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Surgeon experience influence lymphadenectomy during VATS lobectomy: National VATS database results☆

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ABSTRACT

Objectives: Aim of this study is to identify the factors that may influence the lymphadenectomy during VATS anatomical lung resection with particular interest on operator experience.
Materials and methods: Clinical and pathological data from the prospective VATS Italian nationwide registry were reviewed and analysed. Patients with incomplete data regarding tumor and surgical characteristics, GGO, or with distant metastases were excluded. Patients clinical data, tumor characteristics, operation information and surgeon experience were collected and compared to resected lymph nodes number (#RN), resected N2 nodes number (#N2RN) and resected N2 stations number. A multivariable model was built using logistic regression analysis. Surgeon experience was categorized considering the number of VATS major anatomical resection and years after residency.
Results: The final analysis was conducted on 3727 patients. The median #RN and #N2RN were 11 (1–51) and 5 (0–41). Regarding the analysed outcomes, #N2RN > 6 resulted in 1812 (48.8%)cases, #RN > 10 in 2124 (57.0%)cases and more than 3 N2 stations were harvested in 1447 (38.8%)patients.
First operator experience with number of VATS lobectomies>50 ($p < 0.001$), operator seniority after residency5-10years ($p < 0.001$), cTNM II/III($p = 0.017$), lobectomy/bilobectomy vs segmentectomy ($p < 0.001$), and upper/middle lobe tumor location ($p < 0.005$)resulted significantly associated to #N2RN > 6 at the multivariable analysis. First operator experience with number of VATS lobectomies>50 ($p < 0.001$), operator seniority after residency5-10years ($p < 0.001$) and lobectomy/bilobectomy ($p < 0.001$) resulted significantly associated to #RN > 10 at the multivariable analysis.
Conclusions: Our study showed that lymphadenectomy during VATS lobectomy is influenced by tumor factors such as cTstage and tumor location but also by operator experience, with a higher number of resected lymph nodes in surgeons with a high number of VATS procedures and years after residency compared to surgeons with less experience.

1. Introduction

Non Small Cell Lung Cancer (NSCLC) remains the leading cause of tumor mortality in the united states [1] and worldwide. Only a relatively small patients rate present early stage tumours that may benefit from surgical treatment [2]. In the surgical contest, one of the most important points is to ensure an appropriate lymphadenectomy, also because outcomes such as number of resected lymphnodes or nodal station are closely linked to survival [3,4]. However, which is the most appropriate lymphadenectomy remains still undefined, also in consideration of the different available guidelines. Indeed, the extent of lymphadenectomy in early stages is still debated, although lymph node sampling seems to yield similar survival results compared to mediastinal radical lymph-node dissection (MRLD) [5–8]. currently, most guidelines recommend

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sampling instead of MRLD in early stages, but the sampling parameter remains to be defined. The European society of thoracic surgeons (ESTS) guidelines defined sampling as removal of one or more lymph nodes guided by preoperative or intraoperative findings, suggesting the MRLD to define a complete resection [9]. On the other hand, other guidelines suggesta sampling definition based on the number of lymph nodes or the number of nodal station sampled [2,10]. Specifically, the American College of Surgeons Commission on Cancer revised and changed its sampling recommendations from at least 10 lymphnodes independently from the nodal station to at least one hilar and three N2 mediastinal lymph node stations [10]. Adequate nodal assessment, in association with minimally invasive resection, is one of the quality parameter indicated for early stages NSCLC [2,11,12]. However, the adoption and the development of minimally invasive technique may require time and a not negligible number of procedure, being also operator dependent. Moreover, especially in initial procedures, maintaining adequate lymphadenectomy may be challenging, with nodal outcome that are rarely reported and analysed [13,14].

In this study, we analyze lymphadenectomy parameter in terms of number and location of resected lymphnodes and harvested nodal stations using a prospective national video assisted lung anatomical resection database, with the aim to verify if surgeon experience may influence surgical performance concerning lymph nodal dissection.

2. Materials and Methods

The current analysis was reviewed and approved for scientific merit and feasibility by the VATS Group Scientific Committee.

2.1. Data source

The Italian VATS Group database is a multicentre, prospective, web-based data system for collecting data on patients who underwent VATS lobectomy or segmentectomy. In the registry are reported clinical, intraoperative, pathological and survival data of 10,404 patients from 58 participating centers.

2.2. Patients

The database was queried for patients who underwent lung anatomical resection for NSCLC from January 1, 2014 to December 31, 2019.

