Original Article

A Comparison of Surgical Mediastinal Lymph Node Evaluation in Clinical N0 Non-small Cell Lung Cancer between Video-Assisted Thoracoscopic Lobectomy and Open Lobectomy

Omchai Rattananont MD[1]

[1] Cardiothoracic surgery unit, Central Chest Institute of Thailand, Nonthaburi, Thailand

Background: Video-assisted thoracoscopic surgery (VATS) for lobectomy is increasingly a procedure for early-stage lung cancer surgery, but the controversy remains on the adequacy of the lymph node evaluation.

Objective: To compare the completeness of surgical mediastinal lymph node evaluation between VATS lobectomy and open lobectomy in clinical N0 non-small cell lung cancer (NSCLC).

Material and Methods: Between January 2015 and August 2020, 312 patients who underwent lobectomy for clinical N0 NSCLC at Central Chest Institute of Thailand were reviewed, including 149 patients in VATS lobectomy and 163 patients in open lobectomy. Patient characteristics, surgical outcomes, and lymphadenectomy results were analyzed and compared.

Result: VATS lobectomy had prolonged operative time minute at 198.4±46.8 versus 160.9±73.6 ($p \leq 0.001$) but less blood loss at 100 versus 150 ($p=0.034$) than open lobectomy. The sampling procedure was more frequently performed in the open lobectomy at 44.2% versus 19.5% ($p \leq 0.001$), but the VATS lobectomy used the systematic dissection procedure mainly at 67.1% versus 42.9% ($p \leq 0.001$). The median overall number of lymph nodes at 19 versus 12 ($p \leq 0.001$) and the number of stations N2 nodes at 12 versus 6 ($p \leq 0.001$), especially in station 7 were dissected higher in the VATS lobectomy at 130 versus 100 ($p \leq 0.001$), but the number of stations N1 nodes was similar. The rate of lymph node upstaging was not significantly different between the two groups ($p=0.176$). The risk factor for lymph node upstaging was only the tumor size. There were no differences in complication and mortality.

Conclusion: The completeness of mediastinal lymph node evaluation for patients with clinical N0 NSCLC operated on by an experienced surgeon in VATS lobectomy was comparable with the open lobectomy.

Keywords: Video-assisted thoracic surgery; Open thoracotomy; Mediastinal lymph node assessment; Non-small cell lung cancer

Received 12 September 2022 | Revised 10 October 2022 | Accepted 20 October 2022

J Med Assoc Thai 2022;105(12):1216-23

Website: http://www.jmatonline.com

No mediastinal lymph node metastasis in non-small cell lung cancer has a better prognosis than in the metastasis group. Five-year survival was 80% to 90% when treated by surgery alone[1]. If the mediastinal lymph node metastasis occurred, the prognosis was decreased. To improve survival, chemotherapy or radiotherapy is advocated[2]. In recent years, the open thoracotomy for lobectomy has been the standard for lung cancer, and the American College of Chest Physicians recommended the video-assisted thoracoscopic surgery (VATS) lobectomy for stage I lung cancer by experience centers[3]. The benefit of VATS has been established with less postoperative pain, fewer post-op complication, and shorter hospital stay[4,5].

Despite the purpose of the benefit and recommendation for VATS lobectomy in stage I lung cancer compared to open lobectomy, the oncological aspect remains controversial. The reports have conflicted with the adequacy of mediastinal lymph node dissection or sampling to evaluate lung cancer staging during VATS lobectomy and open lobectomy. Watanabe et al[6] demonstrated that the number of systematic node dissections by VATS was not inferior

Correspondence to:

Rattananont O.

Cardiothoracic surgery unit, Central Chest Institute of Thailand, Nonthaburi 11000, Thailand.

Phone: +66-90-9366541

Email: omchai.rat@gmail.com

How to cite this article:

Rattananont O. A Comparison of Surgical Mediastinal Lymph Node Evaluation in Clinical N0 Non-small Cell Lung Cancer between Video-Assisted Thoracoscopic Lobectomy and Open Lobectomy. J Med Assoc Thai 2022;105:1216-23.

