Original Article

Completion lobectomy after thoracoscopic segmentectomy on the left side should be approached with thoracotomy

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Background: Lung segmentectomy is widely used to treat early-stage non-small cell lung cancer (NSCLC), but the risk of local recurrence in the ipsilateral lobe is increased and the surgical treatment of the local recurrence could be a real challenge. The aim of this study is to report our experience in a consecutive series of patients undergoing completion lobectomy (CL) after thoracoscopic segmentectomy.

Methods: We retrospectively reviewed all the medical charts of the patients who underwent thoracoscopic segmentectomy for early-stage NSCLC (cIA) between January 2015 and December 2023, focusing on patients who had NSCLC recurrence in the ipsilateral lobe treated with CL.

Results: Among the 263 segmentectomies performed, 13 patients (4.9%) experienced local recurrence in the ipsilateral remaining lobe, of whom 9 (3.4%) underwent CL, including 5 in the left upper lobe, with a median interval of 31 months between procedures. All patients underwent CL through thoracotomy with the need of central isolation in 5/9 (55.5%); rupture of the pulmonary artery occurred two patients and vascular sleeve resection was necessary in one. No postoperative deaths were observed, complications occurred in 5/9 patients with major complications, defined as Clavien-Dindo grade >3b, in 2/9 (22.2%) patients. Median hospital stay was 11 days. At the end of follow-up 2 patients had distant recurrence 12 median months after the CL.

Conclusions: CL in the left side could be considered a challenging procedure also after minimally invasive segmentectomy and we consider safe to perform CL with thoracotomy due to a scar tissue formation between the bronco-vascular structures leading the need for extensive hilar dissection and central isolation of the pulmonary artery.

Keywords: Completion lobectomy (CL); segmentectomy; lymph node dissection; non-small cell lung cancer (NSCLC); recurrence

Submitted Aug 30, 2024. Accepted for publication Dec 10, 2024. Published online Mar 27, 2025.
doi: 10.21037/jtd-24-1431
View this article at: https://dx.doi.org/10.21037/jtd-24-1431

Introduction

Background

Segmentectomy has gained popularity in the last years and the two randomized controlled trials (RCT) JCOG0802/WJOG4607L and CALBG/Alliance 140503 demonstrated the non-inferiority of segmentectomy in comparison with lobectomy regarding oncological outcomes (1,2) in patients with stage IA <2 cm non-small cell lung cancer (NSCLC). Historically, the major criticism of the application of

segmentectomy for early-stage NSCLC was the fear of an increased risk of local recurrence in the remaining lobe leading to worse oncological outcomes (3). The two RCTs showed that segmentectomy has an increased risk of local recurrence, estimated between 11% and 13% in comparison with 5% (P=0.0018) and 10% of lobectomy, but this increased risk is not associated with a significantly reduced disease-free survival or overall survival (OS) (1,2). Other studies and meta-analyses confirmed the higher rate of local recurrence for segmentectomy (4,5), with a marginal impact on survivals and stated that lobectomy should be the procedure of choice for stage IA3 NSCLC (5).

Rationale and knowledge gap

In case of local recurrence after segmentectomy, the treatment of choice is re-resection with the completion lobectomy (CL) (6). CL is defined as an ipsilateral remaining lobe resection after wedge resection or segmentectomy and it could be considered a challenging procedure due to scar tissue or strong adhesion around hilar structures, especially around the pulmonary artery (PA) (7). Few studies, with limited number of patients, have reported the intraoperative and postoperative outcomes of CL after segmentectomy: no reported postoperative deaths, an increased complication rate and acceptable oncological results.

Although some patients were treated with CL using a minimally invasive thoracoscopic (8) or robotic approach (9), thoracotomy was frequently used as considered a safe approach. Unfortunately, many studies have small numbers and heterogeneous study population including CL for local recurrence of NSCLC, metachronous new primary NSCLC, for lung metastasis from other cancers (7), for complication of the previous surgery (10) and CL after segmentectomy or wedge resection (8,11).

