Can Chest CT Decrease the Use of Preoperative Bronchoscopy in the Evaluation of Suspected Bronchogenic Carcinoma?*

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**Background:** Fiberoptic bronchoscopy (FOB) is frequently used to diagnose and stage bronchogenic carcinoma (BC). However, the value of FOB in diagnosis/staging BC presenting as a pulmonary nodule or mass (PNM) is controversial. Since chest CT is usually obtained in these patients, it may be used in patient selection for preoperative FOB.

**Objective:** Evaluation of the role of chest CT in determining the predictive value of FOB in diagnosing/staging a PNM, by comparing the results of CT and bronchoscopy.

**Design:** Retrospective review of chest CTs and medical records.

**Patients:** Consecutive patients with BC between 1992 and 1994 who had diagnostic FOB and CT in our institution, but without radiographic evidence of (1) pulmonary atelectasis, (2) endobronchial tumor or narrowing of the central airways, and (3) the PNM abutting the central airways.

**Results:** Sixty-four patients met the selection criteria. The size of the PNM ranged from 1.5 to 10 cm; the size was \( \leq 4 \) cm in 62 patients. FOB provided a diagnosis in 22 patients. Bronchoscopy detected endobronchial lesions in 11 patients (17%); 3 had lesions in more than one lobe. In three patients, the PNM was <3 cm. The radiographically undetected endobronchial tumor increased the tumor stage in only two patients. The “CT bronchus” sign had a positive and negative predictive value of 75% and 68%, respectively.

**Conclusions:** (1) In this study, CT failed to detect endobronchial tumor in 11 of 64 patients (17%). Because of the implications of a new staging system, more studies are necessary before abandoning staging FOB. (2) The CT bronchus sign has a very high positive and negative predictive value in the use of diagnostic FOB and should be used to guide the method of biopsy of a PNM.

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**Key words:** bronchogenic carcinoma; chest CT; fiberoptic bronchoscopy; lung cancer staging

**Abbreviations:** BC=bronchogenic carcinoma; FOB=fiberoptic bronchoscopy; PNM=pulmonary nodule or mass; TBBX=transbronchial biopsy; TNB=transthoracic needle biopsy

Bronchogenic carcinoma (BC) is a common cancer affecting men and women in the United States. Fiberoptic bronchoscopy (FOB) is utilized extensively in the initial evaluation of patients suspected of having lung carcinoma. The role of FOB in the evaluation of BC is twofold: (1) confirm the diagnosis of cancer and determine the histology, and (2) inspection of the proximal airways for the presence of endobronchial tumor, ie, tumor staging. Staging bronchoscopy is incorporated into the American Thoracic Society Staging of BC.1 FOB has a high yield when there is clinical (eg, hemoptysis) and/or radiographic (eg, lobar atelectasis) evidence of endobronchial disease. However, the role of FOB in the preoperative evaluation of a peripheral pulmonary nodule or mass (PNM) without other evidence of endobronchial disease (eg, solitary pulmonary nodule) is uncertain. In one study of 91 patients with a PNM <6 cm, FOB provided a histologic diagnosis in only 16 cases (18%) and an endobronchial malignant tumor was found in none.2 In another study, Goldberg et al3 examined the role of staging bronchoscopy in the preoperative assessment of asymptomatic pulmonary nodules <4.0 cm; from a cohort of 33 patients, a diagnosis of malignancy was made by FOB in only 2 patients and no patient had endobronchial disease.
A chest CT is obtained in most of the patients with a PNM. A large body of imaging literature suggests that CT is a sensitive method to evaluate the proximal bronchi for neoplasm. It is also suggested that CT is helpful in predicting the yield of FOB in obtaining pathologic diagnosis of a PNM. In addition to demonstrating the location of the nodule (lobe, peripheral vs central location), CT can also demonstrate if a third- or fourth-order bronchus leads to or is contained within the PNM; such a finding is termed positive "CT bronchus sign." This sign is associated with a high success rate of obtaining diagnostic material with transbronchial biopsy (TBBX). If the chest CT can accurately exclude proximal endobronchial tumor, staging bronchoscopy will not be necessary. Similarly, if CT can predict that FOB is unlikely to provide a pathologic diagnosis, an alternative method of biopsy (e.g., transthoracic needle biopsy [TNB] or thoracotomy) may be chosen. Such a practice can expedite the clinical management and can also be cost effective. The purpose of this study was to retrospectively evaluate the role of chest CT in determining the need for diagnostic/staging FOB in patients with a PNM proven to be BC, by comparing the results of chest CT and bronchoscopy.

