Original Article

Perioperative outcomes of robotic versus video-assisted thoracoscopic surgery in non-small cell lung cancer patients after neoadjuvant chemoimmunotherapy

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Background: Limited data are available regarding perioperative outcomes in patients with non-small cell lung cancer (NSCLC) who undergo robotic-assisted thoracic surgery (RATS) after neoadjuvant chemoimmunotherapy. This study aimed to compare the perioperative outcomes of RATS and video-assisted thoracic surgery (VATS) in NSCLC patients after neoadjuvant chemoimmunotherapy.

Methods: The study involved consecutive NSCLC patients treated with minimally invasive surgery (MIS) after neoadjuvant chemoimmunotherapy at a high-volume single center from September 2020 to October 2022. Short-term effects, including demographic, perioperative and pathological parameters, were compared between the RATS group and the VATS group.

Results: A total of 119 patients were included in this study. Of these, 33 (27.7%) patients received RATS and 86 (72.3%) patients received VATS. Major pathological response (MPR) and pathological complete response (pCR) rates were comparable between the two groups. The RATS group had a higher number of dissected lymph nodes (21 *vs.* 18, P=0.03) and lymph node stations (7 *vs.* 6, P=0.004) compared with the VATS group but no differences were found in perioperative outcomes.

Conclusions: These findings suggest that both RATS and VATS are safe and feasible options for NSCLC patients who have received neoadjuvant chemoimmunotherapy. Furthermore, RATS may offer advantages over VATS in patients who require a more extensive lymph node dissection.

Keywords: Non-small cell lung cancer (NSCLC); neoadjuvant chemoimmunotherapy; robotic-assisted thoracic surgery (RATS); perioperative outcomes

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Introduction

Lung cancer is a significant public health concern, with non-small cell lung cancer (NSCLC) accounting for about 85% of all cases (1). The use of neoadjuvant chemoimmunotherapy has demonstrated a significant improvement in the survival of resectable NSCLC patients (2-6). For instance, the Checkmate 816 trial has demonstrated that patients receiving neoadjuvant therapy with a combination of Nivolumab and platinum-based doublet have a better prognosis than those treated with chemotherapy alone (7). Surgical intervention is a customary therapeutic option for NSCLC patients who have undergone neoadjuvant chemoimmunotherapy (8). However, as the use of neoadjuvant chemoimmunotherapy increases, the optimal surgical approach for NSCLC is becoming increasingly controversial.

Robotic-assisted thoracic surgery (RATS) is becoming increasingly popular in the treatment of NSCLC (9). The Da Vinci robotic system, which has been a revolutionary technology in the treatment of urological and gynecological cancers, has become a recent addition to the thoracic surgery field (10). The utilization of RATS for pulmonary lobectomy was initially documented by Melfi *et al.* in 2002 (11). However, the feasibility and safety of RATS for NSCLC patients receiving neoadjuvant chemoimmunotherapy have not yet been established. Due to the induction of localized inflammation by neoadjuvant chemoimmunotherapy, the pleural and lung tissues may become adhered, resulting in an increase in the surgical intervention required to loosen and separate the adhesions (2,12). This leads to amplified surgical trauma and consequential tissue damage, ultimately prolonging the duration of the surgical procedure. Thus, the feasibility and perioperative outcomes of RATS in NSCLC patients receiving neoadjuvant chemoimmunotherapy is an ongoing area of investigation and research, with few relevant reports currently available.

This study aims to investigate the perioperative outcomes of RATS for NSCLC after neoadjuvant chemoimmunotherapy, with a focus on the feasibility and safety of lung resection through video-assisted thoracic surgery (VATS) and RATS after neoadjuvant chemoimmunotherapy. This study provides pertinent insights into the minimally invasive surgical options for patients with NSCLC undergoing neoadjuvant chemoimmunotherapy. We present this article in accordance with the STROBE reporting checklist (available at https://jtd.amegroups.com/article/view/10.21037/jtd-23-1482/rc).

Highlight box

Key findings

- Robotic-assisted thoracic surgery (RATS) was not associated with increased rates of conversion, reoperation, or worse perioperative outcomes relative to video-assisted thoracic surgery (VATS) in non-small cell lung cancer (NSCLC) patients after neoadjuvant chemoimmunotherapy.

What is known and what is new?

- RATS has comparable perioperative results to VATS for NSCLC patients without neoadjuvant therapy. However, neoadjuvant chemoimmunotherapy escalates the risk of chest adhesions, edema, and fibrosis, thereby augmenting the intricacy of surgical interventions.
- The perioperative outcomes of RATS for NSCLC patients after neoadjuvant chemoimmunotherapy are evaluated.

What is the implication, and what should change now?

- RATS is a safe and feasible option for NSCLC patients after neoadjuvant chemoimmunotherapy.

