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Research Article

# Uniportal Video-Assisted Thoracic Surgery: A Start-Up of almost One Year Experience

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## Abstract

**Background:** The application of uniportal video-assisted thoracic surgery (VATS) for both minor and major thoracic procedures is gaining widespread use across the globe. Believing its advantages, both in superb surgical results and less morbidity. This study presents our initial experience using this technique in procedures and demonstrates the results of postoperative pain level and hospitalization costs.

**Methods:** Between January 2017 and June 2018 we performed, in our Thoracic Surgery Unit, 80 procedures of video-assisted pulmonary lobectomy with uniportal technique, most of the procedures were performed for initial stage NSCLC. We decided to compare this sample with 62 lobectomies which where performed with an open technique in our operating unit. Demographic, clinical and surgical data were gathered, retrospectively analysed and stratified based on the chosen approach for performing the procedure. 30 days morbidity and mortality rates were evaluated.

**Results:** Our sample which underwent Uniportal VATS lobectomy was composed of 80 patients. 50 men (62,5%) and 30 women (37,5%) of an average age of 69 years old. NSCLC was diagnosed in 96,25% (n 77) of the patients, of which 63,9% (n 49) in the stage I and 36,4% (n 28) in the stage II of the malignancy. Sixty two (62) patients underwent uniportal VATS lobectomy procedure, while eighteen (18) patients were converted to a conventional thoracotomy procedure. In the majority of the cases right superior lobectomies were performed (32,5%, n = 25), mainly in the VATS sample group, even though this was not proved to be statistically relevant data (40,3% vs 33,3%). The average duration of the VATS lobectomy procedure was shown to be 128 +- 31 minutes (range 45' - 220', median 190'), on the other hand lobectomies which were performed using a thoracotomy procedure showed to have an average duration of 163 +- 32 minutes (range 95' - 230', median 170'). The difference between the two proved to be statistically relevant ($p < 0,001$). We didn't face in our sample preoperative mortality cases or cases of readmission within 30 days from the operation. The rate of postoperative complication in the time window of 30 days appeared to be 39,5% (n = 49) with 15 cases belonging to the VATS and 34 cases belonging to the open sample group (24,1% vs 54,8%9, p = 0,05). Air leak was more frequent in the VATS group (16,1% vs 14,5%, p = NS), but the result was not statistically relevant.

**Conclusion:** VATS lobectomy represents a valid alternative to the open procedure. It ensures a rate of complications and mortality which is the same, if not even inferior to the one of thoracotomy, it assures advantages for the patients in terms of less pain, better quality of life and a better esthetic outcome. Even though the former procedure is usually burdened by a high-cost due to the material which is needed for its performance, in several studies this aspect is seen to be counterbalanced by a shorter hospital stay. Even though our analysis relies on few data, results are encouraging and it could represent a pilot study to start from to be able to plan the future direction of our learning curve.

***Keywords:*** *Video-Assisted Thoracic Surgery (VATS); Uniportal VATS; Single-Port Thoracic; Surgery; Minimally Invasive Thoracic Surgery; Initial Experience in VATS*

## Introduction

Video-Assisted Thoracic Surgery (VATS) has been, beyond question, the biggest innovation in thoracic surgery of the last half century. No other innovation has changed, so drastically, the way of performing the surgical operation, or at least has improved so greatly the impact on the patients who need to undergo thoracic surgeries. Patients of the 21st century are well aware already of the advantages brought by mini-invasive surgery in every field of surgery. Thoracic surgery not excluded. Worldwide, more and more patients, having to undergo surgical interventions of pulmonary resection, ask for VATS procedures. It becomes everyday harder for thoracic surgeons to justify the choice of not using VATS, considering the rising number of scientific works which bring up undeniable proofs on the advantages of this approach, advantages not only in terms of reduction of the patient's morbidity, but as well as in terms of better surgical outcomes. When VATS was used for the first time it was already two decades ago. During its youth, VATS lobectomy was often referred to only as a trend or as a dangerous procedure with limited concrete applications. The history of how during the last twenty years VATS lobectomy improved, matured and evolved to become nowadays VATS procedure includes several lessons for the modern thoracic surgeon.

