Accuracy of Portable Chest Radiography in the Critical Care Setting

Diagnosis of Pneumonia Based on Quantitative Cultures Obtained From Protected Brush Catheter

Michael S. Lefcoe, M.D.; George A. Fox, M.D., F.C.C.P.; David J. Leasa, M.D., F.C.C.P.; R. Keith Sparrow, M.D.; and David G. McCormack, M.D.

Sixty-six supine portable chest radiographs done on the day of bronchoscopy in 62 critical care unit patients suspected of having pneumonia were examined in a blinded fashion by two radiologists. Quantitative culture results obtained from protected brush catheter (PBC) specimens were compared with chest radiograph scores. For one observer, the sensitivity of the chest radiograph for predicting the presence of positive culture results was 0.60, specificity was 0.29, overall agreement was 0.41, positive predictive value was 0.34, and negative predictive value was 0.55. For the second observer, the values were as follows: sensitivity, 0.64; specificity, 0.27; overall agreement, 0.41; positive predictive value, 0.35; and negative predictive value, 0.55. The kappa statistic was calculated at 0.27 indicating marginal interobserver reproducibility. We conclude the portable chest radiograph in the critical care setting is not accurate in predicting the presence of pneumonia when the diagnosis is based on quantitative cultures obtained from protected brush catheter specimens.

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Nosophomial bacterial pneumonia in the critical care setting continues to complicate the course of 7 to 41 percent of patients receiving continuous mechanical ventilation. The mortality rate is from 50 to 80 percent.

The precise diagnosis of pneumonia in critically ill patients is very difficult and previous studies have suffered from a lack of a consistent gold standard. The usual clinical criteria for pneumonia such as fever, pulmonary infiltrates, purulent sputum, and leukocytosis are not reliable in mechanically ventilated patients. Oropharyngeal and endotracheal tube colonization with pathogenic bacteria can occur within 24 h of intubation and therefore decreases the reliability of expectorated or aspirated tracheal secretions for diagnosis of lower respiratory tract infections. In addition, elevated body temperature and leukocytosis are common with other conditions in critically ill patients.

Assessment of the value of chest radiographic findings in diagnosing pneumonia has also suffered from lack of a gold standard. Patients in critical care settings often have pulmonary edema, secretion retention with atelectasis, or pulmonary emboli that make assessment of the significance of radiographic opacities difficult.

Wimberley and associates\(^1\) in 1979 introduced a fiberoptic bronchoscopic technique using a plugged double-sheath catheter system to obtain lower respiratory tract secretions uncontaminated by organisms that colonize the upper airways. Further modifications have led to the application of quantitative culture techniques to the protected brush catheter (PBC) specimen. These quantitative bacterial culture techniques have increased the accuracy of diagnosing nosocomial pneumonia by identifying significant bacterial counts (> 10\(^3\) colony forming units [CFU]/ml) in specimens isolated from the lower respiratory tract secretions obtained from bronchoscopy.\(^4\) The validity of this method as a gold standard for the diagnosis of pneumonia is supported by clinical studies in the literature.\(^5\)\(^-\)\(^11\)

Chastre and associates\(^12\) obtained PBC specimens from patients shortly after death and verified their results with histologic samples of lung obtained at post mortem examination. There was excellent correlation between cultures of the lung tissue and the protected brush. Further, all patients with histologic evidence of pneumonia had one or more organisms isolated in concentrations of greater than 10\(^2\)/ml from the PBC specimens.

The available data therefore suggest that the use of quantitative cultures obtained from PBC specimens is a highly sensitive and very specific test for the diagnosis of nosocomial pneumonia. The purpose of this study was to examine the diagnostic accuracy of the portable chest radiograph in predicting the presence of nosocomial pneumonia based on an accurate gold standard, that is, quantitative bacteriologic cultures obtained from protected bronchial brushings.
Table 1 — Radiographic Categories

<table>
<thead>
<tr>
<th>Suggestive of Pneumonia</th>
<th>Compatible With Pneumonia</th>
<th>Low Probability of Pneumonia</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cavitation</td>
<td>Diffuse airspace disease in both lungs</td>
<td>Pulmonary edema pattern with Kerley-B lines</td>
</tr>
<tr>
<td>Localized fluffy alveolar opacities without loss of volume</td>
<td>Localized fluffy alveolar opacities with some loss of volume</td>
<td>Line shadows</td>
</tr>
<tr>
<td>Lobar consolidation without loss of volume</td>
<td>Localized ill-defined pulmonary markings without much volume loss</td>
<td>Lobar collapse or segmental collapse</td>
</tr>
<tr>
<td>Localized fluffy alveolar opacities with pleural effusion</td>
<td>Diffuse interstitial reticulonodular pattern</td>
<td>Pleural fluid alone</td>
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<tr>
<td></td>
<td></td>
<td>Normal lung</td>
</tr>
</tbody>
</table>

**Methods**

Sixty-six bronchoscopies were performed over an 8-month period on 62 patients. Patients’ ages ranged from 17 to 83 years with the mean age of 65 years. The reference population was all patients admitted to the critical care unit at Victoria Hospital, and the ICU at University Hospital in London, Ontario. Inclusion criteria were as follows: (1) patients who were ventilated for greater than 48 h; (2) chest radiographs interpreted by the clinical staff showing pulmonary infiltrates that were new or persisted greater than 24 h; (3) the presence of macroscopic purulent tracheal aspirates; and (4) patients older than 18 years of age.

