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From Triportal to Uniportal Video-Thoracoscopic Lobectomy: The Single Surgeon Learning Curve by CUSUM Chart and Perioperative Outcomes

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Highlights

What are the main findings?

- As U-VATS lobectomy becomes globally prevalent, it suggests a period of skill acquisition for thoracic surgeons. CUSUM analysis of learning curve identified 67 uniportal VATS lobectomies as the inflection point for proficiency, with significant reductions in operative time (188 vs. 170.5 min, $p = 0.02$), conversions (15% vs. 2.5%, $p = 0.04$), and complications (42% vs. 22%, $p = 0.04$).
- Prior experience with triportal VATS does not remove the learning curve; a moving average analysis showed that skill acquisition progressed even after the first 67 procedures.

What is the implication of the main finding?

- Provides a benchmark for surgeons transitioning to uniportal VATS, suggesting about 50–70 cases are needed to achieve competency, aligning with ESTS consensus.
- Supports structured training programs, as even experienced multiportal VATS surgeons require dedicated practice to master uniportal techniques.

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Abstract

Background: Uniportal video-thoracoscopic lobectomy has improved postoperative outcomes in lung cancer patients. Thus, thoracic surgeons are increasingly required to learn this new approach. **Methods**: We evaluate the path of a single surgeon switching from triportal video-thoracoscopic lobectomy to the uniportal, using the cumulative sum (CUSUM) analysis, in a single center to assess the learning curve, enrolling 107 uniportal video-thoracoscopic lobectomies consecutively performed. CUSUM analysis detected how many uniportal video-thoracoscopies occur to obtain changes in mean operation time, among all procedures consecutively performed. CUSUM analysis identified the cut-off at the 67th procedure; this value was used to divide all patients into two groups: group A (first 67 patients, early phase) and group B (40 patients, experienced phase). Then, we analyze the perioperative outcomes between the two groups. **Results**: Gender characteristics of the two groups were statistically similar. Median operative time decreased significantly after the early phase [188 min (IQR: 151–236) vs. 170.5 (IQR: 134–202) (*p*-value = 0.02)], respectively. Similarly, during the second phase, the conversions rate decreased: [10 (15%) (group A) vs. 1 (2%) (group B) (*p*-value = 0.04)], as did the postoperative complications [28 cases (42%) vs. 9 cases (22%) (*p*-value = 0.04)] and the length of stay [6 days (IQR 5–9.5) vs. 5 days (IQR 4–8) (*p*-value = 0.04)], giving evidence of skills acquired in the second phase. **Conclusions**: CUSUM analysis identified 67 uniportal lobectomies, after which operative time, conversion rate, and perioperative complications significantly decreased; the moving average analysis further supports a progressive reduction in operative time. Despite prior multiportal video-thoracoscopic experience, switching to uniportal video-thoracoscopy requires a distinct learning process.

Keywords: uniportal VATS lobectomy; learning curve; cumulative sum chart; surgical skills; surgical development

1. Introduction

The uniportal video-assisted thoracoscopic lobectomy (U-VATS) is a minimally invasive thoracic surgery approach for anatomical pulmonary resections that has spread worldwide since Gonzales Rivas described its first case report in 2011 [1]. Thereafter, the effectiveness of U-VATS lobectomy has been demonstrated in several reports, and many thoracic surgeons around the world are constantly using this approach in clinical early-stage lung cancer patients, as well as in technically complex procedures like bronchial and vascular sleeve lobectomies.

In recent years, uniportal VATS has gained increasing interest among thoracic surgeons as a minimally invasive alternative to multiport approaches. Both surgeons in training and those with prior experience in open or multiport techniques have explored the uniportal approach, which is associated with a specific learning curve. However, the number of procedures required to reach proficiency remains variable across published studies.

Several studies concerning the learning curve of U-VATS lobectomies have been published in the scientific literature, but their results are neither uniform nor directly comparable to each other, due to the lack of standardization of the study design, data collection, statistical analysis methods used, and interpretation of the results.