Objective

The literature on this topic is still limited with low evidence and thus the aim of this study is to report our single-institutional experience in a consecutive patient' series undergoing CL after thoracoscopic segmentectomy for local recurrence of early-stage NSCLC. Moreover, we performed a literature review to resume and compare the results of all the recent studies published on this argument. We present this article in accordance with the STROBE reporting checklist (available at https://jtd.amegroups.com/article/view/10.21037/jtd-24-1431/rc).

Highlight box

Key findings

- Completion lobectomy (CL) in the left side could be considered a challenging procedure also after minimally invasive segmentectomy and we consider safer to perform CL with thoracotomy due to a scar tissue formation between the bronco-vascular structures.

What is known and what is new?

- In case of local recurrence after segmentectomy, the treatment of choice is re-resection with the CL. It could be considered a challenging procedure due to scar tissue or strong adhesion around hilar structures, especially around the pulmonary artery (PA).
- When the left upper lobe is involved requiring thoracotomy and central isolation of the PA. Although CL is a challenging procedure, the rate of postoperative complication is low, and the oncological outcomes are in line with previous literature.

What is the implication, and what should change now?

- Knowing that the further apart the procedures are in time, the greater the amount and density of adhesions that may develop in the dissected areas, CL in the left upper lobe should be approach with thoracotomy and it may require a central left PA taping.

Methods

Data from prospectively maintained institutional database of patients who underwent intention-to-treat surgery at Careggi University Hospital of Florence for NSCLC between January 2015 to December 2023 were retrospectively reviewed. Among n=2,668 patients surgically treated in our center, n=263 patients with clinical stage IA NSCLC underwent thoracoscopic segmentectomy and n=42 experienced recurrence and in particular n=13 (4.9%) had local recurrence. Initial segmentectomy was performed through uniportal or three-portal thoracoscopy based on surgeons' preference (12) with systematic hilar and mediastinal lymph node dissection (13). Of these patients, n=9 underwent CL after multidisciplinary tumor board (MTB) evaluation and complete functional assessment. Among the 13 patients with local recurrence, 3 were judged unfit for surgery and the last refused the surgical approach. These 4 patients underwent stereotactic ablative radiotherapy (SABR) treatment, after MTB evaluation and complete functional assessment.

Clinical stage was assessed by whole-body computer tomographic scan (wb-CT), positron emission tomographic scan (18-FDG PET-CT-scan), bronchoscopy,

endobronchial or esophageal ultrasound (EBUS/EUS) and video-mediastinoscopy. Clinical and pathological stages were resumed with the American Joint Committee on Cancer 8th Edition Tumor, Node, Metastasis (TNM) Classification (6,14). All patients underwent conventional preoperative examinations, including cardiological assessment and pulmonary function tests (PFTs), cardiopulmonary exercise test (CPET) and a ventilation/perfusion lung scan if required to estimate the operative risk. Postoperative follow-up was assessed by outpatient visits including medical history, physical examination and enhanced contrast whole body CT scan every six months for the first three years and then annually. Recurrence was defined as a growing soft tissue at the follow-up CT scans with metabolic avidity at the 18-FDG PET-CT scan in the remaining lobe, staple line or segmental hilum. A preoperative cyto-histological diagnosis of recurrence was obtained in every case with bronchoscopy or CT-guided fine needle aspiration.

This retrospective study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). Our Institutional Review Board, the Ethic Committee Regione Toscana Area Vasta Centro reviewed the study and waived the requirement for specific informed consent and a study protocol for this retrospective analysis.

Statistical analysis

Statistical analysis and data reporting were performed using SPSS 24.0 (IBM SPSS Statistics for Macintosh, Version 24.0. Armonk, NY, USA). Standard descriptive statistics have been used to summarize data, with respect to demographic and oncological characteristics. Continuous variables were expressed as median and interquartile range (IQR), whereas dichotomous variables were summarized with numbers and percentages.