**Materials and Methods**

We wanted to identify patients who satisfied the following criteria: (1) a PNM that was proven to be BC by either endobronchial biopsy, TBBX, TNB, or at surgery; (2) a preoperative diagnostic bronchoscopy performed at our institution; and (3) availability of chest radiographs and chest CT performed in our institution. Patients with the following imaging criteria were excluded: (1) presence of radiographic signs of atelectasis of a segment, lobe, or lung; (2) presence of one or more of the following signs on chest CT: (a) bronchial narrowing or occlusion; (b) endobronchial mass; and (c) a pulmonary, hilar, or mediastinal mass abutting a main bronchus, lobar bronchi, or proximal 1 cm of segmental bronchi.

We performed a retrospective review of reports of all chest CT examinations performed at the University of Alabama Hospital and Birmingham Veterans Affairs Medical Center, between January 1992 and December 1994, to screen examinations that meet the necessary CT criteria. The hard-copy images of selected CT examinations were reviewed by one of us (H.N.) to ensure that none of the exclusion criteria described above was present. This group of patients was further screened to select the final group of patients who satisfied the requirements of a final diagnosis of BC and diagnostic/staging bronchoscopy.

The medical records of the eligible patients were reviewed to obtain the demographic data, pathologic diagnosis, and the procedures performed to obtain the diagnosis and their sequence. Bronchoscopic findings were abstracted from the procedure notes. The diagnostic FOB was assisted by a C-Arm fluoroscope. Endobronchial biopsy of all suspicious areas was performed and bronchial washings were obtained from the appropriate bronchopulmonary segments. Fluoroscopically assisted TBBX of the PNM was performed; a minimum of three TBBX specimens were obtained in each patient.

**Results**

Sixty-four patients satisfied the clinical and radiologic inclusion criteria. There were 60 men and 4 women whose mean age was 64 years (range, 38 to 89 years). The size of the PNM in these 64 patients ranged from 1.5 to 10.0 cm and their size distribution is shown in Figure 1. Mediastinal lymphadenopathy was found in 10 patients, and hilar adenopathy was found in 6 patients.

A diagnosis of malignancy was made by FOB in 22 of 64 patients (34%). TNB was performed in 37 patients and provided histologic evidence of malignancy in 32 of these 37 patients (86%). In the remaining five patients, the diagnosis of BC was established at surgery. The details of diagnostic procedures in the 64 patients are shown in Figure 2. Table 1 shows the relative efficacy of FOB and TNB in making a pathologic diagnosis. The histologic types of BC in this group of patients are shown in Table 2.

**Figure 1.** Size, in centimeters, of pulmonary masses distributed among the 64 patients.
Bronchoscopy detected endobronchial lesions in 11 patients (17%). Among these 11 patients, 3 had endobronchial lesions in more than one lobe. In all patients, the endobronchial disease was confined to the lung with the PNM. The biopsy specimen and/or brushing of the endobronchial lesions in seven patients revealed malignancy. In the other four patients, the biopsy specimen of the endobronchial lesion was nondiagnostic. Complete details of these patients are provided in Table 3. In four patients, the PNM was ≤3.0 cm, and the mass was >3.0 cm in the other seven patients. Mediastinal lymphadenopathy was present in three patients and hilar adenopathy was present in another three patients. When we compared the T-factor of the tumor determined from chest CT to T-factor/stage determination by bronchoscopy in these 64 patients (11 who had endobronchial disease and 53 without), despite the presence of radiologically undetected endobronchial tumor, the tumor stage increased in only 2 patients (Table 3).