All patients underwent VATS anatomical resection and lymphadenectomy, defined as either sampling or mediastinal radical lymph node dissection (MRLD).

The extracted data regarded:

- Clinical characteristics: Sex,Age, tumor location, PET SUVmax, cT, cN, preoperative histology, nodule appearance (solid or part solid).
- Intraoperative characteristics: kind of lymph node dissection, method of dissection, surgery duration, operator seniority and operator number of VATS lobectomies performed.
- Pathological characteristics: histology, number of resected lymphnodes, number of resected mediastinal lymphnodes, number of resected lymph node stations, pathological T,pathological N.

Clinical and pathological information were reviewed and adapted according to the VIII TNM edition [15].

Inclusion and exclusion criteria were defined as follows:

Inclusion criteria:

- Pathological lung adenocarcinoma or squamous cell carcinoma
- CT scan with contrast and/or PET
- cN0-cN2 patients
- Lymph node dissection
- Complete resection
- Almost one N1 station analysed

Exclusion criteria:

- GGO nodules
- Incomplete preoperative staging (missing brain, thorax, and abdomen CT)
- cN3 patients
- M+ patients
- Pneumonectomy
- Benign disease
- Missing intra-operative information
- Neo-adjuvant therapy
- cT4 patients

Lymphadenectomy was chosen by the surgeon according to tumor stage, clinical characteristics and own experience based on to the ESTS guidelines [9] as follow:

- Node sampling was performed removing one or more lymph nodes thought to be representative, which was guided by preoperative or intraoperative findings.
- Mediastinal radical lymphnode dissection (MRLD), the entire mediastinal tissue, containing the lymph nodes, was dissected and systematically removed within the anatomical landmarks.

In the database, surgeon experience was categorized considering the years after residency (0–5,5-10 and more than10) and considering the number of VATS lobectomies performed (0–20, 20–50 and more than50).

2.3. Outcomes

The endpoints analysed included the number of resected lymphnodes (#RN), the number of mediastinal resected lymphnodes (#RN2) and number of resected mediastinal stations (#RN2S). In line with the current and previous guidelines, which suggest categorizing lymph node parameters for a more comprehensive qualitative assessment [2,10,16], lymph nodes outcome have been dichotomized in two groups for each category.

For the number of resected lymphnodes was considered a cut off of 10, for resected N2 lymphnodes a cut off of 6 and for number of mediastinal lymph node stations a cut off of 3, according with data and indication present in literature and among available guidelines [2,3,10,16].

A secondary endpoint regarded complications incidence according to surgeons experience in terms of years after residency and number of VATS anatomical resections.

2.4. Statistical analysis

Data are summarized using basic descriptive statistics. The association between categorical variables was tested by the Pearson Chi-Square test. Logistic regression model was applied to estimate univariate Odd Ratios (OR) with their 95% confidence intervals (CI). Significance was defined at the $p < 0.05$ level. Variables were tested in univariable analysis for the outcomes #RN,#RN2N and #RN2S. A multivariable regression model was also developed using stepwise regression (forward selection) with predictive variables which were significant in the univariate analyses. Enter limit and remove limit were $p = 0.10$ and $p = 0.15$ respectively. The SPSS(version 21.0; SPSS,Inc.,Chicago,IL) statistical program was used for all analyses.

3. Results

The final analysis was conducted on 3727 patients. Clinical and

pathological characteristics are reported in Table 1 cTNM stage was I in 2885 (77.5%), II in 543 (14.5%) and III in 299 (8%) patients. Segmentectomy was performed in 275 cases.

The median number of resected nodes and number of N2 resected nodes were 11 (1–51) and 5 (0–41),respectively. Mediastinal radical dissection was performed in 2140 (57.4%) patients, and more than 6 N2 nodes were resected in 1812 (48.8%) cases, more than 10 lymph nodes were resected in 2124 (57.0%) cases, more than 3 N2 stations were harvested in 1447 (38.8%)patients.

About the surgeon experience, most surgeons presented more than 10 years after residency (79.2%) and more than 50 major anatomical resection performed (60.9%). Surgeons had less than 5 years after residency in 343 (9.2%) and 0–20 anatomical resection performed in 705 (18.9%) cases, respectively. Intermediate experience with 5–10 years after residency and 21–50 anatomical resection was present in 434 (11.6%) and 751 (20.2%) surgeons, respectively.