With the improvement of the surgical tools and the development of new technologies, the endoscopic technique offers the chance to perform surgical interventions, even sophisticated and demolitive ones, with indications ranging from pulmonary or mediastinal biopsies to radical treatment of tumors [1]. Mini-invasive procedures have already greatly substituted the traditional approach [2]. VATS lobectomy for the treatment of pulmonary neoplastic diseases in the earlier stages, other than having a better esthetic outcome, allows a faster post-operatory recovery. VATS' advantages if compared to open thoracotomy include a decreased incidence of prolonged air leak, arrhythmias, pneumonia and pain and also a reduction in the inflammatory parameters.

The reduction in post-operatory complications together with a shorter hospital stay contributed to the development of this technique [3]. Pulmonary lobectomy with open procedure, either performed thoracoscopically or robotically, represents the treatment of choice in initial stage NSCLC, it is also currently used for the treatment of metastatic diseases, benign tumors and non-neoplastic lesions as abscesses and malformations. Video-assisted lobectomy has been criticized by some, they questioned its oncological suitability, the safety in terms of complications and mortality, the advantage for patients in terms of lessened pain and better quality of life, and ultimately the high cost of this procedure. Even though thoracotomy still remains to be the most common approach, mini-invasive surgery improved greatly with time and VATS lobectomy proved to bring relevant advantages compared to thoracotomy [4,5]. Taking into consideration the current national and international economic situation, it becomes important to clarify what really is the burden in terms of this procedure's costs and if the advantages this procedure brought can justify the use of this approach. Few works have specifically faced the question on the economic burden of the VATS procedure [6-8]. In this study we refer to our initial experience with the uniport VATS procedure, comparing costs and outcomes with the surgical interventions performed with open technique.

## Methods

Between January 2017 and June 2018 we performed in our Thoracic Surgery Unit, 80 video-assisted pulmonary lobectomies with uniport technique, most of them were performed for the treatment of early stage NSCLC. We decided to compare this sample with 62 lobectomies which were performed with an open technique in our operating unit. Demographic, clinical and surgical data were gathered, retrospectively analysed and stratified based on the chosen approach for performing the procedure. 30 days morbidity and mortality rates were evaluated. The patients who had shown from the definitive histological examination to have an advanced pathological stage, were excluded from the study, while the cases in which a conversion of VATS procedure (for example in the presence of tenacious pleuroparenchymal adhesions or bleeding) they convoluted to the open group. All the patients were studied pre-operatively taking into consideration the clinical picture of the lung disease and their coexisting morbidities based on the protocols of our unit. The eligibility criteria for VATS lobectomy included: disease which is confined to the lung parenchyma, diameter smaller than 5 cm and absent N1 or N2 lymph node involvement from the pre-operatory radiological investigations (CT and PET scan). Statistical analysis was performed using ANOVA

(SPSS, IBM Software). Continuous variables are expressed as mean values ± SD or median and range. Categorical variables were analysed using χ-square test. Continuous variables were compared by Student' s t test. A P value < 0.05 was considered statistically significant.

## Surgical and materials approaches

In our unit we perform video-assisted lobectomy procedures following the Gonzales-Rivas' method, with a mini-thoracotomy on the superior margin of the 5$^{th}$ rib (Figure 1).