Results

Among the intentional 263 thoracoscopic segmentectomies performed between 2015 and 2023 for clinical stage IA NSCLC, n=9 (3.4%) patients had a local recurrence in the ipsilateral remaining lobe and were judged fit to undergo to CL. The median interval between the first surgery and the second procedure was 31 months. Demographic, clinical surgical, postoperative and pathologic data are depicted in *Table 1*. Although the first surgery was performed through a minimally invasive thoracoscopic approach, after a deep review of the preoperative imaging, first surgery report and first pathology report, the majority of patients underwent to CL through thoracotomy (n=1 lateral, n=7 muscle sparing posterolateral, n=1 thoracoscopy converted to lateral thoracotomy). At the first resection, 4 patients were upstaged at pathology: patient 2 had two adenocarcinomas in the resected right S6 and in a small wedge of the middle lobe (pT4N0), patient 3 had a microscopic involvement of intraparenchymal lymph node (pT1bN1), patient 6 had two adenocarcinomas in the left S1+2 resected (pT3N0), patient 8 had a larger squamous cell carcinoma surrounded by parenchymal fibrosis [usual interstitial pneumonia (UIP)]. All the previous segmentectomies were R0 with 14 mm of the median parenchymal margins and no patients received adjuvant therapy after MTB evaluation and complete immunohistochemistry and molecular testing of the tumors.

The study population included 6/9 (66.7%) female patients with a predominant left involvement (8/9, 88.8%) and in particular of the upper lobe (5/9, 55.6%, *Figure 1*). Intraoperative extensive pleural adhesions (that need more than 30 minutes to completely free the lung) were reported in 3/9 (33.3%) patients, whereas hilar scar tissue and dense adhesions were identified in 7/9 patients (77.8%). Central isolation of the main PA and intrapericardial isolation of the veins were required in 5/9 (55.6%) patients. Rupture/injury of the PA occurred in 2/9 (22.2%) patients and vascular sleeve resection was necessary in one. The median intraoperative estimated blood loss was 75 mL and median operative time was 210 minutes. No postoperative deaths were observed, complications occurred in 5/9 patients with major complications, defined as Clavien-Dindo grade >3b, in 2/9 (22.2%) patients: two patients developed respiratory failure with the need of non-invasive mechanical ventilation and one of these had also a ST-segment elevation myocardial infarction (STEMI). The median hospital stay was 11 days. All patients had at least one year of follow-up and 2 patients had distant recurrence 10 and 19 months after CL; median recurrence-free survival (RFS) and OS from CL were 18 and 18 months, respectively.

Discussion

Although segmentectomy is a current practice in the treatment of early-stage NSCLC, the reported rate of local recurrence is low and the requirement of CL is rare (1.38–5.8%) (7-11,15-18). This reflects the oncological adequacy of segmentectomy as local control of NSCLC. However, in case of local recurrence in the staple line, segmental hilum

Table 1 Patients' characteristics, type of resection, pathology, pathological stage, complications of the series of CL after anatomical thoracoscopic segmentectomy

Patient	Age, y	Sex	Previous segmentectomy	1st pathology	1st pTNM	Margins, mm	Time to CL, m	Type of CL	PA Central isolation	Complication	2nd pathology	2nd pTNM	OS, m	RFS, m	Recurrence
1	57	Female	Left S4-5	ADC	T1bN0	15	11	LUL	Yes	–	ADC	T1cN0	12	12	No
2	65	Female	Right S6 + wedge RML	ADC	T4N0	10	68	RU bilobectomy	–	Atrial fibrillation, obstructive pneumonia	ADC	t4N0	18	18	No
3	65	Female	Left S8-9-10	ADC	T1bN1	30	52	LLL	–		ADC	T3N0	19	19	No
4	79	Female	Left S2	ADC	T1cN0	14	31	LUL	Yes	Atrial fibrillation, respirator failure	ADC	T1aN0	17	10	Distant
5	82	Male	Left S1-2-3	ADC	T1bN0	15	24	LUL	Yes	PAL, blood transfusions	ADC	T1aN0	48	43	Distant
6	73	Male	Left S1-2	ADC	T3N0	7	11	Sleeve LUL	Yes	Respirator failure, STEMI	ADC	T2bN1	33	33	No
7	75	Female	Left S2	SCC	T1aN0	24	34	LUL	Yes	PAL	SCC	T1bN0	23	23	No
8	80	Female	Left S8-9-10	SCC	T1bN0	4	17	LLL	No	–	SCC	T2bN0	6	6	No
9	70	Male	Left S6	ADC	T1bN0	11	63	LLL	No	–	ADC	T1bN0	6	6	No