Methods

Ethical statement

The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by the Ethics Committee of Shanghai Pulmonary Hospital (K23-004; approval date: 22 February 2022). Patient consent was waived due to the retrospective study design.

Study population

Clinical data were collected from patients pathologically confirmed NSCLC in minimally invasive surgery (MIS) after neoadjuvant chemoimmunotherapy between September 2020 and October 2022 at Shanghai Pulmonary Hospital. Patients meeting any of the following criteria were excluded: (I) underwent targeted therapy before neoadjuvant chemoimmunotherapy; (II) underwent neoadjuvant chemotherapy or immunotherapy alone; (III) received open surgery; (IV) incomplete clinical or radiographic information; (V) history of previous lung surgery; (VI) recurrent NSCLC; (VII) participation in Good Clinical Practice (GCP); (VIII) with distant metastasis. This investigation comprised a cohort of 131 patients subjected to a therapeutic regimen involving neoadjuvant

programmed cell death protein 1 (PD-1) inhibitors in conjunction with platinum-based doublet chemotherapy. Each patient underwent a course of conventional platinum-based doublet chemotherapy, spanning two to five cycles, with each cycle having a duration of 21 days. After two cycles of neoadjuvant therapy, a comprehensive evaluation of therapeutic efficacy is conducted through computed tomography (CT) or positron emission tomography (PET). If surgery is deemed feasible through the multidisciplinary clinical team (MDT) assessment, the plan is to proceed with surgery 28–42 days after the first day of the last treatment cycle. In cases where complete resection is deemed unfeasible during this assessment, the consideration of additional treatment cycles is pursued.

The VATS and RATS were executed by a proficient and well-qualified thoracic surgical team, which has already mastered the learning curve associated with RATS. The choice of the surgical approach was made in accordance with the principle of voluntary patient selection.

Data collection

This study collected preoperative data, which included sex, age, body mass index (BMI), smoking history, forced expiratory volume in 1 second/forced vital capacity (FEV1/FVC), American Society of Anesthesiologists (ASA) physical status classification, Eastern Cooperative Oncology Group (ECOG) score, and tumor location, for analysis. Perioperative information, including intraoperative details and pathological findings, were acquired from electronic operation records and pathology reports, respectively. The postoperative TNM (tumor node metastasis classification) stage was determined according to the American Joint Committee on Cancer's 8th edition staging system.

The short-term outcomes assessed in this investigation were pleural drainage volume on postoperative days 1–3, postoperative drainage time, hemorrhage, prolonged air leak, empyema, pneumonia, bronchopleural fistula, pulmonary embolus, Clavien-Dindo classification, postoperative length of stay, 30-day reoperation, 30-day readmission, and 30-day mortality. These parameters were carefully evaluated to determine the efficacy of the surgical interventions employed in this study.

Response assessment

Pathological response was assessed by professionals from the Departments of Radiology and Pathology at Shanghai Pulmonary Hospital. The definition of major pathological response (MPR) was the presence of <10% residual tumor cells in the pathological assessment of tumor regression induced by neoadjuvant therapy. On the other hand, pathological complete response (pCR) was achieved when there was no evidence of viable tumor cells in either the resected tumor bed or dissected lymph nodes during pathological examination of the postoperative specimens (13).

Surgery management

The RATS procedure is executed through five ports. The camera port is positioned in the eighth intercostal space along the axillary midline. Three working ports are strategically placed: one in the fifth intercostal space along the anterior axillary line, another in the eighth intercostal space along the posterior axillary line, and the third 2 cm laterally from the eighth intercostal space on the spine's side. Lastly, the assistant port is situated in the eighth intercostal space between the camera port and the anterior port. In comparison, VATS incisions typically measure 4 cm and are located in the fifth intercostal space along the anterior axillary line. In certain scenarios, an additional assistant port may be inserted in the sixth or eighth intercostal space along the axillary midline.

Statistical analysis

Continuous variables that were normally distributed were presented as mean values accompanied by their respective standard deviations (SDs) and underwent statistical analysis utilizing Student's *t*-test. In the case of non-normally distributed continuous variables, median values and interquartile ranges (IQRs) were reported and analyzed using the Mann-Whitney *U* test. Categorical variables were subjected to analysis using either the Chi-squared test or Fisher's exact test. The statistical analyses were conducted through employment of R software (version 4.1.3), and significance was considered at a 2-sided $P<0.05$.

