Endobronchial Ultrasound for the Diagnosis and Staging of Lung Cancer

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The diagnosis of indeterminate mediastinal lymph nodes, masses, and peripheral pulmonary nodules constitutes a significant challenge. Options for tissue diagnoses include computed tomography–guided percutaneous biopsy, transbronchial fine-needle aspiration, mediastinoscopy, left anterior mediastinotomy, or video-assisted thoracoscopic surgery; however, these approaches have both advantages and limitations in terms of tissue yield, safety profile, and cost. Endobronchial ultrasound (EBUS) is a new minimally invasive technique that expands the view of the bronchoscopist beyond the lumen of the airway. There are two EBUS systems currently available. The radial probe EBUS allows for evaluation of central airways, accurate definition of airway invasion, and facilitates the diagnosis of peripheral lung lesions. Linear EBUS guides transbronchial needle aspiration of hilar and mediastinal lymph nodes, improving diagnostic yield. This article will review the principles and clinical applications of EBUS, and will highlight the role of this new technology in the diagnosis and staging of lung cancer.

Keywords: bronchoscopy; endobronchial ultrasound; lung cancer; mediastinal staging

The endobronchial application of ultrasound was first described in 1992 (1). Since that time, major technological advances have occurred, with much published research now reported on the indications and diagnostic accuracy of endobronchial ultrasound (EBUS). Today, EBUS is recognized as an accurate and minimally invasive procedure, developed for the diagnosis of parenchymal lung lesions and the sampling of mediastinal lymph nodes for lung cancer diagnosis and staging. The types of EBUS, EBUS-guided sampling techniques, and their role in the diagnosis and staging of lung cancer are discussed in this review.

HISTORICAL PERSPECTIVE

After the introduction of chest computed tomography (CT) for the staging of lung cancer, its usefulness for evaluation of primary tumors and metastases was clear; however, the reliability in predicting metastatic involvement of mediastinal lymph nodes and airway infiltration was disappointing (2), with a sensitivity and specificity for identifying mediastinal lymph node metastasis of 51% (95% confidence interval [CI], 47–54%) and 85% (95% CI, 84–88%), respectively (3). For this reason, treatment decisions regarding chemotherapy or surgical resection require tissue confirmation in most patients.

Limitations of CT scanning include interobserver variability (4) and the fact that generation of an image of the intrathoracic organs depends on the difference in the density of water (soft tissue) and air-containing tissue (lung) (5). If there is no interface (fat or air) between two adjacent structures composed of soft tissue, those structures are difficult to differentiate. Furthermore, water density structures such as secretions, mucoid impaction, or blood clots inside the airway can be interpreted erroneously as solid intraluminal structures. Finally, even in the face of a known malignancy, mediastinal lymph nodes can be enlarged for reasons other than cancer (e.g., infection, sarcoid).

Bronchoscopy plays an important role in the diagnosis and staging of lung cancer. Endobronchial biopsy under direct visualization can provide a diagnosis in more than 90% of cases. However, the majority of lung cancers present with primary lesions outside the direct view of the bronchoscope, and the yield of transbronchial needle aspiration for sampling the mediastinum varies widely. In a meta-analysis by Holty and coworkers (6), the pooled sensitivity for transbronchial needle aspiration (TBNA) mediastinal staging was 39% (95% CI, 17–61%), and the pooled specificity was 99% (95% CI, 96–100%). The view from a bronchoscope is limited to the lumen and the internal surface of the airways; thus, expanding the bronchoscopist's view beyond the airways could vastly improve the diagnostic capabilities of diagnostic bronchoscopy.

Ultrasound imaging, as opposed to radiographic imaging, is based on signals generated by ultrasonic waves reflected from different anatomic layers, and it depends on the density (impedance) of the tissues passed and on the energy of the ultrasonic wave. Nevertheless, transthoracic ultrasound is insufficient for imaging of the mediastinal structures because of the limited acoustic window resulting from the reflection of the ultrasonic wave by air contained in the lung tissue. For this reason, interest was generated in developing devices for endoluminal applications.

Developed in the 1980s, endoscopic ultrasound (EUS) has become an integral part of the evaluation for gastrointestinal malignancies, in particular esophageal cancers using a radial probe. Because of the anatomical location of the esophagus (posterior and to the left of the trachea), access to the mediastinum became a natural extension of EUS, and its usefulness in the diagnosis and staging of lung cancer through the performance of needle aspiration of mediastinal masses and lymph nodes became possible (7, 8). However, complete visualization of mediastinal structures by EUS was limited because of airway interference, and lymph node stations 2R, 3, and 4R were deemed poorly accessible by this approach (9). In contrast, most of the structures within the mediastinum and the hilum are within reach from the central airways. Thus, the evolution of ultrasound technology for an endobronchial application was undertaken.