Here, we analyze the experience in switching from triportal to uniportal VATS lobectomy performed by a single surgeon in a single center, evaluating the learning curve by the Cumulative Sum charts (CUSUM) and assessing the perioperative outcomes, comparing our work with the other previously published reports that used the same method.

2. Materials and Methods

This is a single-center, single-surgeon retrospective study of patients who underwent U-VATS lobectomy and systematic lymph node dissection for lung cancer, carried out at the Center of Thoracic Surgery, University Hospital of Insubria—Varese, Italy. In our institution, we started to perform VATS lobectomy for lung cancer in 2014, via triportal anterior approach by Hansen (Copenhagen approach) [2] on eligible patients. From November 2019 to May 2023, one of the staff's experienced surgeons on triportal VATS lobectomy switched to U-VATS lobectomy, performing 107 consecutive procedures in lung cancer patients (clinical stage I, II, and IIIA); meanwhile, the other surgeons continued to perform pulmonary lobectomies with the triportal approach. Inclusion criteria were restricted to anatomical pulmonary lobectomies for lung cancer undertaken by the designated surgeon, employing a single-port approach. Exclusion criteria were as follows: (1) non-anatomical resections, (2) cases in which U-VATS was not attempted (e.g., planned open thoracotomy), and (3) patients with incomplete clinical records.

The surgeon who shifted to U-VATS lobectomy has previously performed more than 150 consecutive triportal VATS lobectomies, and he has attended the intensive multi-day Master Class courses on U-VATS in two European referential centers, with wet lab experience.

Preoperatively, the patients underwent a comprehensive set of diagnostic procedures, including chest X-ray, chest tomography (CT), pulmonary function test, bronchoscopy, and endobronchial ultrasound transbronchial needle biopsy (EBUS-TBNB) if clinical N2 was suspected. Additionally, they underwent positron emission tomography (PET), brain imaging, and tumor CT-guided biopsy.

After the diagnosis was confirmed and the disease was recognized in its early clinical stage, the patients were referred for surgery after a Tumor Board discussion. The demographic data (age, gender, and smoking habits) and clinical data (including preoperative lung function, type of surgery, operative time, intraoperative blood loss, duration of chest drainage, length of hospital stay, postoperative complications, number of lymph nodes removed, any conversion to biportal, or to thoracotomy procedures, as well as pathological findings, and stage) have been collected and summarized in Table 1. The lung cancer was classified according to the 8th edition of the TNM classification of the International Association for the Study of Lung Cancer (IASLC) [3].

Table 1. Baseline patient characteristics stratified by learning curve phase.

Characteristics of Patients	Patients (n = 107)	Phase 1 (n = 67)	Phase 2 (n = 40)	*p*-Value
Age, median (IQR)	69 (62–75)	70 (62–75)	68 (2–75)	0.37
Male, n (%)	67 (63)	43 (64)	24 (60)	0.88
Smokers/former smokers, n (%)	70 (65)	43 (64)	27 (67)	0.71
BMI, mean (SD) kg/m^2	25.8 (4.38)	25.5 (4.19)	26 (4.77)	0.43
FEV_1, median (IQR)	103 (90–118.8)	103 (90–117)	104.5 (94–119)	0.74
DLCO, %, median (IQR)	85 (72.5–96)	85 (75–96)	88 (71–99.5)	0.61
Performance status (ECOG), 0, n (%)	91 (85)	56 (84)	35 (87)	0.65
Comorbidities, n (%)				
COPD	24 (22)	17 (25)	7 (17)	0.34
Hypertension	69 (64)	43 (64)	26 (65)	0.9
Diabetes	21 (20)	13 (19)	8 (20)	0.9
Dyslipideamia	41 (38)	27 (40)	14 (35)	0.6
Heart failure	18 (17)	13 (19)	5 (12)	0.3
Tumor characteristics				
Adenocarcinoma, n (%)	79 (74)	47 (70)	32 (80)	0.3
Squamous, n (%)	13 (12)	8 (12)	5 (12)	0.9
Carcinoid, n (%)	7 (6)	5 (7)	2 (5)	0.7
Other cancer, n (%)	8 (7)	7 (10)	1 (2)	0.2
Tumor size, median (IQR) mm	23 (16–33)	23 (16–33)	25 (16–34)	0.6
Tumor site, n (%)				
Right upper lobe	29 (27)	19 (28)	10 (25)	0.7
Middle lobe	4 (4)	2 (3)	2 (5)	0.6
Right lower lobe	25 (23)	18 (27)	7 (17)	0.3
Left upper lobe	28 (26)	17 (25)	11 (27)	0.8
Left lower lobe	18 (17)	9 (13)	9 (22)	0.2
Bilobectomy	3 (3)	2 (3)	1 (2)	0.9
Stage, n (%)				
I	70 (65)	43 (64)	27 (67)	0.7
II	21 (20)	14 (21)	7 (17)	0.7
IIIa	12 (11)	8 (12)	4 (10)	0.7

