Chirurgia (2024) 119: 393-403
No. 4, July - August

http://dx.doi.org/10.21614/chirurgia.2999

Evaluating VATS versus Open Surgery for Non-Small Cell Lung Cancer: A 5-year Retrospective Study

Alin Ionut Burlacu[1,2], Bogdan Cosmin Tanase[1,2]*, Iolanda Augustin[1,2], Gabriel Veniamin Cozma[3,4]

[1]Department of Thoracic Surgery, Prof. Alexandru Trestioreanu Institute of Oncology, Bucharest, Romania
[2]Carol Davila University of Medicine and Pharmacy, Faculty of Medicine, Bucharest, Romania
[3]Discipline of Surgical Semiology I and Thoracic Surgery, Department of Surgery I,
Victor Babes University of Medicine and Pharmacy Timisoara, Timisoara, Romania
[4]Thoracic Surgery Research Center, Victor Babes University of Medicine and Pharmacy Timisoara, Romania

*Corresponding author:
Bogdan Cosmin Tanase, M.D.
Department of Thoracic Surgery
Prof. Alexandru Trestioreanu Institute
of Oncology, Bucharest, Romania
E-mail: cosmin.bogdan.tanase@gmail.com

Received: 30.05.2024
Accepted: 27.07.2024

Rezumat

Analiză comparativă CTVA versus chirurgie clasică pentru cancerul bronhopulmonar NSCLC: studiu retrospectiv pe 5 ani

Context: Eficiența şi siguranța chirurgiei toracoscopice asistate video (VATS) în comparație cu toracotomia deschisă pentru tratamentul cancerului pulmonar non-microcelular (NSCLC) au fost evaluate, concentrându-se pe disecția ganglionilor limfatici mediastinali, recuperarea postoperatorie şi rezultatele pe termen lung, inclusiv ratele de supraviețuire şi intervalele libere de boală.
Metode: Acest studiu retrospectiv a analizat datele de la 228 de pacienți cu NSCLC tratați la Institutul de Oncologie Bucureşti între anii 2016 şi 2022. Au fost comparate abordările chirurgicale VATS şi cele deschise, cu variabile ce includeau date demografice, comorbidități, rezultate chirurgicale şi complicații postoperatorii. Semnificația statistică a fost evaluată utilizând teste chi-pătrat şi t-testuri pentru probe independente.
Rezultate: Printre descoperiri, VATS a demonstrat rate semnificativ mai bune de supraviețuire fără progresia bolii pe doi ani pentru pacienții în stadiile incipiente (Stadiile 1-3) de NSCLC comparativ cu chirurgia deschisă, cu valori p <0.01 şi <0.001, respectiv. În contrast, nu s-au observat diferențe semnificative la Stadiul 4. În plus, VATS a rezultat în timpuri operatorii mai scurte (media 299 față de 347 minute, p<0.001), pierderi de sânge estimate mai reduse (98.68 mL față de 160.88 mL, p<0.001), durate reduse ale drenajului toracic (5.78 zile față de 12.17 zile, p<0.001) şi scurtarea perioadelor de spitalizare (12.0 zile față de 27.7 zile, p<0.001).

Concluzii: VATS este asociat cu îmbunătățirea supraviețuirii pe termen lung fără boală pentru NSCLC în stadiile timpurii şi cu rezultate chirurgicale pe termen scurt mai favorabile, subliniind avantajele sale față de toracotomia deschisă. În ciuda beneficiilor sale, VATS nu a redus semnificativ complicațiile postoperatorii în comparație cu chirurgia deschisă.

Cuvinte cheie: cancer bronho-pulmonar, chirurgie generală, oncologie, chirurgie toracică

Abstract

Background and Objectives: The efficacy and safety of video-assisted thoracoscopic surgery (VATS) versus open thoracotomy in the treatment of non-small cell lung cancer (NSCLC) were evaluated with a focus on mediastinal lymph node dissection, postoperative recovery, and long-term outcomes including survival rates and disease-free intervals.

Materials and Methods: This retrospective study analyzed data from 228 NSCLC patients treated at the Institute of Oncology Bucharest from 2016 to 2022. Both VATS and open surgical approaches were compared, with variables including demographic data, comorbidities, surgical outcomes, and postoperative complications meticulously recorded. Statistical significance was assessed using chi-square and independent samples t-tests.

Results: Among the findings, VATS demonstrated significantly better two-year progression-free survival rates for patients in early stages (Stages 1-3) of NSCLC compared to open surgery, with p-values <0.01 and <0.001, respectively. In contrast, no significant difference was observed in Stage 4. Furthermore, VATS resulted in shorter operative times (mean 299 vs. 347 minutes, p<0.001), less estimated blood loss (98.68 mL vs. 160.88 mL, p<0.001), reduced chest tube duration (5.78 days vs. 12.17 days, p<0.001), and decreased hospital stays (12.0 days vs. 27.7 days, p<0.001).