There were technical challenges related to EBUS as opposed to other sites that extended the timeline to a commercially available product (10). They included the need to miniaturize the probes to assure adequate ventilation and the ability to pass instruments through the bronchoscopic channel. The first investigations began in the early 1990s in Germany, Japan, and the United States using endovascular and other miniaturized probes inside the airways that did not yield clinically significant results and were discontinued after a few years (1, 11, 12). Later,
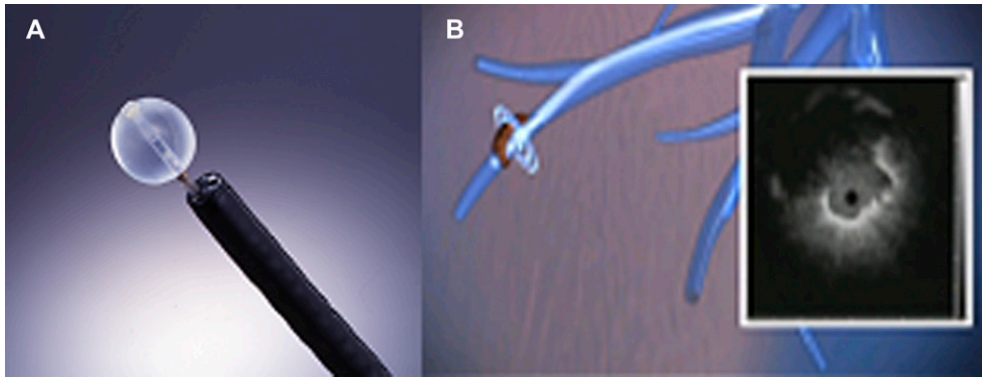
Figure 1. (*A*) A 20-MHz miniature radial probe with the balloon sheath on the tip inflated with water, inserted through a 2.8-mm working channel of a flexible bronchoscope. (*B*) Radial probe ultrasonic image.

Becker developed a flexible catheter with an ultrasound probe for application inside the central airways (13). This probe has a balloon at the tip that allowed circular contact for the ultrasound, providing a 360-degree view of the parabronchial and paratracheal structures, and enhanced tissue penetration. These probes became commercially available in 1999 and can be used through the 2.8-mm working channel of a flexible bronchoscope. In the same year, Kurimoto and colleagues (14) established the utility of EBUS in determining the depth of tumor invasion. More recently, Paone and coworkers (15) examined the utility of EBUS as an adjunct for the diagnosis of peripheral lung lesions and solitary pulmonary nodules. In 2005, a new type of convex ultrasound probe was developed in Japan. The linear EBUS has the ability to perform real-time transbronchial needle aspiration under direct ultrasound guidance (16).

Currently, two types of EBUS exist: radial probe EBUS and linear EBUS. An overview of the equipment, technique, and clinical application in the diagnosis and staging of lung cancer is provided below.

