Acta Chirurgica Belgica

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/tacb20

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Serkan Yazgan, Ahmet Üçvet, Yunus Türk & Soner Gürsoy

To cite this article: Serkan Yazgan, Ahmet Üçvet, Yunus Türk & Soner Gürsoy (2021): The impact of dissection of station 9 on survival and the necessity of pulmonary ligament division during upper lobectomy for lung cancer, Acta Chirurgica Belgica, DOI: 10.1080/00015458.2021.1958189

To link to this article: https://doi.org/10.1080/00015458.2021.1958189

Published online: 26 Jul 2021.

ACTA CHIRURGICA BELGICA
https://doi.org/10.1080/00015458.2021.1958189

ORIGINAL PAPER

The impact of dissection of station 9 on survival and the necessity of pulmonary ligament division during upper lobectomy for lung cancer

Serkan Yazgan[a], Ahmet Üçvet[a], Yunus Türk[a] and Soner Gürsoy[b]

[a]Department of Thoracic Surgery, Dr. Suat Seren Chest Diseases and Surgery, Medical Practice and Research Center, Health Sciences University, Izmir, Turkey; [b]Department of Thoracic Surgery, Izmir Bakircay University, Izmir, Turkey

ABSTRACT

Background: We conducted this study to investigate the need for dissection of station 9 lymph nodes during upper lobectomy for non-small-cell lung cancer (NSCLC) and to find out the operative results of inferior pulmonary ligament division.

Methods: A total of 840 patients who underwent upper lobectomy for NSCLC between January 2007 and June 2020 were evaluated retrospectively. The patients were separated into two groups – those having undergone lymph node dissection of station 9 and inferior pulmonary ligament dissection (Group I) and those who did not (Group II). In these groups, the prognostic value of station 9 lymph nodes and postoperative effects (drainage time, prolonged air leak, dead space and length of hospital stay) of ligament division or preservation were analyzed.

Results: The number of patients with station 9 lymph node metastasis was only one (0.1%) and that was multi-station pN2 disease. Station 9 lymph nodes were found in 675 (80.4%) patients, while 22 (2.6%) patients had no lymph nodes in the dissected material. In the other 143 (17%) patients, the inferior pulmonary ligament and station 9 were not dissected. While 5-year survival was 64.9% in 697 patients of Group I, it was 61.3% in 143 patients of Group II ($p = 0.56$). There was no statistically significant difference between the groups in postoperative effects of ligament division or preservation.

Conclusions: In upper lobectomies, status of station 9 does not have a significant impact on patients' survival and lymph node staging. Additionally, preservation or division of the inferior pulmonary ligament has no significant advantage or disadvantage.

ARTICLE HISTORY
Received 17 March 2021
Accepted 16 July 2021

KEYWORDS
Non-small cell lung cancer; upper lobectomy; MLND; station 9 lymph nodes; staging; pulmonary ligament

Introduction

The most effective treatment modality for early-stage non-small cell lung cancer (NSCLC) is anatomical lung resection performed along with systematic lymph node dissection [1]. Nodal dissection is an integral part of lung cancer surgery, since the status of the lymph nodes should be known for accurate staging of the disease and postoperative treatment planning [2]. However, nodal dissection method is discussed among thoracic surgeons now and again. Although systematic lymph node dissection is recommended for the most accurate histological lymph node staging, different methods such as sampling or lobe-specific lymph node dissection are still used and it remains undetermined which one the optimal method is.

In a previous study, it was found that adaptation of the residual lung following upper or lower lobectomy was associated with a less favorable adaptation in upper lobectomy than that in lower lobectomy [3]. Various opinions have been put forward about the reasons behind this, and a debate has come up in recent years. Some authors argue that division of the inferior pulmonary ligament (IPL) during upper lobectomy is unnecessary, and disagree with the theory that this contributes to the expansion of the residual lobe. They also suggest that this can lead to complications such as bronchial deformation, stenosis, obstruction, or lobar torsion [4].

In this study, we investigated the value of the nodal station 9 as a part of staging, and the operative results of IPL dissection in upper lobectomies performed due to NSCLC localized in the upper lobe.

