Pneumothorax With Fine-needle Aspiration of Thoracic Lesions*

Is Spirometry a Predictor?

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To assess the value of spirometry for predicting the risk of pneumothorax (PTX) following percutaneous fine needle aspiration (FNA) of thoracic lesions, we examined retrospectively the incidence of PTX in 89 FNA and associated spirometry. Spirometry results were classified as normal, obstructed, or restrictive. Overall, the PTX rate was 20 percent. When the PTX occurrence was analyzed based on our spirometry classification, no significant difference was found between the groups. A PTX occurred in 27.8 percent of the FNA performed in patients with normal spirometry. On further analysis of specific spirometry measurements (FEV1, FVC, FEV1 percent predicted, and FEV1/FVC) and incidence of PTX, no significant correlation in PTX rates was found. These data suggest that the FNA pneumothorax is not correlated with lung function as measured by routine spirometry.

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FNA = fine-needle aspiration; PTX = pneumothorax

Percutaneous needle aspirations of the thorax have been described as a successful means of diagnosing chest abnormalities for over 100 years. The popularity of needle aspirations has varied over time. One major limitation to its use is the associated high pneumothorax (PTX) rate. Pneumothorax rates in recent literature are reported between 21 percent and 60 percent (Table 1). There are several reports suggesting that various technical factors affect the risk of PTX such as the use of smaller-gauge needles, fluoroscopy, and limiting the number of needle passes. Additional risk factors for the occurrence of PTX from thoracic aspirations have been sought in order to identify patients at increased risk. Multiple investigations have associated obstructive lung disease by chest radiograph (CXR) criteria with an increased risk of PTX from fine-needle aspiration (FNA) (Table 1). Recent studies suggest that the presence of an obstructive or restrictive defect on spirometry will identify the patient at high risk for PTX.

Our clinical experience with computed tomographic (CT) guided needle biopsies suggested to us that the avoidance of bullae may be more important than the presence of a specific abnormality on spirometry. Because of these concerns, we conducted a retrospective analysis of our experience with FNA to clarify the usefulness of spirometry as a predictor of PTX.

METHODS

Subjects

The medical records of 144 patients who had had 166 percutaneous lung biopsies between 1981 and 1987 were reviewed. Patients were candidates for FNA if their CXR showed a lung or mediastinal abnormality consistent with a diagnosis of malignancy and results of the initial clinical and laboratory evaluation were nondiagnostic. When appropriate, the initial evaluation included all or part of the following: sputum evaluation for abnormal cytology and microbiology, spirometry, flexible fiberoptic bronchoscopy with bronchial washings, brushings and biopsies (possibly including transbronchial lung biopsy), thoracentesis, and percutaneous pleural biopsy.

Patient Preparation

Arterial blood gases, prothrombin time, and partial thromboplastin time were done before all FNA procedures. Informed consent was obtained from each patient. No preprocedural narcotics were given but a peripheral intravenous line was established in all patients.

FNA Technique

The first 11 FNAs were done using standard fluoroscopy techniques to visualize the lesion. The remaining 155 procedures (93 percent) were done with CT guidance. The technique began by locating the lesion by CT. The patient was then positioned on the CT scanner gurney to give the best access to the lesion. All attempts were made to avoid bullae when visualized on CT. When this was not possible, the procedure was terminated. The overlying skin was marked. The area was prepared and draped in sterile fashion. Local anesthesia of the skin, subcutaneous tissue, nearby periosteum, and pleura were obtained by injecting with 1 percent lidocaine. Lesions were aspirated using disposable 20- to 23-gauge spinal needles. The needle was inserted in the appropriate intercostal space to the approximate lesion location. Next, radiographic confirmation of the needle placement within the lesion was obtained with the scanner. At this point, the only adjustment possible in needle position was the depth of insertion. If the positioning was poor and not simply a matter of depth, the needle was removed and redirected. Once in a proper position, the needle stylet was removed and a 20-ml syringe within a suction-promoting aspiration gun was attached. Suction was applied and the needle was moved gently in an up and down motion. The suction was gently discontinued prior to removing the needle from the chest.

A cytotechnologist assisted the physician in preparing smears during most of the FNA. If the first specimen was thought to be inadequate, a second and third aspiration was done. At the conclusion of the procedure, CT scanning (one or two sections) of
Table 1—Summary of Recent Literature Concerning Pneumothorax (PTX) Rate With Thoracic Fine Needle Aspiration (FNA)