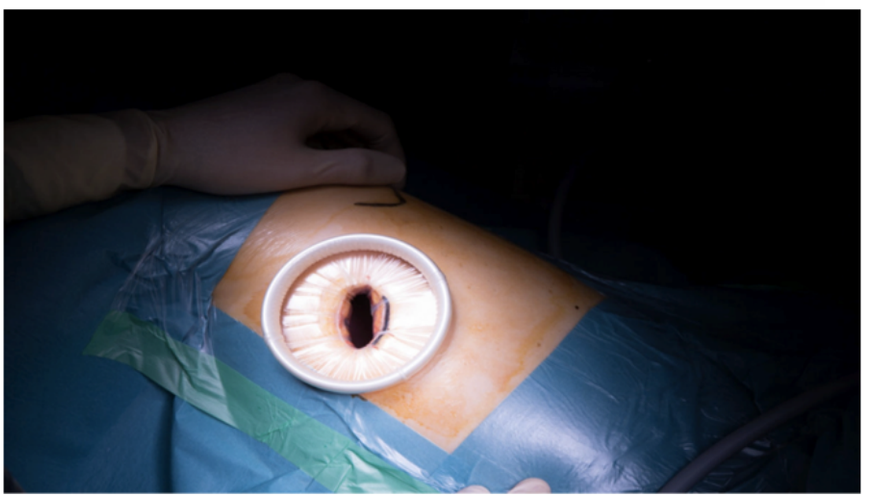

***Figure 1:*** *Location of the incision in uniportal VATS (fifth intercostal space, anterior axillary line).*

The thoracoscopic access is then used for positioning the pleural drain. Alternatively, thoracotomies are mostly performed anteriorly, regardless of the surgical approach, hilar dissection and lymphadenectomy were performed with the same technique. In our Thoracic Surgery Unit there are two types of mechanical staplers and the relative recharges: the Echelon™ Flex 35 mm (Ethicon) and the Echelon™ (45 mm). The uniportal approach was initially described by Rocco., *et al*. for performing minor pulmonary resections [9]. The first uniportal VATS lobectomy was described by Diego Gonzalez-Rivas., *et al*. University hospital de La Coruña, in the 2010. Both the surgeon and the assistant are positioned in front of the patient in order to have the same thoracoscopic view during all the steps of the procedure, thus allowing more coordinated movements. The scrub nurse should be positioned behind the patient (Figure 2).

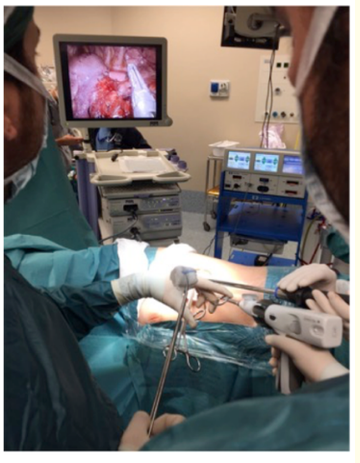

***Figure 2:*** *Positioning of the surgical team during the operation (both the surgeon and the assistant should be positioned in front of the patient).*

Although vision is only obtained through the front access site, the combined movements of the thoracoscope along the incision will create different viewing angles (the 10 mm 30 degrees thoracoscope is strongly recommended for broad vision). The advantage of using the thoracoscope, coordinating it with the instruments, is to obtain a targeted vision, which allows us to place surgical instruments in a way that allows us to face the target tissue from a sagittal perspective. The instrumentation used must be long and curved, to allow the insertion of 3 or 4 instruments simultaneously. Proper lung exposure is essential to facilitate dissection of structures and to avoid interference between the different instruments. The patient is placed in a lateral decubitus position in the same manner as in the conventional VATS, he/she is under general anesthesia and ventilated with a double lumen tube. The incision, about 4 - 5 cm long, is preferably performed at the fifth intercostal space in the anterior position. The incision has the same dimension of the usual thoracotomy which is used in the other multiportal VATS techniques. From this position, according to the author, we are able to acquire the best angles to perform the dissection of the hilum and the insertion of the staplers. There is no need to use a trocar for the thoracoscope. During the hilar dissection and the division of the structures it is useful to incline the operating table away from the surgeons, and vice versa for the lymph node dissection. In the minimally invasive approach the major vascular structures are generally managed with the use of staplers, as well as the lobar bronchus, but in some cases, for the dissection of smaller vessels, advanced bipolar scalpels have been used (Ultracision™ - Ethicon); in other cases the vessels were closed with Hem-o-lock™ clips (Teleflex). For most surgical operations the thoracoscope is placed backward to the thoracotomy site, while the front part is the designated place for the use of the surgical instruments. For the lower lobectomies the normal dissection sequence is as follows: pulmonary ligament, inferior pulmonary vein, pulmonary artery, bronchus and finally completion of the fissure. In case of superior lobectomies, the pulmonary artery is normally dissected first, followed by the dissection of the vein, the bronchi and ultimately the fissure. When the lobectomy is completed, the lobe is removed via an E-bag and a routine lymph node dissection is performed. A drainage tube is inserted at the back of the thoracotomy (Figure 3). Besides the canonical contraindications of VATS Lobectomy, Gonzalez-Rivas add the discomfort for the surgeon and the presence of voluminous neoplasms that require the enlargement of the thoracotomy [10].

***Figure 3:*** *Positioning of the drainage (uniportal VATS).*

## Postoperative management

In this study, post-operative analgesia was not taken into account by virtue of existence in our Operative Unit of a substantially standardized protocol that does not vary greatly between patient and patient. Each patient who undergoes surgery in fact receives a blockage

of the intercostal nerves at the end of surgery with 75 mg of ropivacaine and tramadol for the first 48 hours as needed, with the possibility of increasing the analgesic effect by administering 1g per hour of paracetamol. At the end of the 48 hours, the patient is converted to an oral pain relief therapy based essentially on the administration of paracetamol and tramadol. In our Unit, patients are considered to be dischargeable when they are in a good general condition, with good pain control and when they can be managed on an outpatient basis. Unless persistent air leak or lymphorrhoea, the patients are discharged once the pleural drain is removed (amount of drained fluid in 24 hours < 200 cc and discrete radiological picture). The decision to dismiss a patient or not is not influenced by the type of surgical approach received.

