Case Report

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Dual-Portal Robotic-Assisted Thoracic Surgery (DRATS) and Indocyanine Green-Navigated Segmentectomy

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Abstract: Background: In the landscape of thoracic surgery, innovation continually drives progress, offering novel approaches to address complex pathologies while prioritizing patient well-being. Dual-portal robotic-assisted thoracic surgery DRATS represents the next frontier in this evolution. In this report we describe our experience with the DRATS approach for segmentectomy with the indocyanine green intersegmental plane identification. Methods: We presented the case of a patient who underwent a DRATS lingulectomy and lymphadenectomy stations 5, 6, 7, and 10 using the daVinci Surgical System. Results: The patient's postoperative course was uneventful with chest tube was removed in second post operative day. The final pathological analysis confirmed a low-grade malignant potential adenocarcinoma, with main diameter of 1.1 cm, at 3 cm from lung margins. 12 nodes were removed, from station 5,6,7,10,11, all of the free of metastases. Conclusions: Our initial observations suggest that Dual-Portal Robotic-Assisted Tho-racic Surgery (DRATS) demonstrates notable feasibility.

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1. Introduction

In the landscape of thoracic surgery, innovation continually drives progress, offering novel approaches to address complex pathologies while prioritizing patient well-being. Drawing upon our expertise in uniportal VATS (U-VATS) and standard robotic techniques, we recently embarked on a new frontier by introducing biportal Robotic-Assisted Thoracic Surgery (RATS), subsequently coined Dual-Portal RATS (D-RATS). Traditional approaches often entail substantial incisions, resulting in prolonged hospital stays, increased postoperative pain, and extended recovery times. However, the introduction of robotic assistance has transformed the landscape, enabling surgeons to perform complex procedures with greater precision and minimal invasiveness. D-RATS represents the next frontier in this evolution, offering a nuanced approach that combines the advantages of robotic technology with the versatility of dual-port access, further minimizing invasiveness through a reduction in the number of incisions.

Segmentectomy has emerged as a feasible option for treating small primary lung cancers while preserving lung function (1). Compared to wedge resection, segmentectomy provides superior oncological results and a more appropriate surgical margin (2). However, segmentectomy poses challenges due to the intricacy in precisely identifying the intersegmental plane. Several techniques have been proposed to address this challenge, yet their efficacy is limited, particularly in patients with lung conditions like emphysema, requiring the expertise of a skilled surgeon for implementation.

The most common way to identify the intersegmental plane is the inflation-deflation method, which is achieved by inflating residual segments, leaving the targeted segment atelectatic. (3). Nevertheless, this approach may result in an inaccurate intersegmental plane because of the various

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factors, including presence of Kohn pores, Lambert canals, direct airway anastomosis and difficulties encountered when dealing with patients with emphysema. (4)

An alternative technique for determining the intersegmental plane is using the vascular method, which involves near-infrared fluorescence imaging with intravenous ICG or ligation of the targeted segmental artery (5-6). The ICG fluorescence method is more accurate but technically more complicated. (4)

Addressing these challenges, we explore the fluorescence-guided visualisation with intravenous indocyanine green (ICG) injection during robotic left S4 and S5 (lingula) segmentectomy, aiming to enhance intraoperative precision and optimise oncological outcomes.

2. Materials and Methods

This video presents the case of a 57-year-old female patient with history of malignant melanoma on the right cheek, surgically treated in 2020.

The patient came in 2024 to our attention for assessment after the detection of a subtle enlargement of a subsolid nodule of 11 mm within the lower lingular segment on a recent chest CT scan, prompting concern for primary lung disease or metastatic involvement (Figure S1). Pulmonary function testing demonstrated a preserved spirometric profile with notable findings of increased residual volume (RV) and RV/total lung capacity (TLC) ratio, indicative of potential air trapping. Hence, due to considerations regarding nodule's location, seize and reduced pulmonary function, segmentectomy was indicated to preserve lung parenchyma while ensuring appropriate oncological intervention.

The patient underwent a D-RATS lingulectomy and lymphadenectomy stations 5, 6, 7, and 10 using the Da Vinci® XI Surgical System.