ADC, adenocarcinoma; CL, completion lobectomy; LUL, left upper lobectomy; LLL, left lower lobectomy; m, months; OS, overall survival; pTNM, pathological tumor, node, metastasis staging; PA, pulmonary artery; PAL, prolonged air leak; RFS, recurrence-free survival; RML, right middle lobe; RU, right upper; STEMI, ST-elevation myocardial infarction; SCC, squamous cell carcinoma; y, years.

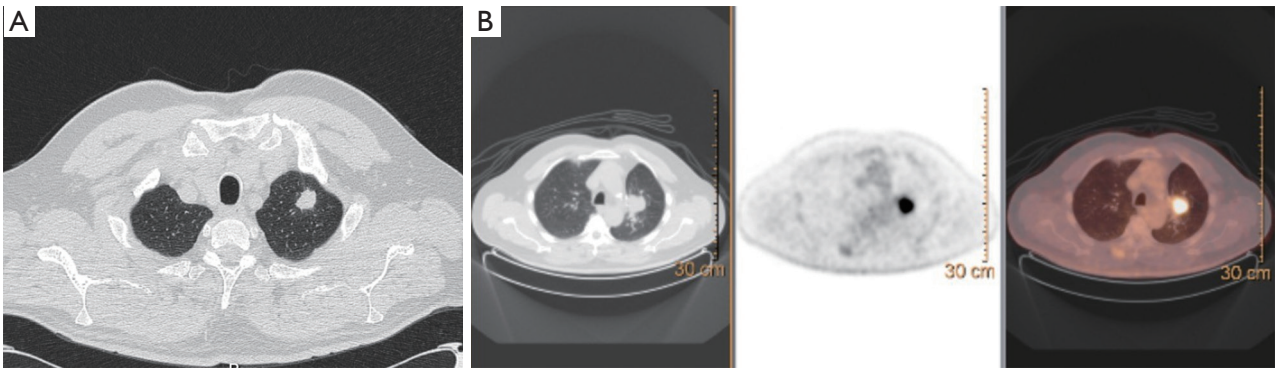

Figure 1 Recurrence after S1+2 left upper lobe segmentectomy. (A) Preoperative CT-scan showing a solid nodule of the left S1, and the patient underwent S1 + S2 thoracoscopic segmentectomy and systematic lymph node dissection. (B) After 11 months, the whole-body 18-FDG PET-CT scan revealed a large area of avidity around the left hilum and a cyto-histological diagnosis of adenocarcinoma recurrence was obtained with bronchoscopy. The patient underwent left thoracotomy and double sleeve lobectomy of the left upper lobe. 18-FDG PET-CT scan, 18-fluorodeoxyglucose positron emission tomography-computer tomography scan.

or a new nodule in the remaining lobe, CL is the treatment of choice, if the patient can tolerate it. The literature on this argument is very limited, with insufficient level of evidence and the aim of our study was to expand the body of literature on CL after segmentectomy.

The reported indications for CL could be different including oncological reasons (cancer recurrence in the parenchyma of the remaining lobe, on the staple line, on segmental or hilar lymph nodes, unexpected pathological upstaging), inflammatory reasons (atelectasis of the remaining lobe or postoperative complications) or margin in-adequacy. After a sublobar resection, a thickened staple line has been frequently reported and only in few cases it reflects a cancer recurrence (19,20). For this reason, we sustain the need for a complete staging using wb-PET-TC-scan and a pathological confirmation to plan the right therapeutic approach.

