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REVIEW ARTICLE

PRACTICAL APPROACH TO PLANNING ENDOBRONCHIAL ULTRASOUND – GUIDED TRANSBRONCHIAL NEEDLE ASPIRATION OF THE LEFT LOWER PARATRACHEAL LYMPH NODE (STATION 4L)

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INTRODUCTION

The purpose of ***"The Practical Approach to Interventional Bronchoscopy"*** exercises is to help learners gain the cognitive, technical, affective, and experiential skills necessary to perform minimally invasive bronchoscopic procedures in a patient focused-care environment. Competency is sought in the three major elements of a procedure: strategy and planning, execution, and response to procedure-related adverse events or complications. While cognitive skills (knowledge of facts) can be learned by reading, and technical skills can be learned using simulators as well as at the patient's bedside, these two forms of knowledge can be combined with experiential learning by working through a case-based learning exercise that helps learners contemplate on a set of patient or procedure-related issues in a structured fashion. Using a four box approach inspired from Albert Jonsen's classic work in medical ethics,[1] "The Practical Approach" helps learners think about the "how" and "why" of their actions, based on background information, pertinent literature, and experience.[2]

Essentially, the learner works through the clinical scenario as one might work through an academic pulmonary consultation. Using this "four box" approach (Fig. 1), one is able to address in greater or smaller detail the major elements that are pertinent to the case, and also answer specific questions pertaining to the case at hand. In the case presented herein, we will use the four box approach to address the planning of endobronchial ultrasound –guided TBNA of left lower paratracheal lymph node (station 4L) and we will provide answers to the following:

1. Describe the yield of EBUS-TBNA versus conventional TBNA at station 4L.

2. Describe how the coronal view of a CT scan can be used to help plan the EBUS-TBNA at station 4L.

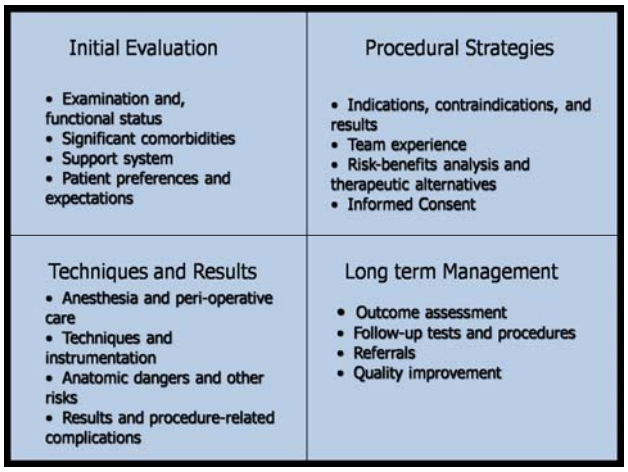

Fig 1. Four box approach to interventional bronchoscopy. The major elements and related details pertinent to a case are represented in separate boxes.

CASE DESCRIPTION

A 69 year-man with a 120 pack –year history of smoking presents with cough. Computed tomography shows a 2.5 X 2 cm left upper lobe mass and a 1.5 cm left paratracheal lymph node suspicious for malignancy (Fig. 2). The patient is referred for diagnosis and staging.

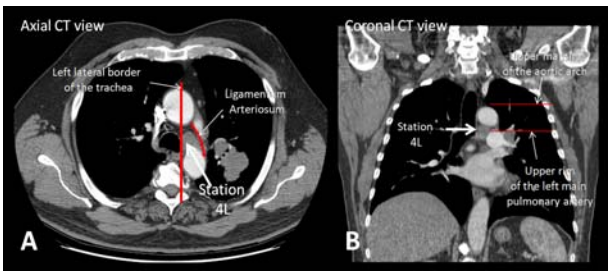

Fig 2. A. Axial CT view reveals the left upper lobe mass and the 1.5 cm left paratracheal lymph node (station 4L) between the left lateral border of the trachea and ligamentum arteriosum.
B. Coronal CT view shows the upper and lower borders of station 4L and reveals the relationship between the left paratracheal node and pulmonary artery and aortic arch.

INITIAL EVALUATIONS

Physical Examination: is significant for decreased air entry bilaterally and prolonged exhalation. The patient has grade II functional status based on World Health Organization scale, namely there is mild limitation of physical activity; there is no discomfort at rest, but normal physical activity causes increased symptoms.