We examined the value of selected CT findings in patients with a PNM >3.0 cm that may predict the yield of diagnostic FOB to provide a pathologic diagnosis of the pulmonary mass (Table 4). The most helpful among these was the “CT bronchus sign” which had positive and negative predictive values of 75% and 68%, respectively.

**Table 1—Efficacy of Bronchoscopy vs Transthoracic Needle Aspiration in Making Diagnosis of Bronchogenic Carcinoma**

<table>
<thead>
<tr>
<th></th>
<th>Bronchoscopy</th>
<th>TTNA*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(n=64)</td>
<td>(n=37)</td>
</tr>
<tr>
<td>Diagnostic</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>22 (34%)</td>
<td>32 (86%)</td>
</tr>
<tr>
<td>No</td>
<td>42 (66%)</td>
<td>5 (14%)</td>
</tr>
</tbody>
</table>

*TTNA=transthoracic needle aspiration.

**Table 2—Histologic Type of Bronchogenic Cancer**

<table>
<thead>
<tr>
<th>Histology</th>
<th>No. of Patients</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Squamous cell carcinoma</td>
<td>26</td>
<td>41</td>
</tr>
<tr>
<td>Adenocarcinoma</td>
<td>18</td>
<td>28</td>
</tr>
<tr>
<td>Non-small cell</td>
<td>11</td>
<td>17</td>
</tr>
<tr>
<td>Small cell</td>
<td>7</td>
<td>11</td>
</tr>
<tr>
<td>Large cell</td>
<td>1</td>
<td>1.5</td>
</tr>
<tr>
<td>Bronchioalveolar</td>
<td>1</td>
<td>1.5</td>
</tr>
</tbody>
</table>

**Discussion**

In clinical practice, FOB is the mainstay of diagnosis of a PNM. Since a PNM in an immunocompetent adult >35 years old is considered malignant until proven to the contrary, the role of FOB includes obtaining a pathologic diagnosis of the PNM as well as assessment of the proximal airways for presence of endobronchial tumor. Both objectives are equally important for successful and efficient treatment of a patient with a presumed malignant PNM. Therefore, separation of diagnostic and staging bronchoscopy is artificial.3

The International Staging System for lung cancer incorporates radiographically visible tumors in the lung parenchyma and endobronchial tumors.1 The detection of the possible endobronchial tumor is the expressed rationale for routine bronchoscopy in all patients with known or suspected BC. In fact, BC is the most common indication for FOB in clinical practice.12 The role of FOB in lung cancer includes the following: (1) inspection of airways to detect ipsilateral and contralateral endobronchial disease and their biopsy; (2) transbronchial biopsy of the PNM; (3) detection of mediastinal and/or hilar adenopathy; and (4) possible transbronchial needle aspiration of the hilar or mediastinal nodes.13 In our
experience, thoracic surgeons also always perform bronchoscopy prior to pulmonary resection, to assess bronchial surgical margins and rare anatomic variations of the bronchial tree that may affect the surgical technique.

The role of routine diagnostic and staging bronchoscopy in this group of patients is controversial. The diagnostic yield of bronchoscopy is obviously very high when clinical or radiographic evidence of endobronchial disease is present (hemoptysis, lobar atelectasis). The frequency of endobronchial disease in patients with a peripheral solitary pulmonary nodule (<3.0 cm) or mass (>3.0 cm) is also controversial. Synchronous multiple pulmonary carcinomas reportedly occur in 2 to 5% of patients.14 Incidental presence of endobronchial tumor is reported in 3.7% of patients with malignant PNM.15 On the contrary, Goldberg et al3 did not find any endobronchial tumor in a study of 31 patients with PNM <4.0 cm. In another study of 91 patients with a malignant PNM <6.0 cm, FOB did not reveal a single instance of endobronchial tumor.2