DOI: 10.35755/jmedassocthai.2022.12.13713

to the open thoracotomy. In contrast, Daniel et al reported that the lower rates of N1 upstaging in the VATS group compared to the open thoracotomy group might indicate variability in the completeness of the peribronchial and hilar lymph node evaluation[7]. The upstaging of the lymph node is one of the methods for evaluating the adequacy of the completeness of lymph node dissection or sampling. Robert et al[8] demonstrated that significantly more lymph nodes were dissected, and a higher percentage of patients were upstaged to N1 or N2 during open lobectomy than VATS lobectomy. The problem of proper lymph node evaluation in the surgery of non-small cell lung cancer (NSCLC) remains unsolved and needs research.

In the present study, the author compared the completeness of mediastinal lymph node evaluation during open lobectomy and VATS lobectomy in patients with clinical N0 NSCLC and determined the rate of nodal upstaging and surgical outcome.

Materials and Methods

Three hundred twelve patients who underwent lobectomy for clinical N0 lung cancer between January 2015 and August 2020 at Central Chest Institute of Thailand were retrospectively reviewed. Patient characteristics included age, gender, smoking status, underlying disease, location of lung cancer, forced expiratory volume in one second (FEV1), Preoperative lymph node staging, the clinical TNM (Tumor, Node, Metastasis) stage, the pathological TNM stage, and histological type were recorded. There were 163 patients in the open lobectomy group and 149 patients in the VATS lobectomy group for comparison.

The perioperative outcome and postoperative outcome included operative time, length of hospital stay, duration of intercostal drainage, margin of resected lung cancer from the pathological report, intraoperative lymph node harvest procedure, recurrent rate, mortality rate, prolonged air leak, chylothorax, pulmonary embolism, infected wound, massive air leak, and pneumonia were reviewed and compared between VATS lobectomy and open lobectomy group.

For clinical and pathological staging, the author used the Eighth Edition of the TNM[9] to determine the stage. The study excluded the patients whose histology diagnose were carcinoid tumors, secondary lung carcinoma, or benign diagnoses, and those that underwent induction therapy, chest wall resection, sleeve resection, sublobar resection, or pneumonectomy. Clinical suspected N1 or N2, or N3 nodal metastasis were also excluded.

Ethical approval

The Ethic Committee of Central Chest Institute of Thailand approved the present study of Central Chest Institute of Thailand, (COA No. 094/2565).

Preoperative staging

All patients underwent computed tomography (CT) scans. If the lymph nodes were larger than 10 mm or significant, patients had the invasive diagnosis test as an endobronchial ultrasound-guided fine-needle aspiration, transbronchial biopsy, or positron emission tomography-computed tomography (PET-CT) scan to evaluate the metastasis lymph node. The Eighth Edition of TNM staging was used to determine the stage, and the lymph node station was determined based on the International Association for the Study of Lung cancer lymph node map.

Operative technique

The individual surgeon judged the selection of VATS or open lobectomy technique. The surgical technique of VATS lobectomy was non-rib spreading incision performed using one, two, or three incisions as uniport, two-port, or three-port technique. The utility port incision was made via the fourth or fifth intercostal space and no larger than 5 cm in the anterior axillary line. If VATS was performed in a two or three-port fashion, the camera port was inserted via the seventh or eighth intercostal space in the anterior to the middle axillary line. The lobectomy procedure was performed by individual ligation pulmonary artery, vein, and bronchus technique. The open lobectomy was performed by posterolateral, anterolateral, or axillary incision, depending on the aptitude of the surgeon. The latissimus dorsi muscle sparing was the technique used in open lobectomy.

The intraoperative mediastinal lymph node assessment was sampling, systematic sampling, or dissection. The sampling technique removed one or more lymph nodes guided by intraoperative or preoperative findings that were considered representative and focus on the macroscopic appearance. The systematic sampling was the lymph node removal by 1) resection of at least three lymph nodes or three stations from hilar and intrapulmonary nodes, 2) resection of at least three lymph nodes or three stations from mediastinal nodes but always subcarinal, and 3) resection of at least six lymph nodes or six stations in total but mediastinal fat or tissue was

not included around the nodes. Systematic dissection was the method that systematically removed the same as systematic sampling but with mediastinal fat or tissue surrounding the nodes. The lymph node evaluation was performed in every patient, but the decision to perform lymph node dissection or sampling was at the discretion of the individual surgeon.