The percentage of surgeons with more than 50 lobectomies performed increased with the years after residency, with 6.1% in surgeons with 0–5 years after residency, 32.5% in surgeons with 5–10 years after residency and 71.5% in surgeons with>10 years after residency (Supplemental Table 1).

Considering the 3 evaluated outcome, in 958 (25.7%) cases, more than 10 lymphnodes, more than 6 mediastinal nodes and more than 3 mediastinal stations were resected simultaneously.

Surgeons with>10 years after residency and surgeons with>50 VATS lobectomies performed presented the highest rate of #RN > 10,#RN2>6 and #RN2S > 3: 723 (75.5%) cases in surgeons with>10 years after residency and 607 (63.4%) cases in surgeons with> 50VATS lobectomies performed (Supplemental Table 2).

Univariable analysis is reported in Table 2. Factors significantly associated with #RN > 10 resulted cT dimension ($p = 0.03$), tumor side ($p < 0.0001$), nodule density ($p = 0.002$), cTNM ($p = 0.007$), preoperative diagnosis ($p < 0.0001$), kind of resection ($p < 0.0001$), node dissection technique ($p < 0.001$), node dissection instruments ($p < 0.0001$), ctSUVmax (0.006) and operative time ($p = 0.002$).

Factors significantly associated with #RN2>6 resulted tumor side ($p < 0.0001$), nodule density ($p = 0.01$), cTNM ($p = 0.003$), preoperative diagnosis ($p = 0.001$), kind of resection ($p < 0.0001$), tumor location ($p = 0.001$), node dissection technique ($p < 0.001$), node dissection instruments ($p < 0.0001$), ctSUVmax ($p = 0.036$) and operative time ($p = 0.001$).

Factors significantly associated with #RN2S > 3 resulted tumor side ($p < 0.0001$), kind of resection ($p < 0.0001$), tumor location ($p = 0.001$), node dissection technique ($p < 0.001$), node dissection instruments ($p < 0.0001$), and patient age ($p = 0.017$).

Surgeon experience was significantly related to all the analysed outcome (Table 2):

- More than 10 resected nodes were present in 60% of cases operated by surgeons with years after residency>5, in 65.7% of cases operated by surgeons with 5–10 years after residency and 55.8% of cases operated by surgeons with years after residency>10 ($p < 0.001$).

According to the number of VATS anatomical resections, #RN > 10 was present in 49%, 57.3% and 60% of patients operated by surgeons with 0–20,21–50 and more than 50 VATS anatomical resections performed, respectively ($p < 0.001$) (Fig. 1).

- More than 6 resected mediastinal nodes were present in 51% of cases operated by surgeons with years after residency>5, in 55.5% of cases operated by surgeons with 5–10 years after residency and 48% of cases operated by surgeons with years after residency>10 ($p < 0.01$). According to number of VATS anatomical resection,#N2RN > 6 was present in the 43%,47.2% and 51.6 % of patients operated by surgeons with 0–20,21–50 and > 50 VATS anatomical resection performed, respectively ($p < 0.001$) (Fig. 2).

Table 1
Clinical and pathological characteristics.

Variable	Number
GENDER	
Male	2329 (62.5%)
Female	1398 (37.5%)
Cronic Obstructive Pulmunary Disease	
No	2781 (74.6%)
Yes	946 (25.4%)
ECOG	
0	2622 (70.4%)
1	1027 (27.6%)
2	78 (2.1%)
SIDE	
Left	1513 (40.6%)
Right	2214 (59.4%)
TUMOR LOCATION	
Upper/middle lobes	2432 (65.3%)
Lower lobes	1295 (34.7%)
cT DIMENSION	
<2 cm	1240 (33.2%)
2–3 cm	999 (26.8%)
3–4 cm	1149 (30.8%)
>4 cm	339 (9.1%)
cN	
0	3369 (90.4%)
1	153 (4.1%)
2	205 (5.5%)
NODULE DENSITY	
Solid	2996 (80.4%)
Part Solid GGO	731 (19.6%)
C TNM	
cIa	2341 (62.8%)
cIb	544 (14.6%)
cIIa	419 (11.3%)
cIIb	124 (3.3%)
cIII	299 (8%)
CT-PET	
No	292 (7.8%)
Yes	3435 (92.2%)
HISTOLOGY	
Adenocarcinoma	3061 (82.1%)
Squamous cell carcinoma	666 (17.9%)
PREOPERATIVE DIAGNOSIS	
No	1472 (39.5%)
Yes	2255 (60.5%)
OPERATOR SENIORITY (years after residency)	
<5	343 (9.2)%
5–10	434 (11.6)%
>10	2950 (79.2%)
FIRST OPERATOR VATS LOBECTOMY NUMBER	
0–20	705 (18.9%)
21–50	751 (20.%)
>50	2271 (60.9%)
RESECTION	
Segmentectomy	275 (7.4%)
Lobectomy	3360 (90.2%)
Bilobectomy	92 (2.4%)
NODE DISSECTION	
No	25 (0.7%)
Yes	3702 (99.3)
NODE DISSECTION TECHNIQUE	
Sampling	1587 (42.6%)
Mediastinal radical dissection	2140 (57.4%)
NODE DISSECTION INSTRUMENT	
Bioenergy	1769 (47.5%)
Elettrocautery	1933 (51.9)
ADHESIOLISIS	
No	2725 (73.1%)
Yes	1002 (26.9%)
NUMBER OF N2 RESECTED NODES	
<6	1884 (50.6%)
≥6	1818 (48.8%)

