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Comparison of VATS and open thoracotomy in anatomical lung resections according to multifaceted parameters

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ABSTRACT

Introduction: In our research, the data of lung cancer patients operated via VATS and thoracotomy methods were investigated. In the evaluation performed by using versatile parameters, both methods were compared on the basis of objective criteria. Our study was carried out in order to assess the outcomes of both methods.

Materials and Methods: 232 patients who underwent surgery with a diagnosis of lung cancer of various stages between the dates of January 2016 and June 2021 were involved in the research, and the patients' data were retrospectively scanned. To ensure balance between both groups, cases that were operated on for benign causes, performed pneumonectomy, received neoadjuvant, underwent chest wall resection, and cases converted to open from VATS were excluded from the research. The patients' hospitalization, amount of drainage, count of dissected lymph nodes, stages, complications and early mortality were reviewed.

Results: There were 81 patients underwent VATS lobectomy and 151 patients underwent thoracotomy, in our study. The mean age was 63.5 in the thoracotomy group, and, 61.8 in VATS group. In the thoracotomy group, there were 31 female and 120 male patients; and in VATS group, 28 female and 53 male patients. The hospitalization times were shorter in VATS group; however, it was not statistically significant. In thoracotomy group, drainage amount and the count of lymph node dissections were significantly higher. The stage was determined significantly earlier in VATS group. Despite the rate of complication was lower in VATS group, there was no statistical difference between the both groups. Early mortality rates were comparable.

Conclusion: Even though our research has limitations, we believe that we will gain better outcomes as our learning curve enhances in VATS.

Keywords: Lung Cancer, Lung Resection, Open Thoracotomy, Video-assisted Thoracic Surgery

Introduction

Lung cancer has the highest incidence and mortality rate in the world among all cancers.[1] In accordance with National Comprehensive Cancer Network (NCCN) Guidelines, the main treatment for lung cancer at Stage 1–2 is surgery; in Stage 3, however, surgical treatment is recommended in selected patient groups.[1] The video-assisted thoracoscopic surgery (VATS) method, which has been

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utilized in lung cancer surgery since the 1990s, has shown great progress recently. Sleeve resections began to be performed using VATS, and uniportal methods were developed over time. Furthermore, other advantages of VATS, such as providing a shorter discharge time, less cosmetic damage, and less pain, have been reported in numerous publications.[2-4] Nevertheless, thoracotomy is still considered the best choice, particularly in advanced-stage cancers and centrally located tumors.

In our study, we compared VATS and thoracotomy based on multifaceted effects in patients with anatomical lung disease due to lung cancer. We aimed to evaluate the advantages and limitations of both methods.

Materials and Methods

Our research was conducted retrospectively, including data from 232 patients who underwent lung cancer surgery at Kartal Dr. Lütfi Kırdar City Hospital over a 5-year period between January 2016 and June 2021. The patients' age, gender, operation side, operation name, operation method, number of dissected lymph nodes, pathological outcome, stage, postoperative complications, hospitalization time, and drainage amounts were recorded. Patients who underwent anatomical resection for benign etiologies, pneumonectomy, post-neoadjuvant cases, lung resection with chest wall resection, sleeve resections, segmentectomy cases, cases that remained in exploration, and cases that were converted to thoracotomy were excluded from the study. All patients were staged after surgery in accordance with the 8th International TNM Classification System for Lung Cancer.[5]

Mediastinal lymph node assessment was conducted using the "systematic mediastinal lymph node sampling method" based on the map proposed by the American Thoracic Society.[6]

The TM&M (Thoracic Morbidity and Mortality) classification, created by Seely et al.,[7] in 2010 by modifying the Clavien-Dindo classification,[8] was used for the classification of complications. Surgical complications were divided into Clavien-Dindo Class 1 and Class 2 (minor) and Classes 3 and 4 (major) (Table 1).

Statistical Analysis

In the descriptive statistics of the data, mean, standard deviation, median, lowest, highest, frequency, and ratio values were utilized. The distribution of variables was tested using the Kolmogorov-Smirnov test. Independent sample t-tests were utilized for the analysis of quantitative independent data. The Chi-square test was used for the analysis of qualitative independent data, and Fisher's exact test was used when Chi-square test requirements were not met. SPSS 27.0 software was used for the analyses.