Conclusions: VATS is associated with improved long-term disease-free survival for early-stage NSCLC and more favorable short-term surgical outcomes, highlighting its advantages over open thoracotomy. Despite its benefits, VATS did not significantly reduce postoperative complications compared to open surgery.

Key words: lung cancer, general surgery, oncology, thoracic surgery

Introduction

Bronchopulmonary cancer has become one of the most common life-threatening diseases and is one of the main causes of death worldwide. The progress in the awareness campaigns and in the early diagnostic fields has led to the growth of the importance of surgical treatment. Surgery represents an important part of the personalized treatment strategies for patients with different stages of lung cancer. Particularly, the concept of minimally invasive, precise surgery techniques has triggered a revolutionary change in the treatment strategy for lung cancer.

Cancer is a major public health concern and is in the top causes of death worldwide. The coronavirus (COVID-19) pandemic led to delays in the diagnosis and treatment of cancer. Although the impact was greater during the mid-2020, the condition of health care system has not fully recovered (1).

Even though the number of bronchopulmonary cancer cases has a descending trend, lung cancer continues to be a major public health issue. Lung cancer has the high-

est mortality in the world population and is the second most frequent diagnosed cancer in both sexes. Furthermore, lung cancer will maintain the same trends in 2024, according to Siegel et al. Meanwhile, in both developed and developing countries, lung cancer has been the largest contributor to the cancer medication burden (2). Despite the devastating effect of the COVID 19 pandemic, a form of screening for bronchopulmonary cancer has emerged, with cases diagnosed in the early stages being more numerous than in the pre-COVID era (3).

Detection rates of early-stage lung cancer has increased thanks to low-dose thin-section CT scans (4). The best choice of treatment for patients with lung cancer of clinical stage I or II is surgery (5). Multiple surgical techniques are now available, including wedge resection, segmentectomy, lobectomy, and pneumonectomy. Lobectomy with complete mediastinal lymph node dissection has traditionally been considered the gold standard for surgical treatment of lung cancer, although recent advancements suggest that segmentectomy is becoming the preferred standard in certain cases. The benefits of lymphadenectomy, while widely practiced, are still a subject of ongoing research and debate, with some studies questioning its definitive advantages. Therefore, a nuanced view acknowledging both the established role of lobectomy and the emerging evidence supporting segmentectomy and the complex considerations surrounding lymphadenectomy is essential for a comprehensive understanding of current surgical approaches to lung cancer (6).

The National Comprehensive Cancer Network (NCCN) guidelines recommend that minimally invasive approaches to lobectomy be strongly considered for all patients who undergo resection for lung cancer (7). For locally advanced NSCLC, neoadjuvant therapy is recommended for selected patients (8,9).

The first pneumonectomy for lung cancer was successfully performed by Graham in 1933 (10) and since then, the surgical methods and techniques for lung cancer are in a constant evolution. The emergence of video-assisted thoracoscopic surgery (VATS) in the 1990s was a breakthrough discovery in the field of cardiothoracic surgery. Since 2006 radical resection of the tumor using VATS is considered standard of care in the NCCN guidelines (11). The last few years brought new innovative techniques, like different types of approach (from multiportal to uniportal VATS) which led to great progress in terms of extent of resection, size and numbers of incisions, tolerance of the patient and length of hospitalization (12).

The primary objective of this study was to evaluate the efficacy and safety of surgical interventions in patients with non-small cell lung cancer (NSCLC) using the video-assisted thoracoscopic surgery (VATS) approach compared to traditional open thoracotomy. Specifically, the study aimed to assess the impact of these surgical techniques on mediastinal lymph node dissection, postoperative recovery, and long-term patient outcomes including survival rates and disease-free intervals. Additionally, the study sought to determine the correlation between surgical approach and the incidence of postoperative complications, such as prolonged air leaks and overall hospitalization duration.

Materials and Methods

This study analyzed retrospectively collected data from 228 patients treated for NSCLC at the Institute of Oncology Bucharest between 2016 and 2022. Approval from the local Institutional Review Board was secured prior to data collection, ensuring adherence to ethical standards. The primary focus of the study was on detailed surgical pathology to thoroughly understand treatment outcomes. All patients provided an informed consent for data collection and research participation.

The inclusion criteria specified for this study were patients diagnosed with NSCLC who had undergone surgical treatment within the study period and for whom complete medical records were available. Exclusion criteria included patients diagnosed with small cell lung cancer (SCLC), those with incomplete

data or medical records, and patients who did not undergo surgical intervention.