SD: standard deviation; BMI: body mass index; FEV_1: forced expiratory volume in the first second; IQR: interquartile; DLCO: diffusion lung carbon monoxide; ECOG: Eastern Cooperative Oncology Group; COPD: Chronic obstructive pulmonary disease.

2.1. Surgical Procedure

Each U-VATS procedure was performed by the same thoracic surgeon, assisted by another thoracic surgeon or trainee and a scrub nurse. A maximum 4 cm skin incision was made in the fifth intercostal space at the level of the anterior axillary line using an X-small wound retractor (Alexis®; Applied Medical, Rancho Santa Margarita, CA, USA) with no ribs spreading. All procedures were performed with a 10 mm, 30 degree video thoracoscope with endoscopic instruments, ultrasonic dissector (Harmonic Scalpel—Ethicon ACE®, Inc., Cincinnati, OH, USA). Endoscopic staplers were used to suture and cut the vessels (Echelon Flex™ Powered Vascular and Stapler, Ethicon ACE®, Inc., Cincinnati, OH, USA) or ligated by using hem-o-locks; in the same way, the bronchi and incomplete fissures were dissected with an endostapler. The thoracoscope was positioned at the posterior part of the utility incision, while the instruments were placed in the anterior part, following the standard uniportal VATS approach [4]. The surgeon and the assistant are placed in front of the patient to obtain the same field of vision. In the upper lobectomy, both right and left, the pulmonary arteries were usually dissected before the pulmonary vein, to achieve better exposition of the vena and to facilitate its easier dissection. The fissure-last technique was adopted as the standard procedure as the last step.

A systemic lymph node dissection was performed, and a thoracoscopic intercostal nerves block administering 0.5% bupivacaine under direct vision from the fourth to sixth intercostal space was performed through external transthoracic infiltration. At the end of the surgical procedure, a 24 French thoracic drainage was placed through the utility incision and connected to a portable vacuum unit for suction and air leak monitoring (Drentech™ Palm Evo, Redax®, Poggio Rusco, Italy), already in the operating room. A chest X-ray was performed after surgery, and thus, the patient was transferred to the ward. Postoperative analgesia followed a standardized institutional enhanced recovery protocol consisting of scheduled intravenous paracetamol 1 g every 8 h (usual care) when not contraindicated; opioid analgesics were used in addition to the usual care according to pain intensity and clinical judgment (increase in pain treatment). Pain was assessed using the Visual Analogue Scale (VAS) on postoperative days (PODs) 1, 2, 3, and at discharge. The chest tube was removed with no air leakage, and the volume of pleural effusion was less than 200 milliliters per day.

2.2. Statistical Analysis

Continuous variables were tested for normal distribution using the Shapiro–Wilk test. Normally distributed variables are presented as mean ± standard deviation and compared with Student’s *t*-test; variables not normally distributed are presented as median (interquartile range, IQR) and compared using the Mann–Whitney U test. Categorical variables were analyzed using Fisher’s exact test or χ^2 test as appropriate. A two-sided $p < 0.05$ was considered statistically significant.

