Endobronchial ultrasound-guided transbronchial needle aspiration for lung cancer diagnosis and staging in 179 patients

Antonio Bugalho\textsuperscript{a,b,c}, Dalila Ferreira\textsuperscript{a}, Rita Barata\textsuperscript{d}, Cristina Rodrigues\textsuperscript{d}, Sara S Dias\textsuperscript{e}, Filomena Medeiros\textsuperscript{f}, Luis Carreiro\textsuperscript{a}

\textsuperscript{a}Unidade de Técnicas Invasivas Pneumológicas, Pneumologia II, Hospital Pulido Valente, Lisboa, Portugal
\textsuperscript{b}Unidade de Pneumologia de Intervenção, Hospital Beatriz Ângelo, Loures, Portugal
\textsuperscript{c}Centro de Estudos de Doenças Crónicas (CEDOC), Faculdade de Ciências Médicas, Universidade Nova de Lisboa, Portugal
\textsuperscript{d}Serviço de Cirurgia Torácica, Hospital Pulido Valente, Lisboa, Portugal
\textsuperscript{e}Departamento Universitário de Saúde Pública, Faculdade de Ciências Médicas, Universidade Nova de Lisboa, Portugal
\textsuperscript{f}Serviço de Anatomia Patológica, Hospital Pulido Valente, Lisboa, Portugal

Received June 17, 2012; accepted October 25, 2012
Available online July 12, 2013

Abstract

Background: Linear endobronchial ultrasound-guided transbronchial needle aspiration (EBUSTBNA) is an important minimally invasive procedure for non-small cell lung cancer (NSCLC) staging. It is also a valid method for diagnosing extraluminal lesions adjacent to the tracheobronchial tree.

Aim: To evaluate our EBUS-TBNA performance regarding diagnostic yield, safety and learning curve for lung cancer diagnosis and staging.

Material and methods: All patients undergoing EBUS-TBNA for lung cancer diagnosis or staging were included. They were divided into three different groups: paratracheal and parabronchial masses sent for diagnosis (Group 1); peripheral lung lesions with abnormal mediastinal lymph nodes sent for diagnosis and staging (Group 2); NSCLC patients sent for mediastinal staging (Group 3). The learning curve was assessed for yield, accuracy, procedure time, size and number of lesions punctured per patient.

Results: A total of 179 patients were included and 372 lesions were punctured. The overall yield and accuracy were 88% and 92.7%, respectively. In Group 1, EBUS-TBNA was performed in 48 patients and sensitivity was 86.1% and accuracy was 87.5%. For the 87 patients included in Group 2, yield was 86.7%, accuracy was 93.1% and cancer prevalence was 51.7%. The diagnostic yield and accuracy in Group 3 was 95% and 97.7% respectively. EBUS-TBNA practice led to an increase number of sites punctured per patient in a shorter time, without complications.
Introduction

Lung cancer is the world’s leading cause of cancer-related mortality. It is the fourth most common cancer in Portugal with an estimated incidence of 41.9 per 100,000 inhabitants in males and 8.5 per 100,000 inhabitants in females and the second highest cause of cancer death with a mortality rate for men and women of 41.8 and 7.8 per 100,000 person-years, respectively. The high incidence, the mortality and socioeconomic burden makes it obligatory that every effort is made to improve disease prevention, prompt diagnosis and correct staging.

Chest radiographs are often the first exam to be performed to evaluate a suspicious lung lesion. However a contrast thoracic and upper abdomen CT scan is also crucial to give the anatomical view of the thoracic structures and detect the precise location and extent of the disease. More recently fluorodeoxyglucose positron emission tomography (PET) has become increasingly important in lung cancer diagnosis and staging. PET and integrated PET-CT provide anatomical and metabolic information about the primary lung lesion, mediastinal lymph nodes and distant metastasis. Although these exams present important clues, a definitive diagnosis is only achieved by histological or cytological examination.