The variables included in the final analysis comprised demographic information and a detailed account of individual comorbidities that were used to calculate the Charlson comorbidity index, a validated predictor of postoperative adverse events (13).

Additionally, the possibility of SCLC was considered through the screening of tumor markers such as NSE and CEA (14). All postoperative events leading to prolonged hospitalization or altering the postoperative course were recorded, along with any postoperative deaths occurring within 30 days of surgery or before hospital discharge. This comprehensive approach allowed for a robust analysis of the surgical outcomes and complications associated with NSCLC treatments.

The decision to use open surgery or VATS was predominantly influenced by the availability of surgical materials and the specific preferences or expertise of the operating surgeon, rather than patient demographic factors. The surgical approach for non-small cell lung cancer (NSCLC) is determined by the clinical stage of the disease and patient-specific characteristics. Procedures such as segmentectomy or lobectomy are conducted under general anesthesia with single-lung ventilation. These can be performed using either video-assisted thoracic surgery (VATS) or traditional open thoracotomy. Thoracoscopic techniques, whether segmentectomy or lobectomy, adhere closely to the principles of open surgery but are executed through minimal incisions.

VATS, as a minimally invasive approach, distinguishes itself from open thoracotomy by utilizing one to three small incisions rather than a single large incision. This technique obviates the need for rib retractors and focuses on minimizing muscle dissection, reducing the use of electrocautery, and preserving the pleura. While traditional thoracotomy involves direct visualization and extensive suturing, VATS leverages thoracoscopic imaging and instruments inserted through thoracic ports, aiming to lessen postoperative pain and expedite recovery. The procedural sequence in VATS is adaptable based on the surgeon's preference and specific case requirements. For instance, while some practitioners may start with the vein to facilitate pulmonary artery access, others may prefer a direct fissure approach to the artery, mirroring techniques used in open surgery. Both VATS and open approaches strive for effective resection and complete mediastinal lymph node dissection, though the oncological benefit of lympha-denectomy remains under investigation. Procedures like lobectomy and segmentectomy are standard in both techniques, with VATS potentially offering improved short-term outcomes and recovery metrics (15,16).

Statistical Analyses

Data for this study were collected and managed using Microsoft Excel, which facilitated organized data handling and preliminary analysis. Statistical analyses were conducted using the Python software. Continuous variables, such as age, operative time, estimated blood loss, chest tube duration, and hospital length of stay were expressed as mean ± standard deviation, and differences between groups were assessed using independent samples t-tests.

Categorical data, including sex, smoking history, diagnosis, and types of surgical procedures, were presented as frequencies and percentages. Comparisons of these categorical variables were performed using the Chi-square test, or Fisher's exact test when appropriate, particularly in cases with small expected frequencies. The threshold for statistical significance was set at a p-value of less than 0.05.

Results

The mean age of patients in the open surgery group was 59 years (±23), while the VATS group had a mean age of 62 years (±25). The difference in age between the two groups was not statistically significant (p=0.621). Regarding smoking history, a significantly higher proportion of patients in the open

surgery group had a history of smoking (59.40%) compared to the VATS group (44.44%), with a significant p-value of 0.043. The gender distribution showed a higher proportion of males in the open surgery group (63.36%) compared to the VATS group (50.79%), while females constituted 37.62% of the open surgery group and 49.20% of the VATS group. However, the difference in sex distribution was not statistically significant (p=0.094) (*Table 1*).

The Charlson comorbidity index, which measures the burden of comorbidities, was similar between the two groups, with mean values of 4.28 (min=2, max=8) for the open surgery group and 4.38 (min=2, max=7) for the VATS group, with a p-value of 0.403). Diagnosis analysis revealed that primary lung cancer was the most common diagnosis in both groups, with 86.16% in the open surgery group and 88.09% in the VATS group. Metastatic cases were present in 10.89% of the open surgery group and 7.14% of the VATS group.

The Forced Expiratory Volume in 1 second (FEV1%) was almost identical between the groups, with values of 79.77% for the open surgery group and 79.73% for the VATS group. This minor difference was statistically significant (p<0.001), suggesting a significant difference in baseline pulmonary function. Surgical types performed included bilobectomy, lobectomy, and segmentectomy. The open surgery group had a higher proportion of bilobectomies (6.93% vs. 1.58%) and lobectomies (87.12% vs. 76.19%), whereas the VATS group had a higher proportion of segmentectomies (22.22% vs. 5.94%). The p-values for bilobectomy and lobectomy were 0.091 and 0.051, respectively, indicating no significant differences. However, the difference in segmentectomy rates was statistically significant (p=0.001).

