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Fast Track Pathway for Lung Cancer: The Integration of ION Robotic-Assisted Bronchoscopy With Robotic Thoracic Surgical Resection

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Abstract

Background: Delays between diagnosis and definitive treatment in early-stage lung cancer can lead to disease progression and patient anxiety. Recent advances in robotic-assisted bronchoscopy and surgery provide opportunities to streamline care and reduce treatment timelines.

To evaluate the feasibility, safety, and diagnostic performance of an integrated Fast Track protocol combining ION robotic-assisted bronchoscopy with radioactive marker placement and subsequent robotic surgical resection in patients with small or indeterminate pulmonary nodules.

Methods: A retrospective cohort study was conducted on consecutive patients undergoing ION-guided bronchoscopy with technetium-99m-labeled marker placement, followed by robotic resection, from December 1, 2024, to March 31, 2025. The protocol included preoperative imaging (Day 1), bronchoscopy with biopsy and marker placement (Day 2), and robotic surgery (Day 3). Primary outcomes included diagnostic yield and need for preliminary wedge resection; secondary outcomes assessed localization accuracy, perioperative results, and procedural complications.

Results: Ten patients were included, with a median age of 59 years and a median nodule diameter of 14.0 mm. Diagnostic yield from bronchoscopy was 90%, and localization success was 100%. Robotic resection (lobectomy in 9 cases, segmentectomy in 1) was performed the day after bronchoscopy. No procedural complications occurred, and the median hospital stay was six days.

Conclusions: This integrated Fast Track pathway is feasible, safe, and effective in expediting diagnosis and treatment for early-stage lung cancer. However, the small sample size of this initial series (n = 10) limits the generalizability of these findings, which should be interpreted in the context of our institutional case selection, favoring nodules accessible by the ION system and patients with good performance status. The protocol enhances clinical efficiency by consolidating diagnostic and therapeutic steps while maintaining high diagnostic accuracy. Broader validation is warranted in larger multicenter studies.

Keywords

lung cancer, fast track pathway, robotic-assisted bronchoscopy, robotic thoracic surgery, diagnostic yield

Introduction

Lung cancer remains the leading cause of cancer-related mortality worldwide, with surgical resection offering the best chance of long-term survival in early-stage disease. Despite advancements in diagnostics and therapeutics, significant delays between diagnosis and definitive treatment persist, contributing to disease progression and patient anxiety. In recent years, the integration of minimally invasive techniques has revolutionized thoracic oncology, enabling safer and more precise interventions. Robotic-assisted thoracic surgery (RATS) has improved perioperative outcomes, reduced hospital stays, and superior lymph node dissection compared to conventional

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approaches.[1] Simultaneously, the emergence of robotic-assisted bronchoscopy platforms—such as the ION system—has enhanced the accuracy of peripheral nodule sampling and mediastinal staging, offering diagnostic yields exceeding 80% in experienced centers.[2]

This manuscript aims to describe and evaluate a streamlined Fast Track pathway that integrates robotic-assisted bronchoscopy for diagnostic staging with robotic thoracic surgical resection to reduce time to treatment, optimize perioperative outcomes, and enhance the overall efficiency of care for patients with operable lung cancer. In the context of this study, the term "Fast Track" refers to a streamlined, coordinated clinical pathway in which patients complete preoperative imaging, diagnostic bronchoscopy with lesion localization, and definitive robotic surgical resection on three consecutive days, with surgery performed within 24 hours of tissue diagnosis.

Material and Methods

A retrospective cohort study evaluated the feasibility and performance of a Fast Track pathway integrating robotic-assisted bronchoscopy and robotic thoracic resection for patients with suspected or confirmed small, early-stage non-small cell lung cancer (NSCLC). The study included all consecutive patients who underwent robotic-assisted bronchoscopy with radioactive marker placement followed by robotic surgery between December 1, 2024, and March 31, 2025. No exclusion criteria were applied.

The Fast Track protocol was structured across a 3-day preoperative sequence, conducted with the patient admitted as an inpatient, to achieve diagnosis, localization, and resection in a condensed timeframe.

On Day 1, patients underwent a whole CT scan and a whole-body PET CT scan.