This study reported our single center experience on CL in a 9-year period in which we had 4.9% of local recurrence after segmentectomy (13 patients) and among these, we treated 9 patients (3.4%) with CL at a median interval between the procedures of 31 months. In line with previous studies, the postoperative outcomes could be considered acceptable with no postoperative deaths, few major complications and a median length of stay of 11 days. In the whole study population, the preferred approach was thoracotomy even if the first procedure was conducted through minimally invasive surgery. The reasons of this choice were:

(I) The location of the recurrence: a large portion of recurrence was in the left upper lobe (LUL).

(II) The extent of lymph node dissection during segmentectomy: in every case, we performed a systematic lymph node dissection with the removal of the upper mediastinal lymph nodes on the right side and the para-aortic and the aorto-pulmonary window lymph nodes on the left side.

(III) The long interval time from the segmentectomy to the CL.

After the literature search, we identified n=9 retrospective studies (excluding two case reports) reporting the intraoperative and postoperative outcomes of CL on 2–46 patients. All the relevant data were reported for comparison in *Table 2*. The minimally invasive approach (thoracoscopic or robot-assisted) was more frequently used in the last years (thoracotomy was the only approach used in 4/9 papers), with conversion rate ranging between 0–12.5%. Extensive pleural or hilar adhesions were frequently reported, and the need of central control of the PA or vein was described in 0–80% of the patients. No postoperative deaths were reported, complications ranged between 20–71% and the median length of stays were 3–13.5 days. The oncological outcomes were reported in 3/9 papers with a median OS or RFS of 19.5–68.5 months and 14.5–68.5 months, respectively.

Some papers reported the use of the minimally invasive approach in CL (8) and Piccoli *et al.* (9) in particular described the outcomes of the more robust series (n=17 patients) of CL treated with the use of the robotic platform without any conversion, although they had n=4 PA injury. No conversions were also reported by Takamori *et al.* (15),

Table 2 Main references for CL after segmentectomy

Study	Year	Type of study	LOE/ GOR	Patients [median age (y)/ gender]	Reason for CL	Lobe of CL	Surgical technique	Conversion from VATS to open	Operative time (min)†	Interval to CL (weeks)†	PA taping	PA injury	Peri-/postoperative complications (%)	LOS (days)†	OS (months)†	DFS (months)†
Nomori (18)	2012	Retrospective	4/D	10 pts, 52.5, 50% men	LN met. 100%	LUL 30%; LLL 30%; RLL 30%; RUL 10%	Thoracotomy 100%	NA	NA	NA	NA	NA	NA	NA	19.50 [8.5–38.25]	14.50 [7.5–34.25]
Omasa (17)	2016	Retrospective	4/D	3 pts, 3 pts, 5 pts	Complications 33.3%/LN metastasis 33.3%/recurrence 33.3%	NA	Thoracotomy 100%	NA	95 [89–100], 274 [202–374], 253 [197–299]	0.8, 4.9, 105	1/3 [33%], 4/5 [80%]	3/5 [60%]	5/11 [45.45%]	NA	NA	NA
Takahashi (7)	2019	Retrospective	4/D	10 pts, 69.5, 50% men	Cancer recurrence 100%	LLL 20%; LUL 30%; RLL 20%; RUL 30%	VATS 50%	1/10, 10%	320 [279.75–389.5]	170 [58–233]	2/10, 20%	3/10, 30%	Post-op AF, azygous v. injury, 20%	12.5 [8.75–14.5]	NA	NA
Suzuki (16)	2021	Retrospective	4/D	4 pts, 74, female 100%	Cancer recurrence 100%	RLL 50%; RUL 25%; LLL 25%	Thoracotomy 100%	NA	269.5 [189–308]	152 [85–162]	NA	NA	PV injury, 25%	13.5 [7.5–20.25]	68.50 [63.25–71.5]	68.50 [63.25–71.5]
Takamori (15)	2022	Retrospective	4/D	8 pts, 69	2nd lung cancer 50%/ pathological upstage 37.5%/ cancer recurrence 12.5%	LUL 25%; LLL 12.5%; RUL 12.5%; RLL 50%	Thoracotomy 62.5%	NA	205 [232–267.5]	103.5, [7.75–129.75]	4/8, 50%	NA	Arrhythmia, PAL, 25%	6 [5.25–7.75]	66.95 [26.9–83.1]	66.95 26.9–83.1]
Liu (10)	2022	Retrospective	3b/C	7 pts, 68, female 57.2%	Staple line recurrence, 42.86%; atelectasis 14.29%; cancer recurrence 28.56%; insufficient margin distance 14.29%	RUL 28.57%; RML 14.28%; RLL 57.14%;	Thoracotomy 57.2%	1/7 12.5%	320 [180–340]	52 [9–120]	1/7, 12.5%	NA	Azygous v. injury, n=3 PAL, diaphragm injury, 71%	7 [6–9]	NA	NA
Piccoli (9)	2023	Retrospective	4/C	17 pts, 69, males 82.35%	Cancer recurrence 100%	LUL 23.53%; LLL 5.88%; RLL 35.3%; RUL 35.3%	Robot assisted surgery 100%	NA	150 [140–170]	78 [52–104]	NA	4/17, 23%	Post-op AF n=2, PAL n=1, pneumonia n=3; overall 41.1%	3 [2–5]	NA	NA
Lee (11)	2024	Retrospective	4/D	2 pts, 59, female 100%	Cancer recurrence 100%	RLL; LLL	Thoracotomy 100%	NA	210.5	42.5	NA	NA	NA	7	NA	NA
Meacci (8)	2024	Retrospective	3/B	46 pts	NA	NA	Uniportal VATS 100%	NA	NA	NA	4, 8.69%	NA	NA	NA	NA	NA