The frequency of superior bilobectomy was nearly identical between the groups, with 1.96% in the open surgery group and 1.58% in the VATS group, resulting in a p-value of 0.986, indicating no significant difference. Inferior bilobectomy was performed in 4.9% of the open surgery cases but was not performed in any of the VATS cases, which was statistically significant (p=0.017). For lobectomies, the right lower lobectomy was more common in the open surgery group (17.64%) compared to the VATS group (9.52%), with a p-value of 0.108, showing no significant difference.

Complete mediastinal lymph node dissection was performed in 93.13% of open surgery cases and 89.68% of VATS cases, with a p-value of 0.496, showing no significant

Table 1. Background characteristics of patients with open intervention and thoracoscopic surgery

Variable	Open surgery (n=102)	Thoracoscopic intervention - VATS (n=126)	P-value
Age (years)	59±23	62±25	0.621
Smoking history	60 (59.40%)	56 (44.44%)	0.043
Sex			0.094
Males	64 (63.36%)	64 (50.79%)	
Females	38 (37.62%)	62 (49.20%)	
Charlson comorbidity index	4.28 (min=2 and max=8)	4.38 (min=2 and max=7)	0.403
Diagnosis			
Primary lung cancer	88 (86.16%)	111 (88.09%)	0.833
Metastases	11 (10.89%)	9 (7.14%)	0.465
Other	3 (2.97%)	6 (4.76%)	0.719
FEV1%	79.77	79.73	<0.001
Surgery type			
Bilobectomy	7 (6.93%)	2 (1.58%)	0.091
Lobectomy	89 (87.12%)	96 (76.19%)	0.051
Segmentectomy	6 (5.94%)	28 (22.22%)	0.001

FEV – Forced Expiratory Volume.

Table 2. Surgical features compared between patients with open intervention and thoracoscopic surgery

Resection type	Open surgery (n=102)	Thoracoscopic intervention – VATS (n=126)	P-value
Superior Bilobectomy	2 (1.96%)	2 (1.58%)	0.986
Inferior Bilobectomy	5 (4.9%)	0 (0.0%)	0.017
Right Lower Lobectomy	18 (17.64%)	12 (9.52%)	0.108
Left Lower Lobectomy	18 (17.64%)	16 (12.69%)	0.392
Middle Lobectomy	6 (5.88%)	8 (6.34%)	0.922
Right Upper Lobectomy	25 (24.5%)	31 (24.60%)	0.961
Left Upper Lobectomy	22 (21.56%)	29 (23.01%)	0.920
Lingulectomy	0 (0.0%)	1 (0.79%)	0.816
Culmenectomy	3 (2.94%)	12 (9.52%)	0.085
Right Apical Segmentectomy (S1)	0 (0.0%)	4 (3.17%)	0.130
Right Anterior Segmentectomy (S3)	1 (0.98%)	2 (1.58%)	0.948
Right Apicobasal Segmentectomy (S6)	0 (0.0%)	7 (5.55%)	0.018
Left Apicobasal Segmentectomy (S6)	2 (1.96%)	2 (1.58%)	0.885
Complete Mediastinal Lymph Node Dissection	95 (93.13%)	113 (89.68%)	0.496

difference between the groups (*Table 2*).

The operative time for open surgery averaged 347 minutes (ranging from 120 to 580 minutes) with a standard deviation of 123 minutes. In contrast, the operative time for VATS was significantly shorter, averaging 299 minutes (ranging from 95 to 765 minutes) with a standard deviation of 96 minutes. The difference in operative time between the two groups was statistically significant ($p<0.001$), indicating that VATS generally required less time than open surgery.

Estimated blood loss was also significantly different between the two groups. Patients who underwent open surgery had an average blood loss of 160.88 mL with a standard deviation of 55.1 mL, whereas those who underwent VATS had an average blood loss of 98.68 mL with a standard deviation of 48.2 mL. This difference was highly significant ($p<0.001$), suggesting that VATS is associated with lower intraoperative blood loss compared to open surgery.

The duration of chest tube placement postoperatively was significantly shorter in the VATS group. The average duration for open surgery patients was 12.17 days with a standard deviation of 4.6 days, whereas for VATS patients, it was 5.78 days with a standard deviation of 2.9 days. This difference was statistically significant ($p<0.001$), indicating that patients undergoing VATS had a faster recovery in terms of chest tube removal.

