Original Article

Streamlining care with single anesthetic robotic lung cancer diagnosis and resection

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Contributions: (I) Conception and design: TA Imai; (II), Administrative support: None; (III) Provision of study materials or patients: B Tokeshi, TA Imai; (IV) Collection and assembly of data: AW Wong, EY Wang; (V) Data analysis and interpretation: AW Wong, EY Wang, TA Imai; (VI) Manuscript writing: All authors; (VII) Final approval of manuscript: All authors.

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Background: Single-setting anesthetic robotic navigational bronchoscopy (RNB) biopsy combined with robotic-assisted thoracoscopic surgery is a promising novel pathway for the diagnosis and treatment of non-small cell lung cancer (NSCLC). With a shorter time interval from diagnosis to definitive surgical treatment, potential reduction in risks with multiple anesthetic events, and decreased social and psychological impact on the patient, it has garnered interest in the treatment of early-stage lung cancer. In this study, we examine our single institution experience with this novel pathway to lung cancer care: taking a patient with an undiagnosed and suspicious lung nodule to cancer diagnosis, staging, and surgical treatment under a single anesthetic event.

Methods: A database of 195 patients with pulmonary nodules undergoing robotic-assisted navigational bronchoscopy biopsy was used to identify those who underwent a single anesthetic event from October 2022 to August 2023. Demographics and clinical characteristics including tobacco use, pulmonary nodule characteristics, procedure time, biopsy technique and surgical intervention, pathologic staging, and perioperative complications were collected.

Results: A total of 15 single-anesthetic cases were identified. Average nodule size biopsied was 17.3 mm [standard deviation (SD) =7.1], with most located in the peripheral third (40%, n=6). Median procedure time of RNB plus robotic resection was 284 minutes [interquartile range (IQR) =114]. When linear EBUS was included for mediastinal staging, the median procedure time was 355 (IQR =42) minutes. Ten patients underwent lobectomy (67%), 4 segmentectomy (27%), and 1 wedge resection. Three patients (20%) had prolonged air leak after surgery. No other complications were noted. Final pathological staging resulted in 7 patients with stage 1A (47%), 7 with stage 1B (47%), 1 with stage 2B (6%).

Conclusions: RNB biopsy with mediastinal staging to robotic resection under a single anesthetic event appears to be a safe and oncologically sound pathway for the management of early-stage lung cancer patients that shortens the time interval from diagnosis to treatment.

Keywords: Non-small cell lung cancer (NSCLC); robotic assisted bronchoscopy; single-setting anesthesia event

Received: 23 October 2023; Accepted: 11 March 2024; Published online: 18 April 2024.
doi: 10.21037/ccts-23-14
View this article at: https://dx.doi.org/10.21037/ccts-23-14

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Introduction

Lung cancer is the second most commonly diagnosed malignancy, accounting for 11–12% of all new cancer cases annually worldwide (1,2). Moreover, it is the leading cause of cancer-related death with nearly 1.8 million cases reported in 2020 (1,3). Although the overall 5-year survival rate of lung cancer (25.4%) is considerably lower than other common cancers such as breast (90.8%), prostate (97.1%), and colorectal (65%), rates improve to 65% when detected at an early stage (I or II) (2). Fortunately, these rates have improved over the years due to advances in early detection and treatment (2,4). The 2011 landmark National Lung Screening Trial (NLST) demonstrated a 20% reduction in lung-cancer associated mortality through screening high-risk individuals with low-dose computed tomography (LDCT) (5). This provided the framework for the current US Preventive Service Task Force recommendations for annual lung cancer screening with LDCT in adults aged 50 to 80 years with a 20 pack-year smoking history and current tobacco use or have quit within the last 15 years (6). This, in conjunction with increased accessibility to CT imaging, has allowed for an estimated 1.57 million new nodules identified annually with 4% receiving a new cancer diagnosis within 2 years of imaging (7). Additionally, lung nodules are being detected at smaller sizes, and up to 80% are located in the lung periphery—both of which pose a clinical challenge in diagnosis and management (5,8,9).

