ECRONICON OPEN ACCESS

EC PULMONOLOGY AND RESPIRATORY MEDICINE

Research Article

Anatomic Segmentectomy in Thoracic Surgery. Experience in Benign and Malignant Pulmonary Diseases

V Abiuso[1], D Gaete[3], B Ortiz[3], G Cardemil[1], G Fernandez[1], J Molina[1], J Salguero[1] and J Clavero[1,2]*

[1]*Thoracic Surgery, University of Chile Clinical Hospital, Chile*

[2]*Thoracic Surgery, Los Andes University Clinic, Chile*

[3]*General Surgery Resident, University of Chile, Chile*

***Corresponding Author:** J Clavero, Thoracic Surgery, University of Chile Clinical Hospital and Thoracic Surgery, Los Andes University Clinic, Chile.

Received: November 02, 2022; **Published:** November 09, 2022

Abstract

Objective: To describe the experience and results of anatomic segmentectomy by three approaches: Thoracotomy, video-assisted thoracic surgery (VATS) multiport and uniportal, by members of the thoracic surgery team of the University of Chile at two university centers throughout the last 15 years.

Materials and Methods: 75 patients who underwent anatomical segmentectomy between April 2007 and March 2022 were analyzed. Data were collected retrospectively considering demographic and clinical variables, surgical approach, length of stay, days of chest drain, localization, morbidity and 30-day/hospital mortality.

Results: Of the 75 procedures, 18 (24%) were done by thoracotomy, 18 (24%) by multiport VATS and 39 (52%) by uniportal VATS. No side predominance was observed. There were 23 cases of benign lesions (31%) and 52 malignant lesions (69%), being the most frequent histology adenocarcinoma (46,6%). The mean surgical time was 165.5 ± 53.9 minutes, hospital stay 5 ± 3.3 days and duration of chest tube drain 3 ± 2 days. The complication rate was 16%. Thirty-day mortality was zero.

Conclusion: Segmentectomy is currently considered a technically complex procedure with similar results to lobectomy in selected cases but with the advantage of preserving pulmonary function. Our results are comparable to other published series, showing that segmentectomies can be performed safely and with more experience, they might be done by minimally invasive techniques achieving optimal results.

Keywords: *Lung Segmentectomy; Video Thoracoscopy; Anatomical Lung Resections*

Introduction

Anatomical segmentectomy is defined as the resection of one or more pulmonary segments, identifying and dissecting the segmental bronchus, artery and vein, which are individually divided [1,2].

Extended segmentectomy is the resection of the affected segment along with the adjacent subsegments and hilar lymph nodes, assessed using a frozen section to confirm the absence of metastatic involvement [3].

Although anatomical segmentectomies have been performed for lung cancer since before 1995, their use was controversial until recently, being recommended mainly for patients with limited lung function or small tumors with favorable histology [4].

Segmentectomies are technically complex procedures either by open approach or even more by minimally-invasive techniques [5]. They require a deep knowledge of the pulmonary anatomy to achieve clear margins while respecting the venous drainage of the adjacent segments [1]. These difficulties have further limited its popularity and routine use.

Despite their technical difficulties, anatomical segmentectomies have produced great interest among thoracic surgeons because of their advantages over lobectomies in terms of morbidity, mortality and preservation of lung parenchyma [6,7]. These advantages have led them to be recommended by different scientific societies for the treatment of low-grade tumors and patients with impaired lung function [8-10].

Sublobar resections have been carried out sporadically in Chile and Latin America in different scenarios. And to our knowledge, no important series of patients undergoing anatomic segmentectomies have yet been published.

Objective of the Study

The objective of our study is to present the results of anatomic pulmonary segmentectomies throughout the last 15 years at the University of Chile.

Materials and Methods

Retrospective descriptive review of all the patients who underwent anatomical segmentectomy by three different surgical approaches (Thoracotomy, multiport VATS, or Uniportal VATS) for either benign or malignant disease. Electronic and paper medical records of patients operated on between April 2007 and March 2022 were reviewed. Demographic variables (age and gender) and clinical variables (preoperative diagnosis, histology, surgical approach, length of hospital stay, length of chest drain, location of the nodule, postoperative complications and 30-day/hospital mortality) were analyzed.