The role of FOB in obtaining a pathologic diagnosis of a PNM is dependent on the size and location of the mass. Diagnostic yield of FOB in nodules <3.0 cm is about 30% compared with 80% in those

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**Table 3—Description of Patients With Endobronchial Disease at FOB***

<table>
<thead>
<tr>
<th>Patient</th>
<th>Nodule Size, cm</th>
<th>Stage CT</th>
<th>FOB (T Factor)</th>
<th>CT Evidence of Adenopathy</th>
<th>Bronchoscopic Findings</th>
<th>Histologic Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3</td>
<td>T1</td>
<td>T1</td>
<td>No</td>
<td>Endobronchial lesion in the lateral basal segment of left lower lobe</td>
<td>SC</td>
</tr>
<tr>
<td>2</td>
<td>3</td>
<td>T1</td>
<td>T1</td>
<td>No</td>
<td>0.5-cm endobronchial lesion in the anterior segment of the right upper lobe</td>
<td>AC</td>
</tr>
<tr>
<td>3</td>
<td>4</td>
<td>T2</td>
<td>T1</td>
<td>No</td>
<td>Endobronchial lesion in the anterior segment of the right upper lobe</td>
<td>SC</td>
</tr>
<tr>
<td>4</td>
<td>6</td>
<td>T2</td>
<td>T1</td>
<td>No</td>
<td>Irregular endobronchial lesion in the posterior segment of the left upper lobe</td>
<td>SC</td>
</tr>
<tr>
<td>5†</td>
<td>5</td>
<td>T2</td>
<td>T2</td>
<td>Hilar</td>
<td>Lesion 1-shiny verrucous endobronchial lesion in the right bronchus intermedius</td>
<td>SM</td>
</tr>
<tr>
<td>6†</td>
<td>3</td>
<td>T2</td>
<td>T2</td>
<td>Hilar and mediastinal</td>
<td>Lesion 2-shiny verrucous endobronchial lesion in the superior segment of the left lower lobe</td>
<td>SC</td>
</tr>
<tr>
<td>7†</td>
<td>3</td>
<td>T1</td>
<td>T1</td>
<td>No</td>
<td>Lesion 1-irregular mucosa in the right upper lobe bronchus</td>
<td>SC</td>
</tr>
<tr>
<td>8‡</td>
<td>10</td>
<td>T2</td>
<td>T1</td>
<td>No</td>
<td>Lesion 2-endobronchial mass between left upper lobe and lingula</td>
<td>SC</td>
</tr>
<tr>
<td>9‡</td>
<td>4</td>
<td>T2</td>
<td>T1</td>
<td>Mediastinal</td>
<td>Lesion 1-endobronchial mass in the apical segment of right upper lobe with approximately 90% obstruction</td>
<td>SC</td>
</tr>
<tr>
<td>10‡</td>
<td>9</td>
<td>T2</td>
<td>T1</td>
<td>Hilar and mediastinal</td>
<td>Lesion 2-endobronchial mass in the medial segment of right middle lobe with approximately 80% obstruction</td>
<td>SC</td>
</tr>
<tr>
<td>11‡</td>
<td>4</td>
<td>T2</td>
<td>T1</td>
<td>No</td>
<td>Endobronchial mass in the medial basal segment of right lower lobe</td>
<td>SC</td>
</tr>
</tbody>
</table>

*AC=adenocarcinoma; SC=squamous cell carcinoma; SM=small cell carcinoma.
†Lesion on the right bronchus intermedius—acute and chronic inflammation. Lesion on the superior segment of the left lower lobe was SM.
‡Both lesions were SC.
Endobronchial biopsy specimen of both lesions demonstrated SC.
Endobronchial biopsy specimen revealed acute and chronic inflammation. Cytology showed atypical squamous metaplasia. Patient underwent surgical resection of right lower lobe; SC was present in the lower lobe bronchus.
Endobronchial biopsy specimen reported chronic inflammation and bronchial brush showing atypical cells. Right lower lobe study revealed AC in the lung and lower lobe bronchus.
Endobronchial biopsy specimen was reported as showing metaplasia, atypical cells, suspicious of malignancy. Patient underwent lobectomy of left upper lobe in which SC was found.
**Endobronchial biopsy specimen and washing were negative. Patient underwent a transthoracic needle aspiration that revealed SC.

