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Which extent of surgical resection thoracic surgeons would choose if they were diagnosed with an early-stage lung cancer: a European survey

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INTRODUCTION

The recent publication of 3 randomized trials has established segmentectomy as a valuable alternative to lobectomy in peripheral lymph node-negative stage IA1 and IA2 non-small-cell lung cancer [1–3].

There are still unmet knowledge gaps including the level of functional benefit provided by sublobar resections compared to lobectomy [1, 4, 5], the most adequate lymph node dissection, the relative merits of video-assisted thoracic surgery (VATS) versus robotic approach, the prognostic role of spread through air spaces (STAS) and the appropriate distance of the tumour from the resection margin among others. In addition, segmentectomies are often perceived as technically complex procedures and a longer learning curve is needed to ensure adequate technical standards and respect for oncologic principles for a lung cancer operation [6].

Despite recent evidence that has generated some enthusiasm among the thoracic surgical community, the general adoption of this procedure remains unexplored. In particular, the risk perception of surgeons playing the role of patients and undergoing segmentectomy in different hypothetical scenarios appears an interesting point of view which may help to identify knowledge and evidence gaps for future investigations or educational activities.

Therefore, the ESTS approved a survey to disseminate to thoracic surgeons to capture the individual preferences of undergoing segmentectomy as opposed to lobectomy in case the surgeon was diagnosed with early-stage lung cancer with different hypothetical scenarios. The rationale is to provide a more personalized representation of the current acceptance of this procedure among the thoracic surgical community based on a subjective standpoint.

METHODS

Ethical statement

No patients were involved in this study and Institutional Review Board approval was not necessary.

A core group of 5 surgeons (Alessandro Brunelli, Rene Horsleben Petersen, Dominique Gossot, Herbert Decaluwe, Michel Gonzalez) with expertise in sublobar resections, minimally invasive surgery and guidelines generated the questions of the present survey. The questions were designed to explore the preferred extent of resection (segmentectomy or lobectomy) in case the hypothetical scenario the respondent was diagnosed with lung cancer and was proposed both procedures (segmentectomy versus lobectomy) by a treating surgeon (assuming that surgeon had a large experience in both procedures, equal experience in open, VATS and robotic surgery and worked in a high-volume thoracic surgical centre).

The questions covered several broad topics such as type of surgical approach, location of the tumour, size of the tumour, intraoperative lymph node dissection, morphology of the tumour, postoperative pathology, tissue diagnosis and three-dimensional (3D) CT scan planning.

These topics were used to generate 7 demographic questions and 18 procedural questions, which are shown in Supplementary

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Material, Table SA1. The questions were collated into a questionnaire, which was electronically sent by email to a group of 219 thoracic surgeons using a commercially available platform (www.surveymonkey.com). The selection criteria to participate to the survey was being a member of the Board, committees or working groups of the European Society of Thoracic Surgeons or being a member of the Thoracic Domain of the European Association of Cardiothoracic Surgery.

The initial survey was sent on 28 June 2023 and 2 additional reminders were sent on 8 July 2023 and 22 July 2023. The survey was closed on 30 July 2023.

Statistical analysis

Descriptive statistics were used to summarize the results.

There were no missing answers since all the answers were mandatory. There was no confidential information required for this study. Data were reported as frequency, number and percentage. The analysis was performed using Stata 15.1 statistical software (Stata Corp. College Station, TX).

RESULTS

A total of 123 surgeons from 32 countries completed the survey (56% response rate).

The completion rate of the responders was 100% (all responders completed all questions).

Eighty-three percent identified themselves as men. 28% were younger than 45 years of age and 10% were older than 65 years of age. Twenty percent were in practice for 10 years or less, whilst 46% were in practice for >20 years. Thirty-one percent of surgeons declared to have performed <50 segmentectomies during their career, whilst 40% performed at least 100 (with 18 surgeons reporting an experience of >200 segmentectomies). Only 2 surgeons reported not to have performed any segmentectomy. Eighty-two percent of respondents considered themselves at low risk for surgery, whilst 16% and 2% at moderate and higher risk, respectively.