Statistical analysis

STATA program version 16.0 was used. Quantitative variables are presented as measures of central tendency and qualitative variables as measures of frequency. For the comparative analyses, a non-parametric median comparison test (Mann-Whitney U) and Fisher's exact test were used to compare proportions. Significant differences p value less than 0.05 are considered. For the calculation of survivals, the Kaplan Meier Method is used.

Indications for surgery

In patients with perioperative suspicion of benign disease, the main indication was the presence of an undetermined or growing lung nodule, bronchiectasis and chondroma (suspected Carney triad). In the case of patients with malignant disease, anatomical segmentectomy was performed in those with stage IA (T1a and T1b) NSCLC, tumors larger than 20 mm but limited cardiopulmonary function, not candidates for lobectomy, or in those with suspected pulmonary metastasis.

Preoperative study

All the patients underwent a CT thorax with contrast and pulmonary function tests (spirometry and gas transfer factor). From 2010 onwards, the preoperative study included a PET scan for lesions greater than 8 mm and suspected malignancy.

Cardiopulmonary tests and echocardiograms were also included in patients with an increased cardiovascular risk.

Surgical technique

The procedures were performed with the patient in lateral decubitus, under general anesthesia and with a double-lumen endotracheal tube. In patients operated by open surgery, epidural anesthesia was used and a posterolateral thoracotomy in the 5th intercostal space preserving the serratus anterior muscle was the elected approach. In the case of multiport VATS, three incisions were made whose location varied according to the segment to be resected. In the case of the uniportal VATS, a 3 to 4 cm incision was made in the 4th, 5th, or 6th intercostal space, anterior to the Latissimus Dorsi muscle in the middle or anterior axillary line.

Segmentectomy was performed, identifying the vessels and bronchus of the segment to be resected at the hilum level, which were dissected and divided individually. Subsequently, after a ventilation test, the lung parenchyma was divided by the intersegmental plane using multiple stapler reloads.

In the case of malignant lesions very close to the intersegmental plane, a bi or tri-segmentectomy was preferred to secure adequate oncological margins. A systematic lymph node dissection was always performed in these cases. The operative tissue was removed using a bag. One or two chest drains were inserted at the end of the surgery and connected to a water seal. All the patients were subsequently transferred to an intermediate care unit to continue their postoperative management for one or two days and later transferred to the ward before being discharged.

Results

In the study period, 75 anatomical segmentectomies were performed, of which 18 were done by thoracotomy, 18 by multiport VATS and 39 by uniportal VATS. The average age of the patients was 61.9 ± 14.9, of whom 61.3% were female. Of the patients, 37 (49,3%) were smokers, with an average pack-year index of 29.3 ± 25.2. Demographic variables and patient characteristics are summarized in table 1.

Demographic variables	
Segmentectomies (n = 75)	
Gender, n (%)	
Female	46 (61.3%)
Male	29 (38.7%)
Age, mean years [range]	61.9 ± 14.9 [14 - 83]
Comorbidities, n (%) Asthma COPD High blood pressure Type II Diabetes Mellitus	60 (80%) 3 (4%) 10 (13,3%) 29 (38,7%) 18 (24%)
Smoking history, n (%)	37 (49,3%)
PYI, mean [range]	29.3 ± 25.2 [2 - 100]
Preoperative images, n (%) Chest CT scan PET scan	 73 (97.3%) 51 (68%)
Major diameter of the lesion (mm) Benign Malignant	20.4 ± 21.3 [4 - 140] 31.2 ± 26.1 16.3 ± 13.3

Table 1: *Demographic variables. PYI: Pack-Year Index; CT: Computed Tomography; PET: Positron Emission Tomography; COPD: Chronic Obstructive Pulmonary Disease.*

Regarding preoperative diagnoses, these corresponded to indeterminate or enlarging lung nodule (69%), pulmonary metastases (17%), lung mass (4%), hamartoma (3%), bronchiectasis (3%), pulmonary hydatid disease (2%), pulmonary chondroma as presentation of Carney triad (2%) and one bronchogenic cyst (2%). The surgical approach, histopathology results and perioperative outcomes are summarized in table 2.