Comorbidities: The patient has COPD with an FEV1 of 40% predicted (GOLD stage III). He is taking tiotropium 18 mcg/day, salmeterol/fluticasone 250/50 mcg twice a day and albuterol MDI as needed.

Support system: He lives with his wife at home.

Patient preferences and expectations: He desires diagnosis and is ready to consider all available active treatment options.

PROCEDURAL STRATEGIES

Indications: The patient requires tissue diagnosis and sampling of station 4L (left paratracheal node) for staging purposes since mediastinal lymph node involvement is commonly found in approximately 26% of newly diagnosed lung cancer patients.[3] The presence of mediastinal lymph node metastasis remains one of the most adverse factors for prognosis in nonsmall cell lung cancer (NSCLC) and suggests stage IIIA or IIIB. This would result in either inoperability and/or need for treatment with chemotherapy and/or radiotherapy.

This patient has ipsilateral mediastinal lymphadenopathy, which if involved with tumor will suggest clinical stage III A with a median survival time of 14 months and estimated 5 year survival of 19%.[4] Bronchoscopic inspection can be performed at the time of EBUS-TBNA to evaluate for possible endobronchial disease. Diagnosis and staging can, therefore, be performed during a single procedure by sampling station 4L.

Contraindications: There are no obvious contraindications to bronchoscopy detected on initial evaluation.

Results: The diagnostic rate of EBUS-TBNA for station 4L is reportedly equal to that of conventional TBNA (72% vs. 71%) but lymphocytes (indicative of an adequate sample) are more often present on EBUS-TBNA specimens (82% vs. 71%).[5]

Team experience: EBUS-TBNA procedure is performed in a tertiary referral center on a weekly basis. There is an experienced team of doctors, nurses, and if necessary, rapid on-site cytologic examination of the specimen is available.

Risks-benefits analysis: No serious complications are reported in the literature with EBUS-TBNA. Agitation, cough, and presence of blood at the needle puncture site are reported infrequently (6). EBUS-TBNA has a high yield and is a safe, same day procedure.[7]

Diagnostic alternatives: Various alternatives are available, each with its advantages and disadvantages. It is ethical to share a description of these alternatives with the patient or

decision-making family member: (a) CT-guided percutaneous needle aspiration of the left upper lobe mass could be performed, for example, since it has a high diagnostic rate (91%) but this would not provide information on staging, and has an increased risk for pneumothorax (5-60%).[8] If cancer were diagnosed, mediastinal sampling would still be warranted for staging purposes. (b) EUS-FNA (esophageal ultrasound- guided fine needle aspiration) could also be performed in this case because the 4L lymph node station is accessible using this diagnostic modality. Overall reported sensitivity is 81-97% and specificity, 83-100%.[9] For station 4L in particular, EUS-FNA has a diagnostic yield similar to EBUS-TBNA.[10] Some might argue that bronchoscopy would still need to be performed to visualize possible airway abnormalities. (c) Mediastinoscopy: is still considered gold standard but it is invasive, is performed in the operating room with general anesthesia and has a morbidity and mortality of 2 and 0.08%, respectively.[11] Mediastinoscopy has a specificity of 100% and offers good access to the stations 2, 4 and 7, but the access to posterior and inferior mediastinal nodes is limited, which results in an overall sensitivity of 80-90%.[8] (d) Video assisted thoracic surgery (VATS): is another invasive alternatives but only provides access to ipsilateral nodes and has an overall 75% sensitivity.[12] Its benefits include access to inferior mediastinal nodes and definitive lobar resection at the same time if the nodes are found to be negative.

Cost-effectiveness: No formal cost effectiveness evaluations have been published yet but in two separate decision-analysis models, both (EUS-FNA + EBUS-FNA) and conventional TBNA + EBUS-FNA were more cost-effective approaches than mediastinoscopy for staging patients with NSCLC and abnormal mediastinal lymph nodes on non-invasive imaging.[13,14] A strategy adding EUS-FNA to a conventional lung cancer staging approach (mediastinoscopy and thoracotomy) reduced costs by 40% per patient.[15] EBUS-TBNA, however, may actually increase health care costs if done in low volume centers by less experienced operators.[16,17] In fact, start- up costs can be significant because it includes training and the cost of equipment (about 100,000 dollars in the United States). Physician reimbursement is reportedly about $280 and the facility reimbursement about $257 according to at least one study.[18]

Informed Consent: There were no barriers to learning identified. The patient has good insight into his disease and has realistic expectations. After being advised of all of the alternatives, he chose to have EBUS-TBNA performed as a same-day procedure.