### Cost analysis

The unit cost of disposable devices, the hourly cost of the operating room including staff and the daily cost of hospitalization in the ward or intensive care unit were obtained from the cost center of our hospital. Data on the duration of interventions and hospital stays were collected prospectively but extracted retrospectively from the company databases; the consumption of the various disposable devices has been deduced from the operative notes. All those "standard" shopping items common to both approaches were not taken into consideration (eg the cost of double-lumen orotracheal tube, gowns and gloves, etc.). In the same way, the cost of the multi - use material (surgical instruments, videothoracoscopes, monitors, ventilators, etc.), purchased or rented, was not taken into consideration in the cost analysis since it is part of the "normal" endowment of an Operating Unit of Thoracic Surgery. The direct costs (single-use material, time of use of the operating room, length of stay) were determined and stratified according to the type of surgical approach.

## Results

Our sample which underwent Uniportal VATS lobectomy was formed by 80 patients. 50 men (62,5%) and 30 women (37,5%) of an average age of 69 years old. NSCLC was diagnosed in 96,25% (n 77) of the patients, of which 63,9% (n 49) in the stage I and 36,4% (n 28) in the stage II of the malignancy the detail is shown in table 1. Sixty two (62) patients underwent uniportal VATS lobectomy procedure, while eighteen (18) patients were converted to a conventional thoracotomy procedure (TT).

| | VATS | % | TT | % | p |
|---|---|---|---|---|---|
| Demography | | | | | |
| Male | 34/50 | 68 | 16/50 | 32 | 0.23 |
| Age | 67.28 ± 8.5 | | 67,8 ± 9 | | NS |
| Diagnosis | | | | | |
| NSCLC | 77 | 96.2 | | | |
| 1a | 42 | 63.6 | | | |
| 1b | 7 | | | | |
| 2a | 23 | 36.4 | | | |
| 2b | 5 | | | | |
| 3a | 2 | 1.6 | | | |
| 3b | 0 | | | | |
| Other | 1 | 0.8 | | | |
| Histology | | | | | |
| Squamous Cell Carcinoma | 27 | 35 | | | |
| Adenocarcinoma | 50 | 65 | | | |
| Other | 3 | 3.75 | | | |

***Table 1:*** *Demographic variables and histology stratified according to the surgical approach. NS: Not Significant.*

In the majority of the cases right superior lobectomies were performed (32,5%, n = 25), mainly in the VATS sample group, even though this was not proved to be statistically relevant (40,3% vs 33,3%). The average duration of the VATS lobectomy procedure was shown to be 128 +- 31 minutes (range 45' - 220', median 190'), on the other hand lobectomies which were performed using a thoracotomy procedure showed to have an average duration of 163 +- 32 minutes (range 95' - 230', median 170'). The difference between the two proved to be statistically relevant (p < 0,001). We didn't face in our sample perioperative mortality cases or cases of readmission within 30 days from the operation. The rate of postoperative complication in the time window of 30 days appeared to be 39,5% (n = 49) with 15 cases belonging to the VATS and 34 cases belonging to the open sample group (24,1% vs 54,8%9, p = 0,05). The detail is shown in table 2. Air leak was more frequent in the VATS group (16,1% vs 14,5%, p = NS), but the result was not statistically relevant.

| | VATS | % VATS | Open | % Open | Total | % Total |
|---|---|---|---|---|---|---|
| Complicated Patients | 15 | 24.1 | 30 | 48.3 | 45 | 36.2 |
| Air Leak | 10 | 16.1 | 9 | 14.5 | 19 | 15.3 |
| Chylothorax | 1 | 1.6 | 0 | 0 | 1 | 0.8 |
| Atrial Arrhythmia | 1 | 1.6 | 3 | 4.8 | 4 | 3.2 |
| Bleeding | 0 | 0 | 4 | 6.4 | 4 | 3.2 |
| Respiratory Failure | 2 | 3.2 | 12 | 19.3 | 14 | 11.2 |
| Wound Infection | 1 | 1.6 | 2 | 3.2 | 3 | 2.4 |