Perioperative outcomes	
Surgical approach	
Thoracotomy	18 (24%)
Multiport VATS	18 (24%)
Uniportal VATS	39 (52%)
Operative time (min)	165.5 ± 53.9 [65-341]
Thoracotomy	165 ± 36
Multiport VATS	175.3 ± 70.9
Uniportal VATS	164.9 ± 60.6
Histology, n (%)	
Benign	23 (30.7%)
Malignant	52 (69.3%)
Primary lung cancer	39/52 (75%)
Metastases	13/52 (25%)
Complications according to Clevien-Dindo, n (%)	12 (16%)
I	3 (4%)
II	7 (9.3%)
III	2 (2.7%)
Hospital stay, mean days [range]	4,7 ± 3,2 [1 - 18]
Length of chest drain, mean days [range]	3,2 ± 2,1 [1 - 12]
30-day/hospital mortality	0

Table 2: *Perioperative outcomes. VATS: Video Assisted Thoracic Surgery.*

Regarding histopathology results, 31% corresponded to benign lesions, whereas 69% to malignant lesions. Of the latter, 75% were primary lung cancer with a mean diameter of 14.8 ± 10 mm [Range 4 - 50 mm]. Details about the histopathology report are described in table 3.

Histology	N	%
Benign (23/75)	23	30.7
Solitary Fibrous Tumour	1	4.3
Bronchiectasis	2	8.7
Bronchiolitis obliterans organizing pneumonia	3	13.0
Pulmonary Hamartoma	2	8.7
Wegener's Disease	1	4.3

Pulmonary Pneumocytoma	1	4.3
Anthracosis	2	8.7
Smoking-related Interstitial Fibrosis (SRIF)	1	4.3
Hydatid Cyst	1	4.3
Others	9	39.1
Malignant (52/75)	52	69.3
Primary pulmonary neoplasm (39/52)	39	75
NSCLC (4/39)	4	10,3
NSCLC (35/39)	35	89.7
Adenocarcinoma (32/35)	32	91.4
In situ (6/32)	6	18.8
Minimally invasive (4/32)	4	12.5
SCC (2/35)	2	5.7
Adenosquamous (1/35)	1	2.9
Metastases (13/52)	13	25.0
Renal and Urothelial	3	23.1
Colon and Rectum	6	46.2
Leiomyosarcoma	1	7.7
Parotid	1	7.7
Cervix and uterus	1	7.7
Thyroid	1	7.7

Table 3: *Details of the histology reports. NSCLC: Non-Small Cell Lung Cancer; SCC: Squamous Cell Carcinoma.*

A single segment was resected in 76% of the patients, most of them by uniportal VATS. The number and location of the segments resected by each surgical approach are detailed in table 4. In three cases, a lobectomy was necessary due to the undetermined result of the frozen section.

Resected segments	Thoracotomy (N = 18)	Multiport VATS (N = 18)	Uniportal VATS (N = 39)	Total cases (N = 75)
Nº of segments				
One	13	14	30	57 (76%)
Two	4	2	6	12 (16%)
Three	1	2	1	4 (5,3%)
Four	0	0	2	2 (2,7%)
Right upper lobe				
Apical (S1)	0	1	8	9
Posterior (S2)	2	5	7	14
Anterior (S3)	2	1	0	3
Right lower lobe				

Apical (S6)	3	5	2	10
Medial-basal (S7)	1	1	2	4
Anterior-basal (S8)	0	0	2	2
Lateral-basal (S9)	1	0	2	3
Posterior-basal (S10)	0	1	4	5
Left upper lobe				
Apical-posterior (S1-S2)	2	0	6	8
Anterior (S3)	3	0	2	5
Lingula (S4-S5)	2	0	2	4
Left lower lobe				
Apical (S6)	3	4	7	14
Anterior basal (S7-S8)	0	1	0	1
Lateral basal (S9)	1	2	2	5
Posterior basal (S10)	0	3	1	4

Table 4: *Description of the number of segments resected by each surgical technique.*

When comparing the perioperative outcomes among the three different techniques, it is possible to identify statistically significant differences in length of hospital stay and length of chest drain tube (Table 5).

