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Original Article

VATS versus open thoracotomy in patients with spontaneous pneumothorax: where do we stand?

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ABSTRACT

Background: Spontaneous pneumothorax (SP) can be surgically treated with video-assisted thoracoscopic surgery (VATS) or conventional open thoracotomy (OT), but there are still controversies in the literature concerning the outcome of both procedures. We aim to compare VATS and OT in the treatment of SP, in perioperative and postoperative outcome, as well as to determine which procedure is more cost-effective for both the patients and the health care system.

Materials and Methods: Overall, 136 patients underwent surgery for SP at our institution, out of which 104 met the inclusion criteria of our study. Patients were further divided into two groups, consisting of 56 and 48 patients who underwent VATS and OT, respectively. Data were collected prospectively for 5 years and comparison of the perioperative and postoperative outcome, as well as cost-effectiveness of both procedures was performed.

Results: The VATS group was superior to the OT with shorter duration of surgery (87.77 vs 132.92 min.; $p < 0.05$), reduced length of hospital stay (7.28 vs 9.81 days; $p < 0.05$) and chest drain duration (4.84 vs 5.98 days; $p < 0.05$). There was no statistically significant difference in the recurrence rate, bleeding and postoperative complications. Average cost per patient for VATS was significantly lower than the cost for open thoracotomy (EUR 1504.93 vs EUR 1973.09; $p < 0.05$).

Conclusions: VATS can be implemented as the optimal approach in the treatment of SP given the current clinical, financial and cosmetic advantages. Like other minimally-invasive procedures, VATS has an associated learning curve which, once is surpassed, any complications are less likely to be prevalent and optimum results can be achieved.

Keywords: pneumothorax, thoracotomy, surgery, video-assisted

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Introduction

Pneumothorax ranks high on the list of common medical conditions, thus being a significant global health problem. It may be encountered by physicians in several clinical specialties and the spectrum of its severity may range from the self-limiting to the life-threatening.

Spontaneous pneumothorax (ST) can be classified as either primary (PSP) or secondary (SPS). Primary spontaneous pneumothorax has an estimated incidence of 18-28/100,000 cases per year for men, and 1.2-6/100,000 for women [1-3], while the incidence for SPS is 6.3 and 2 per 100,000 patients, for men and women, respectively. In terms of recurrence, the majority occurs within the first year, and incidence ranges widely from 25% to 50%. Notably, underlying chronic lung diseases, significantly contribute to recurrence [4]. Despite the global prevalence of pneumothorax, there is a noticeable gap in the literature regarding its epidemiology, incidence rate, and disease demographics in the Republic of North Macedonia.

Recent guidelines from the British Thoracic Society (BTS), published on August 8, 2023, underscore a nuanced approach to spontaneous pneumothorax management [5]. While endorsing conservative and ambulatory management for minimally symptomatic or asymptomatic primary spontaneous pneumothorax in adults, the BTS guidelines acknowledge the individualized nature of treatment decisions. Needle aspiration or tube drainage is recommended as initial interventions, with considerations for chemical pleurodesis in select cases. Thoracic surgery is advised as a consideration for the initial treatment in specific scenarios, such as tension pneumothorax or high-risk occupations. Nevertheless, the definitive treatment for spontaneous pneumothorax remains a subject of ongoing debate among thoracic surgeons, with numerous studies contributing to the discourse.

Our study aims to critically evaluate the effectiveness of video-assisted thoracoscopic surgery (VATS) and compare its outcomes with open thoracotomy, adding valuable insights to this dynamic field.

Materials and Methods

This prospective single-center clinical study was conducted for a five-year time period, between 2018 and 2022, at the University Clinic of Thoracic and Vascular surgery in Skopje, North Macedonia, after fulfilling Ethical Committee requirements (03-275, 26.05.2020) and having written informed consent of the patients. During the time period previously mentioned, a total number of 136 patients were surgically treated for SP, of which 104 met the inclusion criteria and therefore were included in our study. All the surgeries were performed by the same surgical team. Patients were evaluated prior to surgery, as well as after. The timeline for follow-up in evaluation of the clinical data was 1 day post-surgery, the day before the discharge from the hospital and 3 months after the procedure, in order to check for late complications (recurrence).