Day 2 involved diagnostic bronchoscopy using the ION robotic platform. A transbronchial needle aspiration biopsy was performed on the pulmonary lesion, and rapid on-site cytologic evaluation (ROSE) was systematically carried out to provide immediate diagnostic feedback (Video 1). If ROSE confirmed malignancy, the bronchoscopic session proceeded directly to intralesional or perilesional placement of a radioactive marker for surgical guidance (Video 2). The radioactive localization technique employed technetium-99m-labeled macroaggregated albumin (99mTc-MAA), administered through a 25-gauge needle with a mixture of 0.15 mL of 99mTc-MAA and 0.15 mL of nonionic iodinated contrast medium, for a total volume of 0.6 mL. The dose, adjusted based on timing relative to surgery, ranged from 15 to 22 MBq of radioactivity. A limited non-contrast CT scan confirmed correct needle positioning and optimal deposition of the marker. Nuclear medicine scintigraphy was then used to verify successful radiotracer localization within the lung parenchyma.

Day 3 was dedicated to definitive surgical resection via a robotic-assisted approach using the da Vinci platform. A gamma detection probe targeting the radioactive signal facilitated intraoperative lesion identification.[3] In some cases, indocyanine dye was added to assist with visual identification. An initial wedge resection was performed for non-diagnosed lesions, and the specimen underwent frozen section analysis. Based on intraoperative pathology, either the resection was deemed complete, or a formal lobectomy or segmentectomy was performed if malignancy was confirmed or margins were insufficient.

Data collected included patient demographics, lesion characteristics (size, radiographic features, and anatomical location), preoperative diagnostic findings, number of lesions targeted, results of transbronchial biopsy, localization success, final pathology, surgical approach, and type of resection, perioperative course, and any procedure-related complications. The primary endpoint was the diagnostic yield of the ION-guided biopsy and its ability to obviate the need for an initial wedge or segmental diagnostic resection. Secondary endpoints included localization accuracy, operative outcomes, length of stay, and adverse events related to the bronchoscopic or surgical procedures.

Results

A total of 10 patients underwent the proposed Fast Track protocol, incorporating robotic-assisted bronchoscopy with radioactive marker placement, followed by robotic surgical resection. The cohort had a median age of 59 years (range: 59 – 75 years), with a male-to-female ratio of 0.43. Eight nodules had a solid aspect, and 2 had pure ground glass opacities. The median diameter of the lesions was 14.0 mm (range: 6.0 – 21.0 mm). The ION procedure had a median duration of 28 minutes (range: 15 – 65 minutes). Among the analyzed patients, the diagnostic yield of the robotic bronchoscopy was 90%, calculated based on histological confirmation from bronchoscopic specimens, including both ROSE assessment and final histopathology of the biopsy samples. Surgical pathology from the resection specimens was not included in this calculation.

One pulmonary nodule was targeted per patient. In two patients, bronchoscopic biopsy results were non-diagnostic, and the final diagnosis of malignancy was established from the surgical resection specimens. In 8 patients, ROSE evidenced the presence of neoplastic cells. The radioactive marker-guided localization was effective in all cases, enabling accurate identification of the target lesion intraoperatively using gamma probe navigation. Surgical intervention the following day was performed via a robotic approach in all cases (Table 1). The most common resection was lobectomy (9 cases). An initial wedge resection was required in only one patient,

Table 1. Demographics and Clinicopathological Characteristics.

Category	n
Tumor location	
Right upper lobe	5
Left upper lobe	3
Left lower lobe	3
Type of operation	
Lobectomy	9
Atypical segmentectomy	1
Histology	
Adenocarcinoma	10
pT	
T1a mi	1
T1a	2
T1b	5
T2a	2
pN	
N0	9
Stage	
IA1	2
IA2	5
IB	2

who subsequently underwent an atypical segmentectomy for a pure small GGO after intraoperative frozen section confirmed malignancy. Despite the small median tumor size, anatomical segmentectomy was not performed in most cases because lesion location, radiological features suggestive of invasive adenocarcinoma, or the presence of additional risk factors favored lobectomy to ensure oncologically adequate margins following current surgical guidelines. The overall median length of hospital stay was 6 days (range: 5 – 8 days), aligning with enhanced recovery after surgery (ERAS) principles. No postoperative complications related to the bronchoscopic or surgical procedures were recorded. The median time from diagnosis (ION bronchoscopy) to surgery was 1 day, and the median time from radiological detection to surgery was 11 days. In our prior institutional pathway without Fast Track integration, these intervals were typically longer, with a median diagnosis-to-surgery time of about 24 days and a detection-to-surgery time exceeding 30 days.