Surgical resection offers the best opportunity for remission and long-term survival, especially in early-stage or locally advanced tumors. Studies now show overall 5-year survival rates of up to 95% and 83% for stage IA1 and IA2 cancers respectively (10,11). Despite these promising outcomes, one of the largest barriers to optimizing survival remains the delay in the time interval from diagnosis to treatment. The conventional diagnostic and treatment pathway of non-small cell lung cancer (NSCLC) includes consultation by a specialist followed by multiple procedures over many weeks including biopsy to confirm malignancy, mediastinal staging, and finally surgical resection if appropriate. Consultation from providers across different specialties, such as pulmonology, radiology, and thoracic surgery are needed and may further contribute to delays. Delays in care greater than 8 weeks are associated with higher rates of upstaging, increased 30-day mortality, and decreased median survival (12). Primary lung cancer has one of the longest median times from diagnosis to first treatment at 35 days. Older age, black race, treatment at academic centers or veterans affairs centers, and possibly early-stage disease have been identified as risk factors for delays in care (13). As such, the ability to combine diagnostic and therapeutic intervention under a single anesthesia event not only expedites definitive oncologic care but could also be a cost-saving measure and has the potential to improve overall survival in the deadliest cancer worldwide. In this study, we present our institution's experience in the novel approach of robotic navigational bronchoscopy (RNB) biopsy and robotic-assisted thoracoscopic surgery (RATS) to diagnose, stage, and treat early-stage lung cancer within a single anesthetic setting. We present this article in accordance with the STROBE reporting checklist (available at https://ccts.amegroups.com/article/view/10.21037/ccts-23-14/rc).

Highlight box

Key findings

- The single anesthetic approach for lung cancer diagnosis, staging, and treatment is feasible and safe for early-stage non-small cell lung cancer.

What is known and what is new?

- Delays in the time interval between diagnosis and surgical treatment of lung cancer beyond 8 weeks decreases patient overall survival. This study demonstrates feasibility and safety of a novel single-anesthetic pathway for lung cancer diagnosis, staging and treatment to shorten the time interval between diagnosis and definitive treatment.

What is the implication, and what should change now?

- By shortening the time from diagnosis to definitive surgical treatment, the single-anesthetic pathway may increase patient survival. Future studies evaluating the broader feasibility of implementing the single-anesthetic pathway in various institution types and cost comparisons between the traditional and anesthetic pathways are needed to further explore the impact of this novel pathway to change the workflow of early-stage lung cancer. Additionally, short term and long term recurrence and survival analyses comparing the traditional pathway to the single anesthetic pathway are also warranted.

Methods

A prospectively collected database of 195 patients with pulmonary nodules from a single institution who underwent robotic-assisted biopsy using the Ion™ platform (Intuitive Surgical, Sunnyvale, CA, USA) at the Queen's Medical Center from October 1, 2022, through September 1, 2023. The timeframe of this study includes all patients who underwent RNB biopsy since the implementation of this technology at our institution. The data was

retrospectively reviewed to identify patients who underwent diagnosis, staging, and surgical resection under a single-anesthetic event. After a multidisciplinary discussion, patients considered for single-anesthetic pathway included those who had pulmonary nodules with a high index of suspicion for early-stage malignancy [determined at the discretion of the surgeon by evaluating patient risk factors—specifically personal or family history of malignancy, tobacco use, and radiographic characteristics such as spiculation, growing nodule size, and positron emission tomography (PET) avidity], and acceptable cardiac and pulmonary function to tolerate general anesthesia and anatomical lung resection. Patients with lymphadenopathy, PET avid mediastinal nodes, invasion into surrounding structures, metastatic lesions, and limiting pulmonary and cardiac function were excluded.