RADIAL PROBE EBUS

Two types of EBUS radial probes are available. The 20-MHz radial probe EBUS (UM-BS20-26R; Olympus, Tokyo, Japan) fitted with a catheter that has a water-inflatable balloon at the tip (Figure 1) is used to evaluate central airways (trachea/subsegmental bronchus). This probe can be inserted through a 2.8-mm working channel and rotates 360 degrees in a direction perpendicular to the insertion access of the probe, to obtain detailed images of the surrounding structures and the bronchial wall structure. The 20-MHz EBUS has a resolution of less than 1 mm and a penetration of 5 cm, which allows the airway layers to be identified. Initial reports described bronchial walls as having at least three and up to seven echo layers (1, 17). In addition, the effectiveness in the diagnosis of tumor invasion into the bronchial wall has been demonstrated by several studies using the 20-MHz radial probe, with an overall sensitivity of 66.7%, specificity of 100%, and accuracy of 93 to 95% in identifying tracheal wall invasion by malignancy (14, 18–20). A second probe, the ultra-miniature radial probe (UM-S20–20R; Olympus) is used for the detection of peripheral lung nodules. It is also a 20-MHz radial probe with an external diameter of 1.4 mm. The probe is placed into a guide sheath and inserted through a 2.0-mm working channel of a flexible bronchoscope. The guide sheath–covered probe is advanced to the peripheral lesion (usually with the aid of fluoroscopy) to obtain an EBUS image. After localizing the lesion, the probe is removed, leaving the guide sheath in place. A biopsy instrument (forceps, needle, bronchial brush) is inserted through the guide sheath to obtain pathologic and cytologic specimens. A chest radiograph should be performed after the procedure to evaluate for pneumothorax. In 2002, Herth and coworkers (21) demonstrated that EBUS-guided transbronchial lung biopsy had a diagnostic yield of 80%, compared with 76% of patients undergoing fluoroscopically guided transbronchial lung biopsy, in
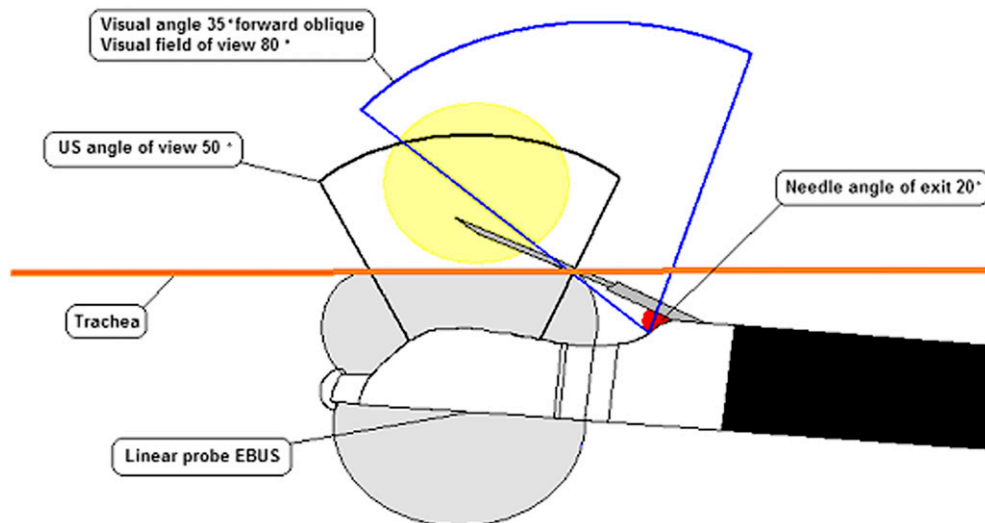

Figure 2. A schematic of the convex probe endobronchial ultrasound (EBUS) system.
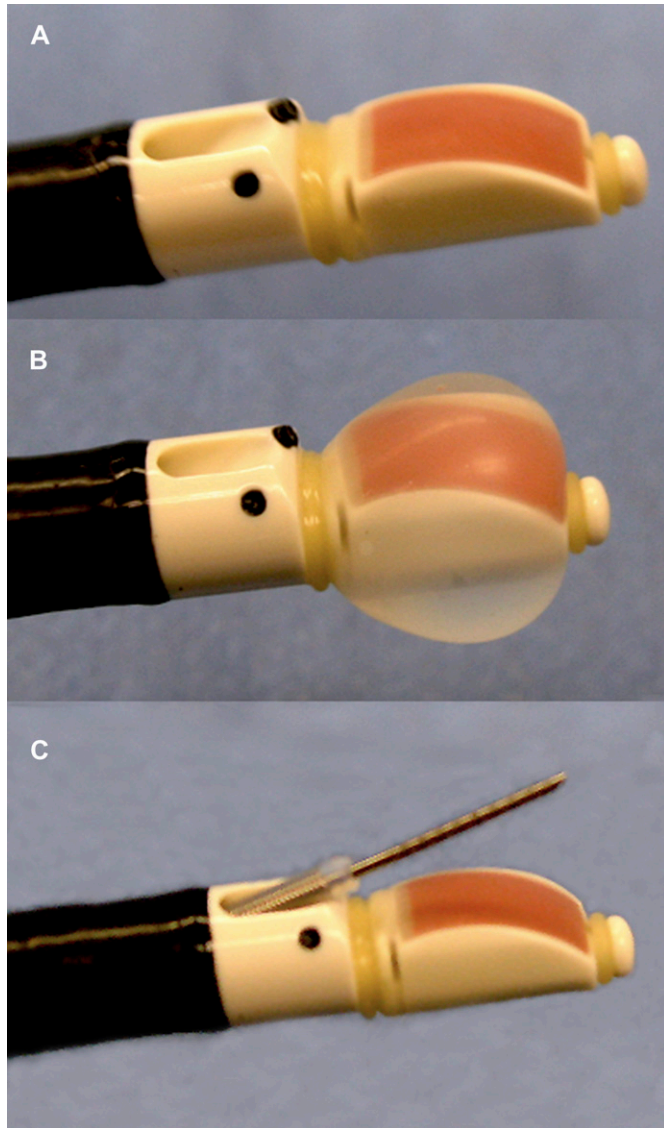
Figure 3. Convex probe EBUS. (*A*) The tip of the convex probe endobronchial ultrasound (Olympus XBF-UC180F-DT8; Olympus, Tokyo, Japan) has a linear curved array ultrasonic transducer of 7.5 MHz. (*B*) The balloon attached to the tip of the bronchoscope is inflated with normal saline. (*C*) A dedicated transbronchial aspiration needle is inserted through the working channel.
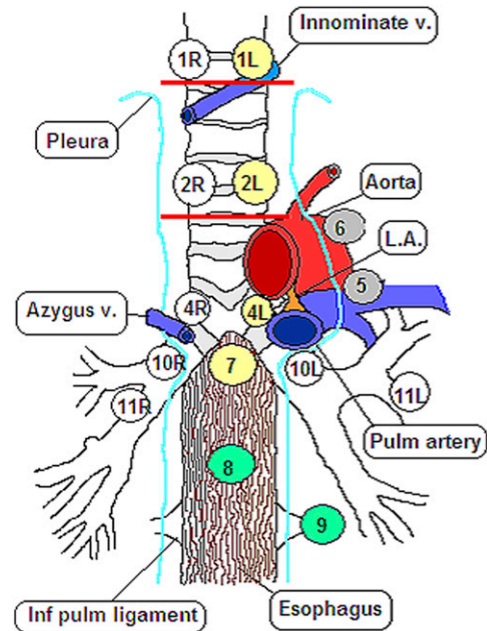