Discussion

The present study outlines the successful implementation of a Fast Track protocol combining shape-sensing robotic-assisted bronchoscopy with 99mTc-MAA localization and subsequent RATS for the management of small or difficult-to-access pulmonary nodules. In our series, we achieved a 90% diagnostic yield using the ION system, and intraoperative localization was successful in all cases with gamma probe navigation. These findings demonstrate the feasibility, safety, and efficiency of this minimally invasive, integrated diagnostic-therapeutic model.

Traditional localization strategies, such as electromagnetic navigational bronchoscopy (ENB) with pleural dye marking, have proven helpful in identifying non-palpable nodules. Bolton et al. reported on 19 patients in whom ENB was used successfully for dye marking before robotic resection, achieving accurate lesion localization without conversion to thoracotomy and procedure-related complications.[4] However, the ENB approach depends heavily on the pleural surface visualization, which may be suboptimal for deep or non-peripheral lesions.

An alternative strategy using CT-guided percutaneous radiotracer injection was previously explored.[3] Nevertheless, this method is associated with significant complications, including a pneumothorax rate of nearly 30%, and requires a separate interventional radiology procedure before surgery. In contrast, our fully endobronchial technique obviates the need for pleural puncture and reduces procedural burden by combining biopsy, localization, and surgical planning into a single coordinated episode.

Moreover, the characteristics of the learning curve across a cohort of operators support the efficiency and effectiveness of robotic bronchoscopy in diagnostic yield and workflow integration. They observed that proficiency in diagnostic sampling was typically achieved within 25 lesions, with subsequent targeting of more complex anatomical areas.[2] Our experience, although in a smaller initial series, aligns with these observations and reflects a high diagnostic yield facilitated by skilled proceduralists and systematic use of ROSE.

The broader context of fast-track, patient-centered cancer care was developed with the Instadiag digital platform for expedited lung cancer diagnosis. Their model demonstrated that online self-referral combined with centralized coordination could deliver diagnostic results efficiently, comparable to traditional general practitioner-referral pathways.[5] While our approach did not employ a digital interface, it shared core principles of diagnostic acceleration, integration of services, and minimization of care fragmentation.

The strengths of this study lie in its demonstration of complete integration between advanced diagnostic bronchoscopy and definitive resection within a 3-day clinical window. All patients underwent robotic surgery guided by intraoperative radiodetection, which allowed confident lesion localization and minimized the need for initial wedge resections. Although most lesions in our series were ultimately treated with lobectomy, intraoperative localization remained valuable to confirm lesion position and ensure margin adequacy. This was particularly relevant in cases where intraoperative pathology

might have led to a change toward a more limited resection. Furthermore, incorporating localization as a standard step supports workflow consistency and protocol applicability to a broader spectrum of resections, including segmentectomies and wedge resections. This protocol also supports enhanced recovery principles through shortened hospital stays and avoidance of unnecessary surgical staging procedures.

However, limitations must be acknowledged. This retrospective study with a small sample size was conducted in a high-volume, specialized center. The cohort reflects our institutional case selection, which prioritizes patients with nodules accessible by the ION robotic platform and with good performance status, potentially introducing a selection bias. The absence of a comparator group prevents us from determining whether the Fast Track approach results in superior outcomes—such as shorter diagnosis-to-treatment intervals, lower complication rates, or improved patient experience—compared to conventional workflows. The present study was designed primarily to assess feasibility and safety, and these comparative aspects will require a prospective controlled evaluation. The results may not be generalizable to lower-volume institutions or those without access to robotic bronchoscopic and surgical platforms. Long-term outcomes regarding recurrence, survival, and cost-effectiveness were not within the scope of this initial report and warrant prospective evaluation. Furthermore, long-term follow-up data on oncologic outcomes, recurrence rates, and patient-reported measures are not yet available due to the recent initiation of this protocol. These will be important to assess in future studies to fully evaluate the clinical impact of the Fast Track approach beyond feasibility and diagnostic yield.

Conclusions

The integration of shape-sensing robotic-assisted bronchoscopy with radioactive marker placement and subsequent robotic thoracic resection within a streamlined Fast Track protocol demonstrates both feasibility and clinical efficacy in the management of small or indeterminate pulmonary nodules. This approach significantly shortens the diagnostic-to-treatment interval, enhances localization accuracy, and minimizes the need for preliminary wedge resections, while maintaining a high diagnostic yield and excellent perioperative safety. By consolidating diagnosis, localization, and definitive treatment into a coordinated, minimally invasive workflow, this model represents a meaningful advancement in patient-centered thoracic oncology care. Broader implementation and validation in larger, multicenter cohorts are warranted to confirm its utility and scalability.

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Supplemental Material

Supplemental material for this article is available online.

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