Efficacy of Transthoracic Needle Aspiration in Community-acquired Pneumonia

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Abstract

Objective To evaluate the indications, efficacy, and safety of transthoracic needle aspiration (TNA) in diagnosing community-acquired pneumonia (CAP).

Methods TNA procedure was performed using an ultrathin needle with ultrasonography and/or computed tomography. The aspirate samples were Gram-stained and sent for cultures. The results were compared with those from conventional microbiological studies.

Patients Sixty patients with CAP who were admitted to the hospital and were studied prospectively between July 1994 and June 1999 were included in the study.

Results TNA culture was positive in 30 cases (50.0%). Streptococcus pneumoniae was the most frequently isolated pathogen, followed by the Streptococcus milleri group, and anaerobes. The results of TNA were consistent with those of quantitative sputum cultures in 9 patients and with those of blood cultures in 4. Complications arose in 3 patients who developed small to moderate pneumothorax.

Conclusions TNA is a safe procedure with a good diagnostic yield. In particular, anaerobes or microaerophils such as the S. milleri group were highly detectable by TNA. The results obtained by TNA were highly consistent with those obtained by the gold standard methods. Combined with conventional methods, TNA is considered highly useful for determining the etiology of CAP.

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Materials and Methods

Patients

During a 5-year period (July 1994 through June 1999), a prospective study into the etiology of CAP was carried out in our 1,100-bed community general hospital. All patients over 15 years of age with CAP admitted to our hospital were evaluated for inclusion in the study. CAP was defined as new infiltrates of the chest revealed by radiographic examination on admission, including at least two of the following: fever, production of purulent sputum, cough, and leukocytosis (white blood cell count ≥ 10,000/µL). Patients were excluded from the study when abnormalities on chest roentgenogram were attributed to other causes, such as congestive heart failure, pulmonary infarction, or obstructive pneumonia due to lung cancer.

Eligible patients for TNA were identified by the authors and informed consent was obtained from all patients after full ex-
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planation of the procedure and possible adverse events involved. TNA was indicated in patients with subpleural consolidations and those in whom definitively positive results could not be obtained by blood or sputum cultures (including Gram staining) immediately before admission. We excluded patients with contraindications to performing TNA, including artificial ventilation, bullous emphysema, hemorrhagic diathesis (platelet \( \leq 50,000/\mu l \)), severe hypoxemia (PaO\(_2\) \( \leq 50 \) Torr at room air), or inability to cooperate. Prior to the study, the protocol was approved by the institutional ethics committee.

**TNA procedure**

In principle, TNA was done immediately after admission. The procedure was performed with ultrasonography to detect subpleural consolidation at the patient’s bedside. Computed tomograph (CT) was also referred to determine the place, trajectory, and depth of the puncture, if available. Intradermal and subcutaneous anesthesia was administered with 0.5% lidocaine. The puncture was carried out using an ultrathin 23-gauge needle with its stylet. Breath control was advised when the pleura was crossed. When the needle was thought to be on the target, the stylet was removed and a 10-ml syringe containing 5 ml of sterile saline was attached to the needle. Then, 4 ml was injected, leaving 1 ml in the syringe as a carrier. Negative pressure was applied to the syringe to ensure that at least 1 ml was recovered. Then, suction was released and the needle and syringe were removed.

Chest X-ray follow-up to detect pneumothorax was performed immediately after TNA and on the following day.

**Management of TNA samples**

The lung aspirate samples were sent for conventional cultures including an anaerobic study. Gram staining was carried out on all samples. Zhiel-Neelsen stain as well as selective culture for mycobacteria was also performed. When Legionella pneumonia or Mycoplasma pneumonia was suspected, buffered charcoal-yeast extract (BCYE) medium or pleuropneumonia-like organism (PPLO) medium was used, respectively.