Our study enrolled patients meeting specific inclusion criteria: individuals aged 18-80 experiencing the first episode of spontaneous pneumothorax (SP) with prolonged air leak or no re-expansion of the lung after non-surgical treatment, as well as those with secondary or recurrent episodes of SP. Conversely, exclusion criteria comprised individuals younger than 18 or older than 80 years, low ejection fraction (< 50%) indicative of cardiac impairment, and those who refused to participate in the study.

Upon meeting inclusion criteria, patients were thoughtfully stratified into two groups, Group A (patients who underwent VATS) and Group B (patients who underwent thoracotomy). For the stratification, several factors were considered such as pneumothorax size (smaller pneumothoraces were treated by VATS), pleural adhesions (in extensive adhesions, OT was preferred) and if the patient expressed a preference for a less invasive approach, VATS was considered (if applicable).

The decision-making process involved a comprehensive evaluation of each patient's unique circumstances, ensuring that the chosen intervention aligned with their clinical profile and personal preferences. This approach aimed to optimize patient outcomes and satisfaction. Subsequently, Group A consisted of 56 patients, and Group B of 48 patients.

Eligible patients with confirmed symptomatic spontaneous pneumothorax underwent comprehensive assessment, including baseline characteristics and symptoms. Comorbidities, such as hypertension and diabetes mellitus, were noted. Clinical evaluation pre- and post-surgery involved standard indicators. Laboratory findings were analyzed before and after the surgical procedure. Imaging techniques (chest radiography and CT) were employed pre-admission, one day before discharge, and three months post-surgery for definitive diagnosis and postoperative evaluation.

All patients underwent general anesthesia with double lumen intubation. Patients were placed on a lateral decubitus position, so that access to the affected hemithorax was provided. Specifically, for patients in Group A, a singular incision, not exceeding 5 cm, was strategically positioned for a port within the 5th intercostal space, complemented by an additional incision for a port in the 7th intercostal space along the mid-axillary line. In Group B, a standard posterolateral open thoracotomy was performed. Selective one lung ventilation was confirmed with the anesthesiologist. For Group A, the ensuing introduction of the thoracoscope facilitated access to the hemithorax, allowing for a detailed examination of the entire thoracic cavity. This visual inspection aimed to identify bullae, discern pleural adhesions, and reveal any associated pathology. Delicate manipulation of lung tissue ensued, utilizing atraumatic instruments, particularly forceps, to ensure precision and minimize tissue trauma. Bullae were subsequently excised using the EndoGia stapler. Thorough inspection was performed in patients from Group B, as well. The excision of abnormal lung tissue was facilitated with linear staplers, and smaller bullae were treated with electrocautery. Both groups underwent mechanical (abrasion) pleurodesis. Pleurectomy was performed in a small number of patients, the indication being recurrent pneumothorax or persistent air leak. Hemostasis was achieved, the pleural cavity was irrigated with warm saline, and a chest tube was inserted.

Statistical Analysis

In evaluating video-assisted thoracoscopic surgery (VATS) versus open thoracotomy (OT), a comprehensive analysis covered key demographic factors and side of pneumothorax. The examination extended to the perioperative and postoperative results. Additionally, assessment of overall costs for VATS and OT patients allowed for a thorough comparison of their cost-effectiveness. The ensuing results will be presented in tables to provide an overview of the comparative outcomes.

Patient data were analyzed using IBM SPSS Statistics 26.0 and expressed as mean ± SD for quantitative variables, and frequency and percentage for qualitative variables. Descriptive analysis included ratio coefficients, proportions, and cross-tabulations for attributive features. Numerical series were analyzed for central tendency (mean, median) and dispersion (SD, variance). Statistical tests, such as Pearson's chi-square and Fischer's exact tests, assessed associations. Normality and homogeneity checks employed Kolmogorov-Smirnov, Shapiro-Wilk, Levene, and Bartlett's tests. Parametric or non-parametric tests were chosen based on variable homogeneity and normal/approximately normal distributions. Student's t-test compared means for homogeneous, normally distributed variables; Mann-Whitney test did so for non-parametric scenarios. Testing significance was set at $p < 0.05$, with results presented in figure and tables.