All respondents preferred the surgical treatment (as opposed to non-surgical alternatives) in case they were diagnosed with a peripheral 1.5-cm solid tumour. Eighty-three percent would prefer a minimally invasive approach, with the majority of them not having a preference between robotic, multiport VATS or single-port VATS as long as the operation was performed through a minimally invasive approach. Among those who expressed a preference for a specific approach, the respondents were substantially equipoised between the 3 minimally invasive choices. Seventeen percent stated that they would not mind the approach as long as the surgeon had appropriate experience with the approach or procedure; however, none of the respondents specifically favoured an open approach. Most of the respondents (57%) would prefer to have a preoperative 'tissue diagnosis' before considering any treatment. However, 24% and 14% of them still prefer to go ahead with the proposed segmentectomy or lobectomy based on serial imaging only.

The majority of respondents valued very much the experience of the surgeon/centre with the procedure. Only 6% would still prefer a segmentectomy even in case the surgeon/centre has of low experience with the procedure. However, 50% would ask to be referred to a centre with large experience in segmentectomy and 39% would ask to have a lobectomy instead.

Table 1: Preferred extent of resection in case of a diagnosis of a peripheral 1.5-cm solid tumour without enlarged lymph nodes according to different locations

Location	Segmentectomy	Lobectomy	Wedge
RUL apex	53 (43%)	67 (55%)	3 (2%)
LUL apex	98 (79.5)	23 (19%)	2 (1.5%)
RLL segm 10	69 (56%)	51 (42%)	3 (2%)
RLL segm 6	84 (68%)	37 (30%)	2 (1.5%)

LUL: left upper lobe; RLL: right lower lobe; RUL: right upper lobe.

Twenty-five percent of surgeons would be reluctant to have a segmentectomy without a '3D reconstruction and planning' whilst a similar proportion would proceed to segmentectomy without 3D reconstruction as they believe CT scan would be sufficient. Twenty percent chose a lobectomy and thought 3D reconstruction would not add much and change their choice, whilst 11% chose a lobectomy but believed that 3D planning might make them change their mind. Eighteen percent of respondents were unsure on the necessity of 3D modelling and planning as it may depend on tumour size and location.

Table 1 shows the preferences in terms of 'extent of resection' in case of a diagnosis of a peripheral 1.5-cm solid tumour according to different locations. From 19% to 55% of respondents would still prefer a lobectomy. The highest frequency of preferred segmentectomy occurred when tumour was located in the apex of the left upper lobe with 57% of respondents favouring an upper division segmentectomy and 23% favouring a left apico-posterior segmentectomy (S1–S2). In case the tumour was located in the right lower lobe (S10), 45% of those choosing a segmentectomy would favour a complete basilar segmentectomy whilst 55% would favour a S9–S10 segmentectomy.

Table 2 summarizes the responses about changing the selected procedure according to increased or reduced tumour size or different morphology (sub-solid lesion).

Most notably, 11% of respondents would still prefer a lobectomy even if the tumour was 1 cm in size, whilst a large proportion of surgeons would change their choice from segmentectomy to lobectomy in case the tumour was 2.2 cm instead of 1.5 cm (41%) or located in the inner third of the lung parenchyma (37%). A large number of surgeons stated that their choice would depend on the lobe or segment location of the tumour in case of smaller size (32%) or sub-solid or partly solid morphology (22%).

Table 3 shows the preferences regarding the 'extent of lymphadenectomy' in the case of a solid or sub-solid tumour. The majority of respondents preferred a radical lymph node dissection in both circumstances. However, more surgeons were satisfied with a nodal sampling or lobe-specific lymphadenectomy if the tumour was sub-solid compared to the solid tumour scenario.

Postoperative considerations

in the event of uncertain resection margins at definitive pathology after removal of the staple line (pRx), most respondents

Table 2: Possible change of preferences according to increased (2.2 cm) or reduced (1 cm) tumour size or different morphology (sub-solid lesion)

	Still prefer lobectomy	Still prefer segmentectomy	Change to lobectomy	Change to segmentectomy	Change to wedge	It will depend on the location
1-cm size	14 (11%)	55 (45%)		11 (9%)	–	39 (32%)
2.2-cm size	52 (42%)	3 (2.5%)	50 (41%)	–	–	13 (11%)
1.5-cm sub-solid or partly solid	20 (16%)	56 (46%)	4 (3%)	–	7 (5.7%)	27 (22%)
Inner third lung location	42 (34%)	12 (10%)	45 (37%)			19 (15%)

A minority of respondents selected the option 'others' in the multiple choices, with a free text description.