All patients selected for the single anesthetic pathway underwent airway mapping with thin-cut (≤1 mm) non-contrast CT chest prior to the single anesthetic procedure. The CT chest protocol includes a slice thickness of 0.5–1.0 mm to have zero to slight overlap, slice spacing of 0.5–0.8 mm to ensure a high-resolution image to identify peripheral airways, pitch of ≥1.0 to reduce motion artifacts from breathing and cardiac motion, and an optimal voltage of 110–140 kV to reduce artifacts in the lung apexes. The operators performing the RNB biopsy included a thoracic surgeon with over 3 years of experience performing over 300 robotic navigational bronchoscopies and an interventional pulmonologist with 1 year experience performing 200 RNBs. The case was scheduled as a joint case in the operating room with a thoracic surgeon available to proceed with resection when indicated. Once navigation was complete and the nodule was in the target range, nodule localization was sometimes confirmed with radial endobronchial ultrasound (rEBUS) at the discretion of the proceduralist. Biopsies were performed by both fine needle aspiration (FNA) for cytology and tissue biopsies obtained with forceps and cryobiopsy.

Specimens were analyzed with rapid on-site evaluation (ROSE) by an on-site pathologist to obtain a diagnosis. If the diagnosis confirmed a malignancy, then invasive mediastinal staging with EBUS with transbronchial node aspiration (EBUS-TBNA) was performed when indicated according to National Comprehensive Cancer Network (NCCN) guidelines (14). Patients without evidence of N2 disease on EBUS-TBNA then had their single-lumen endotracheal tube (ET) switched to a double-lumen ET tube to proceed to robotic anatomic resection for definitive treatment of their newly diagnosed lung cancer. Diagnostic yield was defined as the percentage of RNB pathology/cytology that matched the final surgical pathology.

Patient data was extracted from clinical records in CareLink and deidentified prior to analysis. The following data was collected: age at the date of procedure, race/ethnicity, personal and family history of malignancy, smoking history, indication for the CT scan identifying the nodule, pulmonary nodule characteristics (appearance, mean nodule size, nodule location, PET avidity, bronchus sign), procedure time, biopsy method (needle aspiration, biopsy forceps, cryobiopsy, endobronchial brush), use of adjunct imaging (includes fluoroscopy and rEBUS), biopsy pathology results, type of resection, chest tube duration, length of hospital stay, peri-operative complications (pneumothorax, tube thoracostomy, bleeding, infection, effusion), and final surgical pathology and stage. Data analysis was performed with descriptive statistics including calculation of mean, median, standard deviation (SD), and interquartile range (IQR). The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by the Research and Institutional Review Committee of The Queen's Medical Center (RA-2023-032) and individual consent for this retrospective analysis was waived.

Results

Fifteen patients underwent a single anesthetic event with a mean age of 71 (SD =10) years old. Sixty percent (n=9) were women. The majority of patients were Asian (67%, n=10), and a minority Native Hawaiian Pacific Islander (20%, n=3) or White (13%, n=2). Only 2 (13%) patients were active smokers, most were former smokers (n=10, 67%), and 3 (20%) had never used tobacco products. Three patients (20%) had a personal history of lung cancer, of which 2 had undergone surgical resection previously and subsequently had discovery of a new nodule noted on surveillance imaging. Most pulmonary nodules were identified incidentally (47%, n=7). Lung cancer screening CT scans accounted for 27% (n=4) of nodules identified and 20% (n=3) were discovered on imaging performed for cancer surveillance of all sites (*Table 1*). Median time between obtaining dedicated pre-procedural CT imaging to procedure was 23 days (IQR =27).