Hospital length of stay was another outcome where VATS showed a significant advantage. Patients who underwent open surgery had an average hospital stay of 27.7 days with a standard deviation of 9.3 days. In contrast, VATS patients had an average stay of 12.0 days with a standard deviation of 7.1 days, as presented in *Fig. 1*. The reduction in hospital stay for VATS patients was highly sinificant ($p<0.001$), underscoring the benefits of the

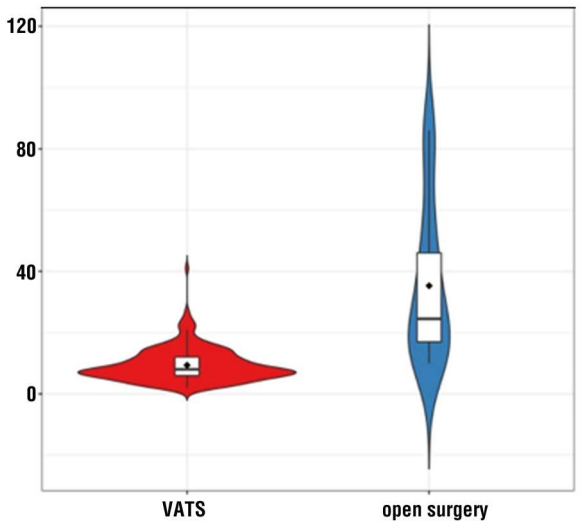

Figure 1. Postoperative duration (days) spent in the ICU.

Table 3. Surgical outcomes compared between patients with open intervention and thoracoscopic surgery.

Resection type	Open surgery (n=102)	Thoracoscopic intervention – VATS (n=126)	P-value
Operative time (minutes)	347 (min=120 and max=580) ± 123	299 (min=95 and max=765) ± 96	<0.001
Estimated blood loss (mL)	160.88±55.1	98.68±48.2	<0.001
Chest tube duration (days)	12.17±4.6	5.78±2.9	<0.001
Hospital length of stay (days)	27.7±9.3	12.0±7.1	<0.001

minimally invasive approach in terms of quicker postoperative recovery and discharge (*Table 3*).

The statistical analysis of two-year progression-free survival rates and Clavien-Dindo classifications from VATS versus open surgery for non-small cell lung cancer (NSCLC) shows that while VATS significantly improved two-year progression-free survival for patients with stage 1, 2, and 3 NSCLC ($p<0.01$ and $p<0.001$ respectively), as presented in *Fig. 2*, it did not demonstrate a significant advantage in stage 4 or in short-term outcomes according to the Clavien-Dindo classification, where no significant difference was found ($p=0.13$), as seen in *Fig. 3*. These results underline VATS as a preferable surgical option for earlier-stage NSCLC in terms of longer-term disease control, although it does not reduce short-term surgical complications compared to open surgery.

Discussions

The analysis of two-year progression-free survival and Clavien-Dindo classifications in the treatment of non-small cell lung cancer (NSCLC) reveals distinct outcomes for patients undergoing video-assisted thoracoscopic surgery (VATS) compared to those undergoing open surgery. Specifically, VATS demonstrated significantly better two-year progression-free survival rates for patients in stages 1, 2, and 3 of NSCLC, with markedly lower odds ratios indicating a higher likelihood of survival without disease progression. However, for stage 4 patients, the advantages of VATS were not statistically significant, highlighting a potential limitation of VATS in treating the most advanced stage of lung cancer. Surgical indications for stage 4 NSCLC are exceptional and highly personalized, and survival outcomes in these cases may not be

Figure 2. Clavien-Dindo scores comparison between VATS and open surgery.