The cumulative sum (CUSUM) chart was applied to define the completion of the learning curve of U-VATS lobectomy, evaluating the relationship between the operative time of each procedure consecutively performed and the number of procedures. CUSUM analysis detected how many U-VATS occur to obtain changes in the mean operation time, among all procedures consecutively performed.

The change in the mean operative time is represented in a time slope on the graph and indicates an increase or decrease in the quality of the parameter; the point of downward inflection of the slope on the graph represents the cut-off value of LC. Subsequently, the cut-off point of the CUSUM score was used to divide all patients into two groups: group A (before cut-off—early experience) and group B (after cut-off—late experience).

Moving average analysis was used to correlate the operative time of a single procedure with the mean operative time. The Pearson correlation coefficient was used for correlation between two sets of data.

3. Results

During study time, we enrolled a total of 107 patients who underwent U-VATS lobectomy for lung cancer consecutively, including 67 (63%) men and 40 (37%) females, with an average age of 69 years (SD 8.94), performed by the same surgeon, who switched from triportal VATS to U-VATS lobectomy. A total of 68% of all cases were smokers with a median body mass index (BMI) of 25.8 kg/m^2 (SD: 4.38). Lung function parameters showed a mean of forced expiratory volume in one second (FEV_1) of 103 L (IQR 90–118.5) and a mean of diffusing capacity of the lungs for carbon monoxide (DLCO) of 85% of predicted value (IQR 72.5–97). ECOG performance status scale was 0 in 91 (85%) patients. We performed 29 (27%) right upper lobectomies, 25 (23%) right lower lobectomies, 28 (26%) left upper lobectomies, 18 (17%) left lower lobectomies, 4 (4%) middle lobectomies, and 3 (3%) bilobectomies. The pathological types included 79 (74%) adenocarcinoma, 13 (12%) squamous cell carcinomas, 7 (6%) carcinoid tumors, and 7% other types of lung cancer. The median tumor diameter was 23 mm (IQR 16–33 mm). Pathological results showed that there were 70 (65%), 21 (20%), 12 (11%), and 4 (4%) of I, II, IIIA, and IIIB (unexpected) stage, respectively. The major comorbidities of 107 patients were hypertension (64%), dyslipidemia (38%), COPD (22%), diabetes (20%), and myocardial infarction (17%). Baseline characteristics are listed in Table 1.

3.1. CUSUM Analysis

The Cumulative Sum (CUSUM) chart showed a downward inflection at the 67th patient, which was considered the cut-off point of the learning curve (Figure 1).