Variables	Thoracotomy (N = 18)	VATS (N = 18)	p-value
Operative time, mean (min)	145 [120-240]	158 [65-293]	0.7866
Complications, n (%)	3 (16.7%)	9 (15.8%)	1
Length of hospital stay (days)	6.5 [3-18]	3 [1-13]	< 0.0001
Length of chest drain (days)	5 [2-8]	2 [1-12]	< 0.0001
30-day/hospital mortality	0	0	-

Table 5: *Perioperative outcomes comparison between thoracotomy and VATS.*

When analyzing the transition and evolution in the surgical technique, a significant increase in the number of minimally invasive procedures was observed during the study period, showing a massive change between the proportion of surgeries performed by thoracotomy at the beginning of the study (2007) and those performed by Uniportal VATS at the end of the period (2022) (Figure 1).

Regarding postoperative complications, these occurred in twelve patients. Two were due to hospital-acquired pneumonia, needing antibiotic treatment with a favorable response. One patient with fever and a hypertensive crisis was treated with antibiotics and an intravenous nitroglycerin pump bomb. One patient presented with an episode of atrial flutter and received conservative treatment and one patient with postoperative neuropathic pain was controlled with oral analgesia on an outpatient basis. One patient presented with hemorrhagic fluid output through the chest drain but was hemodynamically stable and ceased spontaneously without requiring further intervention, one patient with empyema and S6 infarction required reoperation by thoracotomy and resection of the apical segment of the left lower lobe, one patient with atelectasis who received physiotherapy, two patients with subcutaneous emphysema, one of them man-

aged conservatively by keeping the chest tube drain on suction and the other one, due to prolonged air leak, was successfully managed with phrenic nerve blockage, finally, two patients with postoperative atrial fibrillation who were successfully managed with Amiodarone infusion.

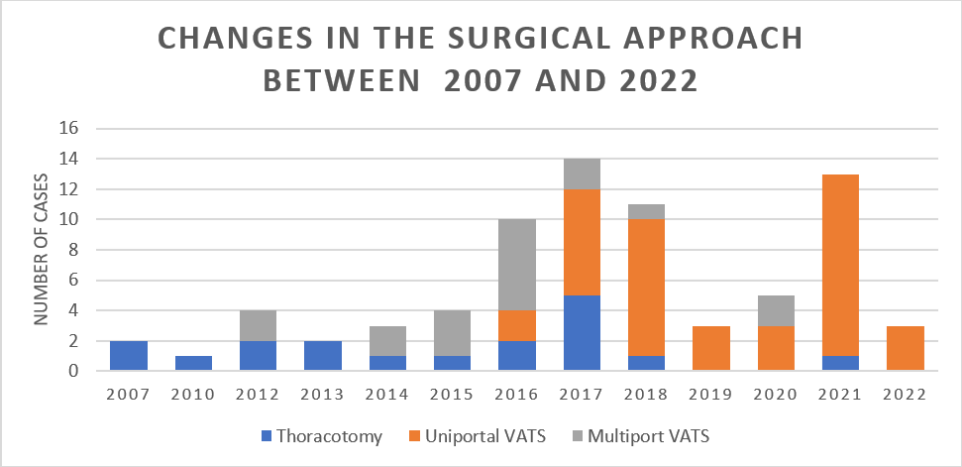

Figure 1: *Changes in the surgical approach throughout the studied period (2007-2022).*

All these complications make up to 16% of the total number of patients analyzed in our series, which, according to the Clavien-Dindo classification, correspond to 3 grade I patients, 7 grade II patients and 2 grade III patients (4%, 9.3% and 2.6% respectively).

Discussion

The first lung segmentectomy, a lingulectomy, was performed by Churchill and Belsey in 1939 to treat bronchiectasis [11], who also defined the pulmonary segment as the surgical unit of the lung. The anatomical studies of Kent and Blades and the systematization of the surgical technique by Overholt and Langer allowed the development of this technique and their broader use in treating diseases such as tuberculosis and bronchiectasis by preserving a more significant amount of lung parenchyma [12].