3. Results

3.1. Surgical Technique

Under general anesthesia with single-lung ventilation, the patient was placed in the lateral decubitus. The da Vinci Xi Surgical System was positioned posteriorly to the patient. The biportal technique does not let the tradional docking of the robot. The laser's cross was placed in the upper part of the skin incision, running parallel to the spine. The D-RATS technique employs just 3 arms, with arm 4 being deactivated during procedures on the left side (arm 3 was used for the camera, arm 1 for the left hand, and arm 2 for the right hand).

In the D-RATS approach, a working port of 2–3-cm was created using a wound protector in the fifth intercostal space (ICS) as a main port for the upper lobe resection (Figure S2). A 12 mm port was positioned at the seventh ICS along the anterior axillary line. However, the positioning of working port is usually adjusted in accordance with the patient's body shape. The D-RATS technique is a total robotic approach, based on the use of the modern robotic staplers. We used a 30-strapler SureForm (Da Vinci® Stapling components) with a curved tip), a 45-stapler with a curved tip and 60-stapler for parenchyma. One of the reasons for having another incision in an inferior location was to facilitate proper articulation of the staplers internally.

A 30° camera was used, usually with a downward orientation to reduce the interference between the surgical instruments. However, during dissection of blood vessels and adhesions or when using staplers, it was sometimes necessary to adjust the camera angle upward. In such way, it was possible to reach any area in the thoracic cavity without any limitation.

An intraoperative video of a lingulectomy using the D-RATS approach is provided (Video S1). An intraoperative video of superior mediastinal lymph node dissection using the D-RATS approach is provided (Video S2).

In our case, the nodule described in the CT scan was confirmed to be in the lingular parenchyma. First of all the artery was found in the anterior side of the fissure, that was opened by means of SureForm stapler 45-mm. Then, after the identification of the lingular artery, it was isolated with the use of fenestrated bipolar forceps and Maryland forceps. The artery was then closed with a SureForm

45 curved-tip stapler. Then, the hilum was accessed to identify the lingular vein, that was first isolated and then closed with a SureForm 45 curved-tip stapler. Beyond the lingular vein, the bronchial branches were identified. Among them, the lingular bronchus was identified thanks to insufflation and disinflation test and then closed with a SureForm 30 stapler.

To delineate the intersegmental plane, intravenous injection of 3-ml indocyanine green (ICG) solution (ICG solution was prepared by dissolving 25 mg ICG in 10 ml distilled water), the intersegmental line was marked on the visceral pleura using an energy device. (Video S3). At this time, the resection of the targeted segment was performed according to the intersegmental plane along the visceral pleura marking determined by the ICG fluorescence method using the 45/60-mm SureForm stapler.

After segmentectomy, a test of air leakage from the lung was implemented by inflating the lung underwater. At the end of the surgery, the assistant surgeon placed a single chest drain toward the apex, through the incision at the 7th ICS.

3.2. Post Operative Outcome

The patient's postoperative course was uneventful, with prompt resumption of ambulation and initiation of respiratory physiotherapy. Serial hematologic and radiologic assessments during the immediate postoperative period demonstrated stable parameters and good lung expansion. The chest tube was removed on the second postoperative day, facilitating expedited recovery and discharge planning, which occurred on the third post operative day. The final pathology was consistent with low-grade malignant potential adenocarcinoma, with main diameter of 1.1 cm, at 3 cm from lung margins. 12 nodes were removed, from station 5,6,7,10,11, all of the free of metastases.

4. Discussion

Minimally invasive surgery has become widely accepted as the standard approach for lung cancer surgery. According to the latest version of the National Comprehensive Cancer Network Guidelines, it is highly recommended to consider VATS or minimally invasive surgery, which may include robotic-assisted approaches, for patients who do not have any anatomic or surgical contraindications, as long as the standard oncologic and anatomic principles of thoracic surgery are not compromised in the process (7).