Figure 5. Regional lymph node stations for lung cancer staging accessible by EBUS (*white circles*) and EUS (*green circles*). *Yellow circles* = EBUS + EUS; *gray circles* = Nonaccessible by EBUS or EUS.

the evaluation of peripheral lung masses and solitary pulmonary nodules. Furthermore, in patients with fluoroscopically invisible peripheral lesions less than 3 cm in diameter but previously identified by chest CT, EBUS identified 48 of 54 (89%) lesions with a solitary pulmonary nodule. This was followed by EBUS-guided transbronchial lung biopsy, with 38 of 48 patients (70%) yielding a specific diagnosis. In nine patients (17%) EBUS prevented a surgical procedure (22). The complication rate of EBUS-guided transbronchial lung biopsy is equivalent to fluoroscopically guided lung biopsy, with minor bleeding and pneumothorax the most common complications described (21, 22). Another new technology, electromagnetic navigation (EMN), which guides the bronchoscopist to the lesion much the way a global positioning system (GPS) guides a car to its destination, uses three separate technologies that in combination enable real-time navigation within the lung. The first component is the planning software, which converts CT images into multiplanar images with three-dimensional reconstruction and virtual bron-
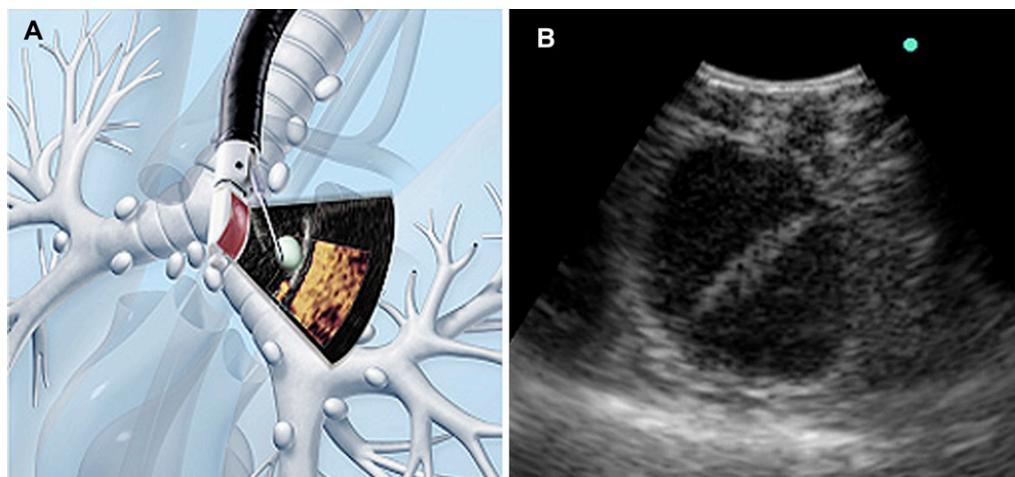