Flexible bronchoscopy with its accessory sampling techniques (biopsy, brushing and lavage) provides a high diagnostic yield in central endoluminal tumors compared to peripheral lesions and CT-guided transthoracic needle aspiration (CT-TTNA) has a high sensitivity when the lesion is located in the periphery of the lung. If the tumour is centrally located and extraluminal (paratracheal or parabronchial lesions) these procedures have a limited role and conventional transbronchial needle aspiration (TBNA) is a valid option. In clinical practice this is an underutilized method owing to the risk of complications, the high cost of needles and, last but not least, the variable yield, because non-ultrasound guided TBNA is operator dependent. The fact that TBNA can be used simultaneously as a
diagnostic and staging tool make it very attractive to the pulmonologist. In order to improve sensitivity and diminish the risks of complications, technological efforts have been made to perform the procedure under real-time guidance and endobronchial ultrasound (EBUS) guided TBNA has emerged as an important minimally invasive exam to stage and diagnose lung cancer. The procedure started in expert centers and immediately its efficacy and safety for mediastinal lymph node staging was appreciated. Current guidelines advocate EBUS-TBNA as one of the options for minimally invasive mediastinal staging and lung cancer diagnosis. Initially, it was reported that a short training of about 10 cases was enough to become competent in EBUS-TBNA but a subsequent study has suggested that the learning curve is longer and also experienced bronchologists vary in their skill and speed of learning.

The aim of the study was to evaluate our EBUS-TBNA performance in relation to diagnostic yield, safety and the learning curve for the diagnosis of pulmonary nodules or masses and mediastinal lymph node staging.

Material and Methods

Patients

Throughout a 30 month period, all consecutive patients referred for EBUS-TBNA with the purpose of diagnosing or staging lung cancer were prospectively included. Exclusion criteria were the following: inability to tolerate general anaesthesia; the target lesion was not visualized by EBUS (e.g. aerated lung parenchyma interposition); no lymph node puncture during the procedure (e.g. due to vessel interposition); patients undergoing EBUS for a highly suspicious benign condition; absence of follow-up after non-diagnostic EBUS-TBNA.

The patients were sent from different hospitals with three different clinical settings: Group 1 with a paratracheal or parabronchial mass detected in a thorax CT scan and without a definitive diagnosis after being submitted to conventional bronchoscopy or CT-TTNA (sent for diagnosis); Group 2 with a suspicious peripheral lung cancer lesion and lymph nodes with a CT scan short axis >10 mm and/or a positive PET scan (sent simultaneously for diagnosis and staging); Group 3 with histologically confirmed non-small cell lung cancer (NSCLC) without evidence of distant metastasis sent for lymph node staging (lymph nodes >10 mm in short axis on CT or PET positive).

A thorax CT scan was mandatory before the procedure. The decision to perform PET or PET-CT was left to the discretion of the referring physician. The study was approved by the ethical committee of our institution and a written consent was obtained.

Procedures

EBUS-TBNA was performed under general anaesthesia with a flexible ultrasound bronchoscope (BF-UC160F, Olympus, Japan) in an outpatient setting. All the procedures were performed by one main operator (AB) who had formal training in EBUS-TBNA and in some of them another pulmonologist assisted (DF or LC). The tests were carried out as previously described.
and proportion tests were performed to verify if there was a statistical difference between these groups.

Results

Two hundred and six patients were referred for eBUS-tBNA and 187 underwent the procedure for lung cancer diagnosis and/or staging at our institution. Eight patients (4.3%) were excluded based on the exclusion criteria described above. A total of 179 patients met the inclusion criteria (mean age $61.9 \pm 11.5$ years, range 36-88, 71.5% males) and 126 were current or former smokers ($55.9 \pm 25.2$ packs-year, range 8-140).

All procedures were done under general anaesthesia. A laryngeal mask was used in 26 cases (14.5%), rigid bronchoscope in 10 cases (5.6%) and endotracheal intubation in 143 cases (79.9%). Total procedure mean time was $35 \pm 12$ minutes. Three hundred and seventy two lesions were punctured by eBUS-tBNA (sonographic mean size $16.3 \pm 6$mm, range 5-36mm) and the average number of needle passes for each site was $5.8 \pm 2.7$ times. No complications associated to the technique were experienced however one patient failed extubation after general anaesthesia and was mechanically ventilated for 48 hours until successful weaning, later found out to be due to muscular weakness related to a Lambert-Eaton paraneoplastic syndrome.

The clinical settings for EBUS-TBNA are displayed in Table 1. In Group 1, eBUS-TBNA was performed in 48 patients and whenever possible, the lesion was punctured using different locations (e.g. right upper lobe mass was punctured through the trachea and right main bronchus). The sensitivity for diagnosing lung cancer in this group was 86.1% and accuracy was 87.5%. In two cases the samples were inadequate and further invasive tests excluded malignancy in one patient and confirmed the presence of lung adenocarcinoma with extensive necrosis in another (Table 2). The eight negative cases were submitted to surgery that established the presence of non-Hodgkin lymphoma ($n=1$), large cell neuroendocrine tumor ($n=1$), thoracic paraganglioma ($n=1$), squamous cell carcinoma ($n=2$), mediastinal goiter ($n=1$), cicatricial or inflammatory tissue ($n=1$) and sarcoidosis ($n=1$).