Ethics Committee Approval

Our study was approved by the Ethics Committee of Kartal Dr. Lütfi Kırdar City Hospital on 20.08.2019 with decision number 2019/514/160/5.

Table 1. Classification of complications

Major Complications	Minor Complications
Pneumonia requiring intensive care	Wound infection
Chylothorax requiring ductusligation	Prolonged air leak (PAL)
Hematoma requiring revision	Subcutaneous emphysema
Myocardial Infarction	Atelectasis
Cerebro-vascular disease (CVD)	Gastrointestinal complications
Renal failure requiring hemodialysis	Urological complications
Pulmonary edema requiring mechanical ventilation	Acute renal failure
	Atrial fibrillation (AF)
Bronchopleural fistula requiring surgery	Pneumonia
Acute respiratory distress syndrome (ARDS)	Chylothorax
	Hematoma
	Pulmonary embolism
	Pulmonary edema
	Bronchopleural fistula

Results

A total of 232 patients who underwent anatomical resection (81 VATS, 151 thoracotomy) were included in the study. The mean age was 63.5 years in the thoracotomy group and 61.8 years in the VATS group. There were 31 female and 120 male patients in the thoracotomy group, and 28 female and 53 male patients in the VATS group. The operation side was principally the right side in both groups (64.6% in thoracotomy and 58.0% in VATS). The demographic characteristics of the patients are summarized in Table 2.

The most frequent operation in both groups was upper lobectomy, with 55.6% in the VATS group and 59.9% in the thoracotomy group (Table 2). After reviewing the exact pathology in both groups, we found that adenocarcinoma was the most common type. Adenocarcinoma was observed in 42.9% of the patients in the thoracotomy group, followed by squamous cell carcinoma in 42.2%. In

Table 2. Demographic data of the patients, operation types, final pathology results, pathological stages

	Thoracotomy Mean±SD/n-%		VATS Mean±SD/n-%		p
Age	63.5±8.7		61.8±8.7		0.170[t]
Gender					
Famele	30	20.4%	28	34.6%	0.019[X²]
Man	117	79.6%	53	65.4%	
Side					
Right	95	64.6%	47	58.0%	0.466[X²]
Left	56	38.1%	34	42.0%	
Anatomical Resection Type					
Lower Lobectomy	44	29.9%	34	42.0%	0.049[X²]
Upper Lobectomy	88	59.9%	45	55.6%	0.689[X²]
Middle Lobectomy	6	4.1%	0	0.0%	0.069[X²]
Bilobectomy Inferior	8	5.4%	1	1.2%	0.170[X²]
Bilobectomy Superior	5	3.4%	0	0.0%	0.166[X²]
Cancer Stage					
1A1	11	7.5%	11	13.6%	0.000[X²]
1A2	40	27.2%	21	25.9%	
1A3	15	10.2%	26	32.1%	
1B	21	14.3%	11	13.6%	
2A	19	12.9%	1	1.2%	
2B	21	14.3%	7	8.6%	
3A	19	12.9%	4	4.9%	
3B	5	3.4%	0	0.9%	
Pathology					
Adenocarcinoma	63	42.9%	55	67.9%	0.000[X²]
Squamous	62	42.2%	18	22.2%	0.006[X²]
Large Cell	11	7.5%	4	4.9%	0.679[X²]
Adenosquamous	5	3.4%	2	2.5%	0.964[X²]
Pleomorphic carcinoma	6	4.1%	1	1.2%	0.447[X²]
Typical carcinoid	2	1.4%	1	1.2%	0.614
Atypical carcinoid	1	0.7%	0	0.0%	1.000
Small cell	1	0.7%	0	0.0%	1.000

[t]: independent sample t test; [X²] Ki-kare test; n: number.

the VATS group, 67.9% had adenocarcinoma, and 22.2% had squamous cell carcinoma. The exact pathology of the patients is summarized in Table 2.

The stage of lung cancer was significantly higher ($p < 0.05$) in the thoracotomy group compared to the VATS group (Table 2). In the thoracotomy group, 57.2% of patients were at Stage 1, and 42.8% were at Stage 2 and above. In contrast, 85.2% of patients in the VATS group were at Stage 1, and 14.8% were at Stage 2 and above. The VATS method was favored more in early-stage cancers (Table 2).