Subsequently, segmentectomies began to be used in patients with limited lung function to treat lung cancer. More recently, they have also been performed in patients with normal pulmonary function. The progressively collected evidence has shown that this type of surgery would have an equivalent cancer survival rate to Lobectomy [13,14].

In addition, with the greater availability of chest computed tomography (CT) and its progressive use in the early detection of lung cancer, an increasing number of pulmonary nodules are being investigated. Corresponding in many cases to low-grade lesions, minimally invasive carcinomas, or early-stage lung cancer, all of which could be resected using sublobar resections as a definite treatment [15]. Furthermore, considering that up to 11% of all patients with lung cancer and up to 8.6% of stage I patients will present a second primary lung cancer within the first ten years of follow-up [16,17], it might be worth asking whether limited lung resections should be preferred to preserve as much lung parenchyma as possible.

Even though several studies have shown the equivalence between segmentectomies and lobectomies in terms of overall survival and recurrence rate in early-stage NSCLC [18-21], most of them lacked sufficient statistical strength to be accepted as a new standard of care in lung cancer treatment. However, to address this discussion, two randomized studies, CALGB 140503 and JCOG 0802, have recently published their results [14,22].

On the one hand, JCOG 0802 is a phase III randomized trial comparing lobectomy versus segmentectomy in patients with small-sized (2 cm) peripheral non-small cell lung cancer. This trial showed that segmentectomy was superior and non-inferior to lobectomy with regards to overall survival (94.3% versus 91.1% at a median follow-up of 7.3 years) [22]. There were no differences in almost all post-operative measures except for more air leak in the segmentectomy arm [23]. Regarding 5-year relapse-free survival, no differences were documented between the two groups (88% for segmentectomy and 87.9% for lobectomy) [22].

On the other hand, the CALGB 140503 is also a phase III randomized trial but compares lobectomy versus sublobar resection (59% of this group were wedge resections) [14]. Some of the results recently presented at the IASCLC 2022 conference regarding the primary endpoint of disease-free survival (defined as NSCLC recurrence or death by any cause) showed that sub-lobar resection was non-inferior to lobar resection (5-year DFS rate was 63.9% and 64.3% for sublobar and lobectomy arms respectively) [24].

In 2009, Kilic., *et al.* reported that elderly patients undergoing limited resections, such as anatomical segmentectomies had a lower complication rate when compared to those undergoing lobectomies (11.5% vs. 25.5%, p = 0.02). However, they did not report statistically significant differences in hospital stay, disease-free time at five years, or overall survival measured at two, three and five years [8].

As in any recently adopted procedure, complication rate and hospital stay are higher at the beginning of the learning curve. It is expected to diminish with increasing surgical team experience and the number of cases performed. According to the literature, Oziumi., *et al.* in his first series of cases in 2009, presented a morbidity rate of 6.8% in a total of 29 patients, Gossot., *et al*. an 11.7% in 117 patients operated by VATS and Schuster., *et al.* in 785 patients operated by VATS and thoracotomy, presented a morbidity rate of 34.9%. These reported an average hospital stay between 4 to 7 days and an average day of chest drain between 1 and 3.3 (Table 6).

Anatomical segmentectomies results					
Author	**n**	**Surgical approach**	**Morbidity (%)**	**Hospital stay/Chest drain (days)**	**Mortality (%)**
Oizumi., *et al*. (2009) [25]	29	VATS	6,8	NR / 1,0	0
Saphiro., *et al*. (2009) [26]	31	VATS	25.8	4 / 2	0
Schuchert., *et al*. (2012) [27]	785	VATS - TT	34.9	6 / NR	1.1
Gossot., *et al*. (2013) [28]	117	VATS	11.7	5,5 / 3,3	NR
Rinieri., *et al*. (2017) [29]	51	VATS - RATS	25.4	5 / 3	1,9
Our Results	75	TT-VATS- U	16	4.7 / 3.2	0

Table 6: *Results in anatomical segmentectomy series. VATS: Video-Assisted Thoracoscopic Surgery; TT: Thoracotomy; U: Uniportal VATS; RATS: Robotic Assisted Thoracoscopic Surgery; NR: Non-reported.*

In our series, we had similar results to those described in the international literature, with an average hospital stay of 4,7 days and chest drain of 3.2 days. It is worth noting that our results in morbidity and mortality (16%) are lower compared to other international series, which in some cases report a postoperative complication rate greater than 20%.