Materials and methods

The study was approved by the institutional review board (IRB date and no: 16/06/2020, 49109414/

CONTACT Serkan Yazgan serkanyazgan@gmail.com SBÜ Dr Suat Seren Göğüs Hastalıkları ve Cerrahisi SUAM, Göğüs Cerrahisi Bölümü, K-Blok, 3. Kat, Yenişehir, Konak, İzmir, Türkiye

604.02/5582) and was conducted in accordance with the principles of the Declaration of Helsinki.

Patient selection

All clinical documents of the patients who had undergone surgery due to NSCLC between January 2007 and June 2020 were analyzed retrospectively. Those who underwent upper lobectomy and mediastinal lymph node dissection were included in the study. Mediastinal lymph node classification was made in accordance with 'The Eighth Edition Lung Cancer Stage Classification' [5]. Sublobar resections or resections wider than lobectomy, bilateral surgeries, rethoracotomies, incomplete resections, stage IV tumors, carcinoid tumors, benign or metastatic tumors, neoadjuvant therapies, and operative mortalities were excluded from the study. Operative mortality was defined as deaths occurring within the first 30 days.

Clinicopathologic data

All patients underwent thoracic computed tomography imaging, fiberoptic bronchoscopy, and positron emission tomography imaging to detect distant metastasis, preoperatively. To exclude N3 disease or to confirm N2 involvement, endobronchial ultrasonography and/or videomediastinoscopy was performed in all patients who required.

All operations were performed by two-person surgical teams following intubation with a double-lumen endotracheal tube. Upper lobectomy via video-assisted thoracic surgery (VATS) was performed using three incisions. Middle lobe fixation was performed in patients with an IPL division when torsion of right middle lobe was deemed possible at the end of the operation. Air leak was checked carefully at the end of the operation. In the event of an air leak, methods such as primary repair of parenchymal tissue, synthetic parenchyma graft, and autologous tissue adhesive were used to prevent the leakage. In the upper lobectomy through VATS, the bronchovascular structures in the hilar region were cut, and the fissure was divided with the fissureless technique.

When the surgeon detected more than one lymph node in a station, he/she sent each lymph node for pathological examination separately. When a single lymph node fragmented during dissection, these lymph node fragments were examined as one single lymph node. The lymph nodes which were found suspicious through preoperative radiological evaluation or according to the findings obtained during the operation were definitely evaluated with frozen section examination during the operation. All dissected lymph nodes were noted and positive and negative lymph nodes were recorded according to pathology results. The patients were separated into two groups – those having undergone lymph node dissection of station 9 and IPL dissection (Group I) and those who did not (Group II). Survival analyses were carried out in these groups to investigate the prognostic value of station 9 lymph nodes. Station 9 lymph node dissection was not performed either in early stage patients, in whom the absence of metastasis in superior mediastinal lymph nodes was proven by frozen section, at the surgeon's own discretion, or when no lymph node was detected in station 9 through a dissection performed with or without dividing the inferior ligament. Similar techniques were used in VATS and thoracotomy in terms of dissection of station 9 lymph node or inferior pulmonary ligament approach. The decision to perform VATS or thoracotomy for tumor resection was made by the same surgical team, taking into account the characteristics of the patient and of the disease. Patients who were converted from VATS to thoracotomy for various reasons were included in the thoracotomy group.

The operation was completed by inserting single chest tube in patients who underwent VATS upper lobectomy and double chest tube in patients undergoing thoracotomy. A daily chest roentgenogram was performed in all patients. In VATS resections, the chest tube was removed when air leak had ceased and the drainage volume had dropped below 100–200 cc. In thoracotomy patients, of the two chest tubes, one apical and one basal, the latter was removed first when the drainage volume was below 100–200 cc. The approach to the apical drain was the same as that described for VATS. The patients whose chest tube was removed were discharged on the same day or the next day after having checked with a chest X-ray at the end of a reasonable period of time. When prolonged air leak (PAL) occurred in both surgical methods, the chest tube was replaced with the Heimlich valve system instead of the closed underwater drainage, enabling the patient to be discharged.

The patients were referred to the oncology clinic, where they were followed up, with their pathology reports. Of patients with stage II–IIIA, those whose general condition was suitable for additional treatment received adjuvant treatment

8–10 weeks after the operation. Criteria such as tumors larger than 4 cm, lymphovascular invasion, and visceral pleural invasion were considered for adjuvant treatment. The patients were subsequently followed up every three months in the first year, every six months in the second year, and then annually with routine blood tests and computed tomography of the thorax. The time period determined for the survival study was defined as the interval between the date of resection for NSCLC and the date of death or the last follow-up of the patients. The latest status of living patients was checked from the national registration system in September 2020.