The complication and follow-up

The complication in 90-day postoperative was recorded as follows, prolonged air leak for seven days or longer, chylothorax, pneumonia, pulmonary embolism, and death. If the surgeon converted the technique from VATS to open lobectomy, it was labeled open lobectomy.

Statistical analysis

The categorical variable was analyzed and compared with Pearson's chi-squared test or Fisher's exact test. The distribution by the histogram analyzed the continuous variable, and then according to the results, two sample Student t-test or Mann-Whitney test was used. Logistic regression was used to decrease the confounding factor and predict node upstaging factors. The significant level was set at p-value less than 0.05. The program Stata/BE, version 17.0 (StataCorp LLC, College Station, TX, USA) was used to analyze the data.

Results

Patient characteristics

Three hundred twelve patients who underwent lobectomy for clinical N0 NSCLC between January 2015 and August 2020 at Central Chest Institute of Thailand were included in this study. One hundred and sixty-three patients were operated on by open lobectomy, including the conversion of 24 patients with VATS lobectomy at a conversion rate of 7.7%, and 149 patients underwent VATS. The patient characteristics are listed in Table 1. There were no statistically significant differences between the groups in age, gender, smoking status, underlying, and location of lung cancer. Preoperative lymph node staging, such as CT only, EBUS-TBNA, Transbronchial biopsy, and PET-CT, were comparable between the groups (p=0.648). Adenocarcinoma was the most histological type of lung cancer in both VATS and open thoracotomy groups at 82.2% and 91.3% (p=0.215). The mean of FEV1 as preoperative pulmonary function test, was over 2 Liters in both VATS and open lobectomy groups with 2.21±0.52 and 2.01±0.58 (p=0.003), respectively.

Table 1. Patient characteristics

Variable	VATS lobectomy (n=149)	Open lobectomy (n=163)	p-value
Age (year); mean±SD	61.77±11.62	63.47±11.02	0.185
Sex; n (%)			0.079
Male	62 (41.6)	84(51.5)	
Female	87 (58.4)	79(48.5)	
Smoking status; n (%)			0.255
Never	105 (70.5)	105 (64.4)	
Current	7 (4.7)	15 (9.2)	
Ex-smoker	37 (24.8)	43 (26.4)	
Underlying; n (%)			0.153
No underlying	116 (77.9)	129 (79.2)	
COPD	3 (2.0)	10 (6.1)	
Diabetes	17 (11.4)	18 (11.0)	
CAD	7 (4.7)	4 (2.5)	
Other cancer	6 (4.0)	2 (1.2)	
Location of lung cancer; n (%)			0.318
Right upper lobe	45 (30.2)	49 (30.1)	
Right middle lobe	12 (8.1)	10 (6.1)	
Right lower lobe	35 (23.5)	31 (19.0)	
Left upper lobe	34 (22.8)	34 (20.9)	
Left lower lobe	20 (13.4)	26 (15.9)	
Right middle and upper lobe	2 (1.3)	8 (4.9)	
Right middle and lower lobe	1 (0.7)	5 (3.1)	
FEV1 (liter); mean±SD	2.21±0.52	2.01±0.58	0.003
Preoperative lymph node staging; n (%)			0.648
Only CT	136 (91.3)	146 (89.6)	
EBUS-TBNA	11 (7.3)	14 (8.6)	
Transbronchial biopsy	1 (0.7)	3 (1.8)	
PET-CT	1 (0.7)	0 (0.0)	
Histological result; n (%)			0.215
Adenocarcinoma	134 (82.2)	136 (91.3)	
Squamous cell carcinoma	18 (11.0)	8 (5.3)	
Undetermined NSCLC	7 (4.3)	3 (2.0)	
Adenosquamouscell	2 (1.2)	1 (0.7)	
Neuroendocrine	1 (0.7)	1 (0.7)	
Adenocarcinoma in situ	1 (0.6)	0 (0.0)	

COPD=chronic obstructive pulmonary disease; CAD=coronary artery disease; FEV1=the first second forced expiratory volume; CT=computerized tomography; EBUS-TBNA=endobronchial ultrasound-guided transbronchial needle aspiration; PET-CT=positron emission tomography-computed tomography; NSCLC=non-small cell lung cancer; VATS=video-assisted thoracoscopic surgery; SD=standard deviation

The clinical staging is listed in Table 2. The clinical stage IA3 lung cancer was resected more by VATS lobectomy technique at 42.3% versus 28.8% (p=0.013), and clinical IIIA lung cancer was resected more frequently by open lobectomy technique at 9.8% and 0% (p≤0.001).