Figure 4. (*A*) Convex probe EBUS in the main airway. (*B*) Ultrasound image shows needle in lymph node (entering from *top right*).

choscopy of the airways. The second component is a steerable probe that contains a position sensor attached to an eight-way steerable device. The third component is an electromagnetic board, which is a field generator connected to a computer containing the planning data. The exact position of the steerable probe when placed within the electromagnetic field is captured on the system monitor. This allows guidance of bronchoscopic instruments to reach lung targets for TBNA, brushing, or biopsy procedures (23). EMN has a diagnostic yield of 63 to 74% for biopsy of peripheral pulmonary lesions (24, 23, 25). With the concomitant use of a radial EBUS probe to verify location of the lesion, the yield of EMN is increased to almost 88% (26).

LINEAR EBUS

The linear EBUS, also known as convex probe EBUS, incorporates a convex transducer with a frequency of 7.5 MHz at the tip of a flexible bronchoscope that scans parallel to the insertion direction of the bronchoscope, generating a 50-degree image (Figures 2 and 3). The outer diameter of the insertion tube of the flexible bronchoscope is 6.7 mm and that of the tip is 6.9 mm, making this scope bulkier than a standard therapeutic bronchoscope. For this reason, intubation using the oral route for insertion is preferred. The angle of view is 80 degrees, and the direction of view is 35 degrees forward oblique. Ultrasound images can be obtained by placing the probe in direct contact to the trachea or bronchial wall, or after inflating the balloon on the tip of the bronchoscope with saline. Using the water-filled balloon can improve the image quality. In addition, the ultrasound images can be frozen, allowing for measurement of the lesion or lymph node in two dimensions. Ultrasound and the white-light bronchoscopic images can be viewed simultaneously. The Doppler mode allows differentiation of tissue from vascular structures. Due to the diameter of the linear EBUS scope, complete inspection of the airways may require performing standard flexible bronchoscopy.

Endobronchial ultrasound–transbronchial needle aspiration (EBUS-TBNA) can be performed under local anesthesia and conscious sedation in an outpatient setting. A 22-gauge TBNA needle equipped with an internal sheath is inserted through the 2-mm working channel of the EBUS bronchoscope. The needle should remain within the catheter during passage through the working channel to avoid damaging the bronchoscope. The inner diameter of the needle allows the sampling of histologic cores in some cases, but most samples are evaluated by cytologic examination. The target lymph node is identified using linear EBUS. Doppler examination may be used immediately before the biopsy to avoid unintentional puncture of vessels between the wall of the bronchi and the lesion. Under real-time ultrasonic guidance, the needle is inserted into the lesion (Figure 4) and suction is applied by a syringe. The needle is moved back and forth inside the lesion for 20 to 30 seconds. Finally, the needle is retrieved, locked, and the internal sheath and the catheter are removed. The optimal number of passes to maximize diagnostic yield appears to be three (27). The aspirated material is smeared onto glass slides, air-dried, and fixed in 95% alcohol. Dried smears can be evaluated by an on-site cytopathologist to confirm an adequate lymph node sampling, and in a substantial number of cases a preliminary diagnosis can be made. Histologic specimens obtained are fixed in formalin before being sent to the pathology department.

EBUS-TBNA is indicated for the assessment of mediastinal and hilar lymph nodes, and diagnosis of lung and mediastinal tumors. It can be used to sample the highest mediastinal (station 1), the upper paratracheal (station 2R, 2L), the lower paratracheal (station 4R, 4L), the subcarinal (station 7), as well as the hilar (station 10), and the interlobar (station 11) lymph nodes (Figure 5). The para-aortic (6), aorto-pulmonary window or subaortic (5), paraesophageal (8), and pulmonary ligament (9) lymph node stations are usually not accessible by this technique.

The safety of this technique is well established, and few serious complications have been reported, including pneumothorax, pneumomediastinum, and hemomediastinum (28, 29). Furthermore, the risk of bleeding with fine needle puncture of the pulmonary artery is likely very low, exemplified by a report of a successful biopsy of a left hilar mass by intentionally traversing the pulmonary artery (30).