Results

Patient characteristics

This study entailed the analysis of a cohort of 119 patients who underwent MIS subsequent to neoadjuvant chemoimmunotherapy, during the period ranging from September 2020 to October 2022 (*Figure 1*). The majority

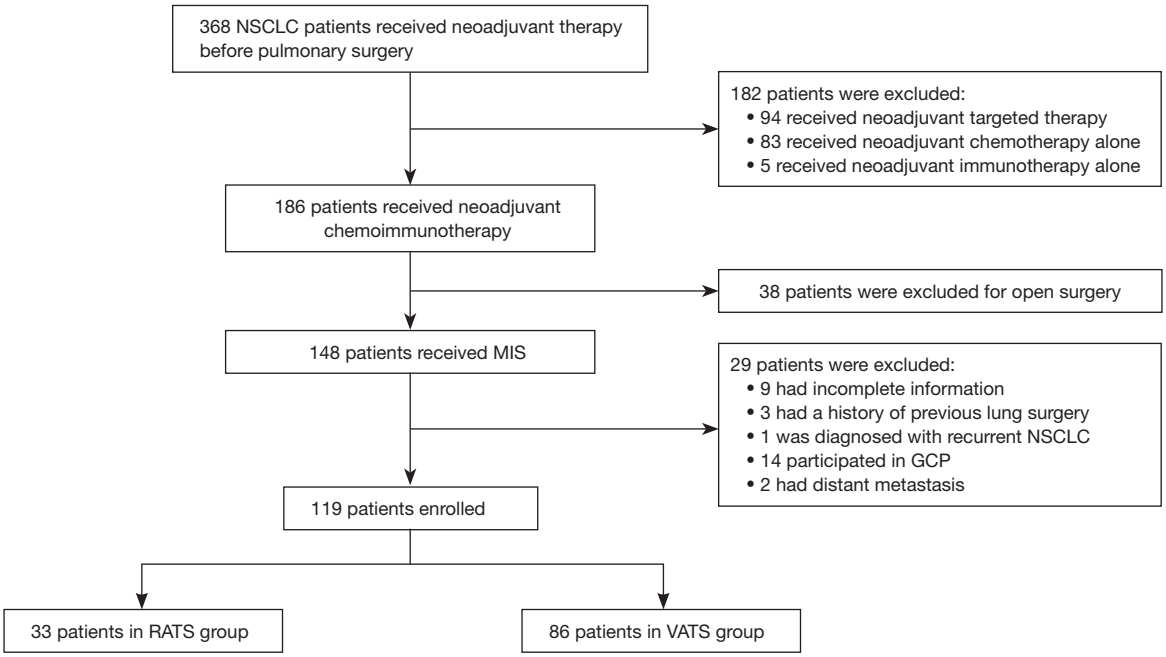

Figure 1 Flow-chart of the study. NSCLC, non-small cell lung cancer; MIS, minimally invasive surgery; GCP, Good Clinical Practice; RATS, robotic-assisted thoracic surgery; VATS, video-assisted thoracic surgery.

of the patients received VATS (n=86, 72.3%), while the remaining individuals received RATS (n=33, 27.7%). In the RATS and VATS groups, the male participants accounted for 75.8% and 89.5%, respectively (25 *vs.* 77, P=0.05). The mean age was 63.18±7.09 years in the RATS group and 62.03±8.31 years in the VATS group (P=0.48). Nineteen (57.6%) patients in the RATS group were current smokers, compared to 53 (61.6%) patients in the VATS group (P=0.68). The baseline clinical characteristics of patients undergoing RATS and VATS after neoadjuvant chemoimmunotherapy for NSCLC did not differ significantly in terms of demographic variables and preoperative factors (*Table 1*).

Intraoperative outcomes

Table 2 presents the intraoperative findings of this study, with the main type of surgery in the RATS and VATS groups being lobectomy (97.0% *vs.* 96.5%, P=0.15). The average operation time in the RATS group was 173 min, compared to 147 min of the VATS group (P=0.13). The median intraoperative blood loss in both groups was 50 mL, and there was no significant difference in the blood transfusion rate (6.1% *vs.* 1.2%, P=0.12). There were four patients (4.7%) in the VATS group converted to open surgery, while none in the RATS group. Among these four patients, three of them converted owing to tissue adhesions and one patient owing to intraoperative bleeding. Nonetheless, no notable difference in the conversion rate was observed between the two cohorts. In terms of intraoperative outcomes, the RATS group demonstrated similar results to those of the VATS group.

Pathological outcomes

R0 resection was successfully achieved in all patients in both the RATS and VATS groups. The pT stage (P=0.58), pN stage (P=0.29), and pTNM stage (P=0.29) were found to be similar between the two groups. No significant differences were observed in tumor diameter, histological type, pleural invasion, perineural invasion, or lymphatic-or-vascular invasion. The RATS group had similar MPR (66.7% *vs.* 51.2%, P=0.12) and pCR rates (33.3% *vs.* 26.7%, P=0.47) compared to the VATS group (*Table 3*).