On the other hand, in order to analyze the postoperative effects of division or preservation of IPL, length of hospital stay, drainage time, PAL and expansion of residual lung on postoperative chest radiographs were examined and the dead space was evaluated. Postoperative chest tube drainage longer than seven days was interpreted as PAL [6–10]. Plain chest X-rays (posterior-anterior) were performed at end-inspiration one month after surgery to evaluate the upward movement of the residual lobes and incomplete re-expansion in the longitudinal axis was regarded as dead space.

The clinical parameters such as gender, age, and date of surgery were retrospectively reviewed. The surgery and pathology reports were examined and the pathological type, lymph node status of each station, the size of the primary tumor and the location of the tumor were obtained.

Statistical analysis

Data were collected from hospital database, operational reports, patient charts and national mortality database. Excel software (Microsoft Corp, Seattle, WA, USA) was used to analyze the data. The means and standard deviations of the continuous variables, and number and percent of categorical variables were given by using descriptive statistics. Taking into consideration all deaths, the estimated survival rate was calculated using the Kaplan–Meier method and compared by the Log-rank test. The groups were compared using the chi-square ($\chi 2$) test and the Mann–Whitney *U* test was used to compare the medians of the groups. Variables with a *p*-value less than 0.05 and station 9 dissection were selected for further multivariable analysis. Multivariable analysis for OS was performed to identify the prognostic factors using the Cox proportional hazard model. A *p*-value less than or equal to 0.05 was considered as statistically significant. All statistical analyses were performed with IBM SPSS Statistics, version 22 (IBM Corporation, Armonk, NY, USA).

Results

During the study period, 2296 primary lung cancer patients underwent curative anatomical lung resection and mediastinal lymph node dissection. There were 840 (36.6%) upper lobectomies meeting the specified criteria. The mean age of the upper lobectomy patients constituting the study population was 61.8 ± 8.3 (range from 35 to 84 years). 728 of these patients (86.7%) were male and 112 (13.3%) were female. While thoracotomy was preferred in 690 (82.1%) patients, VATS was decided in 150 (17.9%) patients. Right upper lobectomy was performed in 475 (56.5%) patients and left upper lobectomy in 365 (43.5%) patients. Upper sleeve lobectomy was performed in 83 (9.9%) patients. Right and left upper sleeve lobectomies were 61 (7.3%) and 22 (2.6%), respectively. 280 (33.3%) patients received adjuvant treatment. Squamous cell carcinoma was determined in 378 (45%) patients, adenocarcinoma in 382 (45.5%) patients, large cell carcinoma in 57 (6.8%) patients, and other histological tumor types in 23 (2.7%) patients. While no lymph node metastasis was observed in 672 (80%) patients, 168 (20%) patients had lymph node metastasis. According to the pathology reports, 675 (80.4%) patients had station 9 lymph nodes. It was found that there were no lymph nodes in the station 9 material in 22 (2.6%) patients. These 697 patients constituted Group I. IPL and station 9 were not dissected in the other 143 (17%) patients (Group II). The number of patients with station 9 lymph node metastasis was only one (0.1%). Tumor diameter was 3 cm or less in 417 (49.6%) patients. While the mean tumor diameter was 3.8 ± 1.9 (0.3–11) cm in Group I, it was 3.5 ± 1.9 (0.6–11) cm in Group II.

At the end of the study, 556 patients (66.2%) were still alive. When all upper lobectomies were considered, five and 10-year survivals were 64.3 and 47.8%, respectively. Five and 10-year survival rates, and median [± SD] survival time of the 697 patients in the Group I were 64.9%, 48.8%, and 103 ± 13.1 months, respectively [95% confidence interval (CI)=77.4–128.6], while these rates and median [± SD] survival time were 61.3%, 44%, and 98.7 ± 8.0 months for 143 patients in Group II (95% CI = 83.1–114.3) ($p = 0.56$) (Figure 1). Five-year