EBUS-TBNA FOR LUNG CANCER STAGING

The objective of non–small cell lung cancer (NSCLC) staging, when there is no evidence of distant metastases, is the evaluation of mediastinal lymph node involvement. Accurate staging of NSCLC is important not only to determine the patient's prognosis, but to aid in deciding on a treatment plan, as the presence of mediastinal lymph node involvement is diagnostic for stage III lung cancer and suggests inoperability and the need for treatment with chemotherapy, radiation, or both. If the patient does not have nodal involvement, surgery is the treatment of choice.

Mediastinal lymph node staging is divided into noninvasive (imaging) and invasive staging. Noninvasive techniques include CT, magnetic resonance imaging (MRI), positron emission tomography (PET), and PET-CT. The sensitivity and specificity of CT scanning for identifying mediastinal lymph node metastasis is 51% (95% CI, 47–54%) and 85% (95% CI, 84–88%), respectively, emphasizing the fact that CT scanning has limited ability to diagnose or to exclude mediastinal metastasis. The sensitivity and specificity of PET scanning for identifying mediastinal metastasis is 74% (95% CI, 69–79%) and 85% (95% CI, 82–88%), respectively (3). These data demonstrate that while PET is more accurate than CT, the technology is still fallible, and all abnormal imaging findings require cytologic or histologic confirmation of malignancy so that patients are not incorrectly staged and denied appropriate treatment.

Invasive staging techniques are divided into surgical and nonsurgical procedures, which include endoscopic and bronchoscopic techniques. Surgical staging includes mediastinoscopy, anterior mediastinotomy (Chamberlain procedure), and video-assisted thoracoscopic surgery (VATS). Mediastinoscopy is considered the "gold standard" for the evaluation of mediastinal lymph nodes, but as a surgical procedure, it is costly, requires general anesthesia, and has an associated morbidity and mortality, albeit very low (31–33). In addition, standard cervical mediastinoscopy is ideally suited to the biopsy of lymph nodes within levels 2, 3, 4, and 7; whereas posterior subcarinal, pulmonary ligament, and subaortic nodes are usually inaccessible. Lemaire and colleagues reported that the false-negative rate for lymph node metastasis was 5.5% (56 of 1,019) among patients with lung cancer undergoing resection. Thirty-two (57%) of the false negatives were due to metastatic disease in lymph nodes not normally biopsied during cervical mediastinoscopy (levels 5, 6, 8, or 9) (34). Although it is considered the "gold standard" one study in the United States showed that this technique is currently underused. Little and collaborators (35) conducted a survey-based study to determine patterns of care in patients with NSCLC. They found that only 27% of 11,668 patients had mediastinoscopy for preoperative mediastinal staging, and of those undergoing this procedure, only 46% had documented evidence of lymph node biopsy material submitted to pathology.

Nonsurgical staging includes minimally invasive needle biopsy techniques such as TBNA, transthoracic needle aspiration (TTNA), esophageal endoscopic ultrasound-guided fine-needle aspiration (EUS-FNA), and EBUS-TBNA.

A wide spectrum of factors must be considered when determining the appropriate tests to assess the mediastinal lymph nodes in NSCLC. These include the sensitivity and specificity of the test, the false-negative and -positive rates, the morbidity of the procedure, the accessibility of the tumor and suspicious lymph nodes, the requirement of general anesthesia, and the institutional availability of technology with skilled clinicians. The performance characteristics of the different invasive techniques for mediastinal staging are summarized in Table 1 (36).

The International Staging System for lung cancer is based on TNM classification, in which tumor size, location, and local invasion determine the T (tumor) category, the regional lymphatic spread the N (node) category, and the presence or absence of metastatic disease the M (metastasis) category. The stage of the tumor (I through IV) depends upon the particular combination of T, N, and M characteristics for the given patient (37). Refinements of the T and M descriptors, as well as the tumor stage groupings, have been proposed and are expected for the seventh edition of the "TNM Classification of Malignant Tumors" (38, 39). In addition, the recommendations for classifying lymph nodes for lung cancer staging published by Mountain and Dresler are shown in Figure 5 (40).

A pooled analysis of twelve studies using EBUS for mediastinal staging (Table 2) (41–52) showed a weighted sensitivity of 93% (range, 79–99%) and a false-negative rate of 9% (range, 1–37%). The specificity is 100%. All but two of the studies of EBUS to stage lung cancer involved patients with lymph node enlargement with a disease prevalence of approximately 70%.