***Table 2:*** *Details of complications stratified according to the surgical approach.*

There was a significant difference in the average hospitalization between the open group and the VATS group, the latter being lower (Table 3).

| | VATS | Open | p |
|---|---|---|---|
| Times | | | |
| Operative Time | 119,2 ± 25,3 | 146,7 ± 37,5 | < 0,0001 |
| Hospitalization | 4,29 ± 2,6 | 6,6 ± 1,9 | 0.0004 |

***Table 3:*** *Summary of times stratified according to the surgical approach.*

In our case series, the operating room cost was significantly higher in VATS lobectomies than in open lobectomies (2030.31 ± 819.6 € vs. 1589.68 ± 958.2 €, p = 0.003) as well as the cost of staplers recharges (1164.80 ± 338.0 € vs. 854.13 ± 395.04 €, p = 0.003) and fixed costs (which include standard suture kits by type of surgery and, in the case of VATS, the costs of disposables except staplers and recharges: € 181.70 vs. € 101.60, p < 0.001); all these factors resulted in a significantly higher total cost of the endoscopic surgical procedure in statistical sense (3961.32 ± 717.40 € vs. 2901.83,03 ± 513,215 €, p < 0.001).

Substantial statistical differences between groups have been highlighted, however, as regards hospitalization and related costs (4,199 ± 1557,2 € vs. 6,544,07 ± 2544,5 € with p = 0,002) this figure is also reflected in the cost total admission (identified by the sum between the cost of the intervention and the hospitalization) which is superimposable, from a statistical point of view, between the two groups.

| | VATS | Open | P |
|---|---|---|---|
| **Costs** | | | |
| Operating Room | 2030,31 ± 819,6€ | 1589,68 ± 958,2€ | 0.003 |
| Specialist Materials | 1749,31 ± 266,59 € | 1210,55 ± 210,44 € | 0.08 |
| Common Use Materials | 181,70 ± 0,0€ | 101,60 ± 0,0€ | < 0,001 |
| Other Hospitalization Costs | 4.199 ± 1557,2€ | 6.544,07 ± 2544,5€ | 0.002 |
| Total | 6.229 ± 2398,67€ | 8.133 ± 2461,57€ | 0.001 |

***Table 4:*** *Summary of the costs stratified according to the surgical approach.*

## Discussion

Simultaneously with the growth and the diffusion of the several video-assisted lobectomy techniques, also some scientific studies were published with the aim of evaluating this type of therapeutic approach to cure lung tumor, both from the point of view of the efficacy and the point of view of its economical impact. As a matter of fact, even though this method's advantages have been already shown and well accepted, the procedure's cost has been taken into account as an obstacle to the growth of the thoracoscopic technique [11,12]. In an article which was presented by Gossot [12], the total price of the VATS was shown to be higher (2861 ± 458€ vs. 2260 ± 398€, p > 0,001) with a small although relevant difference, unlike Casali and Walker ((2533 ± 230€ vs. 1280 ± 54€)) which in their case studies reported a greater difference. From the analysis of our cases it emerged that VATS as a relevantly higher cost compared to the open lobectomy procedure, in terms of all that concerns the surgical intervention ((3961,32 ± 717,40€ vs. 2901,83,03 ± 513,215€, p < 0,001).

The factors taken into account for determining this difference are the cost of the operating room, the staplers' recharged and the fixed costs of the two approaches. The cost of the operating room is determined mainly by the surgery's duration. In our case study, the surgery's duration in the TT group was longer of an average of 31' (p = 0,0001); Gossot [12] reports for his entirely endoscopic technique a time difference of 77 minutes, with much greater averages compared to the other authors. The recharges' cost is obviously determined by their usage, sensibly higher in endoscopic procedures (6,76 ± 1,96, median 7 Vs. 4,93 ± 2,31, median 5). Fixed costs, which as we said are constituted by the disposable material (for ex. Sutures, metallic clips, sterile sleeve for the camera etc.) which is routinely used during the performance of the two approaches, result higher in VATS, with an average difference of 80 €, indeed, the money which can be saved in terms of sutures in the mini-invasive technique is promptly counterbalanced from the cost of the other materials needed for this approach, especially from the endobag. Even though this might seem economically unconvenient, the usage of these plastic bags is necessary for the removal of anatomical pieces in order to lower the risk of malignant cells' implants in the surgical accesses [13,14] and also necessary, on our opinion, to be able to guarantee an oncologically right surgery. Regarding the hospital stay, as said before, we highlighted significant variations between the two groups, patients who undergo VATS usually have an hospital stay of two days less; this mirrors a better trend of the thoracoscopic procedures, hence the necessity to institute a standardized "fast-tracking" process for the patients who undergo mini-invasive procedures. This data is in line with the data reported by Nakajima, Cho and Gossot [12-15] which have wider case studies and a consolidated experience of VATS lobectomy. They declare a shorter hospital stay for those who undergo VATS lobectomy, their cases results to be slightly inferior in an absolute value to the one observed in our patients; the hospital stay related to the open group results to be in line with the one mentioned in the other studies: this could suggest us that with the progressive increase of our experience on the field of mini-invasive surgery, we could reduce sensitively the hospital stay and therefore the costs.

