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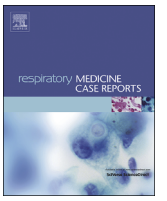

Case Report

Longitudinal use of three different navigational bronchoscopy systems to sample lung nodules in a single patient

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ABSTRACT

Bronchoscopic techniques to sample suspicious lung nodules have progressed from traditional bronchoscopy to guided navigational bronchoscopy systems. Here we present the case of a patient who underwent navigational bronchoscopies using three different systems over a period of 41 months that diagnosed two primary and one metastatic thoracic malignancy. As guided bronchoscopy systems for the diagnosis of lung nodules continue to advance, it is important to recognize that the full utilization of accessible tools and technologies combined with shared decision making may often lead to a successful procedure and accurate diagnosis.

Abbreviation list

ENB	electromagnetic navigational bronchoscopy
RAB	robotic-assisted bronchoscopy
r-EBUS	radial endobronchial ultrasound
CBCT	cone beam computed tomography
ssRAB	shape sensing robotic assisted bronchoscopy
PET/CT	positron emission tomography/computed tomography
CTTB	CT-guided transthoracic biopsy

1. Introduction

The technologies used in advanced diagnostic bronchoscopy procedures have progressed over the years from traditional bronchoscopy with self-navigation to ultra-thin bronchoscopy, pre-planning software for virtual bronchoscopy, manual electromagnetic navigational bronchoscopy (ENB), and robotic-assisted bronchoscopy (RAB). These bronchoscopic procedures are often combined with advanced imaging modalities such as radial endobronchial ultrasound (r-EBUS), digital tomosynthesis, cone beam computed tomography (CBCT) and augmented fluoroscopy to confirm catheter to lesion location prior to biopsy. As advanced diagnostic bronchoscopy has progressed, the primary goal has remained the same: devise a technology that allows for the safe diagnosis of lung nod-

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ules and mediastinal staging in a single procedure with comparable diagnostic accuracy to percutaneous biopsy. The hope is that these technologies allow the diagnosis of smaller nodules and earlier stage lung cancer, ultimately leading to improved patient care and outcomes.

Although each technology has certain limitations, full utilization of accessible resources may often lead to a successful procedure and accurate diagnosis, even when less advanced technology is available. It is important to recognize that the people behind the tools and the shared decision making that occurs will ultimately impact patient care the most, rather than just the specific technology utilized. Here we present the case of a patient who underwent navigational bronchoscopies using three different systems over a period of 41 months that diagnosed two primary and one metastatic thoracic malignancy.

2. Case presentation

A 75-year-old patient with an active 50 pack year smoking history and COPD was initially referred for evaluation of an incidentally identified 2.3 cm left lower lobe lung nodule without mediastinal or hilar adenopathy (Fig. 1A). She underwent ENB utilizing the SPiN Thoracic Navigation System (Veran Medical Technologies, St. Louis, Missouri) with biopsies performed under fluoroscopic guidance. Pathology was positive for small cell carcinoma. She underwent treatment for limited stage disease with concurrent chemotherapy and radiation therapy.

Surveillance imaging approximately 12 months later revealed interval development of a 7 mm right lower lobe nodule. Given the small size, this nodule was followed with serial CT imaging. Interval growth was noted and given increasing concern for malignancy, a biopsy was attempted (Fig. 1B). She underwent repeat bronchoscopy and biopsy 19.6 months after the initial procedure utilizing ENB with the super Dimension Navigation System (Medtronic, Minneapolis, Minnesota) with r-EBUS combined with fluoroscopy. Pathology was positive for squamous cell carcinoma, and she was treated with stereotactic body radiation therapy for a second primary lung malignancy.

Routine serial imaging was performed, and a new 1.4 cm left upper lobe nodule was identified approximately 39 months from the initial squamous cell carcinoma diagnosis (Fig. 1C). She then underwent a third navigational bronchoscopy procedure with shape sensing robotic assisted bronchoscopy (ssRAB) using the Ion endoluminal system (Intuitive Surgical, Sunnyvale, California) with combined r-EBUS, CBCT and augmented fluoroscopy that diagnosed squamous cell carcinoma. Based on subsequent positron emission tomography/computed tomography (PET/CT), she was diagnosed with stage IV disease and treated with immunotherapy. Unfortunately, months later she experienced a large cerebrovascular accident and was transitioned to palliative care.