Our favorable results obtained could be explained by two reasons: first, most of the malignant cases are tumors smaller than 2 cm with less damaged adjacent parenchyma; and secondly, the significant number of patients operated by VATS, which like those reported in the literature [30], were associated with less postoperative pain, shorter hospital stay and fewer days of chest drain (Table 4).

In our series, VATS anatomical segmentectomies (76%) had better postoperative outcomes compared to those performed by thoracotomy. We observed statistically significant differences in the days of hospital stay and chest drain and a tendency towards a lower percentage of complications among this group of patients compared to those operated by thoracotomy.

As mentioned, an anatomic segmentectomy is considered a complex procedure by either thoracotomy or minimally invasive techniques [5]. Dissection, identification and individual division of the segmental bronchus, artery and vein can be challenging, especially in the lower lobe basal segments [10].

The anatomical variations and distribution of the vessels represent an additional challenge when performing a VATS resection as well, as the identification and dissection of the inter-segmental plane, which are critical steps in this procedure, might be challenging, especially when obtaining adequate oncological margins is concerned [1,10].

Due to these technical difficulties, different series show a higher conversion rate or adverse event episodes during the learning curve of VATS segmentectomy. In this regard, the most frequent causes of conversion, as described by Gossot., *et al*. are vascular or pulmonary parenchymal lesions, intraoperative inability to find the nodule to be resected, inadequate oncological margins and an inexperienced surgical team [31,32].

In our series, there was only one case of conversion to thoracotomy in a patient with a left S3 segmentectomy who presented with bleeding from the distal end of the segmental vein, which was ligated using harmonic energy. The decision to convert to thoracotomy allowed adequate vascular control without compromising the venous drainage and the extension of the resection. Making a conversion rate of 1.7% of the total VATS procedures (1/57).

Careful preoperative planning and different localization techniques are also essential to carry out a successful procedure, especially by VATS.

As minimally-invasive approaches cannot rely on direct palpation for intraoperative localization of small nodules, several alternative methods have been described for marking these lesions, such as microcoils, hook wires, methylene blue dye injection and lipiodol, among others [9]. Different surgical techniques have also been developed: preoperative planning of the segments to resect and oncological margins with three-dimensional reconstructions based on CT images, segmental bronchial insufflation and indocyanine green dye use to identify the intersegmental plane [33].

In our patients, a careful analysis of high-resolution CT scans was performed routinely in different planes before surgery, looking particularly for anatomical variations. Preoperative three-dimensional modeling was performed in two patients with doubtful anatomy requiring complex segmentectomies. In five patients, preoperative Lipiodol marking with intraoperative radioscopy was used, identifying the lung nodules in all cases.

In our series, 39 cases (52%) were performed by the uniportal approach. Like any new surgical technique, uniportal segmentectomy requires a learning curve. In his series of 40 Uniportal VATS in 2016, Cheng reported a learning curve of 33 interventions to achieve a plateau regarding operative time [34]. Duan performed 156 anatomical segmentectomies by Uniportal VATS, with an average operating time of 123 minutes with a statistically significant difference between the patients operated on in 2015 and those in 2016 (146 ± 56 vs. 113 ± 32, $p < 0,001$), which shows the improvement of the technique over the years [35].

In our series, the operating time of the uniportal group was similar to those who underwent thoracotomy (p = 0.7) or multiport VATS segmentectomy (p = 0.8), being slightly less (164.9 ± 60.6 minutes), which should continue to decrease with further development and improvement of the technique in our team.

As mentioned before, the oncological results of segmentectomies have been extensively studied and appear to be equivalent to lobectomies in low-grade tumors [22].

In our series, 52 patients (69.3%) had surgery for malignant lesions, of which 39 (75%) were for non-small cell lung cancer (NSCLC). The median follow-up period of these patients was 46.1 months [range 2.2 - 142.2]. No recurrences were reported throughout this period. Once a longer follow-up has been completed, we will be able to analyze the oncological results of the current series, which is not the aim of the present study.