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**Table 4—Predictive Value of Radiographic Findings for a Positive Diagnostic FOB for Pulmonary Mass >3 cm**

<table>
<thead>
<tr>
<th>Radiographic Finding</th>
<th>Positive Predictive Value</th>
<th>Negative Predictive Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apical location</td>
<td>3/12</td>
<td>10/21</td>
</tr>
<tr>
<td>Medial location on posteroanterior and lateral view</td>
<td>2/8</td>
<td>13/25</td>
</tr>
<tr>
<td>CT bronchus sign</td>
<td>6/8</td>
<td>17/25</td>
</tr>
<tr>
<td>Air bronchogram</td>
<td>7/13</td>
<td>13/20</td>
</tr>
<tr>
<td>3+ necrosis on CT</td>
<td>1/6</td>
<td>14/27</td>
</tr>
<tr>
<td>Pleural based on CT</td>
<td>7/21</td>
<td>5/12</td>
</tr>
</tbody>
</table>

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>4 cm. Nodules located in the periphery of the lung may have even lower yield. The success rate of FOB in obtaining diagnostic pathologic material is significantly higher when a third- to fifth-order bronchus can be traced to the pulmonary nodule on a chest CT (positive CT bronchus sign).9,11

Since the diagnostic yield of FOB in diagnosing a malignant PNM is limited and its value as a staging technique in BC is controversial, some authors suggested abandoning FOB in the management of PNM.23 However, these series include relatively small numbers of patients and more patient data will be helpful in making these decisions with greater confidence. Also, none of these studies assessed the role of chest CT (which is almost always obtained in a patient with PNM) in patient selection for diagnostic/staging FOB. CT is considered to be highly accurate in depicting focal abnormalities within the central airways.4,6,17,20-23 From a CT perspective, central airways include all endoscopically visible airways—trachea, carina, main, lobar, and proximal segmental bronchi.5 If so, normal central airways on CT should make staging bronchoscopy unnecessary. The CT may also predict the yield of FOB in making a tissue diagnosis of PNM; if the predictive value of FOB is low, an alternate method of diagnosis (eg, TNB or thoracotomy) may be chosen. This is the hypothesis we set out to test through a retrospective analysis of consecutive patients with a proven malignant PNM and absence of CT evidence of endobronchial disease who also had diagnostic bronchoscopy. We chose not to set an upper limit to the size of PNM, as in other studies, because we wanted to test the role of FOB in both making a diagnosis as well as endobronchial staging.

In this cohort of 64 patients in whom chest CT did not detect any abnormality in the central airways, 11 patients (17%) were found to have endobronchial lesions at FOB. In 4 of these 11 patients, the PNM measured ≤3.0 cm, and in another 5 patients it was ≤6.0 cm. In only one patient was the endobronchial lesion in a lobar bronchus (patient 5, Table 3), and in all others the airway abnormalities involved segmental bronchi. Biopsy specimens of the endobronchial abnormality revealed malignancy in seven patients. In another patient, a surgical specimen confirmed the presence of malignant endobronchial disease. The nature of the endobronchial pathologic condition in the other three patients is uncertain, but presumed to be tumor. In only three patients (3.75%) did the endobronchial disease extend beyond a segmental bronchus of the pulmonary lobe containing the PNM (patients 5, 6, and 7, Table 3), thus changing the clinical stage. In one patient, the tumor was a small cell carcinoma, and the presence of more extensive tumor probably did not affect clinical management. In another patient with a 3.0-cm PNM in the right upper lobe, endobronchial masses were found in the apical segment of the right upper lobe as well as the medial segment of the right middle lobe. Since both lesions were squamous cell carcinoma, the tumor was classified as a stage IIIB tumor.24 In this case, FOB clearly affected the patient treatment. In the third patient, a PNM was present in each upper lobe and an endobronchial lesion was confined to the subsegmental segmental bronchus. However, since both tumors were squamous cell carcinoma, one of the tumors is considered a distant metastasis, and therefore, stage IV lung cancer (it is also possible that in some patients the tumor in each lung may represent synchronous squamous cell cancer).24 In the remaining eight patients (73%), the undetected endobronchial disease did not change the tumor stage or the patient treatment.