Patients were excluded from the protocol if they (1) had a condition not permitting bronchoscopy, (2) had a clinical diagnosis of pneumonia on admission to the ICU, (3) were immunocompromised (patients with organ transplants, hematologic malignancy, tumor, or cellular immune deficiency), (4) had gross aspiration as a cause of the pneumonia, or (5) were receiving more than 0.5 mg/kg per day of prednisone or its equivalent. Informed consent was obtained from the patient or the next of kin and upon entry into the study, all patients had lower respiratory tract secretions obtained through flexible bronchoscopy with PBC within 12 h of entry into the study.

Specimens were immediately transported to the Microbiology Laboratory and quantitatively cultured on MacConkey agar, 5 percent horse blood agar. Identification of pathogenic bacteria and antibiotic sensitivities were determined according to routine laboratory protocol. Cultures were considered positive if > 10^5 CFU/ml of one or more potentially pathogenic bacteria were isolated from the PBC.

A portable chest radiograph was obtained in all patients on the day of the bronchoscopy prior to the bronchoscopy. The radiographs were done with the patient in a supine position using portable x-ray equipment (average technique 85 kV, 1.5 to 2 mas, Kodak TML film, Lanex regular screens). The radiographs were independently examined in a blinded fashion by two radiologists (K.S., M.L.) and the film was classified into categories “suggestive for pneumonia,” “compatible with pneumonia,” or “low probability of pneumonia” based on radiographic appearance (Table 1).

**Results**

A comparison of the chest radiologic category with the PBC results in the 62 patients for the two observers is shown in Tables 2 and 3.

Using both the suggestive and compatible radiographs as positive for pneumonia, and the low-probability radiographs as negative for pneumonia, sensitivity for observer A (K.S.) is 0.66, specificity is 0.29, overall agreement is 0.41, positive predictive value is 0.34, and negative predictive value is 0.55. For observer B (M.L.), the values are as follows: sensitivity, 0.64; specificity, 0.27; overall agreement, 0.41; positive predictive value, 0.35; and negative predictive value, 0.55.

Interobserver reproducibility was illustrated in Table 4 where the kappa statistic was calculated at 0.27 indicating marginal reproducibility between the observers.

Only one patient had an autopsy within 1 month of the bronchoscopy and this patient had the autopsy the day following the bronchoscopy. The radiograph was suggestive of pneumonia and the PBC culture was positive. The pathologic findings confirmed the presence of bilateral bronchopneumonia.

**Discussion**

The results are not particularly surprising in view of the difficulties involved in radiographic interpretation of portable chest radiographs in the critical care situations.
setting. False positives on radiography are probably related to secretion retention that occasionally occurs without much loss of volume and produces fluffy alveolar opacities. Atypical pulmonary edema due to underlying emphysema or asymmetrical clearing of pulmonary edema also causes difficulties. It is possible that following the radiographs over a period of days might be of more value than just reading a single radiograph on the date of the bronchoscopy and might increase accuracy although we have not done this in our study.

False negatives are likely related technical difficulties in assessing all areas of the lung on a portable supine radiograph. Using chest computed tomography as the gold standard, Beydon et al.\(^1\) recently showed that the sensitivity of the portable chest radiograph in detecting lung consolidations was between 0.33 and 1.00 depending on the lung zone considered.

One case in our study had a completely normal portable radiograph and a protected brush culture was quantitatively abnormal. One possible explanation for this situation is that in the very early stages of pneumonia, the presence of organisms in the lung parenchyma may not result in sufficient alveolar exudation to cause a radiographic opacity.

**Conclusions**

We conclude that the portable chest radiograph in the critical care setting is not accurate in predicting the presence of nosocomial pneumonia when the

diagnosis is based on a gold standard of quantitative culture of PBC specimens.

**References**


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**Table 4 — Interobserver Reproducibility**

<table>
<thead>
<tr>
<th>Observer A (K.S.)</th>
<th>Low Probability of Pneumonia</th>
<th>Suggestive of Pneumonia</th>
<th>Compatible With Pneumonia</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low Probability of Pneumonia</td>
<td>10</td>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td>Suggestive of Pneumonia</td>
<td>6</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Compatible With Pneumonia</td>
<td>4</td>
<td>1</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>13</td>
<td>33</td>
</tr>
</tbody>
</table>

* Kappa = 0.27.