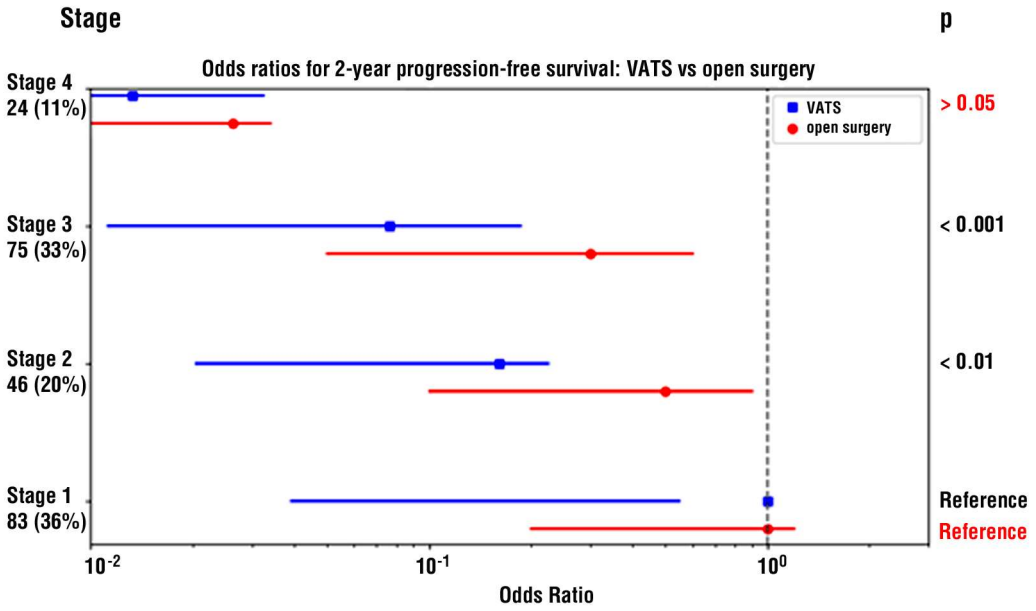

Figure 3. Two-year disease-free survival (VATS vs. Open Surgery).

strongly influenced by the surgical approach.

In contrast, the short-term postoperative outcomes, as measured by the Clavien-Dindo classification, did not show significant differences between VATS and open surgery. The lack of significant difference in this classification suggests that both surgical approaches have comparable immediate postoperative risks and complications. This finding is particularly important for surgical decision-making, as it implies that the choice of surgical method may not influence the immediate postoperative recovery as much as it does long-term outcomes. These results suggest that while VATS offers considerable advantages in terms of longer-term disease control for earlier-stage NSCLC, it does not necessarily reduce the risk of short-term postoperative complications. This critical insight emphasizes the need for ongoing evaluation of surgical techniques to optimize both immediate and long-term patient outcomes. Moreover, the distinct advantage of VATS in earlier stages may guide clinicians in surgical planning and patient counseling, particularly in selecting appropriate candidates for minimally invasive procedures.

Ultimately, these findings contribute to the growing body of evidence supporting the efficacy of VATS in the management of NSCLC, particularly in the early stages of the disease. However, the comparable short-term safety profiles of VATS and open surgery necessitate a balanced discussion with patients about the potential benefits and risks associated with each surgical option. Further studies are needed to explore the reasons behind the lack of significant differences in short-term outcomes and to assess whether modifications in VATS techniques could lead to improvements in both short-term and long-term results.

Hospital length of stay was another outcome where VATS showed a significant advantage. Patients who underwent open surgery had an average hospital stay of 27.7 days with a standard deviation of 9.3 days. In contrast, VATS patients had an average stay of 12.0 days with a standard deviation of 7.1 days. The reduction in hospital stay for VATS patients was highly significant ($p<0.001$), underscoring the benefits of the minimally invasive approach in terms of quicker postoperative recovery and discharge. However, it

is important to contextualize these findings within the healthcare system in Romania, where hospital stays tend to be longer due to factors such as resource availability and local practices. Internationally, the standard post-operative hospital stay after VATS is around 2 days and around 6 days for open surgery. Discussing these differences provides a more comprehensive understanding of the results and highlights the need to adapt international standards to local healthcare realities.

We argue that the minimally invasive approach is a modern solution for treating bronchopulmonary cancer despite the apparently increased immediate costs, compared to the thoracotomy approach. But we have to mention that analyzing the costs associated with the longer duration of hospitalization, the number of post-operative admissions required for various complications, the longer duration of sick leave, the lower compliance of patients to adjuvant treatment with subsequent complications specific to the minimally invasive approach ensures low costs in the long term, a higher turnover of patients in experimented centers and an increased quality of the medical act (17).

Other studies examining VATS versus open surgery techniques for lung cancer offer distinct insights into the efficacy and safety of these surgical approaches in different contexts. Hireche et al. (18) focused on stage III NSCLC, utilizing propensity score matching to compare VATS and open lobectomy, finding no significant differences in postoperative complications, chest tube duration, or 30-day mortality between the two groups. However, VATS was associated with a notably shorter hospital stay ($p<0.0001$), although overall survival and recurrence-free survival rates were similar across both techniques. On the other hand, Luo et al. (19) investigated VATS versus open pneumonectomy, observing no significant differences in major complications and perioperative mortality post propensity-score matching. Interestingly, the study highlighted a lower major complication rate in the VATS group for patients with stage pT2 tumors compared to the Open group (7.6% vs. 20.6%, $p=0.042$). Both studies underline VATS as a viable option that does not increase perioperative risks compared to open surgery, with specific benefits in reducing hospital stay and complications in selected patient groups, enhancing the case for VATS in surgical oncology.

