Reliability of the Bronchoscopic Protected Catheter Brush in Intubated and Ventilated Patients*

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The reliability of a bronchoscopic protected catheter brush (BPCB) in the diagnosis of lower respiratory tract infection was studied in 17 intubated and ventilated patients, including seven patients free from such infection (group 1) and ten patients with suspected infection (group 2). A first sample was obtained in the lower trachea by aspiration through the fiberoptic bronchoscope and a second in a distal bronchus by the BPCB procedure. In group 1, all BPCB cultures were sterile, although lower tracheal cultures yielded two or more bacterial species, showing that uncontaminated specimens can be obtained by the BPCB procedure. In three patients of group 2, BPCB cultures remained sterile as a nonbacterial pulmonary disease was certified by open lung biopsy. In seven patients from group 2, BPCB cultures yielded all of the organisms isolated simultaneously by reference methods (ie, cultures of blood or pleural fluid, serologic tests, and open lung biopsy). In two of these patients, contamination of the BPCB specimens was ascertained by the reference method bacterial results. In this study the BPCB procedure was able to obtain uncontaminated specimens in intubated and ventilated patients and was mainly accurate in identifying the bacterial etiologic agents of lower respiratory tract infections.

In the management of patients with suspected lower respiratory tract infection, Wimberley et al1 proposed the use of a bronchoscopic protected catheter brush (BPCB) to obtain uncontaminated specimens for bacterial culture. This technique was shown to have a high sensitivity and specificity not only in vitro but also in intubated animals2,3 and in nonintubated patients4,5 or without lower respiratory tract infection. The purpose of the present study was to evaluate the reliability of this procedure in intubated and ventilated patients.

Materials and Methods

Two groups of patients in the intensive care unit whose ages ranged from 21 to 70 years were selected for this study. Group 1 was composed of seven neurologic patients intubated for at least three days and with no evidence of acute or chronic lower-airway disease. Patients in group 2 were selected from among 38 consecutive intubated and ventilated patients with suspected lower respiratory tract infection who underwent a BPCB procedure between January 1983 and July 1984. For inclusion in group 2, each patient had either to have positive results of blood cultures or pleural fluid (or both) or positive serologic tests, or to have undergone an open lung biopsy at the same time as the BPCB procedure. Ten of the 38 patients satisfied at least one of these criteria and were included in group 2. Six patients had suspected nosocomial pneumonia (patients 8, 11 to 13, 15, and 16), and four (patients 9, 10, 14, and 17) had suspected primary pneumonia (Table 1).

In the two groups, each patient or his family gave informed consent to the study. For the fiberoptic bronchoscopic procedure, no tracheobronchial anesthesia was used, either in the neurologic patients (group 1) or in the patients of group 2, in whom sedation was obtained by intravenous administration of fentanyl (2µg/kg) and of midazolam (0.2 mg/kg).

As patients were ventilated with pure oxygen, the fiberoptic bronchoscope (Olympus BF B3) was introduced directly into the trachea through a 6.5-mm endotracheal tube by a connector (Bodai Suction-Safe, Sontek Medical) that provided an air-tight seal. A first sample was obtained in the lower tracheas by suction through the inner aspirating channel of the fiberoptic bronchoscope. After withdrawal of the instrument from the endotracheal tube, the inner channel was flushed with sterile saline solution; the fiberoptic bronchoscope was then reintroduced and was wedged into a subsegment, in the middle lobe for group 1 and in the area of suspected pneumonia for group 2. Then a second sample was obtained with the BPCB (BFW brush, Meditech Corp) as previously described by Wimberley et al.1 After removal, the brush was cut aseptically and placed into a vial containing 1 ml of Mycoplasma broth base with 5 percent fetal calf serum. The two samples were promptly delivered to the laboratory where the vial containing the brush and transport medium was vigorously vortexed. One aliquot of each sample was streaked onto four agar plates. Media for aerobic cultures, including bromcresol purple lactose agar, sheep blood agar, and chocolate agar, were incubated in air and carbon dioxide at 37°C. The anaerobic medium was a meat yeast agar with 5 percent horse blood, incubated in gaspack jars (BBL). All specimens were cultured on broth and agar for Mycoplasma pneumoniae and on charcoal yeast extract agar for Legionella.

The bacterial results of the BPCB specimens were compared with those obtained from the lower tracheal samples, with the clinical and radiologic evolution in the absence of antimicrobial therapy in group 1 and with the results of bacterial reference methods in group 2 (ie, cultures of blood or pleural fluid (or both), serologic tests, or open lung biopsy). This most aggressive procedure was only required for patients with very severe clinical illness.
Table 1—Bacteria Recovered from BPCB, Lower Tracheal, and Reference Method Cultures in Group 2