(*continued on next page*)

Table 1 (*continued*)

Variable	Number
NUMBER OF TOTAL RESECTED NODES	
<10	1578 (42.3%)
≥10	2124 (57%)
RESECTED N2 STATION	
<3	2133 (57.2%)
≥3	1447 (38.8%)
pN	
0	3033 (81.4%)
1	360 (9.7)
2	278 (7.5%)
pTNM	
1a	1904 (51.1%)
1b	658 (17.7%)
2a	184 (4.9%)
2b	581 (15.6%)
3	344 (9.2%)

- More than 3 resected mediastinal stations were present in 40% of cases operated by surgeons with years after residency>5, in 43% of cases operated by surgeons with 5–10 years after residency and 40% of cases operated by surgeons with years after residency>10 ($p = 0.48$). According to number of VATS anatomical resection, patients with #RN2S > 3 were the 40.8%,36% and 41.7 % operated by surgeon with 0–20,21–50 and more than50 VATS anatomical resections performed, respectively ($p = 0.03$).

In the multivariable analysis, the first operator experience with number of VATS lobectomies >50 ($p < 0.001$), operator seniority after residency 5–10years ($p < 0.001$), cTNM staging II/III($p = 0.017$), lobectomy/bilobectomy ($p < 0.001$), and upper/middle lobe tumor location ($p < 0.005$) resulted significantly associated with #N2RN > 6 (Table 3).

The first operator experience with number of VATS lobectomies>50 ($p < 0.001$), the operator seniority after residency 5–10 years ($p < 0.001$), lobectomy/bilobectomy ($p < 0.001$) and upper/middle lobe tumor location ($p < 0.001$)resulted significantly associated with #RN > 10 in the multivariable analysis.

Lobectomy/bilobectomy ($p = 0.003$) and upper/middle lobe tumor location ($p < 0.001$) resulted significantly associated to #RN2S > 3 in the multivariable analysis.

Complications occurred in 179 (4.8%) patients (Supplemental Table 3): lung related issues (pneumonia, empyema, pleural effusion) in 144 (3.9%), chylotorax in 15 (0.4%), recurrent laryngeal nerve palsy/dysphonia in 29 (0.8%) and chest tube duration>5days in 797 (21.4%) of cases (supplemental table). Only years after residency were significantly correlated to chest tube duration>5days, resulting in 57 (16.6%),85(19.6%) and 655 (22.2%)cases operated by surgeons with <5, between 5 and 10, >10 years after residency ($p = 0.010$).

The mean blood loss amount was significantly higher in surgeons with 20–50 VATS lobectomies performed compared to surgeons with <20 or >50 lobectomies: 178 ± 303 vs 123 ± 133 vs 129 ± 121 ml ($p < 0.001$), respectively.

4. Discussion

In this study, we analysed a large national databases of patients who underwent VATS anatomical resection to investigate if surgeons experience could be related with lymphadenectomy performance. We observed contrasting results when surgeon experience was categorized as years after residency, with higher rate of number of resected nodes and resected N2 nodes in surgeons with 5–10 years after residency compared to the other categories. Conversely, we found that the number of total resected and N2 resected nodes increased with the number of major anatomical resections performed: more than 6 N2 resected nodes in the 43%,47.2% and 51.6 % of patients operated by surgeons with 0–20,21–50 and > 50 VATS anatomical resections, respectively.

These results raise important questions regarding the association between the development of minimally invasive surgery and the quality outcomes during lung cancer surgery.