FOB did not provide a pathologic diagnosis in most patients. A diagnosis of malignancy was made in 22 of 64 patients (34%). If the seven patients with endobronchial disease are excluded, FOB had a diagnostic yield of only 23% (15 of 64). While the low yield of FOB in PNM <3.0 cm is well known, limitations of diagnostic FOB in masses >4.0 cm have received little attention. We examined several CT features to determine the predictive value of FOB (Table 4). As suggested in several previous reports, the CT bronchus sign was the most helpful, with positive and negative predictive values of 75% and 65%, respectively.9,10

This study reconfirms many observations previously reported, but also differs from other studies in important aspects. Endobronchial tumor was found in a significantly higher percentage of patients (11 of 64, 17%) than previously suggested. Size of the PNM was <4.0 cm in seven of these patients (7/64 [11%]) and these seven patients represent 64% of all the patients with endobronchial tumor in this group (7/11). Goldberg et al3 found no patient with endobronchial disease among 33 patients with malignant nodules of the same size (<4.0 cm). The incidence is even higher when the size of the PNM is increased to 6.0 cm, as in the study reported by Torrington and Kern.2 This cohort of patients represents consecutive patients seen in a large tertiary care hospital over a 3-year period. The incidence of malignant PNM is similar to the other two reports. However, the incidence of 3.75% of multiple sites of endobronchial disease is similar to the 3.5% figure reported by Wallace and Deutsch15 and in contrast to the previously cited studies.

It is also of interest that in 14% of patients, CT failed to detect endobronchial disease. In this study, we did not systematically explore the reasons for this failure. However, this finding is probably closer to reality in daily practice than several previous reports on the efficacy of CT in detecting central airway
disease. While all the CT examinations were initially interpreted by experienced, dedicated chest radiologists, in none of the patients were there clinical findings to suggest an endobronchial disease apart from the presence of PNM. Thirteen of 14 endobronchial abnormalities were confined to segmental bronchi. In a study of interobserver variability, as part of the Radiologic Diagnostic Oncology Group study, Webb et al.\(^{25}\) reported only 50% agreement among four very experienced readers for detection of bronchial involvement. In two recent reports of BC missed on chest CT, 14 of 24 cancers were in the central airways.\(^{26,27}\) Satisfaction of the search (in this case the finding of a PNM), a factor suggested in both studies, may have contributed to the failure of the detection of bronchial involvement in our patients as well.

The recently suggested modifications to the international staging system for lung cancer may make detection of endobronchial disease in patients with malignant PNM even more important.\(^{28}\) According to the newer system, satellite nodules in the same lobe are considered as T4 lesions, increasing the cancer stage to III B. We assume that the term “satellite nodules” refers to parenchymal nodules; however, it can be argued that in a patient with a malignant pulmonary nodule, an endobronchial mass in the proximal airways of the same lobe also represents a satellite lesion, therefore a T4 tumor, irrespective of the size of the PNM. According to this argument, presence of endobronchial disease not detected by CT upstaged the extent of disease in all 11 patients (11/64, 17%), which is significant.

**CONCLUSIONS**

(1) In this study, CT failed to detect endobronchial tumor in 11 of 64 patients (17%). Because of the implication of new staging system, more studies are necessary before abandoning preoperative staging FOB.

(2) The CT bronchus sign has a very high positive and negative predictive value in the use of diagnostic FOB and should be used to guide the method of biopsy of a PNM.

**REFERENCES**