<table>
<thead>
<tr>
<th>Patient</th>
<th>BPCB</th>
<th>Lower Tracheal Cultures</th>
<th>Reference Methods</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>Sterile</td>
<td>Acinetobacter sp; Staphylococcus epidermidis;</td>
<td>Pneumocystis carinii*</td>
</tr>
<tr>
<td>9</td>
<td>Sterile</td>
<td>Acinetobacter sp; α-hemolytic streptococcus;</td>
<td>Carcinomatous lymphangitis*</td>
</tr>
<tr>
<td>10</td>
<td>Sterile</td>
<td>Acinetobacter sp; Staphylococcus epidermidis;</td>
<td>Eosinophilic pneumonia*</td>
</tr>
<tr>
<td>11</td>
<td><em>Pleuris</em></td>
<td>P aeruginosa 06; Acinetobacter sp</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td><em>Pneumonia</em></td>
<td>P aeruginosa 06; P aeruginosa 06; L. pneumophila</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td><em>E coli</em></td>
<td>E col; Acinetobacter sp; Str pneumoniae sp;</td>
<td>Str pneumoniae†</td>
</tr>
<tr>
<td>14</td>
<td><em>Legionella</em></td>
<td>Str pneumoniae sp; E. coli; Acinetobacter sp;</td>
<td>E. coli† Acinetobacter sp†</td>
</tr>
<tr>
<td>15</td>
<td><em>Staphylococcus</em></td>
<td>Str pneumoniae sp; E. coli; Staphylococcus 14;</td>
<td>Str pneumoniae 14†</td>
</tr>
<tr>
<td>16</td>
<td><em>Escherichia coli</em></td>
<td>Staphylococcus 14;</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td><em>Hemophilus influenzae</em></td>
<td>Staphylococcus 14;</td>
<td></td>
</tr>
</tbody>
</table>

*Open lung biopsy.
†Blood culture.
‡Pleural fluid culture.
§Serologic test.

Results

Group 1

All BPCB cultures were sterile, in contrast with the lower tracheal cultures, which all yielded two or more bacterial species, as shown by the following tabulation listing the bacteria recovered from lower tracheal cultures in Group 1:

Patient 1
Corynebacterium sp
Streptococcus D
Escherichia coli

Patient 2
Acinetobacter sp
Staphylococcus aureus

Patient 3
Acinetobacter sp
Streptococcus D

Patient 4
Staphylococcus
Streptococcus F

Patient 5
Staphylococcus
Hemophilus influenzae
Klebsiella pneumoniae

Patient 6
Staphylococcus
Acinetobacter sp

Patient 7
Staphylococcus
Proteus

All patients remained free from lower respiratory tract infection during the period of observation (minimum, five days; maximum, 30 days), as judged by the clinical and radiologic evolution.

Group 2

In three patients (patients 8 to 10), BPCB cultures remained sterile as lower tracheal cultures yielded three bacterial species. In these patients, open lung biopsy confirmed a nonbacterial pulmonary disease (Table 1).

In seven patients (patients 11 to 17), all of the organisms established as responsible for pneumonia by the reference methods were isolated in BPCB cultures. In four patients (patients 11 to 14), BPCB cultures yielded two bacterial species. In patients 12 and 13, as lower tracheal cultures provided a third bacterial strain, bacteriologic reference methods isolated only the two organisms recovered from the BPCB cultures. In patients 11 and 14, as lower tracheal and BPCB cultures yielded the same two organisms, reference methods isolated only one bacterial strain.

In the three remaining patients of group 2 (patients 15 to 17), BPCB cultures yielded only one organism. Whatever the number of organisms recovered from lower tracheal cultures, reference methods isolated the same organism as BPCB cultures did.

During these 17 BPCB procedures, two pneumothoraces occurred, although no significant hemorrhage was noted.

Discussion

The best way to evaluate the reliability of the BPCB procedure is to compare the results obtained by this
technique with those given by other bacteriologic reference methods carried out simultaneously. In several studies\(^4,5\) the accuracy of the BPCB technique was evaluated by the clinical and radiologic response to antimicrobial therapy directed against the organisms isolated by the BPCB procedure. Since any antimicrobial drug is active against several bacterial species, this clinical evaluation cannot exactly establish the causative organism of each pneumonia and does not provide a bacteriologic reference method. Therefore, in group 2, we only included patients in whom bacteriologic reference methods were available, in order to determine precisely the reliability of the BPCB procedure. In intubated and ventilated patients with lower respiratory tract infection, bacteriologic reference methods are rarely available. As observed during this period of study, where 32 (84 percent) of the 38 patients had negative results of blood cultures, Sullivan et al.\(^6\) and Bartlett\(^7\) reported an incidence of 70 to 90 percent for negative blood cultures in patients with bacterial pneumonia. Pleural puncture involves some risk in ventilated patients, and pleural pyogenic effusion is uncommon in bacterial pneumonias;\(^8,9\) however, this procedure is highly specific when bacteriologic cultures are positive. Transthoracic needle aspiration exhibits a high specificity but is not suitable, as it is not very sensitive.\(^3,10\) and, moreover, it carries a considerable risk of bleeding and life-threatening tension pneumothorax among ventilated patients.\(^3,11\) Open lung biopsy\(^12\) is the most reliable antemortem diagnostic procedure,\(^14\) although, as it is mostly invasive, it cannot be used routinely.