Results

Out of 104 patients surgically treated for SP at our center, 48 (46.20%) underwent open thoracotomy, while 56 (53.8%) underwent video assisted thoracoscopic surgery, as a minimally invasive technique (Figure 1). The mean age of the patients was 47 ± 17 and 45 ± 15 in Group A and Group B, respectively. Subsequently, with $p = 0.553$, there was no statistically significant difference.

For VATS, out of 56 patients, 44 (78.57%) were male and 12 (21.43%) were female. For OT, out of 48 patients, 40 (83.33%) were male and 8 (16.67%) were female. Therefore, the ratio for spontaneous pneumothorax in male to female patients is roughly 4:1, or SP is 4 times more common in men than women. Also, there was no statistically significant difference in the distribution of the variable 'gender' between the OT and VATS group ($p = 0.539$).

A great number of our patients had a history of cigarette smoking. Out of 104 patients included in the study, 55 (52.88%), or more than half, were smokers. In the VATS group, 28 patients out of 56 (26.92% of the total number of patients) had a positive smoking status. At the same time, in the OT group, 27 out of 48 patients (25.96% of the total number of patients) were also smokers, with no statistically significant difference between both groups ($p = 0.524$). 19 smokers in the VATS group had primary pneumothorax (67.86% of smokers in this group), while 15 smokers in the OT group experienced primary pneumothorax (55.56% of smokers in this group).

In the VATS group, out of 56 patients, 16 have HTA (15.38% of all patients evaluated), and 5 have DM (4.81% of all patients evaluated). In the OT group, or Group B, out of 48 patients, 13 have HTA (12.50% of all patients evaluated), and 5 have DM (4.81% of all patients evaluated) (Table 1).

In both groups, the right side of the hemithorax was more frequently affected. That is, out of 104 patients in total, 58 (55.77%) presented with a right-sided pneumothorax. This was established using the imaging methods; chest radiography and CT, preoperatively. Out of 56 patients in the VATS group, 33 (58.93%), presented with a right-sided SP, while 23 (41.07%), with a left-sided SP. When it comes to the 48 patients in the OT group, 25 of them (52.08%), had right-sided pneumothorax. Left-sided SP was noted in 23 (0.48%) patients. (Table 1).

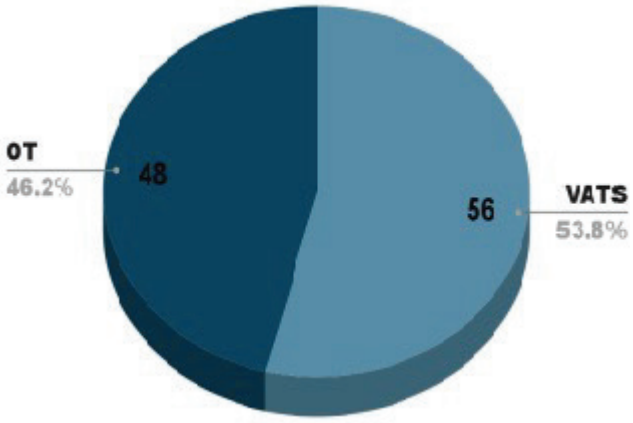

Figure 1. Distribution of patients according to type of surgery.

For patients who underwent open thoracotomy, the intervention lasted significantly longer (average of 132.92 minutes) than the intervention for patients who underwent video-assisted thoracoscopic surgery (average of 87.77 minutes). We observed intraoperative bleeding only in a small number of patients, which is 9 out of the total number of patients (for VATS and OT), or 8.65%. Out of these 9 patients, 3 underwent VATS and 6 open thoracotomy. There was no conversion to thoracotomy from VATS required in any of our cases.

The patients who underwent VATS, had a shorter length of hospital stay (statistically significant), when compared to those who underwent OT. The mean duration of hospital stay is directly related to the chest drain duration, with the patient being discharged the day following the removal of the chest drain. Therefore, there was also a statistically significant difference in the chest drain duration of both groups, in favor of patients who underwent VATS. The results are shown in table 2.