Indeed, the extent of lymphadenectomy, particularly adequate lymph node sampling, is one of the points addressed as quality metrics in association with various factors, including time of surgery (surgery within 12 weeks of radiographic suspicion), anatomic resection (lobectomy or segmentectomy), minimally invasive approach and achieving negative margins [17,18]. These metrics play a crucial role in assessing the quality and effectiveness of lung cancer surgery.

Different studies have analysed the learning curve in VATS surgery, highlighting the need of approximately 50 lobectomies to complete this curve, with additional procedures contributing to gaining proficiency [13,14,19]. However, most reported intra-operative data such as operative time, complication rate, conversion rate etc, while quality assessment in terms of lymphadenectomy was rarely reported. Li et al. [19] reported a significant improvement in resected nodes after 150 Uniportal lobectomies, while Vieira et al. [14] reported a progressive increase of mediastinal nodal stations harvested according to VATS learning curve: 1.5 ± 1.2 mediastinal nodal stations removed during the initial phase (first 60 lobectomies),1.8 ± 1.0 removed during the transition phase, and 2.4 ± 0.9 stations removed after attaining proficiency (140 lobectomies).

Our results align with these studies, indicating that surgeons with more than 50 lobectomies performed presented the highest rate of resected and N2 resected nodes. On the other hand, years after residency did not appear to be a reliable parameter in this context. Indeed, a higher number of years after residency was not directly associated with lymphadenectomy outcomes. In fact, fewer resected nodes and N2 resected nodes were observed in both experienced and young surgeons, while the highest rate was present in surgeons with 5–10 years after residency. This observation is consistent with Scheel et al. [20] who reported the highest number of resected mediastinal station rate in surgeons with 5–15 years after residency. This finding pose challenges in interpretation. It's possible that the lower importance given to nodal sampling in the past decades or the increased involvement of trainee with highly experienced surgeons, that may left some parts of the operation (including lymph node assessment) to the residents, may contribute to the observed patterns. Another interpretation could be that the number of VATS anatomical resections and years after residency are not directly linked. VATS lobectomy rates have increased in the last 10–15 years, and the adoption of this approach varies across hospitals. Therefore, it is plausible that some experienced surgeons initiated their learning curves not immediately after residency, contributing to these results.

Moreover, we observed the only the 6% of surgeons with less than 5 years had more than 50 VATS lobectomies performed, suggesting that the learning curve, in this cohort, started after a discrete number of years after residency. Finally, the ESTS guidelines [9] implies the choice of representative lymphnodes by the surgeons, so experienced surgeons may decide to sample a limited number of lymphnodes. Similarly, no differences in complication rate was detected considering different experience categories, and the difference in blood loss amount was minimal even if significant. Conversely, chest tube duration seems to be longer in experienced surgeons, but it was not possible to know who took the decision for removal or if chest tube closure attempts were performed, making consideration about this topic extremely careful.

Another interesting point concerns the association between lymphadenectomy and type of anatomical resection. We observed that patients who underwent segmentectomy had a significant lower number of resected nodes, resected N2 nodes and resected N2 stations compared to lobectomy/bilobectomy. Considering that we included patients with at least 1 hilar station sampled, the mediastinal nodal assessment in these patients remains insufficient. while this represent only a small percentage of cases, it may reflects the possible surgeon approach to sublobar resection and need to be underlined in consideration of the recent

Table 2
Univariable analysis.