The two studies investigating VATS versus open surgery for NSCLC present differing perspectives and data on the viability and outcomes of thoracoscopic approaches. Yun et al. (20) focused on large tumors (over 5 cm) in NSCLC patients, finding that VATS lobectomy resulted in a shorter hospital stay compared to open lobectomy (6 days vs. 7 days; $P<0.001$) without compromising long-term oncological outcomes. Both five-year overall survival (71.5% for VATS vs. 64.4% for thoracotomy) and recurrence-free survival (60.1% for VATS vs. 51.5% for thoracotomy) showed no significant differences, highlighting the oncological safety of VATS even for larger tumors. Conversely, Yamashita et al. (21) assessed VATS in early-stage adenocarcinoma, noting statistically significant benefits of VATS in operation time, blood loss, length of hospital stay, and number of lymph nodes dissected. They reported superior disease-free survival for VATS (5- and 10-year survival rates of 91.4% and 79.0%, respectively) compared to open surgery (85.1% and 73.6%, respectively; $P=0.04$), though overall survival rates did not differ significantly. These findings collectively suggest that VATS is advantageous for early-stage adenocarcinoma and viable for larger NSCLC tumors, offering reduced hospitalization and comparable long-term survival outcomes, thereby supporting its expanded use in diverse clinical scenarios.

Among the study limitations, it should be noted that this paper conducted a retrospective analysis of significant variables associated with open versus minimally invasive surgical approaches in the treatment of pulmonary tumors. Although some results lacked statistical significance, the majority of the data aligned with findings reported in the specialized literature. Notably, the analysis occurred during a transitional period from traditional to mini-

mally invasive surgical techniques, incorporating the learning curve of the surgical teams. An examination of the patient outcomes in the final two years of the study revealed results comparable to those of high-volume thoracic surgery centers in Europe and the USA, such as shortened lengths of hospitalization and reduced chest tube durations.

Minimally invasive techniques, such as video-assisted thoracoscopic surgery (VATS), have shown significant benefits over open thoracotomy in the surgical management of non-small cell lung cancer (NSCLC). VATS is associated with improved long-term outcomes, including better two-year progression-free survival rates for early-stage NSCLC patients, and favorable short-term surgical outcomes such as shorter operative times, less blood loss, reduced chest tube duration, and decreased hospital stays. However, certain complex resections, such as bilobectomy, may present technical challenges for VATS. Despite these difficulties, the advantages of VATS, including its minimally invasive nature and associated patient recovery benefits, make it a preferred approach for many NSCLC patients, aligning with the broader literature that supports its efficacy and safety in diverse clinical scenarios.

In our department, minimally invasive techniques such as segmentectomy, lobectomy, and pneumonectomy began to be implemented in mid-2017. By 2020, these techniques were used in over 70% of cases, and currently, they are employed in more than 90% of procedures. The results of this study are also influenced by the surgical volume of the department, which saw a significant reduction during the COVID-19 pandemic (2020-2022) due to various socio-economic factors. Additionally, during this period, an increased number of stage I diagnoses were made, facilitated by the diagnostic and monitoring tools developed for COVID-19, which also served as a screening method for patients at risk of developing bronchopulmonary cancer. While not all analyses in our study yielded statistically significant outcomes, the findings support the non-inferiority of the minimally invasive approach and reinforce the data presented in international literature. This approach is now considered standard practice in modern thoracic surgery.

A limitation of this study is the heterogeneity of the patient cohort and the learning curve associated with VATS, which may affect the short-term postoperative outcomes.

Conclusions

This study substantiates the superiority of VATS over open surgery for early-stage non-small cell lung cancer, evidenced by enhanced two-year disease-free survival and more favorable short-term surgical outcomes such as reduced operative time, less blood loss, shorter chest tube duration, and decreased hospital stays. While VATS presents clear advantages in managing early-stage NSCLC, it did not significantly lower the rate of post-operative complications compared to open surgery, indicating that both surgical approaches maintain comparable safety profiles. These findings support the continued use and potential expansion of VATS in surgical oncology for appropriately selected patients.

Conflicts of Interest

The authors declare no conflicts of interest.

Funding

No funding was received.

Ethical Statement

The study was conducted according to the guidelines of the Declaration of Helsinki and approved by the Ethics Committee of the Institute of Oncology from Bucharest.

References

1. Melocchi L, Mengoli MC, Bogina G, Facchetti M, Migliorati F, Gandolfi L, Rossi G. COVID-19 and lung cancer. Pathologica. 2023;115(5):284-291.
2. Siegel RL, Miller KD, Wagle NS, Jemal A. Cancer statistics, 2023. CA: a cancer journal for clinicians. 2023;73(1):17-48.