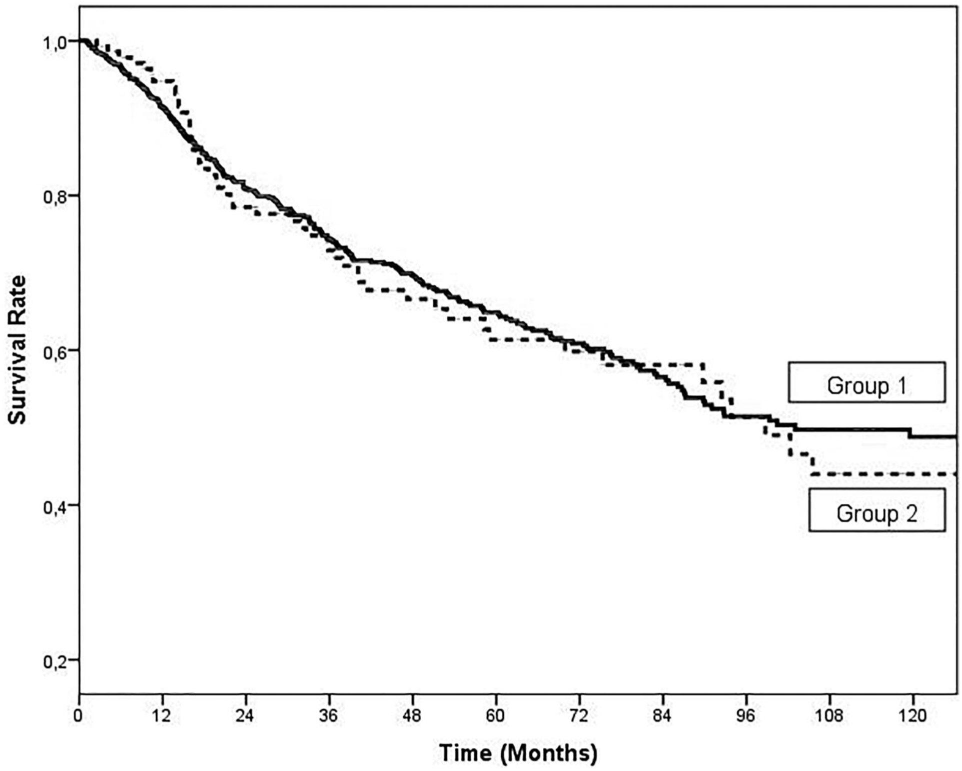

Figure 1. Kaplan–Meier survival curve of Group I ($n = 697$) and Group II ($n = 143$) patients.

Table 1. General characteristics and survival of patients who underwent upper lobectomy due to non-small cell lung cancer (overall population, $n = 840$).

Variables	*n*	5-Year survival (%)	Median survival (month)	Univariate *p*-value	Multivariate *p*-value	95% CI
Age						
≤60	357	68.4	136.0	**0.006**	**0.002**	**1.14–1.84**
>60	483	60.6	87.0			
Operation type						
Thoracotomy	690	63.0	98.7	**0.02**	**0.05**	**1.00–2.75**
VATS	150	74.4	NA			
Tumor location						
Right	475	64.3	102.3	0.75		
Left	365	64.3	100.4			
Sleeve resection						
No	757	63.9	100.4	0.43		
Yes	83	67.8	NA			
Pathological type						
Squamous	378	66.2	102.3	0.62		
Non-squamous	462	62.8	99.3			
N status						
N0	672	68.6	126.5	**<0.001**	**<0.001**	**1.42–1.98**
N1	99	64.2	93.8			
N2	69	24.0	25.4			
Primary Tumor						
3 cm or less	417	69.9	127.3	**0.001**	**0.003**	**1.13–1.81**
Above 3 cm	423	58.7	89.8			
Dissection						
Yes	697	64.9	103.0	0.56	0.37	0.64–1.17
No	143	61,3	98.7			

Bold value represent statistically significant outcomes. CI: confidence interval; NA: not available; VATS: video-assisted thoracic surgery.

survival was 63% in upper lobectomy patients who underwent thoracotomy, while it was 74.4% in the VATS group ($p < 0.05$). While station 9/IPL dissection was performed in 593 (85.9%) of the patients for whom thoracotomy was preferred, this number was 104 (69.3%) in VATS patients. Five-year survivals of these two groups were 63.7 versus 80.9%, respectively ($p = 0.03$). General characteristics and survival results of the 840 patients are shown in Table 1. Five-year survival comparisons for different prognostic variables between Group I and Group II patients are shown in Table 2.