Table 2. Clinical staging

Clinical TNM staging	VATS lobectomy (n=149); n (%)	Open lobectomy (n=163); n (%)	p-value
IA1 (T1aN0M0)	1 (0.7)	3 (1.9)	0.624
IA2 (T1bN0M0)	31 (20.8)	24 (14.7)	0.159
IA3 (T1c N0M0)	63 (42.3)	47 (28.8)	0.013
IB (T2aN0M0)	38 (25.5)	38 (23.3)	0.653
IIA (T2bN0M0)	6 (4.0)	16 (9.8)	0.046
IIB (T3N0M0)	10 (6.7)	19 (11.7)	0.133
IIIA (T4N0M0)	0 (0.0)	16 (9.8)	<0.001

VATS=video-assisted thoracoscopic surgery

Surgical outcomes

The surgical outcome is shown in Table 3. There was no intraoperative mortality. The mean duration of the procedure was higher in the VATS lobectomy group minute at 198.4±46.8 versus 160.9±73.6 (p≤0.001), but the median of blood loss was more in the open lobectomy group mL at 150 versus 100 (p=0.034). There was no significant difference between the group in the length of hospital stay, duration of intercostal drainage, and surgical margin. The sampling procedure was more frequently performed in the open lobectomy group at 44.2% versus 19.5% (p≤0.001), but in the VATS group performed the systematic dissection procedure more than the open lobectomy group at 67.1% versus 42.9% (p≤0.001).

Number of dissected lymph node

The median overall number of lymph nodes was higher in the VATS lobectomy than in the open lobectomy at 19 versus 12 (p≤0.001). The median number of lymph node station N2 has dissected more in the VATS lobectomy than in the open lobectomy at 12 versus 6 (p≤0.001), and the number of station 7 nodes was dissected higher in the VATS group at 130

Table 3. Surgical outcomes

Variable	VATS lobectomy (n=149)	Open lobectomy (n=163)	p-value
Operative time (minute); mean±SD (range)	198.4±46.8 (85 to 365)	160.9±73.6 (30 to 400)	<0.001
Length of hospital stay (days); median (p25 to p75)	8 (6 to 10)	8 (7 to 11)	0.120
Duration of intercostal drainage (days); median (p25 to p75)	5 (4 to 7)	5 (4 to 8)	0.137
Blood loss (mL); median (p25 to p75)	100 (100 to 200)	150 (50 to 400)	0.034
Margin; n (%)			0.065
Negative	147 (98.7)	154 (94.5)	
Positive	2 (1.3)	9 (5.5)	
Lymph node procedure; n (%)			
Sampling	29 (19.5)	72 (44.2)	<0.001
Systematic sampling	20 (13.4)	21 (12.9)	0.888
Systematic dissection	100 (67.1)	70 (42.9)	<0.001

VATS=video-assisted thoracoscopic surgery; SD=standard deviation

Table 4. Number of dissected lymph node

Variable	VATS lobectomy (n=149)		Open lobectomy (n=163)		p-value
	Mean±SD	Median (p25 to p75)	Mean±SD	Median (p25 to p75)	
The overall number of nodes	19.9±11.1	19 (12 to 25)	14.3±11.4	12 (6 to 20)	<0.001
Total node per station					
Station N1	6.5±4.6	6 (3 to 9)	5.7±4.4	5 (2 to 8)	0.126
Station N2	13.5±9.2	12 (8 to 18)	8.6±9.3	6 (1 to 13)	<0.001
Station 7; n (%)					<0.001
Include	130 (87.3)		100 (61.3)		
Not include	19 (12.7)		63 (38.7)		
Station count; mean±SD					
N1	1.8±0.8		1.8±0.8		0.516
N2	2.7±0.9		1.91±1.3		<0.001

VATS=video-assisted thoracoscopic surgery; SD=standard deviation

Table 5. lymph node upstaging

Variable	VATS lobectomy (n=149); n (%)	Open lobectomy (n=163); n (%)	p-value
Overall lymph node upstaging	28 (18.8)	41 (25.2)	0.176
pN1	9 (6.0)	19 (11.7)	0.082
pN2	19 (12.8)	22 (13.5)	0.683