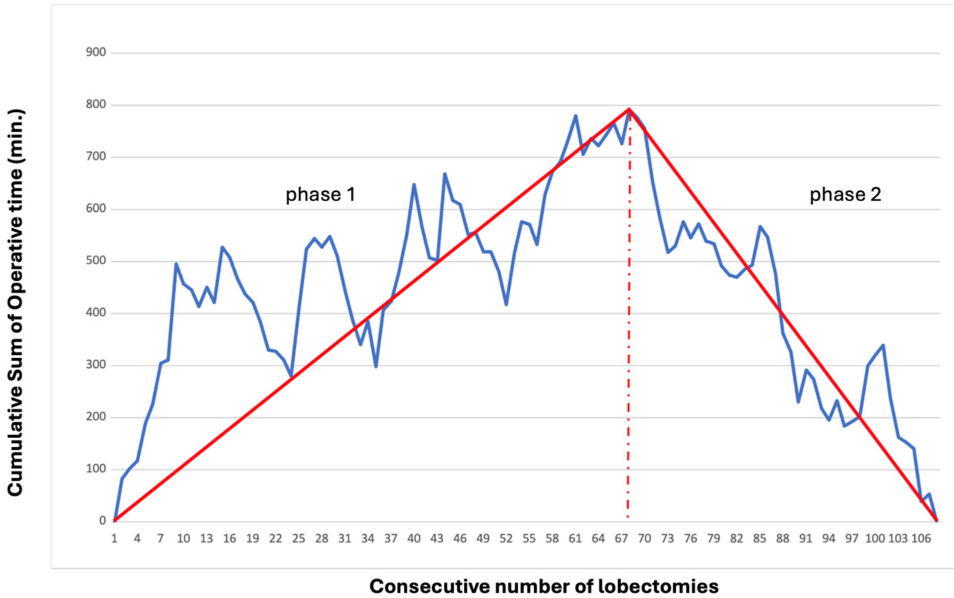

Figure 1. CUSUM curve for the length of U-VATS operations. The CUMSUM curve showed the inflection point at procedure number 67 (dotted line). The graph showed an ascending slope of the curve (Phase 1, from 1 to 66 patients), and a descending slope (Phase 2, from 67 to 107 patients).

Based on this threshold, the cohort was divided into group A (first 67 lobectomies—learning phase) and group B (last 40 lobectomies—proficiency phase). Demographic and clinical characteristics were comparable between the two groups, confirming the uniformity of the analyzed population (Table 1). In the CUSUM graph, two distinct phases can be observed:

a rising slope during the first 66 lobectomies and a declining trend after the 67th. This pattern reflects the cumulative performance relative to the overall mean operative time: when cases take longer than the mean, the curve rises; when cases are shorter than the mean, it declines. The inflection point marks the shift from below-average to above-average performance, indicating the surgeon's progression toward proficiency.

Furthermore, moving average analysis showed that after 47 U-VATS lobectomies, the operative time consistently fell below the overall mean, confirming the trend toward increased efficiency (linear correlation: $R^2 = 0.0604$; Pearson coefficient = −0.246; $p = 0.010$) (Figure 2).

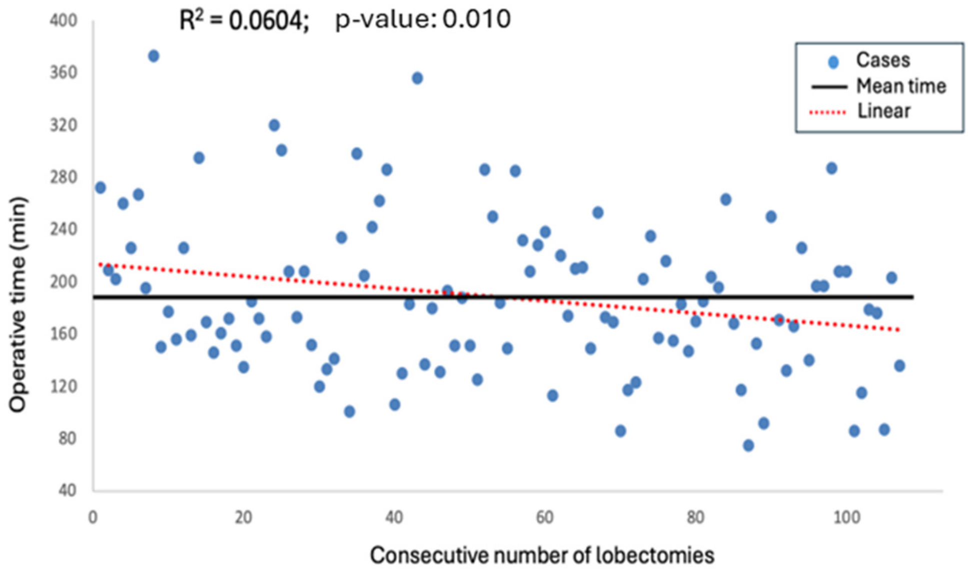

Figure 2. Correlation between the operation time and the consecutive number of U-VATS. The Pearson correlation coefficient = −0.246, p-value = 0.010.

This means that there is a weak inverse relationship between the number of consecutive lobectomies and the operative time of each procedure.