The patient with positive station 9 lymph nodes was still alive at 118 months. This patient was multiple-station pN2 positive. Among all patients who underwent upper lobectomy, 99 (11.8%) had only pN1 disease and 69 (8.2%) had pN2 disease. Skip pN2 disease (pN2a1) was detected in 31 (3.7%) of pN2 cases and 38 (4.5%) cases were pN2 disease with pN1 (pN2a2). The pN2a1 ratio was 44.9% in those with pN2 disease.

pN2 positivity was observed in 93 different stations in 69 cases with pN2 disease. Multiple-station N2 disease was detected in 22 patients. According to this, station 4 had the highest pN2 positivity with 32 stations. It was followed by station 6 with 19 station positivity, station 5 with 21 stations, station 7 with 10 stations, station 2 with 6 stations, station 8 with 4 stations and station 9 with one station.

When postoperative parameters were analyzed within the two groups with or without Station 9/ IPL dissection, PAL was detected in 271 (38.9%) patients in Group I and in 60 (42%) patients in Group II. In the postoperative period, a problem with the residual lung filling the empty space in the upper thorax was observed in 323 (46.3%) patients in Group I and in 72 (50.3%) patients in Group II. The mean drainage time was 9.7 ± 7.5 (2–52) days in Group I, whereas it was 9.9 ± 7.7 (2–48) days in Group II. When similar analyses were examined separately in the IPL division and preservation groups, no statistically significant difference was found in terms of mean drainage time, postoperative hospital stay, PAL, and the free space filling rate of the residual lung in the upper thorax (Table 3). In the subanalysis of the patient group that had PAL and free space in the postoperative period, gender, operation type, tumor location and size of the primary tumor had a significant impact on survival, whereas lymph node positivity and sleeve resection did not have a significant impact (Table 4).

Table 2. The effect of station 9 and pulmonary ligament dissection on survival in patients who underwent upper lobectomy for non-small cell lung cancer (Overall population, $n = 840$).

	Group I		Group II		
Variables	*n*	5-Year survival (%)	*n*	5-Year survival (%)	*p*-Value
Age					
≤60	299	68.3	58	68.6	0.95
>60	398	61.9	85	55.3	0.47
Operation type					
Thoracotomy	593	63.7	97	59.2	0.43
VATS	104	80.9	46	69.9	0.62
Tumor location					
Right	372	64.8	103	62.1	0.85
Left	325	65.0	40	59.1	0.44
Sleeve resection					
No	618	64.3	139	62.2	0.80
Yes	79	69.6	4	33.3*	**0.009**
Pathological type					
Squamous	317	67.4	61	59.8	0.49
Non-squamous	380	62.8	82	62.5	0.91
N status					
N0	556	69.3	116	65.6	0.70
N1	88	60.7	11	90.9	0.20
N2	53	27.0	16	17.5	0.35
Primary tumor					
3 cm or less	336	70.4	81	67.9	0.57
Above 3 cm	361	59.7	62	53.1	0.62

Group I: Those undergoing station 9 and pulmonary ligament dissection; Group II: those who did not undergo station 9 and pulmonary ligament dissection; VATS: video-assisted thoracic surgery, *2-years survival. Bold value represents statistically significant outcomes.

Discussion

Lymphatic metastasis is the most important mechanism in the spread of lung cancer and is one of

Table 4. Rates of patients with free space and/or prolonged air leak in the postoperative period and analysis of effective variables ($n = 840$).

Variables	*n*	Complication rate (%)	Univariate *p*-value	Multivariate *p*-value
Age				
≤60	173	48.5	0.49	
>60	222	46.0		
Sex				
Male	364	50.0	**<0.001**	**<0.001**
Female	31	27.7		
Operation type				
Thoracotomy	347	50.3	**<0.001**	**0.002**
VATS	48	32.0		
Tumor Location				
Right	255	53.7	**<0.001**	**<0.001**
Left	140	38.4		
Sleeve resection				
No	360	47.6	0.36	
Yes	35	42.2		
Pathological type				
Squamous	175	46.3	0.73	
Non-squamous	220	47.6		
N status				
N0	328	48.8	0.12	
N1	40	40.4		
N2	27	39.1		
Primary tumor				
3 cm or less	172	41.2	**0.001**	**0.02**
Above 3 cm	223	52.7		
Dissection				
Yes	323	46.3	0.41	0.27
No	72	50,3		

Bold value represents statistically significant outcomes. VATS: video-assisted thoracic surgery.