The average nodule size of those treated with the single anesthetic pathway was 17.3 mm (SD =7.1) with the majority located in the peripheral third (40%, n=6) and the remainder distributed in the central third (27%, n=4) and

Table 1 Patient demographics

Variables	Value (N=15)
Age, years	71±10
Gender	
Female	9 (60%)
Male	6 (40%)
Ethnicity	
Asian	10 (67%)
NHPI	3 (20%)
White	2 (13%)
Smoking	
Current	2 (13%)
Former	10 (67%)
Never	3 (20%)
History of lung cancer	3 (20%)
Family history of lung cancer	1 (6%)
History of lung resection	2 (13%)
Nodule identification	
Incidental	7 (46%)
Screening	4 (27%)
Surveillance	4 (27%)
Mean nodule size (mm)	17.3±7.1
Location (lobe)	
Right upper lobe	4 (27%)
Right middle lobe	3 (20%)
Right lower lobe	4 (27%)
Left upper lobe	3 (20%)
Left lower lobe	1 (6%)
Location (axial)	
Peripheral	6 (40%)
Middle	5 (33%)
Central	4 (27%)

Data are presented as mean ± SD or n (%). NHPI, Native Hawaiian Pacific Islanders; SD, standard deviation.

in the middle third (33%, n=5). Two nodules (13%) were characterized as round glass opacities, 5 (33%) spiculated, and 7 (47%) solid nodules. None of the nodules had a radiographic bronchus sign. All nodules (100%, n=15) were hypermetabolic (SUV greater than 2.0) on PET CT. Median total procedure time when RNB biopsy and surgical resection was performed was 284 minutes (IQR =114). When mediastinal staging with EBUS was included in the procedure, the median procedure time was 355 minutes (IQR =42). All procedures used 2-dimensional fluoroscopy as an adjunct imaging modality for safe sampling of the nodule. rEBUS was used in 60% (n=9) of patients for nodule confirmation intraoperatively. Utilization of rEBUS was performed based on provider discretion and nodule localization was 100% (n=9) when performed. Five patients (33%) underwent EBUS-TBNA for mediastinal staging, the remainder had previously obtained PET imaging for staging preoperatively. All nodules were sampled with transbronchial FNA, cryobiopsy, and the majority also with biopsy forceps. The endobronchial brush was not routinely used in all patients (36%, n=5). Nodule and EBUS samples demonstrating malignancy, pathology concerning for malignancy, or a specific benign diagnosis (infection, granuloma) were considered diagnostic. RNB achieved a diagnostic yield of 93% (n=14) (*Table 2*). Only one patient had a non-diagnostic tissue sample (ROSE demonstrated scant degenerative macrophages) on RNB biopsy. Due to a high index of suspicion for malignancy and multiple risk factors including personal history of lung cancer and active tobacco use, this patient first proceeded with wedge resection. Once frozen pathology confirmed malignancy, completion lobectomy was performed. Final pathology ultimately demonstrated squamous cell carcinoma.

Ten patients received lobectomy (67%), 4 segmentectomy (27%). All patients were intended to proceed to anatomic resection with lobectomy or segmentectomy if the RNB was positive for cancer. Only one patient with a history of head and neck cancer treated with radiation underwent wedge resection in lieu of planned lobectomy due to intraoperative challenges with post-radiation fibrosis and scarring at the hilar structures and adhesions to the aorta. The mean lymph node yield was 11 nodes (SD =5). There were no conversions to open surgery. Median chest tube duration was 3 days (range, 1–7 days, IQR =1.5) and the median length of hospital stay was 3 days (range, 1–12 days, IQR =1). Three patients had prolonged air leaks greater than 5 days after resection: two after segmentectomy and the other after lobectomy. No other perioperative complications including pneumothorax, bleeding, or infection occurred (*Table 3*). Plain film chest radiography was routinely obtained prior to outpatient follow up. Two patients developed a small pleural effusion after lobectomy

Table 2 SABR procedure characteristics

Variables	Value (N=15)
Median procedure time (min)	
RNB biopsy	59 [39]
RNB biopsy + surgery	284 [114]
RNB biopsy + EBUS + surgery	355 [42]
Fluoroscopy	
Yes	15 (100%)
No	0
Radial EBUS	
Yes	9 (60%)
No	6 (40%)
Biopsy method	
Transbronchial fine needle aspiration	15 (100%)
Forceps biopsy	14 (93%)
Cryobiopsy	15 (100%)
Endobronchial brush	5 (33%)
Biopsy results	
Adequate tissue	15 (100%)
Diagnostic	14 (93%)
Non-diagnostic	1 (6%)

Data are presented as median [IQR] or n (%). SABR, single-anesthetic bronchoscopy and resection; RNB, robotic navigational bronchoscopy; EBUS, radial endobronchial ultrasound; IQR, interquartile range.