In conclusion, comparing the average of the total costs for the two methods a break of 1280 € is observed. Additionally decreasing the duration of the hospital stay in those patients who undergo mini-invasive surgery we could reach a total cost which is remarkably inferior to VATS. Yet to achieve this result it is necessary to proceed to a revision on the way we approach our patients who submit to mini-invasive surgeries, analyzing deeply the algorithms for therapy management and drainages and aiming at a faster post-operative mobilization. A valuable help in the resolution of this issue could come from the replacement of the most traditional draining systems with the latest ones already in use in our Unit, equipped with a digital display which provides real time objective data which allows to easily monitor the therapeutic progression, making it 'smarter' (for ex. Thopaz - Medela©). In our case study the surgery conversions have determined an increase in the costs related to the surgery and the ones related to the hospital stay, as mentioned in other works [10].

Prolonged air leak appeared to be a complication having a ruinous impact on the economic variable, defined in our study of a duration >7 days; patients with air leak, regardless of the type of surgery they received, cost as an average around 3000 € more than the patients without complications, mainly because of a 4-5 days longer hospital stay. Concerning VATS, we observed an higher cost for left superior lobectomies (2484,674€) and right inferior lobectomies (2297,09€) compared to the other lobectomies (average 1967,45€) as a result of a longer duration of the surgery and the use of an higher number of staplers (p < 0,0001). In fact they are considered to be the most

complex lobectomies to be performed with thoracoscopy; the left superior ones because of the great anatomical variations of the arterial trunk, the right inferior because of the position of the A6 branch (superior segmentary) which often needs to be isolated and clamped separately and because of the difficulties to be faced with the completion of the posterior scissure as well.

This data contrasts with what is mentioned by other authors, which find the right superior lobectomy to be the most expensive surgery to be performed with VATS [6-12,15].

This study acknowledges the existence of some limitations: first of all the limited statistical sample owing to the fact that we are currently at an initial stage of our experience with VATS (19 months).

As other studies on VATS lobectomy, this is not a randomized study, because of obvious ethical reasons: the perspectives for the actualization of randomized trails are scarce because patients are reluctant to the idea of engaging in a study which could randomly assign them to be candidates for a more invasive technique.

Along with this we can also assume that being VATS a technique that remarkably reduces post-operative pain granting a better quality of life, patients are more prone to a fast recovery in order to go back to their everyday activities, as well as their job, additionally amortizing as a matter of fact the costs of this method. In the current epidemiological panorama this data appears to be noteworthy because lung tumor is diagnosed earlier and earlier, meaning a younger population that has to undergo lung lobectomy.

## Conclusion

VATS lobectomy represents a valid alternative to the open procedure. It ensures an inferior rate of complications and mortality compared to thoracotomy, it assures advantages for the patients in terms of less pain, better quality of life and a better esthetic outcome. Even though the former procedure is usually burdened by a high-cost due to the material which is needed for its performance, in several studies this aspect is seen to be counterbalanced by a shorter hospital stay. Even though our analysis relies on few data, results are encouraging and it could represent a pilot study to start from to be able to plan the future direction of our learning curve.

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## Availability of Data and Materials

Dataset and materials are available to readers and editor.

## Authors' Contributions

Conception and design of the work, data analysis and interpretation, drafting the article, critical revision of the article, final approval of the version to be published. All authors read and approved the final manuscript.

## Competing of Interests

The authors declare that they have no competing interests.

## Consent for Publication

The corresponding author accepts responsibility for releasing this material on behalf of any and all Co-authors.

## Ethics Approval and Consent to Participate

Our institutional review board granted approval and waived the requirement for specific informed consent for this retrospective study.

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