Table 3. Postoperative parameters compared in patients with divided and preserved pulmonary ligament.

Variables	Group I ($n = 697$)	Group II ($n = 143$)	*p*
Drainage time (days), (mean ± SD)	9.7 ± 7.5	9.9 ± 7.7	0.80
Postoperative dead space, *n* (%)	323 (46.3)	72 (50.3)	0.41
PAL, *n* (%)	271 (38.9)	60 (42.0)	0.51
Postoperative hospital stay (days), (mean ± SD)	8.0 ± 3.4	8.3 ± 4.0	0.40

Group I: divided pulmonary ligament; Group II: preserved pulmonary ligament; PAL: prolonged air leak; SD: standard deviation.

the factors affecting prognosis. Mediastinal lymph node dissection is therefore an important component of lung cancer surgery. However, the extent of lymph node dissection is still controversial, especially for upper lobe tumors. Some studies suggest that upper lobe tumors are less likely to metastasize to inferior mediastinal lymph nodes than middle and lower lobe tumors. These studies also indicate that the possibility of regional metastasis to the superior mediastinal lymph nodes is higher [11]. Moreover, it is known that the metastasis rate of station 9 lymph nodes in lung cancer patients is significantly lower than that of other mediastinal stations [2]. Therefore, in upper lobe tumors, the effect of the inclusion of inferior mediastinal lymph nodes, especially station 9, in routine dissection on prognosis is currently being discussed.

On the other hand, some other reports state that IPL dissection does not significantly contribute to lung volume in upper lobectomies; on the contrary, according to these reports, it may cause some complications because it leads to a change in bronchial angle [12]. From this point of view, in routine mediastinal lymph node dissection accompanying upper lobectomy, which is performed due to primary NSCLC localized in the upper lobe, the necessity of station 9 and the division of the IPL are open to discussion, seeing that there was no significant impact on survival in patients who underwent selective mediastinal lymph node dissection for the upper lobe [13].

In a study investigating the metastasis rate of station 9 lymph nodes in patients undergoing radical surgery due to NSCLC, the rate was 3.45% [2]. In this study, it is seen that some of the patients who underwent sublobectomy at early stage or who had selective mediastinal lymphadenectomy were not included. Considering this, it is certain that the possibility of metastasis of station 9 will be even lower in all lung cancer patients. Station 9 metastasis is thus a significantly lower probability than other mediastinal lymph nodes. Moreover, when this condition was investigated solely in terms of upper lobectomies, the number of station 9 metastases was only one (0.23%) in 423 left upper lobectomies and only six (1.36%) in 440 right upper lobectomies. While the rate of station 9 metastasis was 0.81% in a total of 863 upper lobectomy patients in the aforementioned study, it was observed only in one (0.14%) of 697 patients in our study, and this rate was even more remarkable. We may wonder whether the nodal staging would be incomplete if station 9 lymph node dissection had not been performed in this patients. However, the remarkable detail in this case was that it was multi-station pN2 positive. The situation was different for station 8, which was another station where we observed a small number of metastases. There, we detected metastasis in a single station or positivity together with station 7 due to its anatomical proximity. Therefore, unlike station 9, we believe that station 8 should be dissected separately along with the subcarinal lymph nodes. Station 9-positive patient had adenocarcinoma histology. The tumor was 4 cm in size and was located peripherally. Stations 5 and 9 were metastatic in the patient who underwent left upper lobectomy. The patient, who received adjuvant treatment, is still alive in the 10th year of follow-up.