3. Haineala B, Zgura A, Badiu DC, Iliescu L, Anghel RM, Bacinschi XE. Lung Cancer, Covid-19 Infections and Chemotherapy. In Vivo. 2021;35(3):1877-1880.
4. Sung H, Ferlay J, Siegel RL, Laversanne M, Soerjomataram I, Jemal A, Bray F. Global cancer statistics 2020: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. CA: a cancer journal for clinicians. 2021;71(3):209-249.
5. 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: American College of Chest Physicians evidence-based clinical practice guidelines. Chest. 2013;143(5).
6. Hoy H, Lynch T, Beck M. Surgical Treatment of Lung Cancer. Crit Care Nurs Clin North Am. 2019;31(3):303–313.
7. Kim D, Woo W, Shin JI, Lee S. The Uncomfortable Truth: Open Thoracotomy versus Minimally Invasive Surgery in Lung Cancer: A Systematic Review and Meta-Analysis. Cancers (Basel). 2023;15(9):2630.
8. Sedighim S, Frank MI, Heutlinger O, Lee C, Hachey SJ, Keshava HB. A Systematic Review of Short-Term Outcomes of Minimally Invasive Thoracoscopic Surgery for Lung Cancer after Neoadjuvant Systemic Therapy. Cancers (Basel). 2023;15(15):3908.
9. Fu S, Niu Y, Yang H, Fang W. Minimally invasive surgery role in central squamous lung cancer after neoadjuvant chemoimmunotherapy. J Thorac Dis. 2024 Jan 30;16(1):285-295.
10. Graham EA, Singer JJ. Successful Removal of an Entire Lung for Carcinoma of the Bronchus. JAMA. 1984;251(2):257–260.
11. He J. History and current status of mini-invasive thoracic surgery. J Thorac Dis. 2011;3(2):115.
12. Bulgarelli Maqueda L, García-Pérez A, Minasyan A, Gonzalez-Rivas D. Uniportal VATS for non-small cell lung cancer. Gen Thorac Cardiovasc Surg. 2020;68(7):707-715.
13. Birim Ö, Maat APWM, Kappetein AP, van Meerbeeck JP, Damhuis RAM, Bogers AJJC. Validation of the Charlson comorbidity index in patients with operated primary non-small cell lung cancer. Eur J Cardiothorac Surg. 2003;23:30–34.
14. Nistor CE, Stefan-van Staden RI, Dumitru AV, Stanciu Gavan C. A Screening Test for Early Diagnosis of Microcellular Bronchopulmonary Cancer-Pilot Study. J Clin Med. 2019;9(1):76.
15. Zhao R, Shi Z, Cheng S. Uniport video assisted thoracoscopic surgery (U-VATS) exhibits increased feasibility, non-inferior tolerance, and equal efficiency compared with multiport VATS and open thoracotomy in the elderly non-small cell lung cancer patients at early stage. Medicine (Baltimore). 2019;98(28):e16137.
16. Bongiolatti S, Gonfiotti A, Viggiano D, Borgianni S, Politi L, Crisci R, Curcio C, Voltolini L; Italian VATS Group. Risk factors and impact of conversion from VATS to open lobectomy: analysis from a national database. Surg Endosc. 2019;33(12):3953-3962.
17. Kneuertz PJ, Singer E, D'Souza DM, Abdel-Rasoul M, Moffatt-Bruce SD, Merritt RE. Hospital cost and clinical effectiveness of robotic-assisted versus video-assisted thoracoscopic and open lobectomy: A propensity score-weighted comparison. J Thorac Cardiovasc Surg. 2019;157(5):2018-2026.e2.
18. Hireche K, Lounes Y, Bacri C, Solovei L, Marty-Ané C, Canaud L, Alric P. VATS versus Open Lobectomy following Induction Therapy for Stage III NSCLC: A Propensity Score-Matched Analysis. Cancers (Basel). 2023; 15(2):414.
19. Luo J, Ji C, Campisi A, Chen T, Weder W, Fang W. Surgical Outcomes of Video-Assisted versus Open Pneumonectomy for Lung Cancer: A Real-World Study. Cancers (Basel). 2022;14(22):5683.
20. Yun J, Lee J, Shin S, Kim HK, Choi YS, Kim J, Zo JI, Shim YM, Cho JH. Video-assisted thoracoscopic lobectomy versus open lobectomy in the treatment of large lung cancer: propensity-score matched analysis. J Cardiothorac Surg. 2022;17(1):2.
21. Yamashita SI, Tokuishi K, Moroga T, Nagata A, Imamura N, Miyahara S, et al. Long-term survival of thoracoscopic surgery compared with open surgery for clinical N0 adenocarcinoma. J Thorac Dis. 2020;12(11):6523-6532.