†, data are presented as median [interquartile range] or median. AF, atrial fibrillation; CL, completion lobectomy; DFS, disease-free survival; GOR, grade of recommendation; LOE, level of evidence; LOS, length of stay; LN, lymph nodes; LUL, left upper lobe; LLL, left lower lobe; NA, not available; OS, overall survival; PA, pulmonary artery; pts, patients; PV, pulmonary vein; PAL, prolonged air leak; RLL, right lower lobe; RUL, right upper lobe; RML, right middle lobe; VATS, video-assisted thoracoscopic surgery.

Takahashi *et al.* (7) and Liu *et al.* (10) reflecting the accurate selection criteria and a meticulous surgical technique. These papers showed comparable postoperative results between the two approaches without an increased risk of complications for patients undergoing thoracotomy. In our opinion and in our experience, CL is a great surgical challenge for the dense adhesions developed around the hilum and it is reflected by the need of taping the main PA in a large portion of our patients (5/9). The LUL hilum is more complex than other lobes, the anatomical variations of the PA are more frequent, and the segmental branch of the PA are small, short and close to each other leading an increased risk of injury during dissection almost in a not-naïve hilum. Suzuki *et al.* (16) considered upper lobe CL technically more difficult than lower lobe CL for three reasons: the bronchovascular structures of the respective segments are adjacent to each other; the presence of dense adhesions along the main PA due to the previous dissection performed that could not be required in a lower lobe segmentectomy; the effect of superior mediastinal LND on the upper limb of the PA. Our intraoperative findings are completely aligned with these conclusions, and we can confirm that the mediastinal lymph node dissection in the paraaortic and aorto-pulmonary window have a deep influence in the development of dense adhesions along the left main PA and left hilum. This finding is also demonstrated by the need of central isolation and taping of the left main PA. Another issue associated with the development of adhesions is the time between segmentectomy and CL: the further apart the procedures are in time, the greater the amount and density of adhesions that may develop in the dissected areas. This fact was also reported by Omasa *et al.* (17) in a series of 11 patients undergoing CL for various indications and they concluded that CL may become more difficult 5 weeks after segmentectomy. Other studies (7,8) are in line with this conclusion and then we can assume that CL for cancer relapse is a complex and challenging procedure because the interval time between the procedure could be long and then the probability of dense adhesions at the hilum should be high.