**Routine microbiological studies**

In all cases, two sets of blood cultures were collected at the time of admission. Sputum samples were processed for Gram stain and culture, if available. In the case of pleural effusion, an aspirated pleural fluid sample was cultured. Samples obtained under bronchoscopic examination (bronchoalveolar lavage or protected specimen brush) were also used for microbiological studies in selected patients. Blood samples were also drawn for serological studies (Legionella pneumophila, Mycoplasma pneumoniae, Chlamydia psittaci, Chlamydia pneumoniae, and viruses).

**Criteria for etiologic diagnosis**

Bacteria were considered definitive causative agents when isolated from blood cultures, thoracentesis, or TNA. We considered the results of sputum culture presumptive when it revealed heavy growth \( \geq 10^7 \) colony-forming units (CFU/ml) on quantitative culture. Any microorganism isolated from bronchoalveolar lavage or protected specimen brush was considered to be a presumptive pathogen when its concentration reached \( \geq 10^5 \) or \( 10^3 \) CFU/ml in quantitative culture, respectively.

For serological tests, a four-fold increase in the antibody titer level between paired sera was considered presumptive.

**Statistics**

We analyzed the frequency distributions of categorical variables using the \( \chi^2 \) test. A \( p \) value \( \leq 0.05 \) was considered significant.

**Results**

**Patient characteristics**

A total of 552 episodes of CAP in 540 patients were admitted to our hospital during the study. TNA was performed on 60

| Table 1. Characteristics of Patients Who Underwent Transthoracic Needle Aspiration |
|---------------------------------------|-------------------------------|
| Patients                              | 60                            |
| Sex, M: F                             | 48: 12                        |
| Age, year                             | 64.1±14.3                     |
| range                                 | 20–86                         |
| Antibiotics within 48 h               | 23 (38.3)                     |
| Comorbidity                           | 37 (61.7)                     |
| Radiology                             |                               |
| Lobar                                 | 8 (13.3)                      |
| Unilateral/Bilateral                  | 49/11 (81.7/18.3)             |
| Pleural effusion                      | 5 (8.3)                       |
| Abscess formation                     | 5 (8.3)                       |
| Mortality                             | 4 (6.7)                       |

<p>| Table 2. Organisms Identified by TNA |
|-------------------------------------|-------------------------------|</p>
<table>
<thead>
<tr>
<th>Organism</th>
<th>Number of cases*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Streptococcus pneumoniae</td>
<td>12</td>
</tr>
<tr>
<td>the Streptococcus milleri group</td>
<td>7</td>
</tr>
<tr>
<td>Anaerobes</td>
<td>6</td>
</tr>
<tr>
<td>Streptococcus spp.</td>
<td>3</td>
</tr>
<tr>
<td>Klebsiella pneumoniae</td>
<td>3</td>
</tr>
<tr>
<td>Haemophilus influenzae</td>
<td>2</td>
</tr>
<tr>
<td>Staphylococcus aureus</td>
<td>2</td>
</tr>
<tr>
<td>Escherichia coli</td>
<td>2</td>
</tr>
<tr>
<td>Pseudomonas aeruginosa</td>
<td>1</td>
</tr>
</tbody>
</table>

*Including 6 cases with double isolates (the S. milleri group + anaerobes, 2; S. pneumoniae + the S. milleri group, 1; Streptococcus spp. + anaerobes, 1; Streptococcus spp. + K. pneumoniae, 1; K. pneumoniae + E. coli, 1) and 1 case with triple isolates (S. pneumoniae + S. aureus + E. coli).
of these patients. The clinical characteristics of these patients are summarized in Table 1. Thirty-seven patients (61.7%) had at least one underlying disease. The major underlying diseases were diabetes mellitus (n=8), chronic alcoholism (n=5), cerebrovascular disease (n=5), chronic obstructive pulmonary disease (n=4), chronic liver disease (n=4), and chronic heart disease (n=3). A total of 23 patients (38.3%) had received antibiotic treatment prior to hospital admission.