Although the number of harvested positive lymph nodes was similar between the two cohorts (P=0.90), the RATS group had a significantly higher number of lymph nodes dissected (21 *vs.* 18, P=0.03) and more dissected stations (7 *vs.* 6, P=0.004) compared to the VATS group. Upon further analysis, it was found that RATS surpassed VATS in

Table 1 Baseline clinical characteristics of the patients stratified by surgical approach

Variables	RATS (n=33)	VATS (n=86)	P value
Sex			
Female	8 (24.2)	9 (10.5)	0.05
Male	25 (75.8)	77 (89.5)	
Age (years)	63.18 (7.09)	62.03 (8.31)	0.48
BMI (kg/m^2)	25.24 (3.10)	24.91 (2.75)	0.58
Smoking history			
Never/former smoker	14 (42.4)	33 (38.4)	0.68
Current smoker	19 (57.6)	53 (61.6)	
FEV1/FVC	96.60 [92.60, 100.00]	95.10 [89.53, 101.00]	0.55
ASA score			
I	1 (3.0)	1 (1.2)	0.19
II	31 (93.9)	73 (84.9)	
III	1 (3.0)	12 (14.0)	
ECOG score			
0	24 (72.7)	57 (66.3)	0.49
1	9 (27.3)	29 (33.7)	
Tumor location			
LLL	9 (27.3)	11 (12.8)	0.43
LUL	8 (24.2)	22 (25.6)	
RLL	6 (18.2)	21 (24.4)	
RML	1 (3.0)	4 (4.7)	
RUL	9 (27.3)	28 (32.6)	
Tumor size before surgery (mm)	23.00 [16.00, 33.00]	26.00 [16.00, 36.00]	0.56
ycT stage before surgery			
T0	0 (0.0)	1 (1.2)	0.85
T1	20 (60.6)	55 (64.0)	
T2	10 (30.3)	20 (23.3)	
T3	3 (9.1)	9 (10.5)	
T4	0 (0.0)	1 (1.2)	
ycN stage before surgery, n (%)			
N0	4 (12.1)	18 (20.9)	0.65
N1	3 (9.1)	7 (8.1)	
N2	25 (75.8)	60 (69.8)	
N3	1 (3.0)	1 (1.2)	
ycStage before surgery, n (%)			
CR	0 (0.0)	1 (1.2)	0.61
I	3 (9.1)	15 (17.4)	
II	4 (12.1)	8 (9.3)	
III	26 (78.8)	62 (72.1)	

Data are presented as n (%), mean (SD) or median [IQR]. RATS, robotic-assisted thoracic surgery; VATS, video-assisted thoracic surgery; BMI, body mass index; FEV1/FVC, forced expiratory volume in 1 second/forced vital capacity; ASA, American Society of Anesthesiologists; ECOG, Eastern Cooperative Oncology Group; LLL, left lower lobe; LUL, left upper lobe; RLL, right lower lobe; RML, right middle lobe; RUL, right upper lobe; CR, complete response; SD, standard deviation; IQR, interquartile range.

Table 2 Intraoperative findings of the patients stratified by surgical approach

Variables	RATS (n=33)	VATS (n=86)	P value
Surgical type			
Limited resection	1 (3.0)	0 (0.0)	0.15
Lobectomy	32 (97.0)	83 (96.5)	
Pneumonectomy	0 (0.0)	3 (3.5)	
Conversion to open surgery	0 (0.0)	4 (4.7)	0.20
Blood loss (mL)	50.00 [50.00, 50.00]	50.00 [50.00, 100.00]	0.18
Transfusion	2 (6.1)	1 (1.2)	0.12
Operation time (min)	173.00 [125.00, 210.00]	147.00 [110.50, 204.75]	0.13

Data are presented as n (%) or median [IQR]. RATS, robotic-assisted thoracic surgery; VATS, video-assisted thoracic surgery; IQR, interquartile range.

terms of the number of dissected N1 (10 *vs.* 8, P=0.002) and N2 (13 *vs.* 10, P=0.01) lymph nodes, as well as the number of dissected N1 (3 *vs.* 3, P=0.01) and N2 (4 *vs.* 4, P=0.005) lymph node stations. Additionally, it was observed that RATS dissected significantly more lymph nodes at the 8th (1 *vs.* 0, P<0.001), 10th (2 *vs.* 2, P=0.040), and 11th (3 *vs.* 2, P=0.001) lymph node stations compared to VATS (*Figure 2*).

Upon examining the distribution of positive lymph nodes across different lymph node stations, a notable concentration of positive lymph nodes was identified in the 10th, 11th, and 13th stations (*Figure 3*). In fact, these three stations accounted for a significant proportion of all positive lymph nodes. Thus, a meticulous cleaning of lymph nodes in the 10th, 11th, and 13th stations is imperative for the effective management of this condition.