TECHNIQUES AND RESULTS

Anesthesia and perioperative care: EBUS-TBNA can be performed under conscious (moderate) sedation or under general anesthesia using laryngeal mask airway or endotracheal tubes.

Conscious (moderate) sedation: offers the advantage of performing the procedure in the bronchoscopy suite and results in better cost savings -safety ratios when compared to general anesthesia.[19] Cough and respiratory movements may impair coupling of the transducer with the airway wall and may result in significant artifacts and suboptimal ultrasound imaging. Biopsy of smaller nodes may be technically more difficult than with general anesthesia.

General anesthesia with laryngeal mask airway (LMA): At least a number #4 or 4.5 LMAs should be used to allow for easier manipulation of the scope inside the airway.[20] LMAs of this size allow passage of endotracheal tubes (ETT) if necessary. Anesthesia with LMA allows better visualization of higher nodes (station 1 and 2) compared with the endotracheal tubes (ETT), for obvious reasons since the tip of the ETT is at least 3 cm below the vocal cords. This is because the distance between the tip of the tube and the ETT cuff is usually 1 cm and the cuff length approximately 2 centimeters. This anesthesia technique can be used in the bronchoscopy suite but is usually done in the operating room. Patients should be carefully selected since LMA use may not be appropriate in severe obesity or severe untreated gastro-esophageal reflux (GERD) because of increased risk for aspiration of gastric contents.

General anesthesia with endotracheal tube (ETT): A #8.5 ETT for female and #9 ETT for male patients should be used to allow for proper ventilation during the procedure and to potentially prevent elevated peak airway pressures and development of auto PEEP. These tubes provide at least a 2 mm difference between the scope diameter and the ETT since the EBUS-TBNA scope outer diameter is 6.2 mm. This bronchoscope/ETT ratio may prevent critical alterations in ventilatory parameters.[21] The procedure is usually performed in the operating room. Because the EBUS scope is directed more centrally in the airway through the ETT, coupling of the transducer and the wall may be impaired and biopsies may be more difficult than with LMA or moderate sedation techniques.[20]

Instrumentation: The EBUS bronchoscope most commonly used for diagnosing and staging mediastinal lymph nodes in lung cancer has a curved array 7.5 MHz ultrasound transducer incorporated into its distal end (BF-UC 160F: Olympus Optical Co. Ltd, Tokyo, Japan). This scope has a low resolution but a depth of penetration of approximately 5 cm that allows clear visualization of mediastinal structures surrounding the airways. The ultrasound processor (Fig. 3) (Olympus Endo Echo EU C2000) allows for adjustable gain and depth to improve image quality

and for Doppler capabilities which help distinguish lymph nodes from mediastinal structures. The dedicated 22 gauge acrogenic needle has a stylet, a lockable sheath and allows precise needle projection up to 4 cm (Fig. 3).

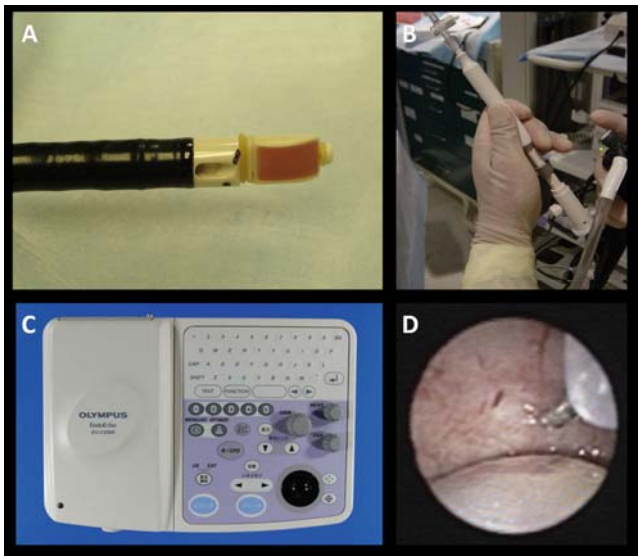

Fig 3. Endobronchial ultrasound equipment. A. EBUS scope (BF-UC 160F) with the curved array 7.5 MHz ultrasound transducer incorporated in the distal end of the bronchoscope. B. The 22 gauge needle system is being locked to the bronchoscope. C. The ultrasound processor unit (EU C 2000) allows for adjustable gain and depth to improve image quality and has Doppler capabilities. D. Endoscopic view showing the water -inflated balloon against the airway wall and the needle out of its sheath and penetrating the airway wall during EBUS–TBNA.