Variable	Total number resected nodes		p	Number N2 resected nodes		p	Number N2 resected stations		p
	<10	≥10		<6	≥6		<3	≥3	
	(%)	(%)		(%)	(%)		(%)	(%)	
cT dimension									
<2 cm	44.4	55.6	**0.03**	52.4	47.6	**0.17**	60.5	39.5	**0.5**
2–3 cm	43	57		52	48		59.6	40.4	
4–5 cm	41.7	58.3		49	51		59.5	40.5	
>5 cm	37.4	62.6		47.2	52.8		55.8	44.2	
T lung									
Left	46.4	53.6	<**0.0001**	60.5	39.5	<**0.0001**	64.7	35.3	<**0.0001**
Right	40	60		44.3	55.7		56	44	
cN									
0	43	57	**0.48**	51.3	48.7	**0.3**	60	40	**0.15**
1	38	62		45.8	54.2		53	47	
2	42.4	57.6		48.3	51.7		56.2	43.8	
Nodule density									
solid	41.4	58.6	**0.002**	50	50	**0.01**	60	40	**0.32**
Part Solid GGO	47.8	52.2		55	45		58	42	
C TNM									
cIa	44.8	55.2	**0.007**	53.3	46.7	**0.003**	60	40	**0.31**
cIb	40.7	59.3		48	52		61	39	
cIIa	37.2	62.8		46	54		59.3	40.7	
cIIb	36.3	63.7		42.7	57.3		54.6	45.4	
cIII	39	61		47.5	52.5		54.7	45.3	
Preoperative diagnosis									
No	46.4	53.6	<**0.0001**	54.3	45.7	**0.001**	57.6	42.4	**0.06**
Yes	40.2	59.8		48.7	51.3		60.8	39.2	
Operator Seniority (years after residency)									
<5	40	60	<**0.0001**	49	51	**0.01**	60	40	**0.48**
5-10	34.3	65.7		44.5	55.5		57	43	
>10	44.2	55.8		52	48		60	40	
First operator VATS lobectomy number									
0-20	51	49	<**0.0001**	57	43	<**0.0001**	59.2	40.8	**0.03**
21-50	42.7	57.3		52.8	47.2		64	36	
>50	40	60		48.4	51.6		58.3	41.7	
Resection									
Segmentectomy	55.3	44.7	<**0.0001**	66.5	33.5	<**0.0001**	69.8	30.2	<**0.0001**
Lobectomy	42	58		50	50		59	41	
Bilobectomy	29.7	70.3		40.7	59.3		48.3	51.7	
Tumor location									
Upper/middle lobes	42	58	**0.42**	49	51	**0.001**	55.6	44.4	<**0.0001**
Lower lobes	43.5	56.5		54.6	45.4		67	33	
Node dissection technique									
sampling	62.0	38.0	<**0.001**	69.2	30.8	<**0.001**	50.4	49.6	<**0.001**
Mediastinal radical dissection	28.5	71.5		37.5	62.5		27.1	72.9	
Node dissection instruments									
Bioenergy	39.2	60.8	<**0.0001**	45.3	54.7	<**0.0001**	53.3	46.7	<**0.0001**
Elettrocautery	45.7	54.3		56	44		65.4	34.6	
Adhesiolisis									
No	41.8	58.2	**0.12**	49.6	50.4	**0.01**	58.6	41.4	**0.056**
Yes	44.7	55.3		54.3	45.7		62.1	37.9	
Patient Age*			0.**207**			0.**793**			0.**017**
cT SUV max*			0.**006**			0.**036**			0.**076**
Operative time*			0.**002**			0.**001**			0.**083**

•Continuous variables

trials in terms of guidelines for parenchymal resection in NSCLC [20–22]. Indeed, if recent studies and prospective trials have demonstrated a non-inferiority of segmentectomy vs lobectomy in early stages NSCLC with tumor dimension less than 2 cm. However, comprehensive data on lymphadenectomy were not described by both JCOG0802/WJOG4607L and Cancer and Leukemia Group B(CALGB)140,503 trials [20,22]. Only in the paper of Saji et al. [20] the type of lymphadenectomy was reported, revealing a higher systemic nodal dissection in the lobectomy group compared to the segmentectomy group. However, despite the fact that surgeons may choose between systematic or selective lymph node dissection, and may avoid nodal sampling altogether, no data regarding the number of lymph nodes and mediastinal stations harvested were provided.

Another study by Samson et al. [23], pointed out a significant difference in terms of number of resected lymph nodes between lobectomy and segmentectomy, with only the 15% of patients that received more than 10 resected nodes compare to more than one-third of lobectomies.

The tendency toward a less nodal assessment in segmentectomy may be not negligible, and the needed of an appropriate lymphadenectomy also in sub-lobar resection should be mandatory to ensure the adequate therapy for these patients.