Postoperative complications

The postoperative complication rate, mortality rate, and recovery data are presented in *Table 4*. Overall, major complications (Clavien-Dindo classification III–IV) occurred in one of 33 patients in the RATS group (3.0%) and one of 86 patients in the VATS group (1.2%), with no statistically significant difference between the groups (P=0.47). The incidence rates of bleeding, prolonged air leak, pneumonia, bronchopleural fistula, and pulmonary embolism did not differ significantly between the two groups. None of the patients in either group developed postoperative empyema. The two groups had similar drainage volume, drainage time, and postoperative hospital stay. There was one readmission within 30 days in the RATS (attributed to bacterial pneumonia) and two in the VATS (one due to bronchopleural fistula and another due to bacterial pneumonia) (3% *vs.* 2.3%, P=0.82). Only one patient in the VATS group underwent reoperation within 30 days due to bronchopleural fistula, and none in the RATS group (0.0% *vs.* 1.2%, P=0.53). Mortality within 30 days was also similar (3.0% *vs.* 1.2%, P=0.47), with one patient in the RATS group died of acute myocardial infarction and one patient in the VATS group died of heart failure.

Discussion

Neoadjuvant chemoimmunotherapy is increasingly used in patients with NSCLC, presenting new perioperative challenges for surgeons. This research aims to compare the perioperative outcomes of NSCLC patients treated with neoadjuvant chemoimmunotherapy using RATS and VATS, which is currently scarce, to the authors' knowledge. The study found that RATS had comparable perioperative results to VATS for NSCLC patients receiving neoadjuvant chemoimmunotherapy. In addition, the RATS group had a higher number of dissected lymph nodes and lymph node stations.

Thorough lymph node dissection is crucial for anatomical resection of NSCLC because it affects staging and recurrence (14). Our team's previous research has shown that the assessment of lymph nodes is crucial for accurate staging and adequate treatment, and examining an increasing number of lymph nodes to detect gradually rising N components is essential for predicting stage escalation and survival outcomes (15). The robotic system provides RATS with the capability of managing lymph node anatomy from various perspectives, giving it an edge over

Table 3 Pathological outcomes of the patients stratified by surgical approach

Variables	RATS (n=33)	VATS (n=86)	P value
Tumor size (mm)	25.00 [19.00, 32.00]	27.00 [20.00, 36.00]	0.39
Pleural invasion	3 (9.1)	7 (8.1)	0.86
Perineural invasion	2 (6.1)	1 (1.2)	0.12
Lymphatic or vascular invasion	8 (24.2)	9 (10.5)	0.05
R0 resection	33 (100.0)	86 (100.0)	NE
MPR	22 (66.7)	44 (51.2)	0.12
pCR	11 (33.3)	23 (26.7)	0.47
Examined lymph node station			
N1 station	3.00 [3.00, 3.00]	3.00 [3.00, 3.00]	0.01
N2 station	4.00 [3.00, 5.00]	4.00 [3.00, 4.00]	0.005
Total	7.00 [6.00, 8.00]	6.00 [6.00, 7.00]	0.004
Harvested lymph nodes			
N1 station	10.00 [7.00, 14.00]	8.00 [5.00, 10.00]	0.002
N2 station	13.00 [8.00, 15.00]	10.00 [5.00, 12.75]	0.01
Total	21.00 [17.00, 27.00]	18.00 [13.00, 22.75]	0.03
Harvested positive lymph nodes	0.00 [0.00, 2.00]	0.00 [0.00, 1.00]	0.90
ypT stage			
T0	11 (33.3)	23 (26.7)	0.58
T1	16 (48.5)	37 (43.0)	
T2	6 (18.2)	21 (24.4)	
T3	0 (0.0)	4 (4.7)	
T4	0 (0.0)	1 (1.2)	
ypN stage			
N0	22 (66.7)	52 (60.5)	0.29
N1	1 (3.0)	11 (12.8)	
N2	10 (30.3)	23 (26.7)	
ypStage			
CR	11 (33.3)	23 (26.7)	0.29
I	11 (33.3)	23 (26.7)	
II	1 (3.0)	15 (17.4)	
III	10 (30.3)	25 (29.1)	

Data are presented as n (%) or median [IQR]. RATS, robotic-assisted thoracic surgery; VATS, video-assisted thoracic surgery; NE, not evaluable; MPR, major pathological response; pCR, pathological complete response; CR, complete response; IQR, interquartile range.

other techniques (16-20). The study conducted by Kneuertz *et al.* showed no significant differences between RATS and VATS with respect to the number of N1, N2, and total lymph nodes dissected (21). Another clinical study analyzed 62,206 cases of NSCLC from the US National Cancer Data Base (22). The results of this study indicated that RATS performed better than open surgery in terms of the number of lymph nodes dissected. In our current study, we

found that RATS had a higher number of dissected lymph nodes (21 *vs.* 18, P=0.03) and lymph node stations (7 *vs.* 6, P=0.004) than VATS, suggesting potential superiority in lymph node assessment for NSCLC patients undergoing neoadjuvant chemoimmunotherapy. This is primarily attributed to the high-definition, three-dimensional view, and tenfold magnification provided by RATS. Furthermore, RATS offers highly operable and dexterous mechanical arms, providing significant convenience for operators in harvesting lymph nodes around vessels and bronchi.