3.2. Perioperative Results

Perioperative outcomes in the two groups of cases identified by the CUSUM chart were compared. The initial period had the overall longest time, while the mean operative time decreased significantly in the second phase of the learning curve: average minutes 188 (IQR: 151–236) vs. 170.5 min (IQR: 134–202) (p-value = 0.02), respectively. Further significant drop was observed in conversion to open thoracotomy during the second period: 10 (15%) (group A) vs. 1 (2%) (group B) (p-value = 0.04); however, the conversion to biportal VATS was necessary in 11 and 10 cases among the two groups, recording a non-significant difference (p-value = 0.5).

Other outcomes with significant differences between the initial period and experienced time were the length of stay [6 days (IQR 5–9.5) vs. 5 days (IQR 4–8) (p-value = 0.04)]; the perioperative pulmonary complications [28 cases (42%) vs. 9 cases (22%) (p-value = 0.04)], and in postoperative pain measured with the Visual Analogue Scale (VAS). We observed a significant difference in pain on the second postoperative day (p-value = 0.001), and at discharge at home (p-value = 0.002). No differences were recorded for time of chest drainage, number of lymph nodes removed, recurrence of disease, and mortality. (Table 2).

Table 2. Perioperative outcomes of two groups of patients in each phase of learning curve.

Perioperative Outcomes	Patients (n = 107)	Group A (n = 67)	Group B (n = 40)	*p*-Value
Surgery time, median (DS) min	184 (151–226)	188 (151–236)	170.5 (134–202)	**0.02**
Conversion to thoracotomy, n (%)	11 (10)	10 (15)	1 (2)	**0.04**
Length of stay, median (IQR) days	6 (5–9)	6 (5–9.5)	5 (4–8)	**0.04**
Chest drainage time, median (IQR) days	4 (3–5.5)	4 (3–6.5)	3 (3–5)	0.19
Complications, n (%)	37 (35)	28 (42)	9 (22)	**0.04**
Pulmonary complications, n (%)	14 (13)	12 (18)	2 (5)	0.05
Prolonged air leak	10 (9)	8 (12)	2 (5)	0.3
Pneumonia	1 (1)	1 (1)	0 (0)	1
Not pulmonary complications, n (%)	25 (23)	19 (28)	6 (15)	0.1
Atrial fibrillation	11 (10)	9 (13)	2 (5)	0.2
Anemia	9 (8)	6 (9)	3 (7)	1
Urinary tract infections	4 (4)	3 (4)	1 (2)	1
Fever	8 (7)	6 (9)	2 (5)	0.7
Postop. pain, VAS score, median (IQR)				
VAS I GPO	3 (1–5)	3 (1–5)	2 (2–3)	0.07
VAS II GPO	2 (1–4)	3 (1–4)	2 (0–2)	**0.001**
VAS III GPO	2 (0–3)	2 (1–3)	1 (0–2)	0.52
VAS at discharget home	0 (0–1)	0 (0–1)	0 (0–0)	**0.002**
Increase in pain treatment, n (%)	35 (33)	26 (39)	9 (22)	0.08
30 days mortality, n (%)	1 (1)	0 (0)	1 (2)	0.2

DS: Standard deviation; IQR: interquartile range; VAS: Visual Analogue Scale; GPO: postoperative day.

4. Discussion

Since Gonzalez-Rivas described the first U-VATS lobectomy in 2011 [1], the uniportal approach has proven to be a safe and feasible surgical procedure as the last evolution of minimally invasive thoracic surgery for early-stage lung cancer treatment. The U-VATS comes from triportal and biportal VATS, with several advantages, mainly regarding chest pain and enhanced recovery.

Thereafter, several studies have been published in the literature concerning the U-VATS lobectomy learning curve; however, the U-VATS learning curve cut-off reported by the authors is in a wide range of values, due to different evaluation methods. Typing in the Medline/PubMed (National Library of Medicine, Rockville Pike, Bethesda) [5] search string the keywords [(uniportal VATS lobectomy) AND (learning curve)] as basic Boolean research, a total of 34 papers were returned by the search engine.