Table 3 Perioperative outcomes

Variables	Value (N=15)
Surgery	
Lobectomy	10 (67%)
Segmentectomy	4 (27%)
Wedge	1 (6%)
Median length of hospital-stay (days)	3 [1]
Median length chest tube (days)	3 [1.5]
Perioperative complications	
Air leak >5 days	3 (20%)
Pneumothorax	0
Bleeding	0
Infection	0
Pleural effusion	2 (6%)

Data are presented as median [IQR] or n (%). IQR, interquartile range.

necessitating referral for thoracentesis, otherwise no other complications were reported (*Table 3*).

Mean nodule size was 15.2 mm (SD =5.3) for patients undergoing segmentectomy and 18.1mm (SD =8.1) for patients undergoing lobectomy. Final surgical pathology included 87% demonstrating adenocarcinoma (n=13) and 13% squamous cell carcinoma (n=2). The benign resection rate was 0%. Most tumors were pathologic stage T2aN0 (46%, n=7) followed by T1aN0 (20%, n=3), T1bN0 (20%, n=3), T1cN0 (7%, n=1), and T3N0 (7%, n=1) (*Table 4*).

Discussion

Modalities for lung nodule biopsy have traditionally relied upon CT-guided percutaneous transthoracic needle biopsy, conventional bronchoscopy with transbronchial biopsy, rEBUS, and first-generation electromagnetic navigation bronchoscopy (ENB) without robotic assistance. Each technique varies in its advantages and limitations with regard to accessibility, diagnostic yield, and peri-procedural complications (15). CT-guided biopsy carries a high sensitivity and specificity of 92.5% and 97.8% respectively and is most effective for peripheral nodules. Complication rates are high, however, especially with smaller and deeper lesions with the incidence of pneumothorax and hemorrhage at 23% and 8% respectively (15). Conventional bronchoscopy with transbronchial biopsy boasts considerably lower rates of pneumothorax and hemorrhage 0.4% and 0.6% respectively, however, this comes at the cost of diagnostic yield which widely varies between 25–84% based on biopsy technique and use of adjunct navigational guidance such as fluoroscopy, EBUS, and ENB (16-21).

RNB is the latest advancement in diagnostic techniques and aims to resolve many of the limitations of conventional bronchoscopy. Currently, three robotic platforms are approved for use by the Food and Drug Administration (FDA): Monarch™ by Auris Health (Redwood City, CA, USA, now acquired by Johnson & Johnson), Ion™ Endoluminal System by Intuitive Surgical (Sunnyvale, CA, USA), and Galaxy™ by Noah Medical (San Carlos, CA, USA). RNB allows for endobronchial navigation into the lung periphery under direct visualization while simultaneously maintaining catheter stability to maximize precision during sampling. Numerous studies have

Table 4 Pathologic diagnosis and staging

Variables	Value (N=15)
Surgical pathology	
Adenocarcinoma	13 (87%)
Squamous cell	2 (13%)
Benign	0
Pathologic stage (T)	
T1a	3 (20%)
T1b	3 (20%)
T1c	1 (7%)
T2a	7 (46%)
T3	1 (7%)
T4	0
Pathologic stage (N)	
N0	15 (100%)
N1	0
N2	0
N3	0
Pathologic stage (N)	
M0	15 (100%)
M1	0
AJCC 8th edition stage	
Stage 1A	7 (47%)
Stage 1B	7 (47%)
Stage 2A	0
Stage 2B	1 (6%)
Stage 3	0
Stage 4	0