VATS=video-assisted thoracoscopic surgery

Table 6. Postoperative outcome

Variable	VATS lobectomy (n=149); n (%)	Open lobectomy (n=163); n (%)	p-value
Postoperative complication			
Prolong air leak	15 (10.1)	22 (13.5)	0.349
Chylothorax	0 (0.0)	1 (0.6)	1.000
Pulmonary embolism	2 (1.3)	0 (0.0)	0.227
Infected wound	1 (0.7)	0 (0.0)	0.478
Massive air leak	0 (0.0)	1 (0.6)	1.000
Pneumonia	0 (0.0)	1 (0.6)	1.000
Recurrent	26 (17.5)	31 (19.0)	0.720
Dead	2 (1.3)	1 (0.6)	0.608

VATS=video-assisted thoracoscopic surgery

versus 100 p≤0.001), but the median number of lymph node station N1 was similar between the two groups. (Table 4). The percentage of lymph node upstaging from N0 to N1 or N2 was not statistically significant different between the two groups (p=0.176) (Table 5).

Postoperative outcome

Three patients died from cancer-related within a one-year follow-up. Two cases in VATS lobectomy group had upstaging of lymph nodes to pathological N1 and N2, respectively, and already received the adjuvant chemotherapy but could not decrease the progression of the disease, and one patient died from cancer-related cause. One case in the open lobectomy group was not found upstaging of lymph nodes but tumor size increased over 5 cm. The patient received adjuvant chemotherapy but could not decrease the progression of the disease. There was no significant difference in recurrence rate between VATS lobectomy and open lobectomy groups (p=0.720) (Table 6). The prolonged air leak was the most frequent complication in both groups, and there was no statistically significant difference in postoperative complications between VATS lobectomy and open lobectomy.

Risk factor for lymph node upstaging

Logistic regression analysis demonstrated that the risk factor for lymph node upstaging was the tumor size when tumor size was over 3 cm and under 5 cm in univariate analysis (Table 7). No statistical association in age, gender, the position of cancer, lung cancer histology, type of procedure, lymph node procedure, number of lymph nodes, and the number of lymph node stations with N upstaging.

Discussion

The prognosis of non-small cell lung cancer depends on the accuracy of the staging. Staging is the factor for the physician to determine the proper treatment. If the patient had pathological stage I, the treatment should only be the surgical treatment, which could provide survival above 80% to 90%[1]. The appropriate lymph node evaluation reduces staging error and decreases the omission of micrometastasis. The CALGB 9761 prospective trial by D'Cunha et al demonstrated the patient's clinical stage I (T1-2, N0) by CT scan or cervical mediastinoscopy had 27.5% upstaging to N1 or N2 after lobectomy[10]. This means that there is a poor correlation between clinical and pathological staging. The importance of complete lymph node evaluation is vital to ensure accurate staging for deciding the operation for the patient. The Union for International Cancer Control (UICC) guidelines recommend that to confirm pN0 status, at least six lymph nodes/stations free of the disease must be removed. Three of the sample nodes/stations should be taken from the mediastinum, including subcarinal nodes, and three from nodes/stations of the hilar/intrapulmonary area[11]. Furthermore, the NCCN 2022 suggests a minimum of three N2 station samples should be resected or have a complete dissection[12]. However, factors that affect the insufficient number of sampled nodes includes advanced age, left side, and T1 stage[13]. The intraoperative mediastinal lymph node removal procedure remains an essential component of lobectomy in NSCLC lung cancer, but the early stage can be performed by mediastinal lymph node dissection or sampling. Those techniques are not different in survival[14].

VATS for lobectomy is increasingly becoming the surgical approach for early-stage lung cancer. Studies show that VATS procedures are less traumatic than open thoracotomy, with reduced blood loss, less postoperative complication, and shorter hospital stay[15]. The present study could not find the difference in postoperative complications and hospital stay but had significantly lesser blood loss in VATS lobectomy group and the operative time was higher than in the open lobectomy group. Despite the benefits of VATS lobectomy in early-stage NSCLC, the completeness