In terms of complications, we observed air leak, recurrence and ICU admissions. The total number of patients who presented with either one of the complications mentioned, was 23 or 22.12%. Out of 104 patients included in our study, 2 from the VATS group (3.57%) and 3 from the OT group (6.25%) presented with early recurrence of pneumothorax. Late recurrence was the case for 4 patients from the VATS group (7.14%) and 3 from the OT group (6.25%). Although the follow-up in this study was determined to be 3 months after the surgery, no limitation was placed on its duration when investigating for a recurrence and mainly because at our center, patients are referred back to our service if they develop a recurrent pneumothorax at any time following operative intervention. Air leak was also not very common and presented in 2 patients from the VATS group and 4 from the OT group (3.57% and 8.33%, respectively). Also, only 2 patients from the VATS and 3 from the OT group were admitted at the ICU. The results regarding complications following surgery, are also presented in table 2.

Table 1. Distribution of patients according to common comorbidities and side of pneumothorax.

	VATS	OT	Total	P value
Hypertension,	16	13	29	0.866
Diabetes mellitus	5	5	10	0.797
Right sided / left sided	33 (58.92%) / 23 (41.07%)	25 (52.08%) / 23 (47.92%)	58 (55.77%) / 46 (44.23%)	0.483

Table 2. Distribution of patients according to postoperative outcome and complications.

	VATS	OT
LOHS Mean ± SD (95% CI)	7.38 ± 4.061(6.29 - 8.46)	9.81 ± 3.993(8.65 - 10.97)
Min.-Max. LOHS	2 - 20	4 -21
Chest drain duration in days Mean ± SD (95% CI)	4.84 ± 2.749 (4.10 - 5.58)	5.98 ± 2.058 (5.38 - 6.58)
Min.-Max. Chest drain duration in days	2 – 14	3 - 15
Early recurrence	2 (3.57%)	3 (6.25%)
Late recurrence	4 (7.14%)	3 (6.25%)
Air leak	2 (3.57%)	4 (8.33%)
ICU admission	2 (3.57%)	3 (6.25%)

Abbrev.; LOHS: length of hospital stay; ICU: intensive care unit

We estimated the total financial cost per patient for the surgical procedure itself, accompanied by the cost of the hospital stay, as well as the diagnosis and follow-up methods. The average cost (in MKD) per patient for video-assisted thoracoscopic surgical treatment for SP is EUR 1504.15, whereas the average cost for open thoracotomy is EUR 1972.27. The difference of EUR 468.12 is statistically significant, with p being 0.000 ($p < 0.05$).

Discussion

After it was established that there was no statistically significant difference in the demographic and clinical characteristics of the patients between the two groups, VATS and OT, we moved on to the comparison of the two surgical techniques in terms of the duration of surgery. In the current literature, the operating time was reported to be shorter for VATS, the same for both procedures or longer for VATS than for thoracotomy [6-8]. In our study, VATS lasted significantly shorter than OT.

When it comes to intraoperative complications, we observed bleeding (500-700 mL) in 8.65%, which is 3 of the patients who underwent VATS and 6 of those who underwent OT. Unfortunately, the specific vascular involvement or other details of the bleeding events were not delineated in our dataset. This also came in agreement with Laohathai et al [9] who reported that the operative time was longer and there was more blood loss in patients who underwent open thoracotomy. In addition, Vohra et al [10] and Lin et al [6] have demonstrated that VATS results in a shorter duration of surgery and less intraoperative blood loss than open thoracotomy.

There are different views on the postoperative outcome of VATS for the treatment of spontaneous pneumothorax. Although a great number of large studies state that the recurrence rate is higher with VATS [11,12], that was not the case in our study; on the contrary it was lower. This may be attributed to lesser trauma to lung tissue, which may contribute to enhanced tissue healing and a lower likelihood of recurrence. The patient selection criteria (our patients that underwent OT had more extensive pleural adhesions), could also play pivotal roles in the observed lower recurrence rates. We came to the same conclusion when comparing the air leak between both groups. In accordance with our results, several studies report a lower recurrence rate for patients that underwent VATS for the treatment of SP, two of which, providing long term date (up to 53 months). Unfortunately, we were not able to conduct a longer follow-up and collect date for all of our patients, hence the parameter set to 3 months after surgery (in line with the median time to recurrence in a large propensity score analysis) [13]. Extending the follow-up duration for a subset of patients would risk introducing bias.