In 2006, Herth and colleagues (44) evaluated EBUS-TBNA in patients with lung cancer and a radiographically normal mediastinum; this study showed an unexpected detection rate of mediastinal metastases of 17% in 119 lymph nodes 5 to 10 mm in size. In one out of six patients a futile thoracotomy was averted using EBUS. This was followed by a study evaluating the accuracy of EBUS-TBNA for staging mediastinal lymph nodes in patients with lung cancer without enlarged lymph nodes on CT and no detectable PET activity in the mediastinum (42). There was a 9% prevalence of mediastinal lymph node metastases. The sensitivity, specificity, and negative predictive value were 89%, 100%, and 99%, respectively.

COMBINING ENDOSCOPIC ULTRASOUND-FINE NEEDLE ASPIRATION AND ENDOBRONCHIAL ULTRASOUND-TRANSBRONCHIAL NEEDLE ASPIRATION

Endoscopic ultrasound-fine needle aspiration (EUS-FNA) and EBUS-TBNA are sometimes combined because EUS has better access to the posterior and inferior mediastinum, and EBUS to the anterior and superior mediastinal lymph nodes. New data suggest that the combination may allow complete access to all mediastinal lymph node stations (53), constituting a more appropriate initial sampling method that may replace mediastinoscopy. Wallace and coworkers (54) compared the diagnostic accuracy of transbronchial needle aspiration, EBUS-TBNA, EUS-FNA, and their combinations. They reported a sensitivity of 93% (95% CI, 81–99%), and a negative predicted value of 97% (95% CI, 91–99%) for the combination of EUS-FNA and EBUS-TBNA in a population with a prevalence of mediastinal metastases of 30%. In addition, they reported that the combination of EUS-FNA and EBUS-TBNA was better than either alone, even when evaluating scenarios that favored one technology over the other. Both technologies far outperformed blind TBNA in assessing mediastinal lymph nodes.

CLINICAL IMPLICATIONS

EBUS is minimally invasive, safe, and highly accurate. Radial probe EBUS can assess tumor invasion into a bronchus, the depth of penetration into surrounding tissue, and is useful in guiding biopsies of peripheral lung lesions. The most important application of this technology, however, is the use of linear EBUS to accurately stage the mediastinum in patients with known or suspected lung cancer. EBUS offers the advantage of simultaneously obtaining the diagnosis and stage of lung cancer in a single procedure in the outpatient setting, especially in patients who present with a lung mass, mediastinal adenopathy, and no evidence of distant metastatic disease. Accurate diagnosis and staging of lung cancer is crucial for prognostic and therapeutic decision making. Figure 6 provides a framework for the clinician approaching the patient with known or suspected lung cancer that may require invasive staging of the mediastinum.

TABLE 1. TECHNIQUES FOR MEDIASTINAL LYMPH NODE STAGING

Technique	Nodal Stations Accesible	Sensitivity (%)	Specificity (%)	FP (%)	FN (%)
Cervical Mediastinoscopy	1, 2, 3, 4, anterior 7	78 90*	100	0	11 7*
Anterior Mediastinotomy	5, 6	75	100	0	6
VATS	5, 6, 8, 9 ipsilateral	75	100	0	7
TBNA	2, 4, 7	78	100	0	28
TTNA	Mediastinal	89	100	0	
EUS-FNA	2, 4, 5, 7, 8, 9	84	99.5	0.4	19
EBUS-TBNA	1, 2, 4, 7, 10, 11	93	100	0	9

Definition of abbreviations: EBUS-NA: endobronchial ultrasound-guided transbronchial needle aspiration; EUS-FNA = esophageal endoscopic ultrasound-guided fine-needle aspiration; FN = false negative; FP = false positive; TBNA = transbronchial needle aspiration; TTNA = transthoracic needle aspiration; VATS = video-assisted thoracoscopic surgery.

* Videomediastinoscopy.