Table 7. Univariate analysis

Variable	Non-upstage (n=243)	Node upstage (n=69)	Univariable analysis	
			OR (95% CI)	p-value
Age; n (%)				0.446
≤50 years	34 (13.9)	9 (13.0)	1	
51 to 60 years	64 (26.4)	20 (28.9)	1.1 (0.48 to 2.87)	
61 to 70 years	94 (38.7)	20 (28.9)	0.80 (0.33 to 1.94)	
71 to 80 years	39 (16.1)	17 (24.7)	1.65 (0.65 to 4.17)	
>80 years	12 (4.9)	3 (4.5)	0.94 (0.22 to 4.08)	
Sex; n (%)				0.369
Male	117 (48.2)	29 (42.0)	1	
Female	126 (51.8)	40 (58.0)	1.28 (0.75 to 2.19)	
Tumor size; n (%)				0.044
≤3 cm	133 (54.7)	25 (36.2)	1	
>3 to 5 cm	78 (32.1)	34 (49.3)	2.32 (1.29 to 4.17)	0.005
>5 to 7 cm	22 (9.1)	7 (10.1)	1.69 (0.65 to 4.39)	0.278
>7 cm	10 (4.1)	3 (4.4)	1.59 (0.41 to 0.21)	0.500
Lobe; n (%)				0.367
RUL	79 (32.5)	15 (21.7)	1	
RML	16 (6.6)	6 (8.7)	1.98 (0.67 to 5.87)	
RLL	51 (20.9)	15 (21.7)	7.55 (0.69 to 3.44)	
LUL	49 (20.2)	19 (27.5)	2.04 (0.95 to 4.39)	
LLL	36 (14.8)	10 (14.5)	1.46 (0.59 to 3.57)	
RML+RUL	6 (2.5)	4 (5.8)	3.51 (0.88 to 13.96)	
RML+RLL	6 (2.5)	0 (0.0)	1	
Histology; n (%)				0.430
AIS	1 (0.4)	0 (0.0)	1	
Neuroendocrine	2 (0.8)	0 (0.0)	1	
Adenosquamouscell	1 (0.4)	2 (2.9)	1	
Adenocarcinoma	211(86.8)	59 (85.5)	0.14 (0.13 to 1.57)	
Squamous cell	20 (8.3)	6 (8.7)	0.15 (0.12 to 1.96)	
Undetermined	8 (3.3)	2 (2.9)	0.13 (0.01 to 2.18)	
Procedure; n (%)				0.175
Open thoracotomy	122 (50.2)	41 (59.4)	1	
VATS	121 (49.8)	28 (40.6)	0.69 (0.40 to 1.18)	
LN procedure; n (%)				0.209
Systematic sampling	34 (13.9)	7 (10.1)	1	
Systematic dissection	126 (51.9)	44 (63.8)	0.59 (0.24 to 1.43)	
Sampling	83 (34.2)	18 (26.1)	0.62 (0.33 to 1.15)	
Number of lymph node; median (p25 to p75)	15 (8 to 22)	15 (10 to 26)	1.01 (0.99 to 1.04)	0.124
Number of lymph node station; mean±SD				
Station N1	1.75±0.81	1.96±0.85	1.35 (0.97 to 1.88)	0.078
Station N2	2.28±1.27	2.39±1.14	1.08 (0.87 to 1.34)	0.510

RUL=right upper lobe; RML=right middle lobe; RLL=right lower lobe; LUL=left upper lobe; LLL=left lower lobe; AIS=adenocarcinoma in situ; VATS=video-assisted thoracoscopic surgery; LN=lymph node; SD=standard deviation; OR=odds ratio; CI=confidence interval

of lymph node evaluation remains questionable when compared to the open lobectomy procedure.

The evaluation of lymph node between VATS lobectomy and open lobectomy by Medbery et al[16] based on the National Cancer Database (NCDB), report that VATS harvested a greater total number of lymph nodes or nine LNs or more at 43.7% versus 38.8%, in the unmatched analysis as well as in the propensity-matched analysis of 4,437 patients, which had 10.3 versus 9.7 LNs. The present study also found