Table 3: Preferred extent of lymphadenectomy in case of a solid or sub-solid/part-solid tumour

	No dissection	Nodal sampling only	Lobe-specific lymphadenectomy	Radical lymph node dissection
Solid tumour	0	9 (7.3%)	25 (20%)	89 (72%)
Part-solid or sub-solid tumour	0	17 (14%)	32 (26%)	74 (60%)

Table 4: Preferred management in case of unexpected pN1 or pN2 disease found at definitive pathology

	Follow-up	Adjuvant systemic treatment	Completion lobectomy and adjuvant systemic treatment
pN1	3 (2.4%)	76 (62%)	41 (33%)
pN2	1 (0.8%)	86 (70%)	33 (27%)

would choose to undergo a completion lobectomy (78%). Eleven percent would choose a more frequent follow-up only with serial CT scans and only 6.5% radiotherapy at the resection margins.

Table 4 shows the preferences in case of unexpected pN1 or pN2 disease found at definitive pathology. The majority of respondents would choose to have adjuvant systemic treatment (chemotherapy, chemo-immunotherapy or targeted treatment). Only 33% and 27% of surgeons would prefer to go back and have a completion lobectomy (followed by adjuvant treatment) in case of unexpected pN1 or pN2, respectively.

Subgroup analyses

We performed subgroup analyses to check whether surgical preferences varied based on the age, experience, years of practice and fitness of surgeon (Supplementary Material, Tables SA2–SA5).

In general, we found a trend of increased preference for segmentectomies in the younger surgeons (with the exception of tumours located in segment 6 of right lower lobe) and in those who considered themselves at higher risk for surgery.

We were not able to find any difference in respondents with different experience with the procedure or according to years of practice, with the exception of an increased trend of preference for segmentectomy in those with <10 years of practice and tumour located in segment 10 of the right lower lobe.

In addition, among those who chose a segmentectomy, their surgical experience with the procedure was not associated with changing opinion if 3D planning were not available (46% of the less experienced surgeons vs 57% of the experienced ones, $P = 0.60$).

DISCUSSION

Preferences based on size and location

All respondents to this survey chose the surgical approach (as opposed to non-surgical treatments) in case of a 1.5-cm tumour, even though 18% considered their surgical risk to be moderate or high. This shows that thoracic surgeons are not only convinced that surgery is recommended for patients but also for themselves, despite the necessary general anaesthesia and related morbidity. The minimally invasive approach is preferred by 83% of respondents whereas 17% privilege the surgeon's experience over the surgical approach. Nowadays, VATS is the preferred approach for patients with clinical stage I NSCLC [7, 8]. Current data suggest that VATS lobectomy is associated with better perioperative outcomes, decreased pain, better quality of life and equivalent oncological results when compared to open resection [9–12]. In the Violet trial, 503 participants were randomly assigned (247 to VATS and 256 to open lobectomy) for resection of early-stage lung cancer [13]. The VATS patients had significantly better physical metrics after 5 weeks, lower rate of adverse events, shorter length of hospitalization, lower readmission rate and less pain, without difference in oncological outcomes compared to thoracotomy patients. In another randomized controlled double-blind trial, 201 patients were randomly assigned to VATS ($n = 102$) or anterolateral thoracotomy ($n = 99$) [14]. For the first year after surgery, VATS was associated with fewer episodes of moderate-to-severe pain ($P < 0.0001$) and better self-reported quality of life ($P = 0.014$) compared to anterolateral thoracotomy. Conventional three-port VATS anatomical resection is a well-established technique, successfully adopted by many surgeons over the past 2 decades but is preferred only by 15% of responders [15, 16]. Since 2011, the