Indeed, as previously mentioned, adequate nodal assessment appears to confer survival advantages in patients underwent surgery for early stage non small cell lung cancer, but the identification of the adequate

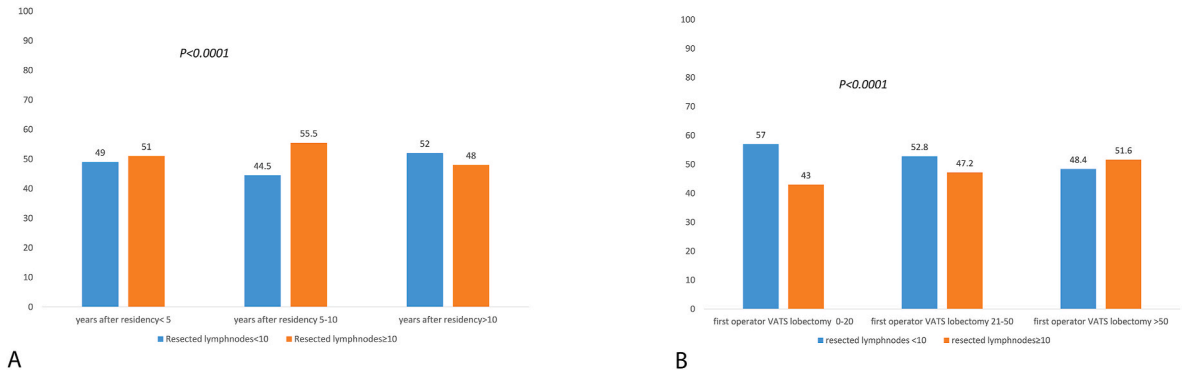

Fig. 1. A) number of total resected nodes according to operator years after residency; B) number of total resected nodes according to operator number of VATS lobectomy performed.

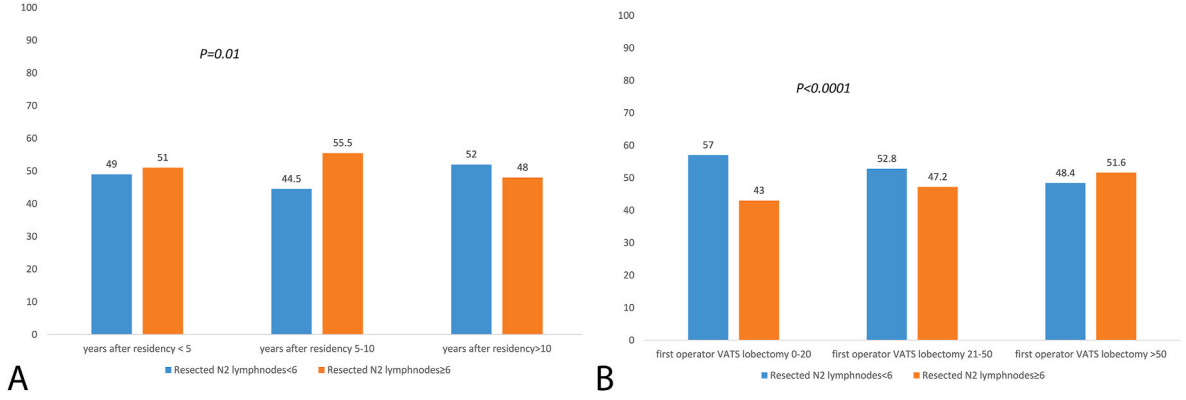

Fig. 2. A) number of N2 resected nodes according to operator years after residency; B) number of N2 resected nodes according to operator number of VATS lobectomy performed.

Table 3
Multivariable analysis. NS: not significant. HR; Hazard ratio; Ci: Confidence Interval.

MULTIVARIABLE ANALYSIS – RESECTED NODES						
Variable	N2 + N1 NODES ≥10		N2 NODES ≥6		Resected N2 stations ≥3	
	OR (CI95%)	p	OR (CI95%)	p	OR (CI95%)	p
TUMOR LOCATION						
Lower vs upper lobes	–	–	0.820 (0.714–0.942)	0.005		
TUMOR SIDE						
Right vs left	–		–	–	1.368 (1.187–1.576)	<0.001
C TNM						
I (ref)	ns	ns	–	0.017	–	–
II			1.290 (1.042–1.597)	0.019		
III			1.479 (1.022–2.141)	0.038		
SENIORITY						
(years after residency)						
<5 (ref)	–	<0.001	–	<0.001	–	–
5–10	1.004 (0.739–1.363)	0.980	1.030 (0.767–1.385)	0.843		
>10	0.505 (0.387–0.659)	<0.001	0.608 (0.469–0.788)	<0.001		
FIRST OPERATOR VATS LOBECTOMY NUMBER						
<20 (ref)	–	<0.001	–	<0.001	ns	ns
20–50	1.730 (1.385–2.161)	<0.001	1.389 (1.114–1.731)	<0.001		
> 50	2.268-1.849-2.781	<0.001	1.869 (1.526–2.289)	<0.001		
RESECTION						
Segmentectomy (ref)	–	<0.001	–	<0.001	–	0.003
Lobectomy	1.908 (1.478–2.646)	<0.001	1.973 (1.508–2.580)	<0.001	1.535 (1.155–2.039)	0.003
bilobectomy	3.024 (1.849–2.781)	<0.001	2.796 (1.701–4.597)	<0.001	2.169 (1.304–3.606)	0.003

parameter is still far from definition. The various available guidelines may differ, taking into account different combinations of number and location of resected nodes and mediastinal stations [2,9,10], even if the recent tendency is to consider the number of resected stations [10], recognizing that the number of lymphnodes present may vary among individual [24].