significant higher mean number of the lymph node in VATS lobectomy group compared to open lobectomy group at 19.9±11.1 versus 14.3±11.3 nodes (p≤0.001). In addition, the mean number of N2 lymph nodes was significantly higher in the VATS lobectomy at 13.5±9.2 versus 8.6±9.3 nodes (p≤0.001), and the station number of N2 was nearly three stations in the VATS lobectomy at 2.7±0.9 versus 1.9±1.3 (p≤0.001). However, the mean number of N1 was not statistically different between the two groups. In contrast to the study by Zhang et al[17], VATS harvested fewer total lymph nodes than open thoracotomy (95% CI –1.52 to –0.73, p≤0.001). N2 nodes were poorly evaluated (95% CI –1.38 to –0.49, p≤0.001). Total lymph node stations evaluated were not different (95% CI –0.28 to 0.06, p=0.20). Despite the difference in number, station of lymph node resection, and technique of lymph node harvest between VATS lobectomy and open lobectomy, the upstaging of lymph nodes from N0 to N1 or N2 did not have significant difference at 18.8% versus 25.2% (p=0.176) in the present study. Similar to the report by Stephens et al[18], they conducted a retrospective study on 963 patients with clinical Stage I NSCLC from Texas (VATS, n=307; posterolateral thoracotomy, n=656). The result showed the two groups had similar rates at 35% VATS versus 38% open, in terms of postoperative nodal upstaging. The observation in the present study may be from the removal of the number of lymph nodes. Both groups were at least six lymph nodes/stations, and three of the sampled nodes/stations were taken from the mediastinum, including subcarinal nodes, and three from nodes/stations of the hilar/intrapulmonary area same as recommendation from UICC[11].

Furthermore, the present study demonstrated the risk factor for lymph node upstaging and found that the pathological tumor size greater than 3 to 5 cm is the only the risk factor for clinical N0 to pathological N1or N2. The lobe location of the tumor, the procedure of lymph node harvest, the type of incision for lobectomy, and the number of lymph nodes were not significant risk factors for upstaging the lymph node. The study by Moulla et al[19] reported that the independent risk factor for lymph node upstaging was central tumor localization and tumor size greater than 3 cm.

The interpretation of the result in the present study was limited by the retrospective study design, and many surgeons performed the surgery. The study also covered the multiport and uniport VATS lobectomy. However, the learning curve of VATS lobectomy for surgeons is more than 60 lobectomies and lymphadenectomy in lung cancer, as Zhao et al suggested[20]. The surgeons possibly differed in the preferred mediastinal lymph node harvest technique and surgical access. In larger tumor sizes, especially over 5 cm, there may be some surgeon limitations for performing VATS procedures and preferred open lobectomy, which was the reason for the difference in clinical staging between groups. This is one of the limitations of the present study. Despite differences in the surgeon's decision to perform lymph node assessment and surgical access, the present study showed adequate number of lymph nodes and station of a lymph node, as followed by the recommendation of UICC[11].

Conclusion

The completeness of mediastinal lymph node evaluation for patients with clinical N0 NSCLC operated on by an experienced surgeon in VATS lobectomy was comparable with open lobectomy.

What is already known on this topic?

The intraoperative lymph node evaluation and harvesting is crucial to reducing staging error in lung cancer. The open thoracotomy for lobectomy is the standard for lung cancer surgery, but VATS lobectomy has become the current method. The current study on the efficacy of VATS lobectomy in lung cancer in intraoperative lymph node evaluation is still controversial.

What this study adds?

This study shows that the mediastinal lymph node evaluation can be performed by VATS lobectomy, which is non-inferior to the open lobectomy if the surgeon improves skill and has a good learning curve. Additionally, there is no significant difference in upstaging of lymph nodes between both procedures.

Conflicts of interest

The author declared no conflict of interest.

References

1. Albano D, Bilfinger T, Nemesure B. 1-, 3-, and 5-year survival among early-stage lung cancer patients treated with lobectomy vs SBRT. Lung Cancer (Auckl) 2018;9:65-71.
2. Dziedzic DA, Zbytniewski M, Gryszko GM, Cackowski MM, Langfort R, Orlowski TM. Video-assisted versus open thoracotomy lobectomy: comparison on lymphadenectomy and survival in early stage of lung cancer. J Thorac Dis 2021;13:101-12.
3. Howington JA, Blum MG, Chang AC, Balekian AA,