**TNA results**

TNA culture was positive in 30 cases (50.0%). The organisms identified by TNA are shown in Table 2. *Streptococcus pneumoniae* was the most frequently isolated pathogen (12 cases), followed by the *Streptococcus milleri* group (7 cases), anaerobes (6 cases), other *Streptococci* (3 cases), *Klebsiella pneumoniae* (3 cases), *Staphylococcus aureus* (2 cases), *Haemophilus influenzae* (2 cases), *Escherichia coli* (2 cases), and *Pseudomonas aeruginosa* (1 case). Double pathogens were isolated in 6 cases, and triple pathogens in 1 case. A pathogen was detected in only 9 of 23 cases (39.1%) where antibiotic therapy had been given before TNA, while the patients without prior therapy had a high diagnostic yield of 56.8% (21 of 37 cases). However, no significant difference was observed between them.

**Conventional methods results**

Conventional methods provided a microbial etiology in 34 cases (56.7%). Sputum cultures showed positive findings in 22 cases, blood cultures in 7, pleural fluid cultures in 2, serological studies in 8, and histological studies in 2. *S. pneumoniae*
The best advantage of TNA is that it provides definitive findings. We identified pathogens in 3 patients with Chlamydia pneumoniae, 3, K. pneumoniae in 3, the S. milleri group in 2, other Streptococci in 2 (Streptococcus agalactiae and Streptococcus oralis), S. aureus in 2, anaerobes in 2 (Bacteroides ureolyticus and Fusobacterium nucleatum), Chlamydia psittaci in 2, H. influenzae in 1, P. aeruginosa in 1, Legionella pneumophila in 1, and Mycobacterium tuberculosis in 1. Double or triple pathogens were isolated in 2 cases (K. pneumoniae + S. oralis, S. pneumoniae + S. aureus + E. coli). Conventional testing plus TNA method showed a microbial etiology in 48 of 60 cases (80.0%).

Results of TNA and conventional methods (sputum and blood cultures) for the 30 patients in whom TNA identified pathogens are shown in Table 3. The results of TNA were consistent with those of quantitative sputum cultures in 9 patients (30%), and with those of blood cultures in 4 (13.3%).

Complications of TNA
TNA caused complications in 3 patients (5.0%), all of whom developed pneumothorax. In two cases, pneumothorax was minor, and pleural drainage was not required. However, one case was moderate, and a drainage tube was inserted. There were no cases of hemoptysis or air embolism.

Discussion
The diagnostic yield of TNA in this study (50%) was not higher than those reported in the literature (3, 5–12). Various reasons for this are considered. First, 38.3% of our patients had been treated with antibiotics prior to TNA. In these patients, the detection rate of organisms was decreased compared with that in untreated patients although no significant difference was observed between the two groups. Secondly, our series included 5 patients with Chlamydia pneumoniae (C. pneumoniae, 3 patients; C. psittaci 2 patients). Culture and detection of chlamydia are difficult with our routine method of examination. Moreover, we attempted to detect mycoplasma using PPLO medium, but the success rate of mycoplasma culture is generally low, and the organisms could not be cultured from any patient in the present study. The third is that in those cases without guidance by CT, the puncture site may have been inappropriate. When the pneumonia lesion was in an area distant from the pleura, the puncture needle may have not reached the lesion.

The best advantage of TNA is that it provides definitive findings, and the detected organisms per se are likely to be the causative organisms of inflammation. If organisms are detected in gram-stained aspirates, it is possible to assume that they are causative organisms of inflammation during the early stage and to administer the most suitable antibiotics.

The results of TNA were consistent with those of sputum cultures in only 30% of the patients. In particular, the S. milleri group was seldom detected as pathogens by sputum culture because this organism is indigenous in the oral cavity. We indicated TNA for those in whom positive results could not be obtained by sputum culture at the time of admission in this study. Therefore, there may have been a selection bias in that the detection rate of the S. milleri group increased.

