high inflation pressures required.

**Cystic Fibrosis**

Most of the therapeutic efforts in the treatment of cystic fibrosis are directed toward the removal of the thick, viscous secretions which obstruct the airways and result in a progressive deterioration of pulmonary function. Limited forms of bronchial lavage with acetylcysteine and saline solution have been recommended, but saline solution alone is probably preferable because high concentrations of acetylcysteine can be hazardous. Volume controlled lavage of an entire lung in the manner which we have described is at present limited to older children with larynges and tracheas large enough to accommodate a Carlens catheter. We have performed only one lavage on one patient who did not return for followup studies, so we do not know if his pulmonary function improved. Kylstra reported ten patients with cystic fibrosis treated with volume controlled lavage. Substantial clinical improvement with decreased sputum volume and viscosity occurred in eight of the ten. In only five, however, was there a rise in arterial Pao₂ and improvements in lung volumes and flow rates were less common. Fever during the first 24 hours postlavage was universal.

Although removal of the viscous secretions which accumulate and produce deterioration of pulmonary function in this disease would theoretically be of great benefit, the use of bronchopulmonary lavage for this purpose must still be considered experimental. If the technical problems of performing a lavage in a child with a small larynx and trachea can be overcome, the procedure may have more applicability. In this regard, simultaneous bilateral lung lavage has been successfully performed in children using partial cardiopulmonary bypass, and dogs have survived bilateral lavage with hyperbarically oxygenated saline, although the latter has led to severe respiratory acidosis.

**Chronic Obstructive Lung Disease**

The rationale for the use of lavage in chronic obstructive lung disease is the hope that removal of
thick, purulent secretions will improve pulmonary function.

Limited forms of lavage have yielded marginal or no success. Ramirez-R and Obenour have lavaged entire lungs of five patients with chronic bronchitis. Although mild to moderate hypoxemia was present none of the patients had hypercapnia prelavage. Immediately postlavage, however, severe hypoxemia and mild to moderate hypercapnia was common. Although a subjective clinical response occurred, no more than a transient physiologic improvement in one patient could be documented.

One might conclude that the mucosal edema, increased mucus gland hypertrophy, infection, bronchospasm and diminished elastic recoil play a more important role in the clinical picture of chronic obstructive lung disease than secretions in the airway. The slight improvement one might expect is probably offset by trapping of a large amount of saline solution in the lung and development of infiltrates which could be due to dissemination of infection or retained saline. It is therefore difficult at this time to recommend bronchopulmonary lavage for chronic obstructive pulmonary diseases other than asthma.

Other Diseases

Kylstra lavaged four patients with bronchiectasis and reported a decrease in the daily volume of sputum postlavage. However, he stated that “there was not enough quantitative data to substantiate the clinical impression that lung lavage was of benefit to them.”

Rogers and Tantum have lavaged a patient with Goodpasture’s syndrome in renal and respiratory failure. The patient’s clinical course was not altered and she died following cardiac arrest 56 hours postlavage. We have recently lavaged a patient with desquamative interstitial pneumonitis whose steroids had to be discontinued due to severe osteoporosis and multiple vertebral fractures. It is noteworthy that the procedure was successful in removing moderate quantities of desquamated alveolar cells (Fig 9). However, her clinical course has not been noticeably altered to date. Lavage has also been successful in the removal of inhaled radioactive particles in dogs and in a single patient following accidental exposure.

Potential Uses of Bronchopulmonary Lavage

Segmental or other forms of limited lavage may have potential in the treatment of lung abscesses and aspergillomas, and in obtaining cells for diagnostic purposes. Bronchopulmonary lavage may be useful in the treatment of overwhelming pneumonias, aspiration pneumonias, Pneumocystis carinii infestation, pulmonary alveolar microlithiasis, allergic aspergillosis, and alveolar cell carcinoma. We are not aware of any trials of lavage in these diseases and would like to discuss some of the theoretical considerations of lavage in the treatment of aspiration pneumonia.

Pneumonia

In spite of considerable advances in antimicrobial therapy and respiratory physiology, pneumonia remains a leading cause of death. Bacterial pneumonia in previously healthy young adults is uncommon, but the disease continues to attack the elderly and the debilitated, as well as patients with diabetes mellitus, alcoholism, congestive heart failure, and chronic lung disease. Although the incidence of Gram-negative pneumonias is increasing, many cases of pneumonia sensitive to the commonly used antibiotics do not resolve possibly because of the patient’s inability to clear secretions. If this is the case, debridement of the airways and alveoli might be expected to benefit these patients.

Early attempts to prevent the development of
Aspiration Pneumonia

Aspiration of gastric contents, a potentially lethal complication of general anesthesia, was initially described by Mendelson in 1946. It also occurs in patients who are debilitated or in coma, or have neurologic disorders of the pharynx, and has been noted with improperly functioning nasogastric or endotracheal tubes. Large pieces of solid material can be removed by bronchoscopy, whereas small pieces and liquid material may lie beyond the reach of the bronchoscope. Aspiration of liquid vomitus may produce an acute chemical pulmonary edema with diffuse pulmonary infiltration, diminished lung compliance, bronchospasm, and severe hypoxemia, which may be uncorrected by increasing inspired oxygen concentration (ie, right-to-left shunt). The large shunt has been attributed to alveolar instability and collapse, and the clinical picture is that of the respiratory distress syndrome of adults (see Sugerman, Rogers—this issue).

The demonstration that the severity of the clinical and pathologic picture of aspiration pneumonia is related to the pH of the aspirated fluid has led to the speculation that lavage might be used to dilute or neutralize the aspirated acid. In addition, the demonstration that systemic steroid therapy is of value has led to the suggestion that steroids be included in the lavage fluid. A limited pilot study suggested that volume controlled lavage of an entire lung may be beneficial in experimentally induced aspiration pneumonitis of Beagle dogs; however, the data are very preliminary. Since the chemical damage from acid is immediate, and the acid is neutralized within ten minutes by the lung tissues, the use of lavage in aspiration pneumonia would seem to be useful only for the removal of particulate matter which is beyond the reach of the bronchoscope. The addition of steroids to the lavage fluid is based upon the assumption that the ratio of lung tissue to serum steroid concentrations is higher after local administration than it is after systemic administration. This has never been demonstrated and in fact, the rate of absorption of steroids from lavage fluid has not been quantitated.

At the present time, the most efficacious therapeutic modalities available for the treatment of aspiration pneumonia continue to be systemic steroids, prompt treatment of complicating infection, careful monitoring of fluid and electrolyte balance, and administration of oxygen and ventilatory support as needed, and, when indicated, the judicious use of positive end-expiratory pressure ventilatory support.

Summary

Bronchopulmonary lavage is a technique whereby large amounts of material can be removed from the airways and alveoli. The use of a double lumen catheter permits adequate gas exchange while one lung is being lavaged. The procedure has been performed safely even in the presence of severe hypoxemia and may have applicability to many diseases in which debridement of small airways and alveoli is desirable. Acute histologic changes and changes in compliance associated with increased surface forces are transient.

The principal indication for lavage is pulmonary alveolar proteinosis and we feel that lavage is the treatment of choice for this disease. Dramatic improvement may occur in status asthmatics, but management is difficult and lavage should be reserved for those cases unresponsive to more conservative therapy. Insufficient data are available with respect to other diseases to draw conclusions regarding the usefulness of lavage. Preliminary observations, however, are encouraging, particularly with cystic fibrosis.

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