In the study of Sun et al. [2], among all NSCLC patients who underwent resective surgery, the median survival time was 42 months in station 9-positive patients and 48 months in station 9-negative patients, and the difference was not significant. They have reported lymph node positivity at station 9 as 0% in 557 surgery patients with stage 0-IIb according to TNM staging. They argue that metastasis status of station 9 does not directly affect prognosis once the influence of other factors is eliminated. Okada et al. [14] and Asamura et al. [15] stated in their studies that upper lobe tumors tend to metastasize to the superior mediastinum. Deng et al. [16] reported that there is no need for dissection of the lower mediastinal lymph nodes, particularly in cases of upper lobe tumors ($\leq$3 cm). These and similar studies have recently led some thoracic surgeons to perform more specific lymph node dissection, considering early-stage tumor, its location and size. The basis of these different trends is the same as that in shortening the incisions, the increasing trend in performing endoscopic surgery, and the proliferation of parenchyma-sparing surgery. Likewise, this is an attempt by surgeons to reduce surgical trauma and avoid non-pathologic lymph node dissection by minimizing lymph node dissection. Considering the fact that prophylactic lymphadenectomy does not have a positive effect on survival in patients without nodal metastasis, it becomes inevitable to prevent unnecessary lymph node dissection. From this aspect, when there is no pathologic lymph nodes, it would not be wrong to discuss the station 9 dissection, especially in upper lobe tumors, also considering the 0.1% metastasis rate in our study. Our study showed that the lymph node staging of upper lobe tumors does not change whether station 9 is dissected or not.

In our study, station 9/IPL dissection was performed in 85.9% of thoracotomy patients, while this rate was 69.3% in VATS patients. While some surgeons work on upper lobe tumors using VATS method, they less frequently resect station 9, thus reducing the total number of sampled lymph node stations [17]. The assessment of the lymph node depends on the patient and the surgeon and not on any technical limitations of VATS. However, since station 9 nodal metastases are rare in upper lobe tumors, the value of such additional sampling should be discussed for both intervention methods.

Another controversial issue is IPL division during upper lobectomy. Some surgeons cut the pulmonary ligament during upper lobectomy. This, in theory, reduces the free space in the upper thorax by increasing the mobility of the residual lobes [4]. However, division of the ligament can cause bronchial obstruction, bronchial stenosis, or atelectasis in the postoperative period, as it will change the bronchial angle. Some studies link the intractable cough and shortness of breath that occur after upper lobectomy to this condition [18]. In a report analyzing the status of IPL in upper lobectomy, eight articles that best answered the questions on the subject were reviewed [4]. As a result, it was reported that there was no convincing evidence on the fact that IPL division in upper lobectomy significantly improves results and reduces complications. In another meta-analysis, these patients were compared in terms of conditions such as postoperative drainage time, ratio of postoperative dead space, postoperative complication rate, and change in bronchial angle [19]. This meta-analysis confirmed that IPL division does not effectively reduce postoperative complications and does not improve prognosis. It was reported that IPL division is therefore not required after upper lobectomy. As emphasized in this and many other studies, the data of our study also showed that IPL division does not prolong drainage time (9.7 ± 7.5 days in Group I, 9.9 ± 7.7 days in Group II, $p = 0.80$) and hospital stay (8.0 ± 3.4 days in Group I, 8.3 ± 4.0 days in Group II, $p = 0.40$), and does not provide an additional advantage. In the analysis of postoperative dead space, there was no significant difference between our patients with divided and preserved IPL (46.3% for Group I and 50.3% for Group II, $p = 0.41$).

Our study has some limitations. First of all, this is a retrospective study. Secondly, this was a single-center study. If we had included more health centers and compared the results of dissection technique according to their surgical approaches, the results would be more objective. Thirdly, there are several different surgical teams in our center, and this may not provide a proper standard in lymph node dissection technique. Fourthly, division or preservation of the IPL was at the surgeon's own discretion. We did not have a certain standard for IPL division or preservation. Therefore, there may be selection bias in the decision regarding whether to preserve or not. More precisely designed, randomized, controlled studies are needed to demonstrate a more accurate relationship between complications and IPL division.

Our study shows that the status of station 9 does not have a significant impact on the survival of patients in upper lobectomies performed due to NSCLC. Furthermore, the possibility of station 9 lymph node metastasis in upper lobectomies is negligible, and this does not have a significant impact on nodal staging. If further studies support our research, routine dissection of station 9 may not be necessary for upper lobectomies in the future. However, systematic lymph node dissection should not be compromised until sufficient scientific evidence is presented. It will be sufficient to resect the visible station 9 lymph nodes without dividing IPL because preservation or division of the inferior pulmonary ligament has no significant advantage or disadvantage in upper lobectomies. Comparing our views on station 9 and IPL with the studies of other centers in the future will provide a better understanding of this significant issue.

Acknowledgment

The authors have received no funding related to this paper.

Disclosure statement

No potential conflict of interest was reported by the author(s).