Among these, we selected only five papers that analyze the U-VATS learning curve with CUSUM chart analysis based on a single-surgeon, single-center as our study, compared and listed in Table 3.

Table 3. Comparison of previous studies about U-VATS Learning Curve by CUSUM chart, single-center, and single-surgeon.

Authors	n° of U-VATS	Surgeon	Cut-Off Value	Decrease in Time Among LC Phases *p*-Value
Li [6], 2022	538	1	52	0.001
Liu [7], 2018	120	1	44	0.001
Stamenovic [8] 2019	52	1	28	0.002
Zhai [9] 2022	103	1	33	0.002
Laven [10] 2023	324	4	14–26	NA
Cerretani[*]2025	*107*	*1*	*67*	*0.003*

* Present study; LC: learning curve; NA: not available.

The CUSUM chart analysis is a quantitative assessment of the learning curve recommended as a method for assessing technical performance [11], widely used in surgery to evaluate learning curves about new surgical technologies and procedures and to assess the quality of care itself [12]. Thus, in our study, one of the surgeons in our team switched from triportal VATS experience to U-VATS, performing 107 consecutive uniportal VATS lobectomies, obtaining an inflection of slope (by CUSUM) after 67 procedures (cut-off), which was useful to obtain proficiency (Figure 1).

Similarly, Li et al. (2022) reported 538 U-VATS lobectomies performed by a single surgeon, with CUSUM analysis identifying three phases of the learning curve and significant changes at the 52nd and 151st cases [6], in line with our findings. Liu et al. reported a plateau after 30 procedures among 120 U-VATS lobectomies by one surgeon [7]. Stamenovic et al. described proficiency after 28 cases in a single-surgeon cohort of 52 lobectomies [8]. Zhai et al. analyzed 103 lobectomies by an inexperienced surgeon, requiring 61–67 cases to complete the initial learning phase [9]. Finally, Laven et al. evaluated 324 cases by four surgeons, showing reduced operative time after 14–26 procedures in surgeons already experienced with multiportal VATS [10]. Our cut-off of 67 cases appears higher than some thresholds reported by other authors; possible explanations include differences in surgeon background, complexity of cases (bilobectomies and stage III cases), patient selection, and institutional factors influencing the learning process.

Our single-surgeon study and those of other authors mentioned above suggest that at least about 50 procedures are required to reach proficiency in U-VATS lobectomy. This value is in accordance with the value suggested by the U-VATS Interest Group Consensus of the European Society of Thoracic Surgeons (ESTSs) [13].

A comparison of the perioperative results between the early phase versus the second phase of LC showed that the second phase was superior in terms of operative time, length of stay, postoperative pain, postoperative complications, and number of conversions to thoracotomy, as reported in the previous literature reports [14–20]. All these indicators are changing continuously during the study time, showing a decreasing trend in the second phase of the learning curve [21]. The significant reduction in length of stay and postoperative pain observed in the second group is likely due to the increased experience of the surgical and perioperative care teams, which has led to a refinement of the surgical technique, more effective pain management protocols, and enhanced confidence in early discharge protocols.

In our first phase we collected 10 (15%) conversions to thoracotomy due to vascular injury in four cases, bronchial accidents in two patients, and four cases due to technical difficulties, in contrast to only one conversion that occurred in the second period of the study (*p*-value = 0.04), due to intermediate bronchial rupture during an upper right lobectomy (Table 4).

Table 4. Number of conversions to thoracotomy significantly decreases after the learning curve phase.

Causes of Conversion	1st Phase of Learning Curve 67 Patients	2nd Phase of Proficiency 40 Patients	*p*-Value
Conversion to thoracotomy, n (%)	10 (15)	1 (2.5)	**0.04**
Vascular accident, n	4	none	
Technical difficulty, n	4	none	
Bronchial accident, n	2	1	

In our study, at the beginning of the program, the surgeon shifted to U-VATS lobectomy directly, after more than 150 triportal VATS, eliminating both posterior and basal ports. However, when conversion was necessary due to technical difficulties, he added another port, mainly using posteriors. Among the two groups of studied patients, we collected a similar number of conversions to biportal VATS [11 (16%) group A vs. 10 (25%) group

B)], resulting in a non-significant difference (p-value = 0.5). The most frequent reason for conversion to biportal VATS, adding a posterior port, was the bronchial dissection, mainly in upper left lobectomy, as well as the time consumed.