However, all the current indications are in agreement regarding the needed of at least nodal sampling during surgery for NSCLC (2,9,11,12),

even if the sampling characteristics need to be defined and sometimes they closely resemble mediastinal radical node dissection.

Smeltzer et al. [17] defined about 7 different groups according to different combinations of number of resected nodes and hilar/mediastinal stations, defining the most stringent group patients with at least 1 N1 lymph node, a minimum of 10 nodes, and a minimum of 3 mediastinal nodal stations harvested. Using this definition, the authors obtained the best survival rate and the highest reduction in the rate of death.

Other studies focused on the importance of respecting quality measures, including time to surgery, complete resection, anatomic resection and adequate lymph node assessment defined as the resection of at least 10 lymph nodes [18,23].

These studies reported a survival improvement increasing the quality measures adherence, underlying the importance of lymphadenectomy also in this setting.

In this study, we demonstrated that the number of resected nodes, resected N2 nodes and resected N2 stations increase with the surgeon experience in terms of number of VATS major anatomical resections performed.

With the future desirable increase of VATS approaches and segmentecotmies, the goal should be to achieve the adequate nodal assessment in every case, reducing the rate of patients with limited and incomplete nodal assessment. Consequently, more attention and time should be reserved to lymphadenectomy, maybe also changing the surgical management. Especially in beginning of the learning curve, lymphadenectomy could be prioritized, performed when the surgeon is still fresh and without concerns about operative time. Indeed, in our study also noted that operative time increases directly with lymphadenectomy outcomes, suggesting that dedicating adequate time to this aspect may be crucial and can potentially be reduced when the surgeon is fatigued after specimen resection.

This study presents some limitation due its multicentric and retrospective nature, involving data collection from many different centers with different kind of surgical approaches and indication.

Another limitation is related to the surgeon experience categorization, which was codified by the system and it was not possible to reach some information such as the total number of VATS lobectomies performed or the age of the surgeon. This point especially regards the years after residency, that for the last category (more than 10 years) did not permit to know when the learning curve for VATS lobectomy started. This poses the risk of older surgeons having less VATS experience compared to those with less than 10 years after residency.

Finally, according to available guidelines, we also considered the number of examined lymph nodes, that is subject to potential confounding from the manner of counting lymph node fragments and regarding the pathological analysis in terms of dissected nodes in the specimen.

The strength of this study lies in the use of a purpose-built, large database to analyze nodal outcome during VATS resection, and this is, at the best of our knowledge, the first and largest study considering the surgeon experience in this setting. Additionally, regarding the quality of the reported data, the Italian VATS Group database received awards from the European Society of Thoracic Surgeons in September 2017 [25], permitting reliable analysis and results.

5. Conclusion

Surgeon experience in VATS anatomical resections seems to influence lymphadenectomy in terms of number of total resected, number of mediastinal resected nodes and number of harvested mediastinal lymph node stations.

Surgeons with more than 50 VATS major anatomical resections presented a significantly higher rate of total resected/mediastinal resected nodes and N2 resected stations. These findings suggest that VATS development programs should be enhanced to ensure the proper execution of lymphadenectomy by less experienced surgeons.

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Conflict of interest

None.

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Ethical approval

Ethical approval was not required because for this study was needed the VATS Group Scientific Committee approval only.

CRediT authorship contribution statement

Marco Chiappetta: Conceptualization, Methodology, Writing – original draft. **Carolina Sassorossi:** Data curation, Software, and, Investigation. **Filippo Lococo:** Data curation, Supervision, and, Project administration. **Carlo Curcio:** Resources, and, Visualization. **Roberto Crisci:** Resources, and, Visualization. **Isabella Sperduti:** Formal analysis. **Elisa Meacci:** Resources, and, Visualization. **Stefano Margaritora:** Supervision, Writing – review & editing.

Declaration of competing interest

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ejso.2024.108054.

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