Peer Review File

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Reviewer A Comments:

Comment 1: Could the authors please discuss shape sensing technology (lines 111-112) in more detail? Could the authors please compare/contrast shape-sensing technology with EMN?

Reply 1: we added some text.

Changes in text: *The Ion™ catheter employs fiber-optic shape sensing technology which measures the shape of the catheter a hundred times per second and provides immediate feedback as it navigates. Shape sensing localizes and quantifies catheter deformation at one or more locations along the length of a fiber-based sensor. This feedback provides simultaneous measurement of three-dimensional bending, twisting, axial elongation and compression, and temperature changes allowing for shape reconstruction in real-time. Shape sensing technology is not subject to interference from nearby metal objects and thre is no need for an electromagnetic generator, patient sensors, or room mapping.*

References:

1. https://shapesensing.com/3d-shape-sensing-basics/

2. https://www.lungdiseasesjournal.com/articles/review-technology-and-techniques-for-robotic-assisted-bronchoscopy.html#:~:text=The%20Ion%E2%80%99s%20thin%2C%20flexible%20fiber%20optic%20shape%20sensor,not%20subject%20to%20interference%20from%20nearby%20metal%20objects.

Comment 2: Could the authors please discuss the flexibility of the catheter that is used (lines 152-159)? Does it deflect or remain in place while tools are advanced?

Reply 2: We added some text

Changes in text: *Additionally, the 180˚ catheter articulation and four way steering capability allow for sharp turns into upper lobe segments. Passage of biopsy tools is rarely limited by insertion into the target segment. Once at the target lesion, the scope automatically locks in position while the instruments are advanced. For instances where the bend of the catheter is too sharp to allow passage of a larger tool (i.e. forceps), the catheter can be relaxed to allow passage of the tool and then re-articulated and locked into position. In our institution this feature has led to less damage inflicted on bronchoscopes attempting to make sharp turns.*

Reviewer B comments:

Comment 1: Please change the title to: "Robotic Bronchoscopy for Diagnosis of Lung Nodules using the ION system: Technical Aspects and 2 Advantages over Standard Flexible Bronchoscopy with Electromagnetic Navigation bronchoscopy".

Reply 1: We have modified text as advised except did not insert "2," removed bronchoscopy at the end.

Change in the text: Robotic Bronchoscopy for Diagnosis of Lung Nodules using the ION system: A Narrative Review of the Technical Aspects and Advantages over Standard Flexible Bronchoscopy with Electromagnetic Navigation

Comment 2: Additionally within the section "Logistics" I would add a detailed step by step procedural description and cover the following elements:

Reply 2: We have added text.

Change in the text: *Within our institution we have completed over 120 cases between February 2020 and July 2021. With transition of the Ion™ endoluminal system out of the operating room to an endoscopy suite with dedicated respiratory staff, the overall procedure time has improved from 136.1 minutes to 91.5 minutes for cases requiring EBUS and 79.8 minutes to 64 minutes for cases requiring Ion™ only. In patients who have a low clinical likelihood of positive lymph nodes, the Ion™ is done prior to linear endobronchial ultrasound (EBUS). This allows for better visualization before blood is introduced into the airway after lymph node sampling. Additionally earlier navigation when there is less atelectasis can decrease divergence, especially in lower lobe lesions. The following steps delineate the process of preparing for and performing an Ion ™ bronchoscopy.*

1. *Patient selection: When it has been determined a nodule requires a biopsy, the following parameters are used to determine ideal candidates for robotic navigation.*
    a. *Peripheral nodule not accessible by standard bronchoscopy*
    b. *Patient also requiring lymph node staging with endobronchial ultrasound*
    c. *Airway leading to nodule (i.e. bronchus sign)*
    d. *Nodule not accessible via a transthoracic approach*
2. *CT scan: A CT scan for pre-planning is required and is generally obtained 1-2 days prior to the procedure. The parameters recommended by Intuitive include slice thickness and slice spacing of 0.5-0.8mm, and a pitch greater than or equal to one. However, standard 1mm cuts are generally sufficient and older scans can be used. In our institution we avoid using scans older than 1 month old. The scan is then uploaded on the planning laptop where the target is identified and paths are built. Additional airways can be built and computer-generated paths can be edited. Additionally, virtual borders to demarcate pleura or fissures can be added and/or edited so they are easily identified intra-procedurally.*
3. *Positioning: Given the need for fluoroscopy patients are transferred to a fluoroscopy-acceptable OR table in the supine position. The arms are tucked to avoid contact with the equipment.*
4. *Anesthesia: As many patients undergoing a robotic bronchoscopy also require a staging exam via EBUS, the default is to intubate with an 8.0 mm endotracheal tube (ETT). If only robotic navigation is required, a smaller endotracheal tube can be used. Anesthesia*

maintains paralysis throughout the case as well as a positive end expiratory pressure (PEEP) of 10cm H20 to augment airway distention and visualization. Periodically anesthesia can provide recruitment maneuvers, i.e. 10 seconds of PEEP up to 30 or 40mm H20. This can be especially helpful when trying to enter small airways.

5. *Docking: Prior to registration the airways are inspected and cleaned out with a standard flexible bronchoscopy and the distal-end of endotracheal position is adjusted to mid-trachea. The robotic arm is then attached to the ETT via an Ion™ specific magnetic bronchoscopy adapter.*
6. *Registration & Navigation: Registration is then completed using the controller by first matching the virtual carina to the visualized carina. This is followed byentry into the each main stem and each lobe for registration as guided by the prompts. If a patient has had a lobectomy partial registration can be completed. After registration is complete, an arrow delineates the path to the target.*
7. *Fluoroscopy: After navigation to the nodule, fluoroscopy is set up to guide biopsy. The robotic system provide an optimal angle for fluoroscopy to visualize the tools exiting the catheter.*
8. *Radial EBUS: Radial EBUS is utilized at the virtual target to obtain real-time feedback. To do this the vision probe is removed and the radial EBUS is inserted under fluoroscopy as the catheter position is simultaneously adjusted.*
9. *Biopsy: Prior to biopsy the vision probe is reinserted to ensure approximation with the airway wall. Tissue sampling is then completed under fluoroscopy. The most commonly used biopsy tools include the Cook® biopsy forceps and the Flexision 21 gauge needle. Overall yield data is still pending.*
10. *Post-bronchoscopy care: A chest x-ray roentgenogram (x-ray) is completed to evaluate for a pneumothorax. Robotic equipment is sterilized for repeat use and disposed of once it has reached the company-specified life span.*