Group 2 included 87 patients and a total of 195 lymph nodes were punctured at the level of stations right upper paratracheal 2R ($n=18$), left upper paratracheal 2L ($n=5$), right lower paratracheal 4R ($n=47$), left lower paratracheal 4L ($n=18$), subcarinal 7 ($n=64$), right hilar 10R ($n=25$), left hilar 10L ($n=20$), right interlobar 11R ($n=2$) and left interlobar 11L ($n=6$). The sensitivity for this group was $86.7\%$, specificity was $100\%$, NPV was $88\%$, EBUS accuracy was $93.1\%$ and cancer

Figure 1  Peripheral right upper lobe lesion with PET positive 2R lymph node station (A); needle inside enlarged hypoecogenic heterogeneous mediastinal lymph node (B); cytological diagnosis of lung adenocarcinoma $400\times$ (C).
prevalence was 51.7%. One patient with an inadequate sample was sent for mediastinoscopy and the final diagnosis was lung adenocarcinoma. Of the 32 negative cases, 7 patients refused or had no conditions for more invasive procedures and 12 month follow-up proved lesion stability. All other 25 cases were submitted to subsequent surgical procedures (mediastinoscopy, video-assisted thoracoscopy or thoracotomy). In 16 cases, these interventions confirmed the absence of malignancy and the presence of normal or reactive lymphoid tissue (n = 14) and sarcoidosis (n = 2). Four patients, with mediastinal lymph nodes >10mm short-axis in thorax CT, were submitted to thoracotomy (lobectomy plus lymph node dissection) and the pathological staging, obtained in the same anatomical locations, proved that the previously EBUS sampled lymph nodes were negative (N0, reactive lymphoid tissue) although the primary pulmonary lesion was positive for lung adenocarcinoma (n = 3) and squamous cell carcinoma (n = 1). These cases were considered to be true-negatives since the EBUS-TBNA targeted lymph nodes that did not show malignant cells. Among the other EBUS cytological negative cases, the final surgical diagnosis was lymph node metastasis of breast cancer (n = 1), renal cell cancer (n = 1), atypical carcinoid tumor (n = 1) and lymphoma (n = 2).

EBUS-TBNA mediastinal staging was done in 44 patients with confirmed NSCLC (Group 3) and lymph node stations 2R (n = 2), 2L (n = 4), 4R (n = 16), 4L (n = 12), 7 (n = 35), 10R (n = 17) and 10L (n = 7) were assessed. Diagnostic yield and accuracy were 95% and 97.7%, correspondingly. One inadequate sample case was submitted to mediastinoscopy that

### Table 1  EBUS-TBNA findings and performance

<table>
<thead>
<tr>
<th></th>
<th>Group 1 (diagnosis)</th>
<th>Group 2 (diagnosis and staging)</th>
<th>Group 3 (staging)</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patients (n)</td>
<td>48</td>
<td>87</td>
<td>44</td>
<td>179</td>
</tr>
<tr>
<td>PET scan (n)</td>
<td>13</td>
<td>32</td>
<td>30</td>
<td>75</td>
</tr>
<tr>
<td>Punctures sites (n)</td>
<td>84</td>
<td>195</td>
<td>93</td>
<td>372</td>
</tr>
<tr>
<td>EBUS-TBNA findings</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ADC</td>
<td>ADc = 14</td>
<td>ADC = 22</td>
<td>ADC N2/N3 = 11</td>
<td></td>
</tr>
<tr>
<td>SCC</td>
<td>SCC = 9</td>
<td>SCC = 4</td>
<td>SCC N2/N3 = 8</td>
<td></td>
</tr>
<tr>
<td>NSCLC</td>
<td>NSCLC = 3</td>
<td>NSCLC = 7</td>
<td>Negative sample = 24</td>
<td></td>
</tr>
<tr>
<td>SCLC</td>
<td>SCLC = 11</td>
<td>SCLC = 5</td>
<td>Inadequate sample = 1</td>
<td></td>
</tr>
<tr>
<td>Thoracic duct cyst</td>
<td>Thyroid carcinoma</td>
<td>Thyroid carcinoma = 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Negative sample = 8</td>
<td>Sarcoidosis = 9</td>
<td>Sarcoidosis = 9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inadequate sample = 2</td>
<td>Tuberculosis = 6</td>
<td>Tuberculosis = 6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cancer prevalence</td>
<td>89.6%</td>
<td>51.7%</td>
<td>45.5%</td>
<td>60.3%</td>
</tr>
<tr>
<td>Sensitivity</td>
<td>86.1%</td>
<td>86.7%</td>
<td>95%</td>
<td>88%</td>
</tr>
<tr>
<td>Specificity</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>NPV</td>
<td>45% (95% CI 21-72%)</td>
<td>88% (95% CI 75-91%)</td>
<td>96% (95% CI 80-99%)</td>
<td>85% (95% CI 75-91%)</td>
</tr>
<tr>
<td>PPV</td>
<td>100% (95% CI 91-100%)</td>
<td>100% (95% CI 91-100%)</td>
<td>100% (95% CI 96-100%)</td>
<td>92.7%</td>
</tr>
<tr>
<td>EBUS accuracy</td>
<td>87.5%</td>
<td>93.1%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>