<table>
<thead>
<tr>
<th>Source, yr</th>
<th>FNA No.</th>
<th>Needle Size</th>
<th>Imaging Method</th>
<th>Cyto Eval*</th>
<th>Overall PTX Rate, %</th>
<th>PTX Rate (%) by Various Groups</th>
<th>Factors Associated With Increased Risk</th>
<th>Factors Not Associated With Increased Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sinner,14</td>
<td>2,726</td>
<td>0.9-1.6 mm</td>
<td>Fluoroscopy</td>
<td>No</td>
<td>27.2</td>
<td>Empysema†</td>
<td>Emphysema†</td>
<td>Lobe of lung</td>
</tr>
<tr>
<td>1976</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Westcott,16</td>
<td>432</td>
<td>20 g</td>
<td>Fluoroscopy</td>
<td>Yes</td>
<td>27</td>
<td>NS††</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>1980</td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>Harter et al,17</td>
<td>28</td>
<td>20-22 g</td>
<td>CT‡</td>
<td>Yes</td>
<td>60</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>1983</td>
<td></td>
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</tr>
<tr>
<td>Gobien et al,18</td>
<td>40</td>
<td>16-22 g</td>
<td>CT‡</td>
<td>No</td>
<td>29.4</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>1984</td>
<td></td>
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<td></td>
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<tr>
<td>Poe et al,19</td>
<td>103</td>
<td>18 g</td>
<td>Fluoroscopy</td>
<td>Yes</td>
<td>37</td>
<td>TLC§ &lt;=120% Pred</td>
<td>TLC§ Lesion size</td>
<td>No. of needle passes</td>
</tr>
<tr>
<td>1984</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Johnsruge et al,10</td>
<td>84</td>
<td>20-23 g</td>
<td>Fluoroscopy</td>
<td>Yes‡</td>
<td>40-2111</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
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<tr>
<td>1985</td>
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<tr>
<td>Khouri et al,*</td>
<td>650</td>
<td>16-22 g</td>
<td>Fluoroscopy</td>
<td>No</td>
<td>25‡</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
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<tr>
<td>1985</td>
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<tr>
<td>vonSonnenberg et al,11</td>
<td>150</td>
<td>22-23 g</td>
<td>CT‡</td>
<td>Yes</td>
<td>42.6</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
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<tr>
<td>1988</td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Miller et al,*</td>
<td>150</td>
<td>22 g</td>
<td>Fluoroscopy or CT</td>
<td>Yes</td>
<td>34</td>
<td>Spirometry**</td>
<td>FEV₁ Age</td>
<td></td>
</tr>
<tr>
<td>1988</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>Fish et al,*</td>
<td>160</td>
<td>22 g</td>
<td>NS</td>
<td>NS</td>
<td>34</td>
<td>Spirometry**</td>
<td>FEV₁ Age</td>
<td></td>
</tr>
<tr>
<td>1988</td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>Present study</td>
<td>89</td>
<td>20-23 g</td>
<td>CT</td>
<td>Yes</td>
<td>20</td>
<td>Spirometry Normal</td>
<td>None Age</td>
<td></td>
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</table>

*Cytology evaluation done during the procedure.
†Empysema based on chest radiographic (CXR) interpretation.
‡Computed tomography (CT) scan used for patients considered unsuitable for fluoroscopy.
§Total lung capacity (TLC) estimated by CXR using method of Barnhard et al.17
Pneumothorax rate dropped to 21 percent when immediate cytology evaluation was added to methodology.
Patients with FEV₁/FEV₇ <1.0 L were not entered into study; PTX rate dropped from 25 percent to 12.5 percent in second half of procedures.
**Appears to be same group of patients (Miller and Fish); only published studies found that compared spirometry with PTX rates.
††Restriction, obstruction, or normal based on CXR interpretation only.
†‡NS = not stated.

The chest was done to assess for PTX. A standard CXR was ordered within the first 24 h after FNA. All patients remained hospitalized for at least 24 h and were observed closely for the occurrence of complications.

Biopsies were performed and supervised by a staff pulmonologist and by numerous fellows in pulmonary who had variable levels of experience. All FNA were performed on hospitalized patients referred to the Pulmonary Medicine Section at the Veterans Affairs Medical Center, Washington, DC.

**Spirometry**

Spirometry was performed in the laboratory at Veterans Affairs Medical Center, Washington DC. Testing included forced expiratory volume in 1 s (FEV₁), forced vital capacity (FVC), and FEV₁/FVC × 100 (FEV₁/FVC). Percentage of predicted values was based on data from Boren et al.14 In addition, total lung capacity (TLC) by helium dilution was performed in 80 percent of patients. Predicted values for TLC were taken from Goldman and Becklake.*

Classification of Measurements

Spirometry was reviewed and classified based on the following criteria: obstructive defect—FEV₁/FVC was <70 percent of predicted; restrictive defect—FVC was <70 percent of predicted or TLC <80 percent of predicted with an FEV₁/FVC >70 percent of predicted; and normal—no criteria for obstructive or restrictive defect.
Table 2—Occurrence of Pneumothorax (PTX) by Spirometry Classification (N = 89)

<table>
<thead>
<tr>
<th></th>
<th>PTX, %</th>
<th>p Value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>All procedures</td>
<td>20.2 (18/89)</td>
<td></td>
</tr>
<tr>
<td>Obstructed group</td>
<td>22.7 (10/44)</td>
<td>&gt;0.10</td>
</tr>
<tr>
<td>Normal group</td>
<td>27.8 (5/18)</td>
<td></td>
</tr>
<tr>
<td>Restricted group</td>
<td>11.1 (3/27)</td>
<td>&gt;0.10</td>
</tr>
</tbody>
</table>

*p value is from χ² analysis with normal group.