ORCID

Serkan Yazgan http://orcid.org/0000-0001-9763-6336

References

[1] Adachi H, Sakamaki K, Nishii T, et al. Lobe-specific lymph node dissection as a standard procedure in

surgery for non-small cell lung cancer: a propensity score matching study. J Thorac Oncol. 2017;12(1): 85–93.

[2] Sun F, Zhan C, Shi M, et al. Is routine dissection of the station 9 lymph nodes really necessary for primary lung cancer? Int J Surg. 2016;34:53–57.

[3] Ueda K, Tanaka T, Hayashi M, et al. Compensation of pulmonary function after upper lobectomy versus lower lobectomy. J Thorac Cardiovasc Surg. 2011; 142(4):762–767.

[4] Khanbhai M, Dunning J, Yap KH, et al. Dissection of the pulmonary ligament during upper lobectomy: is it necessary? Interact Cardiovasc Thorac Surg. 2013; 17(2):403–406.

[5] Detterbeck FC, Boffa DJ, Kim AW, et al. The eighth edition lung cancer stage classification. Chest. 2017; 151(1):193–203.

[6] Brunelli A, Monteverde M, Borri A, et al. Predictors of prolonged air leak after pulmonary lobectomy. Ann Thorac Surg. 2004;77(4):1205–1210.

[7] Lee L, Hanley SC, Robineau C, et al. Estimating the risk of prolonged air leak after pulmonary resection using a simple scoring system. J Am Coll Surg. 2011; 212(6):1027–1032.

[8] Rivera C, Bernard A, Falcoz PE, et al. Characterization and prediction of prolonged air leak after pulmonary resection: a nationwide study setting up the index of prolonged air leak. Ann Thorac Surg. 2011;92(3): 1062–1068.

[9] Stolz AJ, Schutzner J, Lischke R, et al. Predictors of prolonged air leak following pulmonary lobectomy. Eur J Cardiothorac Surg. 2005;27(2):334–336.

[10] Gilbert S, Maghera S, Seely AJ, et al. Identifying patients at higher risk of prolonged air leak after lung resection. Ann Thorac Surg. 2016;102(5): 1674–1679.

[11] Wang W, Mao F, Shen-Tu Y, et al. [Research for mediastinal lymph node desection style of stage Ib upper lobe non-small cell lung cancer] . Zhongguo Fei Ai Za Zhi. 2013;16(11):584–590.

[12] Kim D-H, Moon DH, Kim HR, et al. Effect of inferior pulmonary ligament division on residual lung volume and function after a right upper lobectomy. Interact Cardiovasc Thorac Surg. 2019;28(5):760–766.

[13] Ishiguro F, Matsuo K, Fukui T, et al. Effect of selective lymph node dissection based on patterns of lobe-specific lymph node metastases on patient outcome in patients with resectable non-small cell lung cancer: a large-scale retrospective cohort study applying a propensity score. J Thorac Cardiovasc Surg. 2010; 139(4):1001–1006.

[14] Okada M, Sakamoto T, Yuki T, et al. Selective mediastinal lymphadenectomy for clinico-surgical stage I non-small cell lung cancer. Ann Thorac Surg. 2006; 81(3):1028–1032.

[15] Asamura H, Nakayama H, Kondo H, et al. Lobe-specific extent of systematic lymph node dissection for non-small cell lung carcinomas according to a retrospective study of metastasis and prognosis. J Thorac Cardiovasc Surg. 1999;117(6):1102–1111.

[16] Deng HY, Zhou J, Wang RL, et al. Lobe-specific lymph node dissection for clinical early-stage (cIA) peripheral non-small cell lung cancer patients: what and how? Ann Surg Oncol. 2020;27:472–480.

[17] Flores RM, Park BJ, Dycoco J, et al. Lobectomy by video-assisted thoracic surgery (VATS) versus thoracotomy for lung cancer. J Thorac Cardiovasc Surg. 2009;138(1):11–18.

[18] Ueda K, Tanaka T, Hayashi M, et al. Clinical ramifications of bronchial kink after upper lobectomy. Ann Thorac Surg. 2012;93(1):259–265.

[19] Lv H, Zhou R, Zhan X, et al. The choice of dissection or preservation of the inferior pulmonary ligament after an upper lobectomy: a systematic review and meta-analysis. World J Surg Oncol. 2020;18(1):5.