CL for NSCLC recurrence after wedge resection is a procedure completely different and less challenging than after CL segmentectomy because adhesions could be limited between the staple line and the parietal or mediastinal pleura or in correspondence to the port/s, whereas the segmental and pulmonary hilum could be less involved in the adhesion formation process. Even if a radical LND has been performed during the first wedge resection, the scar tissue on the broncho-vascular structures could be less than that has been developed after segmentectomy due to the lack of direct dissection on these structures. In our experience, CL after wedge could be performed with the minimally invasive approach, even for upper lobes, but we preferred thoracotomy for CL after segmentectomy due to the above described intraoperative findings.

Moreover, it should be highlighted that even if a minimally invasive approach is the gold standard for almost all thoracic surgeries, in a real-world setting thoracotomy and conversion to open surgery should not be considered as a failure. In this light, the VIOLET RCT (21) showed that video-assisted thoracoscopic surgery (VATS) lobectomies had a shorter length of stay compared to open lobectomies [4 *vs.* 5 days, hazard ratio 1.34; 95% confidence interval (CI): 1.09 to 1.65] and a lower postoperative pain, but this study also showed no differences in terms of postoperative mortality, in the time to uptake of adjuvant chemotherapy (hazard ratio, 1.12; 95% CI: 0.62 to 2.02) and also in terms of in-hospital serious adverse events (SAEs) (risk ratio, 0.98; 95% CI: 0.59 to 1.63) between the two groups. Furthermore, the rate of postoperative pain differed in the first 5 weeks, but then became similar in the two study groups. For all these reasons, we believe that the surgeon must consider the minimally invasive approach (VATS or RATS) for every patient, but above all the safety of the patient, even if this means an open approach.

Regarding the oncological adequacy of CL we had a median OS and RFS of 18 months, data in line with the literature (15,16,18), but a comparison with a homogeneous control group was not possible in our practice due to the presence of several biases for example: patient excluded from surgery because they were not able to tolerate CL due to functional impairment, patients considered unresectable, patients who refused second surgery preferring other types of treatment like SABR, patients lost during the follow-up period.

Our study has several limitations. First, this is a single institution retrospective report on a prospectively collected cohort of patients that is undoubtedly small, precluding any statistical analysis, inference and comparison. The dimension of the cohort is directly dependent on the current rarity of CL. On the other hand, we are not able to analyze a control group of patients who underwent other therapeutic strategies for local relapse after segmentectomy. Second, we are not able to assess the usefulness of the minimally invasive approach on a procedure that we consider a true challenge because the dissection during CL

is affected by an increased risk of intraoperative catastrophic bleeding, thus we prefer a safer approach. Third, the oncological outcomes are influenced by the short follow-up period and lack of a well-balanced control group.

Conclusions

CL for local recurrence after minimally invasive segmentectomy could be considered a surgical challenge especially when the LUL is involved requiring thoracotomy and central isolation of the PA. Postoperative and oncological outcomes are acceptable, but these results are compromised by the small study population and short follow-up time. The available data are also limited, so the results of a systematic review and meta-analysis could be misinterpreted and biased.

Acknowledgments

None.

Footnote

Reporting Checklist: The authors have completed the STROBE reporting checklist. Available at https://jtd.amegroups.com/article/view/10.21037/jtd-24-1431/rc

Data Sharing Statement: Available at https://jtd.amegroups.com/article/view/10.21037/jtd-24-1431/dss

Peer Review File: Available at https://jtd.amegroups.com/article/view/10.21037/jtd-24-1431/prf

Funding: None.

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://jtd.amegroups.com/article/view/10.21037/jtd-24-1431/coif). L.V. serves as an unpaid editorial board member of *Journal of Thoracic Disease* from October 2024 to September 2026. The other authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. This retrospective study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). Our Institutional Review Board, the Ethic Committee Regione Toscana Area Vasta Centro reviewed the study and waived the requirement for specific informed consent and a study protocol for this retrospective analysis.

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Cite this article as: Bongiolatti S, Mugnaini G, Salvicchi A, Gonfiotti A, Borgianni S, Viggiano D, Voltolini L. Completion lobectomy after thoracoscopic segmentectomy on the left side should be approached with thoracotomy. J Thorac Dis 2025;17(3):1561-1569. doi: 10.21037/jtd-24-1431