Often, recurrences are more frequent in patients in whom no blebs or bullae are identified [14]. Also, some evidence suggests that apical lung excision, even in the absence of visible lesion, may reduce SP recurrence [14]. Many authors believe that the recurrence rate is often associated with the surgeons' exposure to the procedure, meaning the efficiency in performing VATS improves over time. In regard to this theory, Waller emphasizes the importance of the learning curve in VATS procedures for pneumothorax [15]. He noted an inversely proportional relationship between recurrence rates and experience in his study population over a seven-year period. While our center has routinely performed video-assisted thoracoscopic surgery in recent years, it was not fully integrated at the inception of this study. Consequently, we anticipate enhanced outcomes over time and in subsequent research, aligning with the trajectory of improved proficiency in VATS procedures.

Our results also show a significantly shorter length of hospital for VATS, when compared to open thoracotomy (7 ± 4 and 9 ± 4, for VATS and OT, respectively). We witness the same conclusion for the chest drain duration, ranging from 2 to 20 for VATS, and 4 to 21 days for OT. If the stay was prolonged it was mostly due complications and postoperative pain. The length of hospital stay was greatly dependent on the chest drain duration, with the patient being discharged the day following the chest drain removal. To remove the chest drain we considered several factors (criteria), through collecting postoperative data, which consisted of daily assessment of the drainage volume until there was 150-200ml or less (performed every morning), no obvious air leakage and complete re-expansion of the lung determined by chest X-ray. A similar study to ours including 100 consecutive patients [16] also reports a shorter length of hospital stay for VATS than OT, with an average of 3.2 and 12 days, respectively.

Finally, we analyzed the cost-effectiveness of video-assisted thoracoscopic surgery and open thoracotomy. We estimated the total financial cost per patient for the surgical procedure itself, accompanied by the cost of the hospital stay, as well as the diagnosis and follow-up methods. The average cost (in MKD) per patient

for video-assisted thoracoscopic surgical treatment for SP is EUR 1504.15, whereas the average cost for open thoracotomy is EUR 1972.27.

The difference of EUR 468.12 is statistically significant, with p being 0.000 ($p < 0.05$). Therefore, we conclude that the VATS procedure is more cost-effective, as it is significantly cheaper than the OT procedure. This is mainly because, as previously shown, patients that underwent VATS for the treatment of ST had a significantly shorter length of hospital stay, as well as less complications, plus the procedure lasted for a significantly shorter period of time. There are several study reports in accordance with our results [17,18].

One additional study by Fung S et al, conducted in 2021, analyzed the socioeconomic impact of recurrent primary spontaneous pneumothorax [19]. Initially, the primary treatment costs per patient, including hospitalization and surgical material in the VATS group, was higher (EUR 1.360) compared to the OT group (EUR 1.247), and mainly due to the higher cost of surgical materials for VATS (EUR 465 vs. EUR 77). However, due to the low rate of recurrence, overall cost for recurrence treatment was lower in the VATS group (EUR 5.412) than in the OT group (EUR 33.825). This disparity resulted in a considerably lower total management cost per patient in the VATS group (EUR 1.473) compared with the OT group (EUR 1. 952), and later increased considerably after addition of the treatment cost for complications (VATS: EUR 1.501 vs. OT: EUR 2.233).

In conclusion, cost may vary according to the clinical center and country, but in our experience, VATS for the treatment of SP seems to be associated with reduced socioeconomic burden for both the patients and the healthcare system. Taking into consideration the other factors, especially the shorter duration of surgery and decreased length of hospital stay, VATS is more cost-effective and a better tolerated procedure for the treatment of spontaneous pneumothorax compared to the open thoracotomy.

Declaration of conflicting interests

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Ethics approval

The study was approved by University Clinic of Thoracic and Vascular surgery in Skopje, North Macedonia Ethical Committee (No: 03-275, Date: 26.05.2020).

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Authors' contribution

NJ; conceived and designed this study, RC,LA; contributed to data collection, analyses and interpretation, DD; contributed to interpretation and revision. All authors have read and approved the final manuscript.

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