In this study, the absence of bacteria in BPCB cultures despite bacterial colonization of the proximal airways, indicates that the BPCB procedure avoids contaminants even in intubated patients (group 1 and three patients in group 2). In the remaining patients of group 2, the BPCB was highly sensitive. Each organism isolated by bacteriologic reference methods was also recovered in the BPCB samples. In this group, for patients 11 and 14, as reference methods yielded only one bacterial strain, the recovery of an additional organism by the BPCB cultures was considered to represent contamination from proximal airways. In these two patients, BPCB and lower tracheal cultures yielded the same two organisms. In the overall study, 15 BPCB samples were considered as not contaminated. In 13 out of these 15 patients, lower tracheal cultures yielded more bacterial species than BPCB cultures, and in two patients, only one organism was recovered from both lower tracheal and BPCB cultures. In the patients under study, a comparison between BPCB and lower tracheal specimens could be used to distinguish significant from contaminated BPCB isolates. When BPCB cultures yielded only one bacterial strain, this organism was of clinical significance. When BPCB cultures yielded more than one bacterial strain, comparison with lower tracheal cultures may have been helpful; when lower tracheal culture gave exactly the same organisms, the BPCB specimens were contaminated; and when lower tracheal cultures yielded more bacterial species than BPCB, then the organisms recovered by the BPCB procedure were responsible for the pneumonia. When BPCB cultures were sterile, nonbacterial pulmonary disease could be suspected only when the patient had not previously received antimicrobial therapy\(^4,6,8\) and when it was certain that the BPCB sample was taken from the bronchopulmonary segment containing the lesion.

Several studies\(^4,5\) suggested that quantitative bacteriologic examination of specimens obtained by the BPCB procedure was necessary for proper differentiation between causative and contaminant organisms and that a colony count of more than 10\(^6\) colony-forming units per milliliter could be used as an interpretative threshold to determine the significance of an isolate in nonintubated patients. Unfortunately, quantitative bacteriology was not available when we started the study. As outlined by Wimberley et al.,\(^4\) quantitative cultures of several serial dilutions are unacceptable for most clinical laboratories. Moreover, in intubated patients, as compared with nonintubated patients, a larger amount of organisms colonize the bronchi, and therefore the interpretative threshold of 10\(^6\) colony-forming units per milliliter may be questionable. In intubated patients, a recent and well-conducted study\(^16\) compared the bacteriologic results of postmortem BPCB samples with those obtained simultaneously in the same area by surgical biopsy. With this cutoff point of 10\(^6\) colony-forming units per milliliter, eight of the 26 studied patients were misdiagnosed and erroneously thought to have pneumonia.

Although some authors\(^1\) argue that the BPCB procedure involves a risk in critically ill patients, in our study, no significant pulmonary hemorrhage was noted; a pneumothorax occurred in two patients with ventilation with positive end-expiratory pressure (PEEP) of more than 10 cm H\(_2\)O; however, the pneumothoraces resolved rapidly with chest tube drainage. In fact, during the period of study, 45 BPCB samples were obtained, and three pneumothoraces occurred in patients ventilated with PEEP of more than 10 cm H\(_2\)O. Two of them were observed in group 2. The BPCB technique requires that the brush should be wedged in a subsegmental bronchus, and subsequently a pleural breach may occur. Although the real incidence of pneumothorax was about 6 percent during the period of study, the use of fluoroscopic control during the BPCB procedure may reduce the frequency of pneumothorax.\(^18\)
CONCLUSION

The results of this study, although concerning a small number of patients, indicate that fiberoptic bronchoscopy, using a protected catheter brush procedure, can obtain uncontaminated specimens from the lower respiratory tract in intubated and ventilated patients. Furthermore, in critically ill patients, this technique is mainly safe and accurate in identifying the agent responsible for the lower respiratory tract infection. In intubated patients the comparison of BPCB and lower tracheal cultures may be associated with quantitative bacteriology to delineate the significance of an isolate.

REFERENCES


National Aspergillus Registry

A National Aspergillosis Registry has been established under the auspices of the National Institute of Allergy and Infectious Diseases, Asthma and Disease Centers Program and through the cooperation of the Allergy-Immunology Sections at the Northwestern University School of Medicine (Dr. Roy Patterson) and the Medical College of Wisconsin (Dr. Jordan Fink), and the Pulmonary Center of Boston University School of Medicine at the Boston VA Medical Center (Dr. Gordon L. Snider). The Registry is interested in collecting and analyzing cases of allergic bronchopulmonary aspergillosis, mycetoma in an existing airspace, chronic necrotizing pulmonary aspergillosis, as well as bronchocentric granulomatosis and pulmonary vasculitis of the Churg-Strauss type whose etiologic relationship to Aspergillus is less certain.

In return for completing a questionnaire and sending a chest radiograph on any category of proven or suspect aspergillosis except acute invasive aspergillosis in the immunocompromised host and hypersensitivity pneumonia due to Aspergillus spores, the Aspergillosis Registry will provide physicians with standardized Aspergillus serology studies and highly standardized Aspergillus antigen to skin test for immediate and late reactions. Contact Dr. L. Jack Faling, Director, National Aspergillosis Registry, 150 South Huntington Avenue, Boston, MA 02130 (617) 232-0500, ext 3345, for further information.