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TABLE 2. ENDOBRONCHIAL ULTRASOUND-GUIDED TRANSBRONCHIAL NEEDLE ASPIRATION OF THE MEDIASTINUM IN LUNG CANCER

Study/Year	Patients	Technique	Sensitivity %	Specificity %	FP %	FN %	Cancer %
Vincent/2008 (50)	152	RT-22 ga	99	100	0	1	74
Herth/2008 (42)*	100	RT-22 ga	89	100	0	1	9
Bauwens/2008 (41)†	106	RT-22 ga	95	97	0	3	55
Koh/2008 (46)	16	Rad-21 ga	83	100	0	13	63
Herth/2006 (43)	502	RT-22 ga	94	100	0	89‡	98
Herth/2006 (44)	100	RT-22 ga	94	100	0	1	17
Plat/2006 (47)	33	Rad-histo	93	100	0	25	82
Yasufuku/2005 (51)	108	RT-22 ga	95	100	0	11	69
Vilman/2005 (49)	31	RT-22 ga	85	100	0	28	65
Rintoul/2005 (48)	20	RT-22 ga	79	100	0	30	70
Kanoh/2005 (45)	54	Rad-19 ga	86	100	0	37	81
Yasufuku/2004 (52)	70	RT-22 ga	95	100	0	10	67
Summary	1292		93	100	0	9	63

Definition of abbreviations: Rad = radial probe; RT = real time.

* Nodes < 1 cm, negative mediastinal activity in PET scan.

† Increased activity in mediastinum in PET scan.

‡ Excluded from calculations because NPV is less reliable with a prevalence of > 90%

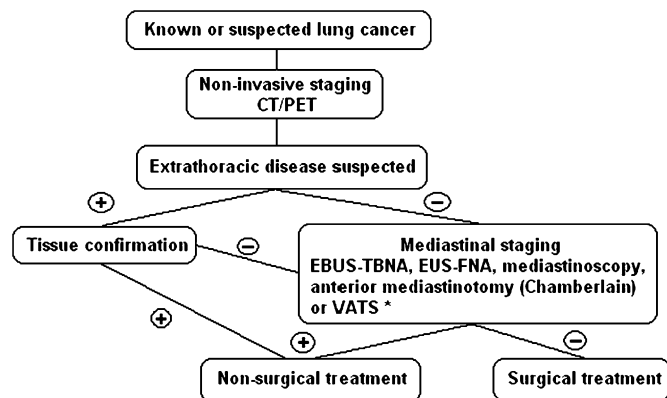Reprinted by permission from Reference 36.

Figure 6. Proposed algorithm for lung cancer staging. CT = computed tomography; EBUS-TBNA = endobronchial ultrasound–fine needle aspiration; EUS-FNA = endoscopic ultrasound–fine needle aspiration; PET = positron emission tomography. * Based on local expertise and lymph node location; negative needle techniques should be followed by surgical staging.

LIMITATIONS

The limitations of linear EBUS include suboptimal quality white light image that limits its use for general inspection of the airways, the possibility of false-negative results, costly damage to the bronchoscope by inadvertent needle penetration of the inner sheath, and the learning process required to master acquisition and interpretation of ultrasound images. The American College of Chest Physicians guidelines for interventional pulmonary procedures (55) states that trainees should be supervised for 50 EBUS procedures and a chest physician should perform 5 to 10 procedures per year to maintain competency. The European Respiratory Society/American Thoracic Society joint statement on interventional pulmonology (56) recommends that the initial training consist of 40 supervised procedures, and that 25 procedures should be done per year to maintain competency. However, these two statements only address the use of radial probe EBUS, and no recommendations are currently available for training in linear EBUS. Furthermore, cost-effectiveness studies are not available to evaluate the economic impact of EBUS. However, EUS-FNA, a similar technology, is a more cost-effective alternative to surgical staging (57). Lastly, widespread use of this technology may be limited to its cost (58) and uncertain reimbursement (59).

FUTURE DIRECTIONS

Studies that investigate the prediction of malignancy through the evaluation of clinical and ultrasonic lymph node characteristics are sparse and have not been adequately applied to EBUS (60–63). Further research would be required to define if there are ultrasonic predictors of malignancy in mediastinal staging for lung cancer via EBUS.

Perhaps the most important question left to be answered is that of whether or not EBUS can replace surgical staging for patients with lung cancer. While a randomized control trial is needed to answer this question, many experienced with this technology have already adopted this practice as their standard of care.

CONCLUSIONS

Endobronchial ultrasound is a relatively new, minimally invasive technology that has proven utility in the evaluation of patients with lung cancer. The radial EBUS probe is useful for evaluation of peripheral pulmonary lesions but more study is needed to compare this technology to traditional transthoracic needle biopsy. The range of lymph nodes that are accessible with linear EBUS is a marked advance over previous technologies available to the bronchoscopist. In patients with known or suspected lung cancer, EBUS alone or in combination with EUS-FNA will likely replace more invasive surgical techniques for tissue acquisition.

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