Even though several factors affect the length of the learning curve of U-VATS lobectomy such as the frequency of consecutive procedures performed after the first one, prior training in experienced centers or in the wet lab, the use of simulators [22], or the previous experience in triportal VATS, we contend that the CUSUM analysis of mean operative time, serves as a valuable tool for evaluating the feasibility and learning progression of a new surgical technique adopted by an individual surgeon.

Limitations

This study has several limitations. First, it is a single-center, single-surgeon retrospective study, which limits external generalizability. Second, the sample size (n = 107) is limited and may affect the precision of the CUSUM inflection estimate. Third, the CUSUM chart provides a useful visual aid, and its findings require cautious interpretation since single results may not be applicable universally, and the cut-off points ought to be treated as suggestions rather than rigid benchmarks [23]. Fourth, intraoperative factors such as adhesions or anatomy that influence operative time are difficult to fully adjust for in a retrospective single-surgeon dataset.

These limitations notwithstanding, we believe that the consecutive nature of case inclusion and the use of standardized operative and postoperative pathways partially mitigate selection bias.

This study does not aim to define new proficiency thresholds, but rather to confirm the applicability of existing benchmarks, such as those proposed by the ESTS, within a single-center setting. Our findings reinforce that the estimated learning curve for uniportal VATS lobectomy (approximately 50 cases) holds even in smaller-volume institutions, underlining the consistency of the learning pattern across different surgical environments.

Conversely, assigning just one surgeon to carry out U-VATS lobectomy minimizes the selection bias inherent in patients' and surgeons' selection; in fact, we believe that the choice to switch to the U-VATS lobectomies by a single surgeon, performing consecutively the new approaches, has mitigated various influencing factors, leading to a more streamlined and effective learning curve. In fact, several intraoperative variables can affect the operation time, such as pleural adhesion, extended lymphadenectomy, site of lobectomy (upper vs. lower), hilar lymph nodes around vascular structures, as well as the wrong choice of intercostal space for the utility incision. However, these variables are part of daily surgical practice and cannot be predicted nor can they change the scheduled approach, according to Laven et al. [12].

5. Conclusions

To conclude, using the CUSUM methodology, we identified an inflection point at the 67th case, after which operative time, conversion rate, and perioperative complications showed a significant decrease. These findings suggest that, despite prior experience with multiport VATS, adopting the uniportal technique requires a distinct learning process, aligning with previous studies on this topic, which show that achieving proficiency in U-VATS lobectomy generally requires approximately 50–70 cases.

The moving average analysis further supports a progressive reduction in operative time, reinforcing the reliability of CUSUM as a tool for assessing surgical learning curves. Future research should focus on larger, multicentric analyses to validate these findings and further refine the assessment of surgical learning curves.

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Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The data supporting the findings of this study are not publicly available because of confidentiality restrictions. However, they can be made available upon reasonable request from the corresponding author.

Conflicts of Interest: The authors declare no conflicts of interest.

Abbreviations

The following abbreviations are used in this manuscript:

CUSUM	Cumulative Sum
U-VATS	Uniportal video-thoracoscopy
CT	Computed Tomography
EBUS-TBNA	Endobronchial Ultrasound Transbronchial Aspiration
PET	Positron Emission Tomography
SD	Standard Deviation
FEV_1	Forced Expiratory Volume in 1 s
DLCO	Diffusion Lung Carbon Monoxide
IQR	Interquartile
ECOG	Eastern Cooperative Oncology Group Performance Status
COPD	Chronic Obstructive Pulmonary Disease
BMI	Body Mass Index
VAS	Visual Analogue Scale
LC	Learning Curve
NA	Not available

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