Examining the number of lymph nodes dissected between both groups, the total number of lymph nodes was 5.75±1.48 in the thoracotomy group and 4.75±1.34 in the VATS group. The total number of lymph nodes in the thoracotomy group was significantly higher ($p<0.05$) compared to the VATS group. The ratio of the number of lymph nodes 2, 4, 8, and 9 was significantly higher ($p<0.05$) in the thoracotomy group compared to the VATS group. However, the ratios of lymph nodes 5, 6, 7, 10, and 11 did not significantly differ between the two groups ($p>0.05$) (Table 3).

In terms of drainage amounts, the total drainage was 747±694 ml in the thoracotomy group and 525±449 ml in the VATS group, with a statistically significant difference between both groups ($p<0.05$) (Table 4). The hospitalization time was 8.5±5.7 days in the thoracotomy group and 7.4±3.4 days in the VATS group, which was not statistically significant ($p>0.05$) (Table 4).

The TM&M system, a modified version of the Clavien-Dindo classification, was used to classify complications. These complications were grouped as major or minor (Table 4). Both minor and major complications, as well as total complications, were higher in the thoracotomy group (22.5%, 11.3%, and 33.8%, respectively). The total complication ratio was significantly higher in the thoracotomy group ($p<0.05$). The rates of prolonged air leaks (PAL), subcutaneous emphysema, pneumonia, chylothorax requiring ligation, chylothorax, atrial fibrillation (AF), pulmonary embolism, bronchopleural fistulas (BPF) requiring an operation, pulmonary edema, wound infection, and cerebrovascular disease (CVD) did not significantly differ between the two groups ($p>0.05$). However, the rates of atelectasis, urinary complications, and hematoma were significantly higher ($p<0.05$) in the thoracotomy group (Table 5).

Mortality data were collected, including patients who died due to postoperative complications during their first month of follow-up. Complications-associated mortality was noted in 4 patients (2.6%) in the thoracotomy group and 2 patients (2.4%) in the VATS group within the first postoperative month. This difference was not statistically significant ($p>0.05$). Mortality data are presented in Table 4.

Discussion

In our research, we compared the VATS and thoracotomy methods based on multifaceted parameters in patients who underwent anatomical resection due to lung cancer. To ensure balance among cases, we excluded patients whose

Table 3. Numbers and percentages of lymph nodes dissected during the operation

	Thoracotomy Mean±SD/n-%		VATS Mean±SD/n-%		p
Side					
Right	95	62.9%	47	58.0%	0.466$^{X^2}$
Left	56	37.1%	34	42.0%	
Total Number of Lymph Nodes	5.75±1.48		4.75±1.34		0.000^{m}
Lymph Node					
2.4	82	54.3%	29	35.8%	0.007$^{X^2}$
5.6	50	33.1%	18	22.2%	0.082$^{X^2}$
7	143	94.7%	71	87.7%	0.056$^{X^2}$
8.9	103	68.2%	37	45.7%	0.001$^{X^2}$
10.11	137	90.7%	73	90.1%	0.881$^{X^2}$

^{m}Mann-whitney u test / X^2 Ki-kare test; ave :average, ss/n : standard deviation/number.

Table 4. Analysis of major-minor complications, total drainage, length of stay, mortality data

	VATS		Thoracotomy		
	Mean±SD/n-%	Median	Mean±SD/n-%	Median	p
Postoperative Complication					
(-)	57/70.4%		103/68.2%		0.735$^{X^2}$
(+)	24/29.6%		48/31.8%		
Major Complication					
(-)	77/95.1%		142/94.0%		0.747$^{X^2}$
(+)	4/4.9%		9/6.0%		
Minor Complication					
(-)	60/74.1%		110/72.8%		0.841$^{X^2}$
(+)	21/25.9%		41/27.2%		
Total Drainage	485.6±453.6	400.0	712.0±696.7	500.0	0.002^{m}
Hospitalization Duration	7.4±3.4	7.0	8.5±5.7	7.0	0.058^{m}
Mortality					
(-)	79/97.6%		145/97.4%		0.069$^{X^2}$
(+)	2/2.4%		4/2.6%		

^{m}Mann-whitney u test / X^2 Ki-kare test (Fischer test); (-) not, (+) available, ave :average, ss/n : standard deviation/number.