uniportal VATS approach was developed. It is potentially less invasive and allows major thoracic operations to be performed through a unique small incision. It is preferred by 16% of responders [17]. Several advantages of uniportal VATS over conventional multiport VATS have been reported including reduced surgical trauma, decreased postoperative pain, faster rehabilitation and improved patient satisfaction, without compromising the oncological outcomes after either lobectomy or segmentectomy [18]. However, the majority of publications are case-based series with severe selection bias. Only 1 RCT has been published showing equity between uniport and multiport lobectomy [19]. Recently, robotic-assisted thoracic surgery (RATS) has increasingly been used for anatomical resections. It presents several advantages over VATS, including high-definition 3D vision, improved ergonomics, softer learning curve, tremor suppression, lower rate of conversion thoracotomy and better manoeuvrability of instruments. However, the superiority of VATS or RATS regarding short-term outcomes is debated [20–22]. Even though studies have reported significantly higher nodal dissection rates during RATS compared to VATS, this was not associated with cancer upstaging. More generally, VATS, RATS and thoracotomy relative nodal upstaging rates yield conflicting results, without evidence of a statistically significant impact on long-term survival [22–25]. In addition, increased costs and limited access for thoracic surgeons makes the robotic approach privileged by 13% of responders only. Finally, the number of incisions appears secondary for thoracic surgeons as long as the operation is minimally invasive, according to 38% of respondents. Segmentectomy differs from lobectomy in terms of surgical difficulty and, despite increased technical complexity, it is technically feasible by VATS and associated with at least similar postoperative outcomes [26–29]. We may observe that for most respondents, the extent of resection would depend on the size (more or less 2 cm), aspect (solid, sub-solid) and location (central/peripheral, lower/upper lobes) of the lesion.

Our survey was conducted after the publication of 2 important RCTs comparing sublobar and lobar resection for NSCLCs smaller than 2 cm, confirming the validity of sublobar resections [1, 2]. Still, 19–55% of respondents indicated a preference for a lobectomy even for a 1.5-cm solid tumour in various locations.

The location of the tumour typically dictates the surgical options, especially when evaluating a patient for sublobar resections. Typically, the safety margin is more difficult to obtain for central lesions than for peripheral lesions, which might explain why most respondents prefer a lobectomy instead of a segmentectomy for a central lesion, and why 10% would choose a segmentectomy only. Regarding the safe minimum resection margins, a recent systematic review has shown that the inflection point for increased local recurrence is a margin shorter than 1 cm or a margin-to-diameter ratio smaller than 1 [30]. A 2-cm tumour should thus be resected with a clear margin of at least 2 cm. Technical quality is of paramount importance when performing a segmentectomy to meet oncologic criteria. These standards have been recently published as expert consensus recommendations from the European Society of Thoracic Surgeons [6]. Several recommendations have been established to facilitate the planning of the safety margin such as perioperative location of the lesion with 3D reconstruction and correct delineation of the intersegmental planes. Some lesions are in locations suitable for a single anatomic (simple) segmentectomy, whilst others may straddle an intersegmental plane and pose technical challenges, thereby requiring a complex segmentectomy, not mastered by all thoracic surgeons. However, when comparing complex and simple segmentectomy in experienced centres in terms of postoperative outcomes, generally no difference is observed [31, 32]. Wedge resection may offer an alternative option to complex segmentectomy, potentially with similar benefits of decreased morbidity and mortality, but this approach is favoured by <5% of respondents. There still seems to be a negative perception of wedge resection despite the results of the CALGB trial, in which 60% of the sublobar resections were wedges [2]. The subsequent post-hoc analysis on the same population did not show any difference between wedge and segmental resections in terms of overall and lung cancer-specific survivals. Locoregional recurrences and reduction in FEV1 were also similar [33]. However, this latter study was not yet published at the time of this survey distribution.

The location of the tumour in specific lobes is another debated point. A recent systematic review reported that there are no statistically significant differences in survival and recurrence rates between superior and basal segments for lung cancer patients, but overall survival and relapse-free survival rates were lower for lesions located in superior segments for early-stage NSCLC in the right lower lobe [34]. Segmentectomies of the superior segment of lower lobe have a relatively lower survival rate in patients with early-stage NSCLC in comparison with lobectomies, however, survival after apical segmentectomies was not better than that after basilar segmentectomy. Interestingly, 30% of respondents would choose lobectomy for tumours of 1.5 cm located in the apical segment of the lower lobe.