In summary, we present our results of anatomic segmentectomies by different surgical techniques. With increasing expertise, we have progressively performed more complex segmentectomies and evolved our surgical technique from thoracotomy to uniportal VATS, achieving excellent outcomes. Our results represent not only the progress and development of the surgical team but of all the staff participating in the perioperative care of our patients.

Conclusion

This series corresponds to our team's first report of anatomical segmentectomies and, to our knowledge, the first in Latin America. It represents the first development period of the minimally invasive approach and the VATS learning curve. The results were comparable to other series with low morbidity, low conversion rate, operative time and hospital stay. The oncological outcomes were encouraging, but a more significant number of patients and a longer follow-up time are needed to analyze the results accurately.

We believe that despite the difficulties of the technique, it can be adopted by other groups with previous VATS experience, reaching good outcomes in a relatively short period and with equivalent results compared to the international reports in our case.

Bibliography

1. Oizumi H., *et al*. "Techniques to define segmental anatomy during segmentectomy". *The Annals of Cardiothoracic Surgery* 3 (2014): 170-175.

2. Rami-Porta R and Tsuboi M. "Sublobar resection for lung cancer". *European Respiratory Journal* 33 (2008): 426-435.

3. Nakamura H., *et al*. "Survival following lobectomy vs limited resection for stage I lung cancer: a meta-analysis". *British Journal of Cancer* 92 (2005): 1033-1037.

4. Oizumi H., *et al*. "Anatomic thoracoscopic pulmonary segmentectomy under 3-dimensional multidetector computed tomography simulation: A report of 52 consecutive cases". *The Journal of Thoracic and Cardiovascular Surgery* 141 (2011): 678-682.

5. Ettinger DS., *et al*. NCCN Guidelines Index Table of Contents (2018): 212.

6. Kim SJ., *et al*. "Factors associated with preserved pulmonary function in non-small-cell lung cancer patients after video-assisted thoracic surgery". *European Journal of Cardio-Thoracic Surgery* 49 (2016): 1084-1090.

7. Charloux A and Quoix E. "Lung segmentectomy: does it offer a real functional benefit over lobectomy?" *European Respiratory Review* 26 (2017): 170079.

8. Kilic A., *et al*. "Anatomic Segmentectomy for Stage I Non-Small Cell Lung Cancer in the Elderly". *The Annals of Thoracic Surgery* 87 (2009): 1662-1668.

9. Park CH., *et al*. "Comparative Effectiveness and Safety of Preoperative Lung Localization for Pulmonary Nodules". *Chest* 151 (2017): 316-328.

10. Sato M., *et al*. "Thoracoscopic stapler-based "bidirectional" segmentectomy for posterior basal segment (S10) and its variants". *Journal of Thoracic Disease* 10 (2018): S1179-1186.

11. Churchill ED and Belsey R. "Segmental Pneumonectomy in Bronchiectasis: The Lingula Segment of the Left Upper Lobe". *Annals of Surgery* 109 (1939): 481-499.

12. Stanley C Fell. "Segmental Resection. Pearson's Thoracic and Esophageal Surgery". 3rd Edition, Churchill Livingstone (2008): 887-894.

13. Sonett JR. "Minimally Invasive Segmentectomy". *Operative Techniques in Thoracic and Cardiovascular Surgery* 17 (2012): 108-124.

14. Altorki NK., *et al*. "Perioperative mortality and Morbidity after Lobar versus Sublobar Resection for early stage lung cancer: A post-hoc analysis of an international randomized phase III trial (CALGB/Alliance 140503)". *The Lancet Respiratory Medicine* 6 (2018): 915-924.

15. Denise R Aberle., *et al.* Reduced Lung-Cancer Mortality with Low-Dose Computed Tomographic Screening". *The New England Journal of Medicine* 365 (2011): 395-409.

16. Maeda R., *et al*. "Long-Term Outcome and Late Recurrence in Patients with Completely Resected Stage IA Non-small Cell Lung Cancer". *Journal of Thoracic Oncology* 5 (2010): 1246-1250.