The use of robotic-assisted surgery has recently increased with the advent of innovations and technologies such as three-dimensional vision, physiological tremors mitigation, camera stability, and a shorter learning curve compared to traditional endoscopic procedures. (4)

To enhance the minimally invasive nature of robotic procedures, conventionally reliant on four thoracoports and a service mini thoracotomy, we have innovatively integrated with the uniportal VATS technique. This amalgamation establishes a novel protocol utilising uniportal VATS access in conjunction with a robotic trocar, thereby advancing the field of surgical innovation.

In our case report, we have explored and merged both VATS and RATS techniques resulting in a single incision on the 5th ICS with an additional utility incision for staplers. This approach yielded similar outcomes of minimal invasiveness, in terms of postoperative outcomes and oncological results.

Furthermore, the segmentectomy offers the advantage of preserving whole lung function. Therefore, it emerges as a viable option not only for patients with compromised lung function but also a curative surgery for patients with stage IA lung cancer. However, the technical complexities associated with segmentectomy pose significant challenges, preventing its widespread application. (8-9)

However, accurately determining the intersegmental plane is one of the most critical steps of segmentectomy. Erroneous identification of this plane can lead to excessive resection of the parenchyma, insufficient surgical margin, and even residue of the lesions. Furthermore, such inaccuracies might increase postoperative complications, such as air leakage, atelectasis, and hemoptysis. As a result, several approaches have been developed to ensure precise identification of intersegmental plane (10-11-12).

The conventional inflation-deflation technique is commonly employed to delineate the intersegmental plane by selectively inflating the target segment while deflating the preserved segment. However, this method is hampered by its tendency of limiting the thoracic operating space. Moreover, the resulting demarcation line may be unclear and inaccurate because of the collateral ventilation pathways such as the Kohn pores, the Lambert canals, and the direct airway anastomosis (3).

An alternative approach involves the use of staining techniques via bronchial injection of dyes, such as methylene blue or ICG, to highlight intersegmental planes (13). This method not only renders the intersegmental visible on the lung surface but also stains the target lung parenchyma. However, a potential drawback of this technique is the possibility of dye spread into adjacent segments through structures like the Kohn pores.

In contrast, the ICG fluorescence method offers distinct advantages, as it obviates the need of intraoperative lung re-inflation, thus preserving manoeuvre space during video-assisted thoracic surgery.

When planning surgery of course one of the main concern is of course patient safety. When deciding to approach this emerging technique, we funded our decision on literature data reporting promising results in terms of safety and feasibility. A big analysis of 5721 cases, from Kent and co workers, compared robotic lobectomy and VATS approaches open technique (14). Robotic and VATS lobectomies were associated with favorable perioperative outcomes compared to the open ones. Robotic-assisted lobectomies were also associated with a reduced length of stay and decreased conversion rate when compared to VATS.

Yang and colleagues already reported and experience with the D-RATS approach, with 18 cases, considering it a safe and feasible technique (15). Watanabe and colleagues in their work describe 20 cases of planned D-RATS for anatomical pulmonary resections, with no need for conversions to thoracotomy and no need for extra ports (16).

5. Conclusions

In conclusion, the identification of the intersegmental plane during segmentectomy represents a complex and intricate aspect of the surgical procedure. However, the integration of indocyanine green (ICG) fluorescence navigation into segmentectomy provides a novel and effective solution, offering real-time visualization of the intersegmental plane. This technique enhances procedural efficiency and expedites surgical decision-making, ultimately contributing to improved patient outcomes.

Furthermore, our initial observations suggest that Dual-Portal Robotic-Assisted Thoracic Surgery (D-RATS) demonstrates notable feasibility. The perioperative outcomes achieved through D-RATS are indeed promising, highlighting its potential as a valuable tool in thoracic surgery.

Given these encouraging results, we underscore the importance of mastering D-RATS techniques before its broader implementation. Comprehensive training and proficiency in D-RATS are essential prerequisites for ensuring optimal surgical outcomes and maximizing the benefits of this advanced approach.

Supplementary Materials: The following supporting information can be downloaded at: Preprints.org, Figure S1: pre-operative CT scan; Figure S2: incision and docking; Video S1: lingulectomy using the DRATS approach, Video S2: superior mediastinal lymph node dissection using the DRATS approach, Video S3: ICG intersegmental plane identification

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