The functional benefit of sublobar resections is optimal when the number of resected segments is limited. This is particularly relevant for individual, basilar segments of lower lobes [35]. Partial resection of the basilar segments is a complex and challenging procedure, especially when performed by VATS, due to anatomical variability, difficult intersegmental plane delineation and 3D stapling of the intersegmental plane caused by the pyramidal shape of the lower lobe. In experienced centres, postoperative outcomes are similar for basilar segmentectomies and lobectomies with no additional morbidity despite surgical complexity [31, 35].

Only 31% of respondents would choose a segmentectomy of segments 9 and 10 for small lesions located in segment 10, probably reflecting the low proportion of surgeons mastering this complex segmentectomy.

The left upper lobe is one of the largest lobes in the lungs, and segmentectomy has been well-established in this location. For lung cancers located in the left apical segment, the different surgical options include S1 + 2 bi-segmentectomy, S1 + 2 + 3 tri-segmentectomy and left upper lobectomy. Segmentectomies, such as S1 + 2 + 3 and S4 + 5 segmentectomies have demonstrated similar oncological outcomes compared to left upper lobectomies even for tumours with diameter >2 cm. This may explain why 57% of respondents would prefer a tri-segmentectomy and only 19% a lobectomy for tumours smaller than 2 cm [34, 36]. Assuming a sufficient oncological margin, S1 + 2 bi-segmentectomy could be indicated rather than left upper lobectomy or S1 + 2 + 3 tri-segmentectomy. Recently, a study reported better postoperative lung function preservation after S1 + 2 bi-segmentectomies compared to upper tri-segmentectomies, but this approach was favoured by 23% of respondents only [37].

There is no such level of evidence for tumours > 2 cm. The threshold of 2 cm seems arbitrary because it is unclear if a

tumour of 1.5 cm would have better prognosis than a tumour of 2.2 cm and if these few millimetres would be associated with a different outcome. We observed that fewer than 10% of respondents would choose a segmentectomy in case of tumours >2 cm, whereas 15% would decide based on the location of the segment or the lobe. Nevertheless, there are some recent retrospective studies, demonstrating that in very selected patients, even stage IA3 tumours can be resected with a segmentectomy without compromising the oncologic results compared to lobectomy [38–41].

The presence of a ground-glass opacity (GGO) component is an important prognostic factor regardless of the size of the solid component, which is considered an oncologically distinct favourable entity. Segmentectomy has demonstrated excellent oncologic outcomes when GGO component was present, and similar loco-regional control compared to lobectomy [42]. Studies have reported similar survival outcomes >90% at 5 years between c-T1b and c-T1c subgroups between segmentectomy and lobectomy, provided that the tumour showed radiologically solid-predominant appearance with a GGO component even in patients with NCSCL >2–3 cm in maximum tumour size. This might explain why fewer than 20% of respondents would choose a lobectomy for a part-solid tumour of 1.5 cm [43, 44].

Recently, the European Guidelines for the surgical management of GGO opacities recommended segmentectomy for part-solid nodules [45].