Murthy SC. Treatment of stage I and II non-small cell lung cancer: Diagnosis and management of lung cancer, 3rd ed: American College of Chest Physicians evidence-based clinical practice guidelines. Chest 2013;143:e278S-313S.
4. Paul S, Altorki NK, Sheng S, Lee PC, Harpole DH, Onaitis MW, et al. Thoracoscopic lobectomy is associated with lower morbidity than open lobectomy: a propensity-matched analysis from the STS database. J Thorac Cardiovasc Surg 2010;139:366-78.
5. Park BJ. Is surgical morbidity decreased with minimally invasive lobectomy? Cancer J 2011;17:18-22.
6. Watanabe A, Koyanagi T, Ohsawa H, Mawatari T, Nakashima S, Takahashi N, et al. Systematic node dissection by VATS is not inferior to that through an open thoracotomy: a comparative clinicopathologic retrospective study. Surgery 2005;138:510-7.
7. Boffa DJ, Kosinski AS, Paul S, Mitchell JD, Onaitis M. Lymph node evaluation by open or video-assisted approaches in 11,500 anatomic lung cancer resections. Ann Thorac Surg 2012;94:347-53.
8. Lababede O, Meziane MA. The eighth edition of TNM staging of lung cancer: Reference chart and diagrams. Oncologist 2018;23:844-8.
9. Ludwig MS, Goodman M, Miller DL, Johnstone PA. Postoperative survival and the number of lymph nodes sampled during resection of node-negative non-small cell lung cancer. Chest 2005;128:1545-50.
10. D'Cunha J, Herndon JE 2nd, Herzan DL, Patterson GA, Kohman LJ, Harpole DH, et al. Poor correspondence between clinical and pathologic staging in stage 1 non-small cell lung cancer: results from CALGB 9761, a prospective trial. Lung Cancer 2005;48:241-6.
11. Sobin LH, Gospodarowicz MK, Wittekind C. TNM classification of malignant tumours. 7th ed. Oxford: Wiley Blackwell; 2010.
12. Ettinger DS, Wood DE, Aisner DL, Akerley W, Bauman JR, Bharat A, et al. Non-small cell lung cancer, Version 3.2022, NCCN clinical practice guidelines in oncology. J Natl Compr Canc Netw 2022;20:497-530.
13. Pawelczyk K, Blasiak P, Szromek M, Nowinska K, Marciniak M. Assessment of adequacy of intraoperative nodal staging and factors influencing the lack of its compliance with recommendations in the surgical treatment of non-small cell lung cancer (NSCLC). J Thorac Dis 2018;10:4902-11.
14. Darling GE, Allen MS, Decker PA, Ballman K, Malthaner RA, Inculet RI, et al. Randomized trial of mediastinal lymph node sampling versus complete lymphadenectomy during pulmonary resection in the patient with N0 or N1 (less than hilar) non-small cell carcinoma: results of the American College of Surgery Oncology Group Z0030 Trial. J Thorac Cardiovasc Surg 2011;141:662-70.
15. Xu J, Ni H, Wu Y, Cao J, Han X, Liu L, et al. Perioperative comparison of video-assisted thoracic surgery and open lobectomy for pT1-stage non-small cell lung cancer patients in China: a multi-center propensity score-matched analysis. Transl Lung Cancer Res 2021;10:402-14.
16. Medbery RL, Gillespie TW, Liu Y, Nickleach DC, Lipscomb J, Sancheti MS, et al. Nodal upstaging is more common with thoracotomy than with VATS during lobectomy for early-stage lung cancer: An analysis from the national cancer data base. J Thorac Oncol 2016;11:222-33.
17. Zhang W, Wei Y, Jiang H, Xu J, Yu D. 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.
18. Stephens N, Rice D, Correa A, Hoffstetter W, Mehran R, Roth J, et al. Thoracoscopic lobectomy is associated with improved short-term and equivalent oncological outcomes compared with open lobectomy for clinical stage I non-small-cell lung cancer: a propensity-matched analysis of 963 cases. Eur J Cardiothorac Surg 2014;46:607-13.
19. Moulla Y, Gradistanac T, Wittekind C, Eichfeld U, Gockel I, Dietrich A. Predictive risk factors for lymph node metastasis in patients with resected non-small cell lung cancer: a case control study. J Cardiothorac Surg 2019;14:11.
20. Zhao H, Bu L, Yang F, Li J, Li Y, Wang J. Video-assisted thoracoscopic surgery lobectomy for lung cancer: the learning curve. World J Surg 2010;34:2368-72.