### Table 2  Final results of EBUS-TBNA negative and inadequate samples by group of patients

<table>
<thead>
<tr>
<th></th>
<th>Group 1 (diagnosis)</th>
<th>Group 2 (diagnosis and staging)</th>
<th>Group 3 (staging)</th>
</tr>
</thead>
<tbody>
<tr>
<td>True-negative</td>
<td>Cicatricial inflammatory tissue (n=2)</td>
<td>Follow-up with lesion stability (n=7)</td>
<td>Normal or reactive lymphoid tissue (n=24)</td>
</tr>
<tr>
<td></td>
<td>Mediastinal goiter (n=1)</td>
<td>Normal or reactive lymphoid tissue (n=18)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sarcoïdosis (n=1)</td>
<td>Sarcoïdosis (n=2)</td>
<td></td>
</tr>
<tr>
<td>False-negative</td>
<td>Lung adenocarcinoma (n=1)</td>
<td>Lung adenocarcinoma (n=1)</td>
<td>Lung adenocarcinoma (n=1)</td>
</tr>
<tr>
<td></td>
<td>Non-Hodgkin lymphoma (n=1)</td>
<td>Breast cancer (n=1)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Large cell neuroendocrine tumor (n=1)</td>
<td>Renal cell cancer (n=1)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Thoracic paragangioma (n=1)</td>
<td>Atypical carcinoid tumor (n=1)</td>
<td>Lung adenocarcinoma (n=1)</td>
</tr>
<tr>
<td></td>
<td>Squamous cell carcinoma (n=2)</td>
<td>Lymphoma (n=2)</td>
<td></td>
</tr>
</tbody>
</table>
Exposed N2 disease (adenocarcinoma). All patients with a negative EBUS-TBNA cytology underwent mediastinoscopy (n = 16) or thoracotomy (n = 8) that did not reveal lymph node metastasis.

EBUS-TBNA overall yield and accuracy were 88% and 92.7%, respectively. The results obtained helped to prevent more invasive procedures in 112 patients and consequently reduced the potential number of hospital admissions.

Table 3 shows the learning curve for groups of 30 consecutive patients. We found that there was a trend to puncture smaller lesions (not significant). The number of lymph nodes punctured per patient was statistically different after the first 60 procedures (p = 0.03) plus it further augmented after 90 procedures (p = 0.008) and occurred progressively in a shorter period of time. EBUS-TBNA accuracy, sensitivity and NPV gradually increased with the number of procedures performed although there were no statistical differences between groups.

**Discussion**

Our results confirm that EBUS-TBNA is a sensitive, accurate and safe technique for diagnosing and staging lung cancer. EBUS-TBNA was able to establish the diagnosis of lung cancer in a high percentage of cases (86.1%) that had previously been submitted to a non-diagnostic bronchoscopy or CT-TTNA and avoided surgical diagnostic procedures. Similar results were obtained in a study by Tournoy et al., in which 60 patients with centrally located intrapulmonary masses were diagnosed by EBUS-TBNA with a reported sensitivity, NPV and accuracy of 82%, 23% and 77%, respectively. The yield in patients without a definite lung cancer diagnosis is lower than to NSCLC patients referred for staging. Anatomical issues, such as the presence of inflammatory, fibrotic or necrotic tissue around the tumor may explain the lower sensitivity and this hypothesis is supported by the EBUS false-negative case that had a final diagnosis of extensive necrotic lung adenocarcinoma. In order to exceed this issue, we made several punctures in different sites of the lesion. The low NPV (45%) is certainly related to pathologies that are hard to diagnose by cytology (e.g. lymphoma, paraganglioma) so a negative EBUS-TBNA result should always be confirmed by more invasive methods. Recently a study has reported higher diagnostic sensitivity and NPV (97.2%, 85.7% respectively) in a population of 126 patients with suspected lung cancer lesions. This study included seventy-three patients (60%) with central tumors but the lung mass could only be punctured in 41 cases. The higher yield may be due to a high prevalence of lung cancer as well as by the selection of a heterogeneous group of patients, some with endobronchial tumors which could overestimate the results.