Blood cultures are considered the gold standard, but revealed a low diagnostic yield (7/60) in this series. There were four cases of a positive TNA result consistent with the results obtained by blood cultures (in one case, blood culture grew K. pneumoniae and S. oralis whereas TNA culture grew K. pneumoniae alone). In one case, blood culture grew S. pneumoniae, but TNA culture grew S. aureus and E. coli. We thought all three organisms may have been pathogens, although there was a possibility that those found only by TNA were contaminants. The organisms obtained by pleural fluid culture were consistent with the TNA results (Bacteroides ureolyticus and Fusobacterium nucleatum).

Garcia et al attempted to detect S. pneumoniae in aspirates obtained by TNA using polymerase chain reaction (PCR) and antigen latex agglutination testing (13). These methods were useful, showing high detection rates even in patients pretreated with antibiotics. If these methods are combined with conventional bacteriological examinations, the diagnostic yield of TNA would be considerably increased. In addition, it would be very useful to introduce PCR methods for detecting atypical pathogens such as mycoplasma or chlamydia, which are generally hard to culture.

A noteworthy finding of this study was that anaerobes or the S. milleri group alone or in combination were frequently detected by TNA. These bacteria are resident oral flora, and have recently attracted attention as causative agents of pneumonia and other thoracic infections (14–16). However, these bacteria are frequently difficult to culture and detect with the typical sputum examination as mentioned above. In our series, of 11 patients in whom anaerobes or the S. milleri group were detected by TNA, sputum culture yielded the same bacteria only in one. Considering that these bacteria as well as anaerobes often induce purulent lesions in the lung, there may have been a selection bias, which increased the detection limit of the S. milleri group, in this study. However, TNA seems to be the most appropriate diagnostic modality to detect these organisms.

TNA is a convenient procedure with an excellent diagnostic yield, but it is not widely used. The reason for this seems to be the fear of complications due to lung puncture. In the present study, however, pneumothorax was noted as a complication in only 3 patients. Neither hemoptysis nor aeroembolism were observed. In this study, we excluded patients with artificial ventilation, bullous emphysema, severe hypoxemia, or inability to cooperate in order to prevent pneumothorax after TNA. If patients are selected, and are informed that breath control during puncture prevents pneumothorax, severe complications can be avoided. Assistance of CT or ultrasonography allows accurate evaluation of the puncture site, and is useful for improving the diagnostic yield and reducing complications. Pneumothorax can be prevented if the site of consolidation can be precisely punctured. In previous studies on TNA, complications were generally mild, suggesting that TNA is a considerably safe procedure.
Efficacy of TNA in CAP

We consider that TNA does not need to be performed in all patients with community-acquired pneumonia, but indications should be established. Indications would include patients in whom bacterial pneumonia is suspected but neither sputum samples nor other significant findings can be obtained, patients demonstrating apparent consolidation on chest X-rays, patients with supplicative pulmonary diseases such as lung abscess in which involvement of anaerobes or microaerophils such as the S. milleri group is suspected, and patients who do not have contraindications and give informed consent. The procedure should be performed by experienced physicians.

Scott and Hall described that TNA may be considered on an individual basis for patients who do not respond to initial therapy, who may have nosocomial superinfection, who are immunocompromised, or in whom tuberculosis is suspected but has not been confirmed by examination of the sputum or gastric lavage (11). In our study, the detection rate was decreased in patients in whom antibiotics were administered prior to TNA, although no significance was observed. We consider that it may be better to perform TNA prior to antibiotic therapy in order to detect the etiological pathogens of CAP.

In conclusion, TNA is a safe method of examination with a high diagnostic yield. The results obtained by TNA are highly consistent with those obtained by gold standard methods, and TNA in combination with conventional methods is considered highly useful for determining the etiology of community-acquired pneumonia.

References