Preferences about intraoperative lymph nodes management

Most of the respondents favoured radical lymphadenectomy; 72% in the case of solid tumours and 60% in part-solid tumours. Interestingly, none of the respondents would avoid lymph node dissection. The evidence for lymph node dissection in tumours <2 cm is conflicting. In JCOG 0802 a systematic or selective mediastinal lymph node dissection was mandatory, sampling was not allowed [1]. In the CALGB 140503 the extent of lymph node dissection was not specified; however, eligibility criteria included confirmation of N0 status from 4, 7 and 10 for right-sided tumours and 5, 6, 7 and 10 for left-sided tumours [2]. The only randomized controlled trial performed to date is the American College of Surgery Oncology Group Z0030 trial [46]. In this study, 1023 patients with NSCLC were randomized to either lymph node sampling or complete lymphadenectomy after confirmation of no malignancy on intraoperative frozen section of the sampled lymph node stations; on the right side 2R, 4R, 7, 10R and the left side 5, 6, 7, 10L. The trial did not show any difference in overall survival, disease-free survival or local nor distant recurrence. Recently, a non-randomized prospective multicentre clinical trial from China evaluated the impact of lymph node dissection in 720 patients with peripheral NSCLC, T1N0M0 [47]. All patients underwent lobectomy or segmentectomy and systematic lymph node dissection. Intraoperative frozen section was performed on hilar lymph node adjacent to the tumour, and on the tumour to determine lepidic predominant pattern and visceral pleural invasion. Six criterions for predicting negative lymph node stations and guiding selective lymph node dissections were setup. None of the patients with consolidation to the maximum tumour size ≤0.5 cm or lepidic predominant adenocarcinoma had mediastinal lymph node metastasis. For patients with tumours in the upper lobes without pleural invasion and negative hilar lymph nodes, none had lymph node metastasis in the inferior mediastinal lymph nodes. Similarly, for tumours in the lower lobes with negative hilar lymph nodes, none had superior mediastinal lymph node metastasis. The accuracy of the frozen section in detecting lepidic predominant pattern, pleural invasion and hilar lymph node involvement were 94.0%, 98.9% and 99.6%, respectively. Thus, indicating a selective strategy for lymph node dissection may be warranted. The concerns of performing systematic lymph node dissection have mainly been the risk of laryngeal nerve injury and chylothorax. However, recently concerns have been raised that the removal of normal lymph nodes may decrease antitumour immunity and be associated with poorer efficacy of immunotherapy for potential recurrent disease [48–51].

Preferences about the management of resection margins

The management of safety margins is a crucial point in the performance of sublobar resections. Since Schuchert's work, it has been clearly established that the risk of local recurrence correlates with tumour size and margin length [52]. This work was recently confirmed by the same team [53]. There are recommendations on the margins to be respected. As a minimum, the safety margin should be ≥1 cm, when the tumour diameter is <2 cm [54]. The ACCP recommends that the margin should be greater than or equal to the maximum diameter of the lesion for tumours <2 cm [7]. The justification for these safety margins is the possible presence of clusters of malignant cells at a distance from the tumour [55]. But this problem has become even more acute with studies on the risk of local recurrence in STAS. Although the results of these studies diverge on the importance of the risk, there is a consensus that there is an excess risk depending on the histology (particularly micropapillary cancers) [55] and the size of the lesion. The presence of STAS is estimated at 8% in cT1a and close to 30% in cT1c lesions [56]. All studies agree that wedge resection is much more likely to result in local recurrence than lobectomy. On the other hand, results are mixed when segmentectomy and lobectomy are compared. But it is essential to respect an optimal safety margin.

The margin can be analysed preoperatively and intraoperatively. It will be confirmed by pathological examination, which will determine the most appropriate course of action on the basis of the results.

Preoperative assessment of safety margins. Margins can be assessed by CT scan and, above all, by 3D modelling [57]. This will help determine whether the tumour is accessible to a single segmentectomy, or whether resection should be extended to the adjacent subsegment or, possibly, an atypical resection. Modelling software can be used to add a virtual margin whose volume is either predetermined or adjustable.

Intraoperative evaluation of safety margins. Margin analysis by modelling does not dispense with a study during the operation. In rare cases, this analysis cannot be carried out because the target nodule is neither visible nor palpable, and only the pathological analysis can analyse the margin. The use of near-infrared imaging is very useful, as the intersegmental plane determined in this way is often wider than that envisaged by the surgeon [58]. Mehta *et al.* [58] have shown that in 61% of cases,

the actual intersegmental plane differs from the planned plane, with a median additional margin of 2.41 ± 1.6 cm.

One of the difficulties of intraoperative examination is related to the staple line and the fact that the lung is deflated. For this reason, some authors have suggested performing the scan on an insufflated operative specimen [59]. In practice, this manoeuvre is difficult to perform routinely. Except when the margin is obviously very wide (>3 cm), it is recommended to perform an extemporaneous examination on the staple line. As it is not possible to examine the entire line, it is necessary to set up landmarks for the pathologist. If the margin is invaded, extension to the segment or sub-segment, or even lobectomy, should be proposed. One of the criticisms made by some is that the frozen section is not 100% reliable. In fact, whilst its specificity is 100%, its sensitivity is only 85%. This already eliminates many unanticipated invasions, and it is likely that results can be improved by techniques such as Touch Preparation Cytology [60].