Concerning Group 2 patients, lung cancer prevalence was 51.7% reflecting the probability of other non-malignant diseases involving lung parenchyma and mediastinal lymph nodes. Ernst et al. reported an EBUS-TBNA diagnostic sensitivity of 91% and NPV of 92.4% in 213 patients with suspected NSCLC and enlarged CT or PET positive hilar lymph nodes. Compared to these previous studies, we can only speculate that the lower sensitivity of our work (86.7%) may be due to the absence of a PET scan in a significant percentage of patients, and the lower cancer prevalence. The present trial proves that in selected cases it is possible to achieve simultaneously a lung cancer diagnosis and staging with a simple minimally invasive technique.

Performance of EBUS-TBNA for mediastinal staging of patients with known NSCLC has been extensively described and our results are consistent with previously published reports. It is important to emphasize that in the 44 NSCLC patients that constituted Group 3, all had radiological mediastinal lymph node enlargement but only 30 (68.2%) had done a PET scan. According to international guidelines every patient sent for EBUS-TBNA should have performed a correct non-invasive mediastinal staging. Although PET is an important staging exam, the notion that positive mediastinal lymph nodes are the result of malignant involvement carries the risk of excluding patients from potentially curative surgery. Yasufuku’s work compared CT, PET and EBUS-TBNA for lung cancer lymph node staging and sensitivities were 76.9%, 80.0% and 92.3%, specificities were 55.3%, 70.1% and 100%, and diagnostic accuracies were 60.8%, 72.5% and 98%, respectively. It proves that is fundamental to confirm imaging abnormalities with subsequent invasive methods, if the result alters the clinical management,
since this approach provides a better lung cancer staging and treatment. In fact, in our population N2/N3 prevalence was only 45.5% and surgical treatment could be offered to N0-1 patients. Ultrasonography can, in selected cases, replace surgical techniques, namely mediastinoscopy, since it has a similar diagnostic yield, it is able to offer a wide window to the mediastinum, does not require hospital admission, and has lower morbidity and costs.

While EBUS-TBNA requires formal training and practice, it is quite safe for the patient. In our series, 372 lesions were punctured and there were no serious complications related to the procedure. In the first thirty procedures sensitivity and accuracy were high and the trend was for continual improvement as the number of exams increased. A correct interpretation of the ultrasound images, accurate puncture location and acquisition of adequate samples in terms of quality and quantity is crucial, in addition to having an experienced pathologist to analyze the samples. Previous studies have shown that the presence of a pathologist during the procedure can play an essential role since it reduces the number of inadequate samples, false-negatives and punctures with the advantage of shortening procedure time. In view of the fact that we did not perform ROSE and there was no pathologist available during the procedure we did at least four punctures per lesion to maximize yield, according to published data. In the real-life clinical setting it is of major importance to establish a good communication between the operator and pathologist to acquire a high EBUS-TBNA efficacy.

Another important aspect of the present study is that the procedures were essentially performed by a single chest physician and this may explain a more rapid learning curve. We may assume that experienced bronchologists after proper training may achieve a short EBUS learning curve.

In conclusion, in our experience EBUS-TBNA is a safe, effective and practical technique for obtaining cytological samples from lymph nodes or masses adjacent to the main airways, with clinical impact in lung cancer diagnosis and staging. The potential of EBUS makes it a very important tool in the modern bronchoscopy suite.

Acknowledgments

We thank Technician Magda Albuquerque for the cytological work performed and contribution to the obtained images.

Ethical disclosures

Protection of human and animal subjects. The authors declare that the procedures followed were in accordance with the regulations of the relevant clinical research ethics committee and with those of the Code of Ethics of the World Medical Association (Declaration of Helsinki).

Confidentiality of data. The authors declare that they have followed the protocols of their work center on the publication of patient data and that all the patients included in the study received sufficient information and gave their written informed consent to participate in the study.

Right to privacy and informed consent. The authors have obtained the written informed consent of the patients or subjects mentioned in the article. The corresponding author is in possession of this document.

Conflict of interests

All authors declare that they do not have any conflict of interest related to this work.

References