Anatomic dangers and other risks: Pulmonary artery and aortic arch surround station 4L (Fig. 2). The risk of puncturing major vessels may be reduced with real time B mode and Doppler mode imaging. "Minor" oozing of blood at the puncture site is reported but there are no reports of major bleeding.[22] Pneumothorax and pneumomediastinum have been reported with conventional TBNA but while possible, there are no reports in the literature with EBUS guided TBNA.[23]

Results and procedure related complications: In this patient, EBUS-TBNA was performed under general anesthesia using a 9.0 ETT. Bronchoscopic inspection showed normal airway mucosa without evidence of endobronchial disease. A total of 3 aspirates were performed from 4L node and with rapid on site cytology examination, a diagnosis of non small cell carcinoma (adenocarcinoma) was made. There were no procedure related complications.

When performing EBUS-TBNA, a cytology specimen can be considered adequate or representative if there is presence of frankly malignant cells such as in our case. Lymphocytes, lymphoid tissue, or clusters of anthracotic pigment-laden macrophages are also signs of being within the lymph node.[24] The specimen is considered inadequate/nonrepresentative if there are no cellular components, scant lymphocytes (defined as <40 per HPF), blood only, cartilage or bronchial epithelial cells only.[24,25] A quantitative cut off value of at least 30% cellularity composed of lymphocytes has been arbitrarily proposed by some experts.[26] Higher yields may be obtained by obtaining aspirates from the periphery of the node.

We chose to use rapid on site examination (ROSE) because of its availability at our institution. The procedure is stopped once the pathologist determines the specimen adequacy. However, if ROSE is not utilized, the greatest yield is obtained by performing 3 aspirates per station (reported sensitivity of 95% and specificity of 100%).[25] Two aspirations per lymph node station seem to be acceptable when at least one tissue core specimen is obtained.[25] If the operator believes targeting is inadequate or insufficient another aspirate should probably be performed regardless of the number of needle passes.

LONG TERM MANAGEMENT

Outcome assessment: The patient was discussed in a multidisciplinary chest conference including cardiothoracic surgery, oncology, and radiation oncology for potential trial enrollment for neoadjuvant treatment of stage IIIA adenocarcinoma of the lung.[27] Five year survival for clinical stage IIIA non-small cell lung cancer is 19%.[4]

Follow-up tests and procedures: Complete staging including whole body PET/CT scan and brain MRI, which in this patient showed no extrathoracic disease. A follow up appointment was arranged 2 weeks after EBUS-TBNA to ensure involvement of subspecialty physicians as part of a multidisciplinary approach to lung cancer management program.

Referrals: To oncology and radiation oncology, in addition to reports back to the patient's referring physician.

Quality improvement: A team meeting each week provides an opportunity to discuss cases and reflect on quality practice. In this case, a diagnosis of lung cancer was made quickly, and N2 metastasis was identified using a single outpatient procedure, resulting in patient satisfaction and cost-effective, quality care.

ANSWER TO CASE QUESTIONS

Question 1: Describe the yield of EBUS-TBNA versus conventional TBNA at station 4L.

Answer: According to a study that directly evaluated the yield of EBUS-TBNA versus conventional TBNA for separate lymph node stations, the diagnostic yield of EBUS-TBNA was similar to conventional TBNA (72% vs 71%) at station 4L but lymphocyte -positive aspirates were retrieved more commonly with EBUS-TBNA (82% vs 71%).[5] In a more recent paper, the yield of EBUS-TBNA for diagnosing station 4L was as high as 96% in expert hands.[28]

Question 2: Describe how the coronal view of a computed tomography scan can be used to help plan the procedure.

Answer: According to IASLC lymph node map (29), station 4L includes nodes to the left of the left lateral border of the trachea, medial to the ligamentum arteriosum. The upper border is the upper margin of the aortic arch and the lower border is the upper rim of the left main pulmonary artery (Fig. 2). Both axial and coronal CT views are useful to define station 4L and identify adjacent vascular structures. The coronal CT view, however, is more useful for correlation with the EBUS image as explained below.