Lobectomy was the main method of lung resection, with 97.0% and 96.5% of the procedures performed in the RATS and VATS groups, respectively. The postoperative complication rates (Clavien-Dindo classification I–IV) were 12.1% in the RATS group and 9.4% in the VATS group, demonstrating a clear advantage of these minimally invasive surgical techniques. However, the use of neoadjuvant chemoimmunotherapy poses a risk of conversion to thoracotomy, which has always been a concern for patients due to the technical difficulties and severe intraoperative complications that can arise (23). Our research findings suggest that the incidence of postoperative complications or conversion to open surgery in RATS did not show an increase compared to VATS. This observation implies that RATS is proficient in addressing the challenges posed by surgeries in patients undergoing neoadjuvant immunotherapy.

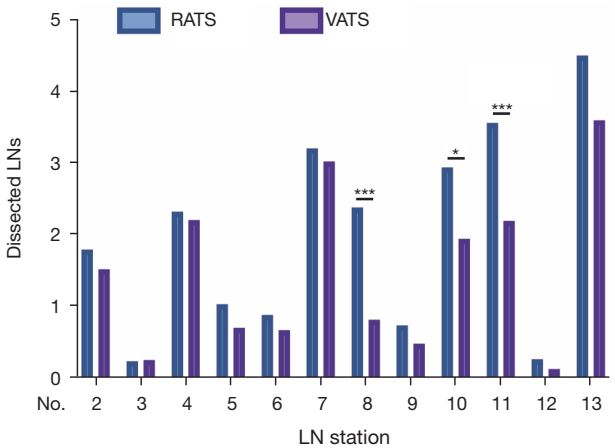

Figure 2 The median number of LNs harvested per patient in the RATS and VATS groups. *, P<0.05; ***, P<0.001. LN, lymph node; RATS, robotic-assisted thoracic surgery; VATS, video-assisted thoracic surgery.

Recent studies have shown that neoadjuvant chemoimmunotherapy may increase the risk of chest adhesions, edema, and fibrosis, which can increase surgical complexity and conversion risk, particularly in patients who have had a significant treatment response (2,12). According to O'Donnell *et al.*, preoperative neoadjuvant immunotherapy can lead to the formation of severe adhesions or fused lymph nodes that become stuck in blood vessel bifurcations during surgery, making tumor and lymph node separation and resection more challenging (24). Similarly, Bott *et al.* reported that over half of the patients who underwent preoperative treatment with nivolumab were converted to thoracotomy due to intrathoracic fibrosis and inflammation (2). Primary tumor invasion, dense adhesions, and fibrosis post-treatment were identified by Zhang *et al.* as the primary reasons for conversion surgery after neoadjuvant chemoimmunotherapy (25). However, the RATS group in our study exhibited a conversion rate to thoracotomy that was lower than the 11% observed in patients undergoing neoadjuvant chemoimmunotherapy in the CheckMate 816 trial. This indicates that the heightened

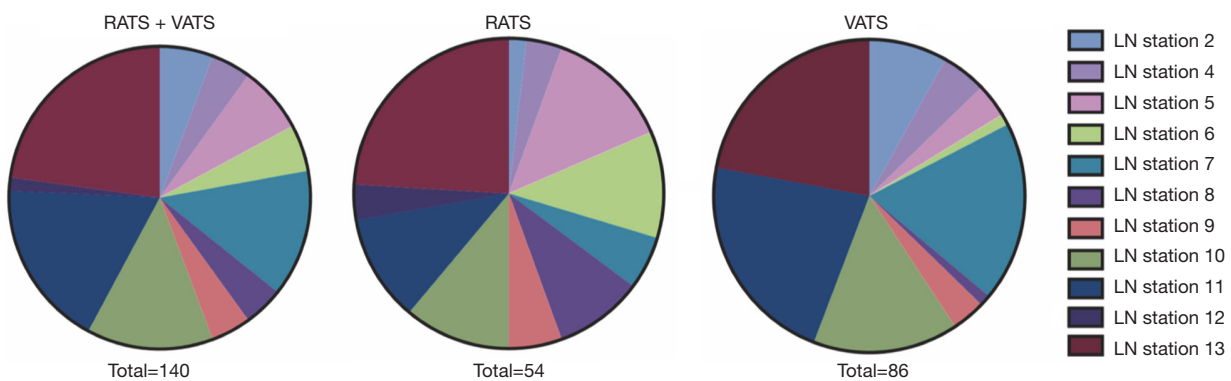

Figure 3 The pie chart exhibits the proportional distribution of the number of positive LNs within each LN station relative to the total number of positive LNs. RATS, robotic-assisted thoracic surgery; VATS, video-assisted thoracic surgery; LN, lymph node.