3. Discussion

This patient had a unique experience in that she underwent bronchoscopic biopsy to sample nodules in three different lobes of the lung using three different navigational systems. Based on the nodules' location (primarily central or middle one-third portion of the lung) with underlying emphysema, it was determined that bronchoscopic biopsy was the best initial diagnostic choice to minimize complications while still acknowledging the limitations of each system regarding the diagnostic yield as reported in the literature. This involved utilizing the best available tools and technology for the time while assessing risk versus benefit of each, combined with shared decision making with the patient.

During the patient's initial procedures utilizing ENB, the global multi-center NAVIGATE trial was underway and has now reported a 24-month diagnostic yield of 67.8% [1]. Meta-analyses of electromagnetic navigational systems report a pooled overall diagnostic accuracy of 74.2% with $<2\%$ complications [2]. The addition of robotic technology with navigational bronchoscopy has allowed for improved precision and stability. The early reported diagnostic accuracy of ssRAB with advanced imaging ranges from 81.7 to 91.2%, with a low rate of complication [3–7]. A multicenter retrospective review of consecutive patients who underwent RAB versus CT-guided transthoracic biopsy (CTTB) for evaluating pulmonary lesions described a similar diagnostic yield between modalities (87.6% for RAB and 88.4% for CTTB). The complication rate for RAB was lower than CTTB (4.4% vs 17%) and within the CTTB cohort, 37.5% patients needed a second procedure (endobronchial ultrasound for mediastinal staging) [8].

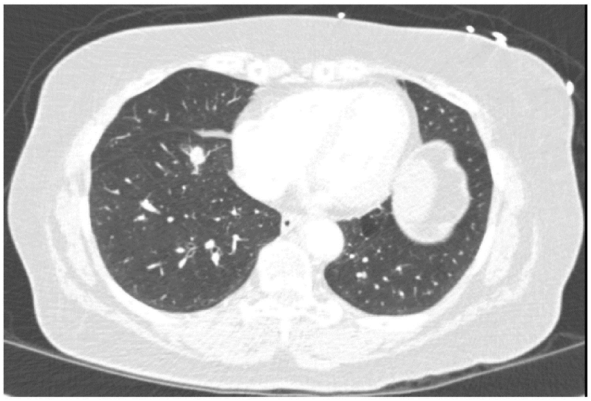
Despite advances in technology, a recent meta-analysis of 16,389 lesions from 126 studies using guided bronchoscopic techniques noted no significance difference in diagnostic yield prior to 2012 (70.5%) versus after 2012 (69.2%), nor significant differences between different technologies utilized. Notably this analysis had a limited number of studies included that utilized robotic assistance [9].

The aim of this report is not to directly compare the diagnostic accuracy of the various technologies, but rather to highlight that as advancements continue to be made with opportunities for improved diagnostic and therapeutic capabilities, the technology is not necessarily the only contributor to patient outcomes and experiences. As illustrated with this patient, multiple tools and technologies were utilized, all of which successfully led to a lung cancer diagnosis allowing for appropriate treatment. Fortunately for this patient, she had three uncomplicated diagnostic procedures, which negated the need for repeat biopsy procedures.

Whereas there is a paucity of data describing the patient experience and satisfaction with various navigational bronchoscopy systems, we do know that patient-physician relationships and communication have an impact on early lung cancer diagnosis [10]. We must acknowledge the humanity of pulmonary procedures and the fact that caring for patients with thoracic malignancies goes beyond the technologies used to make the diagnosis. The outcomes will only be as good as those providing the patient care.

A: Nodule 1, 2.3 cm left lower lobe

B: Nodule 2, 1.2 cm right lower lobe



C: Nodule 3, 1.4 cm left upper lobe

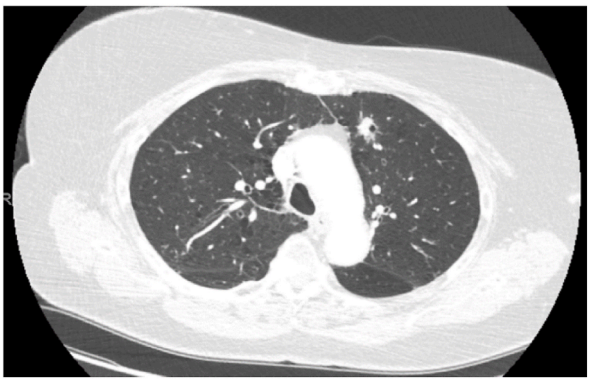


Fig. 1. A: Nodule 1, 2.3 cm left lower lobe. B: Nodule 2, 1.2 cm right lower lobe. C: Nodule 3, 1.4 cm left upper lobe.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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