Table 5.Postoperative complications

	Thoracotomy		VATS		p
	n	%	n	%	
Complication					
Atelectasis	11	7.3%	0	0.0%	0.013$^{X^2}$
Prolonged air leak (PAL)	11	7.3%	3	3.7%	0.275$^{X^2}$
Hematoma Requiring Revision	3	2.0%	1	1.2%	1.000$^{X^2}$
Hematoma	3	2.0%	8	9.9%	0.007$^{X^2}$
Urinary Complication	7	4.6%	0	0.0%	0.049$^{X^2}$
Subcutaneous Emphysema	5	3.3%	5	6.2%	0.306$^{X^2}$
Pneumonia	7	4.6%	2	2.5%	0.415$^{X^2}$
Chylothorax requiring ligation	1	0.7%	3	3.7%	0.124$^{X^2}$
Chylothorax	2	1.3%	1	1.2%	1.000$^{X^2}$
Atrial fibrillation (AF)	2	1.3%	1	1.2%	1.000$^{X^2}$
Pulmonary Embolism	1	0.7%	0	0.0%	1.000$^{X^2}$
Bronchopleural fistula requiring surgery	1	0.7%	0	0.0%	1.000$^{X^2}$
Bronchopleural fistula	0	0.0%	0	0.0%	1.000$^{X^2}$
Pulmonary Edema	0	0.0%	0	0.0%	1.000$^{X^2}$
Wound Infection	1	0.7%	0	0.0%	1.000$^{X^2}$
Cerebrovascular accident	2	1.3%	2	2.5%	0.613$^{X^2}$

X^2 Ki-kare test, n: number.

operations were converted to thoracotomy, those who underwent pneumonectomy, lung resection with chest wall resection, and patients with neoadjuvant therapy.

In numerous studies comparing thoracotomy and VATS, the number of lymph nodes dissected, drainage amount, length of hospitalization, and postoperative complications were evaluated.[9-11] We investigated demographic data, hospitalization, drainage amount, number of lymph nodes, stages, complications, and early mortality in our study.

In a study conducted in 2006,[12] McKenna reported on 1,100 patients who underwent VATS lobectomy over 12 years, 1,015 of whom were operated on for lung cancer. Of the participants, 54.1% were female, and 45.9% were male. The mean age was 71.2 years (range: 16–94). The most common histologic type was adenocarcinoma, with a rate of 63.1%. The most frequent operation type was right upper lobectomy (403 cases, 39.7%). In a multicenter randomized controlled study by Long et al.[13] in 2017, 425 patients undergoing VATS and axillary thoracotomy were included (215 VATS and 210 axillary thoracotomy). Of these patients, 49.8% were female, and 50.1% were male. The mean age was 57.1 years in the VATS group and 58.1 years in the axillary thoracotomy group. The most common histologic type was adenocarcinoma (VATS 82.7%, thoracotomy 76.6%), and the most frequent operation was right upper lobectomy (VATS 26.9%, thoracotomy 35.7%). Of the 232 patients included in our study over a 5-year period, 59 (25.4%) were female, and 173 (74.5%) were male. The mean age was 63.5 years in the thoracotomy group and 61.8 years in the VATS group. The most frequent operation side was the right side (thoracotomy 64.6%, VATS 58.0%), and the most common operation type was upper lobectomy (thoracotomy 59.9%, VATS 55.6%). The most common cancer type was adenocarcinoma (thoracotomy 42.9%, VATS 67.9%). The rate of female patients in our research was lower compared to other studies.[3,4] The mean age of patients was 7 years older than that reported in McKenna's study, while it was 5 years older than in Long H.'s study. Adenocarcinoma was the most common cancer type, as in other studies[3,4] and the most frequently performed operation was right upper lobectomy.

In studies conducted, the length of hospitalization following lung resection was noted to be shorter in the VATS group compared to the thoracotomy group.[13-15] The length of hospitalization ranged between 4.5 and 14 days in the VATS group and between 5 and 15 days in the thoracotomy group.[13-15] In our research, the hospitalization duration was 7.4±3.4 days in the VATS group and 8.5±5.7 days in the thoracotomy group. However, this difference was not statistically significant ($p>0.05$).