Table 4 Postoperative morbidity and recovery of the patients stratified by surgical approach

Variables	RATS (n=33)	VATS (n=86)	P value
Pleural drainage volume on POD 1 (mm)	300.00 [200.00, 400.00]	300.00 [222.50, 450.00]	0.50
Pleural drainage volume on POD 2 (mm)	200.00 [100.00, 300.00]	200.00 [100.00, 300.00]	0.90
Pleural drainage volume on POD 3 (mm)	150.00 [100.00, 250.00]	140.00 [0.00, 235.00]	0.15
Postoperative drainage time (days)	6.00 [6.00, 8.00]	7.00 [5.25, 11.75]	0.42
Hemorrhage	0 (0.0)	1 (1.2)	0.53
Prolonged air leak	3 (9.1)	5 (5.8)	0.52
Empyema	0 (0.0)	0 (0.0)	NE
Pneumonia	0 (0.0)	1 (1.2)	0.53
Bronchopleural fistula	0 (0.0)	1 (1.2)	0.53
Pulmonary embolus	1 (3.0)	0 (0.0)	0.10
Clavien-Dindo			
No complication	29 (87.9)	78 (90.6)	0.47
I	3 (9.1)	6 (7.0)	
II	0 (0.0)	1 (1.2)	
III	0 (0.0)	1 (1.2)	
IV	1 (3.0)	0 (0.0)	
V	0 (0.0)	0 (0.0)	
Length of POD (days)	5.00 [5.00, 7.00]	6.00 [5.00, 7.00]	0.20
Reoperation	0 (0.0)	1 (1.2)	0.53
Readmission	1 (3.0)	2 (2.3)	0.82
Mortality	1 (3.0)	1 (1.2)	0.47

Data are presented as n (%) or median [IQR]. RATS, robotic-assisted thoracic surgery; VATS, video-assisted thoracic surgery; POD, postoperative day; NE, not evaluable; IQR, interquartile range.

maneuverability and improved field of view provided by the robotic surgical system contribute to effective management of pleural adhesions, especially those situated along the lateral chest wall. This facilitates more convenient handling of intraoperative scenarios compared to situations where VATS may be constrained. Hence, RATS may be considered an equally viable option to VATS for patients with NSCLC undergoing neoadjuvant chemoimmunotherapy. At the very least, its perioperative outcomes are comparable to those of VATS.

The study has several limitations. Firstly, there may still be unavoidable selection bias owing to the retrospective nature of the analysis, despite efforts to control for patients having similar baseline and tumor characteristics. Secondly, as this study was conducted at a single center, the generalizability of the results may be limited. Future multicenter studies are needed to confirm the findings and make them more applicable to broader populations. Thirdly, the short follow-up period in this study prevented assessment of long-term survival outcomes for the patients. It is crucial to assess not only perioperative outcomes but also the potential of tumor recurrence and long-term survival to gain a more comprehensive understanding of the efficacy of the treatment approach.

Conclusions

This study provides valuable insights into the perioperative challenges and outcomes of NSCLC patients undergoing minimally invasive surgical resection following neoadjuvant chemoimmunotherapy. The findings suggest that, similar to VATS, RATS is a safe and feasible option for these patients,

with the potential advantage of higher numbers of lymph node and lymph node station dissections.

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Footnote

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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). Ethical approval for this study protocol was obtained from the Ethics Committee of Shanghai Pulmonary Hospital (K23-004; approval date: 22 February 2022) and individual consent for this retrospective analysis was waived.