17. Rice D., *et al*. "The risk of second primary tumors after resection of stage I nonsmall cell lung cancer". *The Annals of Thoracic Surgery* 76 (2003): 1001-1008.

18. Cao J., *et al*. "Survival Rates After Lobectomy, Segmentectomy, and Wedge Resection for Non-Small Cell Lung Cancer". *The Annals of Thoracic Surgery* 105 (2018): 1483-1491.

19. Dziedzic R., *et al*. "Stage I non-small-cell lung cancer: long-term results of lobectomy versus sublobar resection from the Polish National Lung Cancer Registry". *European Journal of Cardio-Thoracic Surgery* 52 (2017): 363-369.

20. Lin Y., *et al*. "Comparison of treatment outcomes between single-port video-assisted thoracoscopic anatomic segmentectomy and lobectomy for non-small cell lung cancer of early-stage: a retrospective observational study". *The Journal of Thoracic Disease* 8 (2016): 1290-1296.

21. Fan J., *et al*. "Sublobectomy Versus Lobectomy for Stage I Non-Small-Cell Lung Cancer, A Meta-Analysis of Published Studies". *Annals of Surgical Oncology* 19 (2012): 661-668.

22. Saji H., *et al*. "Segmentectomy versus lobectomy in small-sized peripheral non-small-cell lung cancer (JCOG0802/WJOG4607L): a multicentre, open-label, phase 3, randomised, controlled, non-inferiority trial". *The Lancet* 399 (2022): 1607-1617.

23. Suzuki K., *et al*. "Comparison of pulmonary segmentectomy and lobectomy: Safety results of a randomized trial". *The Journal of Thoracic and Cardiovascular Surgery* 158 (2019): 895-907.

24. IASLC | International Association for the Study of Lung Cancer n.d (2022).

25. Oizumi H., *et al*. "Total thoracoscopic pulmonary segmentectomy". *European Journal of Cardio-Thoracic Surgery* 36 (2009): 374-377.

26. Shapiro M., *et al*. "Thoracoscopic segmentectomy compares favorably with thoracoscopic lobectomy for patients with small stage I lung cancer". *The Journal of Thoracic and Cardiovascular Surgery* 137 (2009): 1388-1393.

27. Schuchert MJ., *et al*. "Anatomic Segmentectomy for the Solitary Pulmonary Nodule and Early-Stage Lung Cancer". *The Annals of Thoracic Surgery* 93 (2012): 1780-1787.

28. Gossot D., *et al*. "Totally thoracoscopic pulmonary anatomic segmentectomies: technical considerations". *The Journal of Thoracic Disease* 5 (2013): S200-S206.

29. Rinieri P., *et al*. "Perioperative outcomes of video- and robot-assisted segmentectomies". *Asian Cardiovascular and Thoracic Annals* 24 (2016): 145-151.

30. Atkins BZ., *et al*. "Pulmonary Segmentectomy by Thoracotomy or Thoracoscopy: Reduced Hospital Length of Stay with a Minimally-Invasive Approach". *The Annals of Thoracic Surgery* 84 (2007): 1107-1113.

31. Decaluwe H., *et al*. "Major intraoperative complications during video-assisted thoracoscopic anatomical lung resections: an intention-to-treat analysis". *European Journal of Cardio-Thoracic Surgery* 48 (2015): 588-599.

32. Gossot D., *et al*. "Unplanned Procedures During Thoracoscopic Segmentectomies". *The Annals of Thoracic Surgery* 104 (2017): 1710-1717.

33. Sato M., *et al*. "Concepts and techniques: how to determine and identify the appropriate target segment in anatomical pulmonary segmentectomy?" *Journal of Thoracic Disease* 11 (2019): 972-986.

34. Cheng K., *et al*. "Feasibility and learning curve of uniportal video-assisted thoracoscopic segmentectomy". *Journal of Thoracic Disease* 8 (2016): S229-234.

35. Duan L., *et al*. "One hundred and fifty-six cases of anatomical pulmonary segmentectomy by uniportal video-assisted thoracic surgery: a 2-year learning experience". *European Journal of Cardio-Thoracic Surgery* 54.4 (2018): 677-682.

Volume 11 Issue 9 September 2022