To visualize the left paratracheal node (4L), the operator turns the bronchoscope laterally to the 9-o'clock position and scans the area of lymph node station 4 L (Fig. 4a). Therefore, the scanning plane for the EBUS scope is the same as the coronal CT view (Fig. 4b). However, while the coronal CT view is projected as if the scope is vertical, the EBUS image is projected as if the scope is horizontal (Fig. 4c). Thus, to understand the use of the coronal CT view, one must understand the reference points on the EBUS image (Fig. 4d). The green dot on the monitor represents the point where the needle exits the scope and corresponds to the superior (cephalad) aspect of the body. This dot is by default towards the 1'o'clock position on the screen (Fig. 4d). Adjustments need to be made to the coronal CT image in order to bring the scope to a horizontal position and to bring the green dot cephalad (towards the 1 o'clock position on the screen) to match the EBUS image. For practical purposes, one can print out or save the coronal CT image showing station 4L as a separate picture. This picture is then rotated clockwise in order to "horizontalize" the scope and bring the green dot cephalad towards the 1 o'clock position (Fig. 5a). In this fashion, the coronal CT image and the EBUS image correlate and show the same structures in the same locations, as well as the characteristic EBUS image at station 4L (Figs. 5b,c).

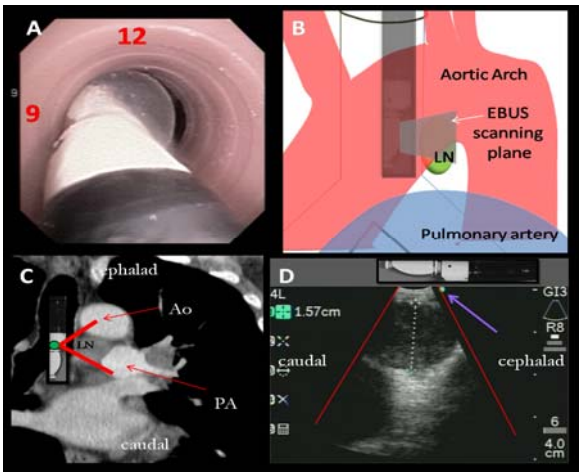

Fig 4. A. Bronchoscopic view showing the EBUS scope with the transducer oriented towards the left lateral wall of the trachea at 9 o'clock position when the patient is bronchoscoped from the head. B. Schematic representation of the EBUS scope orientation and the adjacent vascular structures when scanning station 4L. C. Close view of station 4L, aortic arch (cephalad), pulmonary artery (caudal) and the vertical EBUS scope orientation on coronal CT view. D. Endoscopic ultrasound image is projected as if the EBUS scope is horizontal. The green dot is oriented towards the 1 o'clock position, which is the cephalad portion of the body.

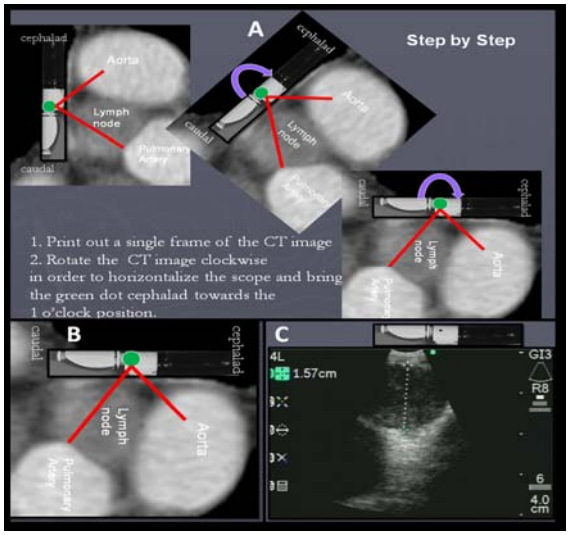

Fig 5. A. Coronal CT image adjustments are made to bring the green dot cephalad as in the EBUS image. B. Coronal CT image is projected as if the EBUS scope is horizontal. The aortic arch is cephalad and the pulmonary artery is caudal. C. EBUS image, being projected by default as if the scope is horizontal, shows the same structures as the adjusted coronal CT image.

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