References

1. DeSantis CE, Lin CC, Mariotto AB, et al. Cancer treatment and survivorship statistics, 2014. CA Cancer J Clin 2014;64:252-71.
2. Bott MJ, Yang SC, Park BJ, et al. Initial results of pulmonary resection after neoadjuvant nivolumab in patients with resectable non-small cell lung cancer. J Thorac Cardiovasc Surg 2019;158:269-76.
3. Shu CA, Gainor JF, Awad MM, et al. Neoadjuvant atezolizumab and chemotherapy in patients with resectable non-small-cell lung cancer: an open-label, multicentre, single-arm, phase 2 trial. Lancet Oncol 2020;21:786-95.
4. Cao C, Guo A, Chen C, et al. Systematic Review of Neoadjuvant Immunotherapy for Patients With Non-Small Cell Lung Cancer. Semin Thorac Cardiovasc Surg 2021;33:850-7.
5. Romero Román A, Campo-Cañaveral de la Cruz JL, Macía I, et al. Outcomes of surgical resection after neoadjuvant chemoimmunotherapy in locally advanced stage IIIA non-small-cell lung cancer. Eur J Cardiothorac Surg 2021;60:81-8.
6. Sepesi B, Swisher SG. Role of neoadjuvant chemoimmunotherapy for resectable NSCLC. Nat Rev Clin Oncol 2022;19:497-8.
7. Forde PM, Spicer J, Lu S, et al. Neoadjuvant Nivolumab plus Chemotherapy in Resectable Lung Cancer. N Engl J Med 2022;386:1973-85.
8. Montagne F, Guisier F, Venissac N, et al. The Role of Surgery in Lung Cancer Treatment: Present Indications and Future Perspectives-State of the Art. Cancers (Basel) 2021;13:3711.
9. Landreneau RJ, Mack MJ, Hazelrigg SR, et al. Video-assisted thoracic surgery: Basic technical concepts and intercostal approach strategies. Ann Thorac Surg 1992;54:800-7.
10. Herrera LJ, Schumacher LY, Hartwig MG, et al. Pulmonary Open, Robotic, and Thoracoscopic Lobectomy study: Outcomes and risk factors of conversion during minimally invasive lobectomy. J Thorac Cardiovasc Surg 2023;166:251-262.e3.
11. Melfi FM, Menconi GF, Mariani AM, et al. Early experience with robotic technology for thoracoscopic surgery. Eur J Cardiothorac Surg 2002;21:864-8.
12. Yang CF, Meyerhoff RR, Mayne NR, et al. Long-term survival following open versus thoracoscopic lobectomy after preoperative chemotherapy for non-small cell lung cancer. Eur J Cardiothorac Surg 2016;49:1615-23.

13. Pataer A, Kalhor N, Correa AM, et al. Histopathologic response criteria predict survival of patients with resected lung cancer after neoadjuvant chemotherapy. J Thorac Oncol 2012;7:825-32.
14. Liang W, He J, Shen Y, et al. Impact of Examined Lymph Node Count on Precise Staging and Long-Term Survival of Resected Non-Small-Cell Lung Cancer: A Population Study of the US SEER Database and a Chinese Multi-Institutional Registry. J Clin Oncol 2017;35:1162-70.
15. Dai J, Liu M, Yang Y, et al. Optimal Lymph Node Examination and Adjuvant Chemotherapy for Stage I Lung Cancer. J Thorac Oncol 2019;14:1277-85.
16. Swanson SJ, Miller DL, McKenna RJ Jr, et al. Comparing robot-assisted thoracic surgical lobectomy with conventional video-assisted thoracic surgical lobectomy and wedge resection: results from a multihospital database (Premier). J Thorac Cardiovasc Surg 2014;147:929-37.
17. Huang J, Tian Y, Zhou QJ, et al. Comparison of perioperative outcomes of robotic-assisted versus video-assisted thoracoscopic right upper lobectomy in non-small cell lung cancer. Transl Lung Cancer Res 2021;10:4549-57.
18. Wu H, Jin R, Yang S, et al. Long-term and short-term outcomes of robot- versus video-assisted anatomic lung resection in lung cancer: a systematic review and meta-analysis. Eur J Cardiothorac Surg 2021;59:732-40.
19. Miyajima M, Maki R, Arai W, et al. Robot-assisted vs. video-assisted thoracoscopic surgery in lung cancer. J Thorac Dis 2022;14:1890-9.
20. Kent M, Wang T, Whyte R, et al. Open, video-assisted thoracic surgery, and robotic lobectomy: review of a national database. Ann Thorac Surg 2014;97:236-42; discussion 242-4.
21. Kneuertz PJ, Cheufou DH, D'Souza DM, et al. Propensity-score adjusted comparison of pathologic nodal upstaging by robotic, video-assisted thoracoscopic, and open lobectomy for non-small cell lung cancer. J Thorac Cardiovasc Surg 2019;158:1457-1466.e2.
22. Rajaram R, Mohanty S, Bentrem DJ, et al. Nationwide Assessment of Robotic Lobectomy for Non-Small Cell Lung Cancer. Ann Thorac Surg 2017;103:1092-100.
23. Krantz SB, Mitzman B, Lutfi W, et al. Neoadjuvant Chemoradiation Shows No Survival Advantage to Chemotherapy Alone in Stage IIIA Patients. Ann Thorac Surg 2018;105:1008-16.
24. O'Donnell JS, Hoefsmit EP, Smyth MJ, et al. The Promise of Neoadjuvant Immunotherapy and Surgery for Cancer Treatment. Clin Cancer Res 2019;25:5743-51.
25. Zhang W, Wei Y, Jiang H, et al. Thoracotomy is better than thoracoscopic lobectomy in the lymph node dissection of lung cancer: a systematic review and meta-analysis. World J Surg Oncol 2016;14:290.

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