Data are presented as n (%). AJCC, American Joint Committee on Cancer.

demonstrated comparable diagnostic yields of 74–85% with robotic platforms compared to traditional bronchoscopy with bronchoscopic biopsy and CT-guided biopsy with similar to lower incidence of pneumothorax and hemothorax (22-28). Additionally, RNB biopsy allows for the ability to concurrently conduct mediastinal staging and the single-anesthetic pathway, thereby shortening the time interval to definitive treatment. Larger clinical trials are needed, however, and are currently ongoing.

RNB biopsy has higher diagnostic yields compared to traditional bronchoscopy with transbronchial biopsy, which increases the ability to proceed to resection in a single anesthetic setting. Our single institution experience demonstrates that a single-anesthetic approach for the diagnosis, staging, and surgical resection of NSCLC offers an expedited pathway that can be performed safely and follows oncologic guidelines. Minimizing the time between cancer diagnosis and definitive surgical treatment has significant implications for clinical perioperative outcomes, patient satisfaction, and overall cancer survival. The British Thoracic Society and the National Institution for Health and Care Excellence (NICE) recommend a maximum time to diagnosis of 14 and 28 days for treatment, however, adherence to these guidelines has proven to be difficult due to issues with access as well as the need for coordination across multiple specialties (29,30). Multiple studies have demonstrated an increased risk of recurrence and decreased overall survival due to disease progression in the interim (12,31). Prior to the implementation of RNB, diagnostic modality was exclusively limited to CT-guided biopsy. As the demand for biopsy greatly outweighed the available resources, many patients with perhaps borderline but stable nodules were monitored with continued surveillance imaging. With the addition of RNB, we are now able to offer patients a pathway that decreases the time interval from biopsy diagnosis of malignancy to definitive surgical treatment. Therefore, we suspect that the time from nodule identification to treatment will greatly diminish as the backlog of patients who were previously relegated to a strategy of watchful waiting is addressed, and patients with newly identified nodules can be managed in a more timely fashion. Nonetheless, this study further highlights the need for larger-scale health care reform to improve access to and timely completion of diagnostic procedures (13).

A recent large retrospective study published in 2021 by Heiden *et al.* demonstrated an increased risk of recurrence [hazard ratio (HR) 0.4%] and worse overall survival for each week of surgical delay after 12 weeks for those with stage 1 NSCLC, with time to surgery defined as the time from most recent preoperative CT-guided biopsy diagnostic imaging to surgical intervention (32). Currently, only one study by Wolf *et al* has examined single-anesthesia biopsy and surgery and demonstrated a shorter time from nodule identification to intervention with lower complication rates, and shorter hospital stay (33). This study aims to add to the current body of literature by demonstrating feasibility and safety of the single-anesthetic pathway in a small cohort.

While the single anesthetic approach can help minimize these delays in care, there are no studies, however, that explicitly quantify or qualify how this reduction in time will translate to meaningful improvement in clinical outcomes and overall survival. Lung cancer patients have been shown to have the highest prevalence of psychologic distress of up to 43% due in part to fear of health-related stigma and perceived futility of care compared to other cancers (34,35). As a result, we suspect that at minimum, patient satisfaction and anxiety will be improved with shorter wait times for intervention (36). Future studies evaluating the financial impact and potential reduction in the overall burden on the healthcare system due to the consolidation of procedural events would be an important area of investigation.