The amount of drainage and the timing of drain removal are crucial factors in determining patient discharge times. In various studies,[4,13] drainage amounts were noted to be higher in thoracotomy patients compared to VATS patients. In our research, the drainage amount in the thoracotomy group was significantly higher than in the VATS group (total drainage: 747±694 ml in the thoracotomy group and 525±449 ml in the VATS group, $p<0.05$). Although the specific day for drain removal was not mentioned, all patients were discharged after a control chest X-ray was taken the day after the drain was removed in our study.

Various studies have compared the number of lymph nodes dissected between VATS and thoracotomy groups.[16-19] In some of these studies, the number of lymph nodes dissected was found to be similar between the two groups.[16,18,19] However, other studies reported that the number of lymph node dissections was higher in the thoracotomy group.[17,20,21] In our study, the total number of lymph nodes in the thoracotomy group was significantly higher ($p<0.05$) compared to the VATS group.

Numerous publications on lung cancer treatment suggest that VATS lobectomy should be preferred in early-stage cancers.[9-11] Some studies, however, have demonstrated that VATS also provides successful outcomes in tumors larger than 5 cm (Stage 3).[22,23] In some studies comparing VATS and thoracotomy, VATS was less frequently preferred in advanced stages.[13,21,24] A similar trend was observed in our research, where the selection of VATS diminished in higher stages.

In McKenna's 2006 study, no postoperative complications were reported in 932 of the 1,100 patients who underwent VATS (82% of the patients).[12] Wang et al.[25] included a total of 10 studies involving 1,514 patients in their meta-analysis and found a lower incidence of postoperative complications in the VATS group. In a study involving 269 patients, Erdoğu et al.[24] reported an early postoperative complication rate of 17.9% in patients who underwent VATS and 32.2% in those who underwent thoracotomy. In a study with 516 patients, Lee et al.[17] reported a major complication rate of 4.3% in the VATS group and 9.6% in the thoracotomy group. The minor complication rate was 13.9% in the VATS group and 13% in the thoracotomy group. The complication rate for VATS lobectomy has

been noted to be lower than that for thoracotomy in many studies.[26,27] In our study, the total complication rate was 26% in the VATS lobectomy group and 34% in the thoracotomy group. The major complication rate was 8.7% in the VATS group and 11.3% in the thoracotomy group, while the minor complication rate was 17.3% in the VATS group and 22.5% in the thoracotomy group. The difference in total complications was found to be statistically significant in favor of the VATS group. Additionally, the complication rates in the thoracotomy group were similar to those in other studies. In the VATS group, the rate of hematoma was reported to be between 0.9% and 1.5% in other studies,[13,17,26,27] whereas in our research, the rate was 2.5%.

The mortality rate following VATS lobectomy due to lung cancer ranges between 0.3% and 3% and between 0.7% and 6% following thoracotomy.[12,17,25-28] In our study, early mortality rates were 2.4% in the VATS group and 2.6% in the thoracotomy group. There was no significant difference in early-term mortalities between the two groups.

The limitations of our study include its single-center design, the lack of postoperative pain scoring between the two groups, and the fact that long-term postoperative complications and survival outcomes were not examined.

Conclusion

For lung cancer in the first two stages, the ideal treatment option is surgery. VATS has become increasingly popular in lung resections due to its numerous advantages.

In our study, although the length of hospitalization was shorter in the VATS group, no statistically significant difference was observed between the two groups. However, the drainage amount was greater in the thoracotomy group, and this difference was statistically significant. The number of lymph node dissections was also higher in the thoracotomy group, and this difference was significant as well. We believe there is a direct correlation between the number of lymph node dissections and the amount of drainage, and the outcome from the data supports our opinion.

In the thoracotomy group, there were more patients in higher stages of lung cancer, and the stage was significantly higher compared to the VATS group. The major-minor complication ratio and total complications were found to be lower in the VATS group, with the total complication rate being significantly lower. No significant difference was noted in early mortality rates between the two groups.

Our study did not address pain, quality of life, cost, long-term outcomes, or the distribution of VATS over the years. However, in alignment with our results, we believe that VATS should be favored, particularly for early-stage tumors, as the length of hospitalization is shorter, the drainage amount is less, and complications are fewer. Despite the limitations of our study, we anticipate achieving better outcomes as our learning curve for VATS improves.

Disclosures

Ethics Committee Approval: Our study was approved by the Ethics Committee of Kartal Dr. Lütfi Kırdar City Hospital on 20.08.2019 with decision number 2019/514/160/5.

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