The FNAs were divided into PTX group vs non-PTX group based on immediate postprocedure CT or CXR documentation of a PTX within 72 h of FNA procedure.

Data Analysis

Pneumothorax rates between the normal spirometry group and the obstructive and restrictive defect groups were reviewed for a significant difference. The spirometry results and age were also compared between the PTX and the non-PTX group to look for additional factors that might be associated with the occurrence of PTX. Only patients who had had spirometry within 18 months of their percutaneous needle biopsies were included in the final study group.

Statistical Analysis

Statistical analysis was performed using the χ² method when comparing rates of PTX between normal spirometry and the obstructive and restrictive defect groups. Student’s t test analysis was used to determine significance of factors associated with occurrence of PTX. Both analyses used p value of <0.05 as a level of significance.

Results

Of the group of 166 FNAs performed, 56 procedures on review did not have spirometry measurements and 21 procedures had inadequate CXR assessment for a PTX.

The final study group included 89 FNAs in 87 male patients (age range, 51 to 68 years; mean, 60.1 years). A PTX developed in 18 (20 percent) of these FNAs.

No significant differences in the incidence of PTX were found between normal, obstructive, or restrictive spirometry groups (Table 2). Neither age nor specific spirometry measurements were found to be significant risk factors for PTX (Table 3). Where spirometry was normal, 27.8 percent (5/18) developed a PTX. Although the FEV₁ and FVC were higher in the patient group without a PTX, these differences were not statistically significant when they were compared with each group. Subgroup analysis by severity of obstruction was attempted in the obstructive group. There was a trend for higher rate of PTX in the more severely obstructed subgroups; however, the subgroups were too small for data to be statistically significant.

In patients who had TLC measurements and developed a PTX, the TLC was 92.8 percent (mean) of predicted compared with 86.2 percent in the non-PTX group. Since only 67 percent of patients who developed a PTX had a TLC measurement available, we considered it too small for meaningful analysis.

In 56 FNAs without spirometry measurements, only 3 (5 percent) developed a PTX. If these patients are included, our overall PTX rate becomes 14 percent.

Discussion

Our results suggest that the risk of FNA PTX is not related to the presence of an obstructive or restrictive defect as measured by spirometry.

The results of this study conflict with those reported by Miller et al.⁶ and Fish et al.⁷ These investigators reported that patients with airflow obstruction by standard spirometry had approximately 2.5 times the PTX rate (46 to 47 percent) compared with patients with normal function. In addition, they also reported a significantly increased risk of PTX in patients with a restrictive defect noted on spirometry.

We used classification criteria slightly different from those used by Miller et al.⁶ and Fish et al.⁷ but reanalyzing our results using their criteria still failed to produce statistically significant differences.

Furthermore, our results did not demonstrate that the use of the absolute FEV₁ serves as a predictor of risk for PTX as previously suggested by Fish et al.⁷

Taken together, the findings of this study are consistent with the hypothesis that the post-FNA PTX is related to a combination of technical and possibly operator-related factors such as the depth of the lesion and the number of needle passes, as previously reported.⁸⁻⁹ The use of CT vs fluoroscopy with the deliberate avoidance of bullae may also significantly lower the rate of PTX. This hypothesis does not imply that each of these factors causes an increased PTX rate or is a primary factor, but rather the data are most consistent with the possibility of shared risk factors.

Supporting this hypothesis is our PTX rate of only 14 percent (21/145) for our total group (with and without spirometry). This rate is the lowest that we could find in our search of the literature. The methodology used in this study made every attempt to reduce risk by using thin-gauge (20 to 22 g) needles, engaging a cytotechnologist on site to evaluate aspirations, thus minimizing the number of needle passes and performing 93 percent of procedures using CT.
guidance. Computed tomography enabled the operator to visualize the lung parenchyma, thus avoiding crossing bullae with the needle. There are reports suggesting that PTX rates with CT-guided needles are as high as 30 to 60 percent, but these reports limited CT use to only those patients unsuitable for fluoroscopy. A recent report suggests that sonographic guidance may result in reduced PTX rate.

Although our data are insufficient to draw any firm conclusions, they do suggest that the risk of pneumothorax is greatly reduced by combining multiple risk-reducing techniques. Unless controlled, prospective methods are used, risk analysis will remain difficult to quantitate.

CONCLUSION

The results of this study do not support previous studies that suggest a linear relationship between spirometry measurements and the development of PTX following FNA of thoracic lesions.

Our findings suggest that low PTX rates are achieved by combining several techniques to reduce risk of PTX. Future studies that identify risk factors for PTX from thoracic FNAs should focus attention on a randomized comparison of technical factors.

ACKNOWLEDGMENT: The authors wish to thank Ms. Patricia Allen for her help with this article.

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5. Johnsrude IS, Silverman JF, Weaver MD, McConnell RW. Rapid cytology to decrease pneumothorax incidence after percutaneous biopsy. AJR 1985; 144:793-94
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