Successful implementation of a single anesthetic program requires participation and coordination from a multidisciplinary thoracic oncology team. This process begins with appropriate patient selection as patients must have adequate cardiopulmonary function to tolerate general anesthesia and single lung ventilation. Thorough evaluation of patient risk factors for lung cancer, radiographic appearance of the nodule, and assessing PET avidity on PET CT scans facilitate the selection of patients with high-risk nodules and minimizes both benign biopsy diagnoses not requiring resection and benign resection rates. Coordination of schedules between proceduralists is paramount as a thoracic surgeon must be on standby to proceed with resection if malignancy is confirmed or if suspicion for malignancy is high. Furthermore, from an oncologic perspective, patient selection is focused on those that have true early-stage disease, and minimizing the incidence of occult N2 disease rates. Patients with the potential to have invasion into surrounding structures are not ideal candidates for the single anesthetic approach since many are candidates for neoadjuvant therapy and require extensive *en bloc* resection that may necessitate coordination of multiple surgeons from various specialties.

The success and feasibility of a single anesthetic pathway is attributed to the high diagnostic yields achieved with RNB and ability to concurrently perform mediastinal staging. In comparison, the more variable diagnostic yields of 25–84% associated with conventional transbronchial biopsy could limit the ability to more confidently proceed to resection under a single anesthetic event (16-21). Our study shows improved diagnostic rates at 93% compared to prior studies at 80–83% for nodules less than 2 cm (16,27,37-39). This may be due to unique features of the robotic technology, specifically the ability to drive out far into the periphery under direct visualization utilizing a 2 mm camera, the ability for the catheter to lock in place during tool exchange and the use of flexible needles to maneuver acute angles such as nodules in the lung apex. When performing RNB to biopsy lung nodules, one of the challenges that can affect the diagnostic yield is CT-to-body divergence. This refers to the difference between the expected and actual location of the target nodule due to the variation in anatomy seen on a static CT image compared to the dynamic bronchoscopic images produced while the patient is breathing. As a result, this divergence impairs the provider's ability to properly overlap the virtual roadmap for nodule targeting, thus increasing procedure time and decreasing diagnostic yield. Strategies to mitigate this divergence focus on reducing atelectasis and include increasing the PEEP to 10 during the procedures and minimizing the time from intubation to procedure start time. The single anesthetic pathway has the potential to replace traditional pathways of lung cancer care for patients who are surgical candidates, however future long-term studies investigating the impact on survival are needed.

Study limitations include the retrospective study design, small sample size of 15 patients, and acquisition of data from a single institution without a matched control cohort may limit its generalizability. Additionally, inherent selection bias exists in our cohort as only patients with a high index of suspicion for early-stage malignancy were selected to proceed with the single-anesthetic pathway. Finally, the recent nature of our data precludes our ability to comment on recurrence, mortality, long-term outcomes, or survival and will be a topic of interest for future studies.

Conclusions

A single-anesthesia approach encompassing lung cancer diagnosis, staging and surgical treatment appears to be a safe, feasible, and guideline-adherent pathway for early-stage NSCLC patients with the potential benefit of shortening the time from diagnosis to definitive treatment. Future studies are needed to investigate the potential impact on cancer recurrence, survival, healthcare costs, and patient satisfaction. Additionally, future randomized controlled trials comparing the traditional pathway to the single anesthetic pathway will be necessary.

Acknowledgments

Funding: None.

Footnote

Reporting Checklist: The authors have completed the STROBE reporting checklist. Available at https://ccts.amegroups.com/article/view/10.21037/ccts-23-14/rc

Data Sharing Statement: Available at https://ccts.amegroups.com/article/view/10.21037/ccts-23-14/dss

Peer Review File: Available at https://ccts.amegroups.com/article/view/10.21037/ccts-23-14/prf

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://ccts.amegroups.com/article/view/10.21037/ccts-23-14/coif). The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by the Research and Institutional Review Committee of The Queen's Medical Center (RA-2023-032) and individual consent for this retrospective analysis was waived.

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doi: 10.21037/ccts-23-14

Cite this article as: Wong AW, Wang EY, Fong A, Pyarali F, Ideta TR, Tokeshi B, Imai TA. Streamlining care with single anesthetic robotic lung cancer diagnosis and resection. Curr Chall Thorac Surg 2024;6:6.