Management of invaded margins. The results of the survey show that, in the event of an invaded margin on definitive pathological examination, almost 80% of surgeons would opt for reoperation, with the remainder preferring radiotherapy or surveillance. The difficulty lies in the fact that the definitive pathological result is often available several days after the patient's discharge. If the delay is short, reoperation is sometimes possible, at the cost of minor operative difficulties. If the delay is long, a new operation becomes more difficult due to inflammatory changes and therefore carries a higher risk. This highlights the importance of a frozen section on margins to avoid such an uncomfortable situation.

Preferences about management of positive lymph nodes found at definitive pathology

Recruitment for the JCOG 0802 and CALGB 140503 [1, 2] required frozen section intraoperatively and confirmation of N0 disease. Interestingly, the majority of the responders in this study favoured adjuvant chemotherapy without a redo completion lobectomy in case of N1 or N2 disease on final pathology (62% for N1 and 70% for N2). In the JCOG 0802 study, 17 patients (3.1%) were N1 positive and 17 (3.1%) N2 positive in the segmentectomy group on final pathology; however, 16 underwent completion lobectomy. There is no prospective study to data that show equal survival between lobectomy and segmentectomy in NSCLC stage II. The efficacy of completion lobectomy in this group, however, is uncertain. A study on 4556 patients with clinical stage I NSCLC <−3 cm and node-positive disease on final pathology from the National Cancer Data Base found similar 3-year overall survival between segmentectomy and lobectomy (66.3% and 68.1%, $P = 0.723$) [61]. Other studies have shown that when a lymph node proximal to the segmental bronchus is positive, the risk of lymph node involvement in the adjacent segment may be up to 40% [62]. Adjuvant chemotherapy however is only completed in 50–60% of patients and the overall survival benefit is only 5%. Further prospective studies are warranted in this area.

Preferences about surgical experience

One in 4 of the respondents would prefer lobectomy if the surgeon or centre has little experience in segmentectomy and half of them prefer a referral to a centre with a large experience in segmentectomies. Of note, most respondents have 15 years of experience with 77% of the respondents working in university hospitals, and a majority performed >50 segmentectomy cases.

Several studies have demonstrated a relationship between procedural volume and better outcomes in lung cancer surgery [63].

Analysis of the National Cancer Database on segmentectomies showed that high-volume centres used more minimally invasive techniques, had lower conversion rates, that patients had lower 90-day mortality, had more lymph nodes sampled and had lower incidence of positive margins [64]. Several studies including variable approaches or number of ports have looked at the learning curve of segmentectomy and found proficiency after 40–80 cases [65, 66].

The impact of the experience of the surgeons in the 2 recent RCTs on sublobar resections was not clearly reported. In the Japanese JCOG0802 study, demonstrating a better survival after segmentectomy in lesions up to 2 cm and with at least 50% solid component, a mean of 19 patients were included per institution (1106/70) [1]. In the CALGB140503 trial, patients were recruited from 83 academic and community-based institutions in the USA, Canada and Australia. Surgeons who were not previously VATS credentialed were required to have performed at least 10 VATS or RATS lobectomies within the prior 12 months and submit 3 operative and pathology reports for central review [2].

Preferences about preoperative tissue diagnosis

Fifty-seven percent of the respondents stated that tissue diagnosis would be important when deciding the treatment strategy and the extent of resection. Histologic subclassification is related to outcome with very good survival in the case of premalignant lesions like AAH, AIS and MIA, good prognosis in lepidic subtype, intermediate prognosis with acinar and papillary adenocarcinoma and worst prognosis in solid and micro-papillary subtypes and STAS. The latter 3 have a higher risk of recurrence [67]. Histology is also related to survival in a 2021 analysis of segmentectomies in the National Cancer Database [68].

JCOG 0802 demonstrated twice the amount of loco-regional relapse (but equal when adding distant relapse) in the segmentectomy group versus the lobectomy group.

As a higher (loco-regional) recurrence is both related to subtypes of histology and sublobar resection and less so after lobectomy, one could intuitively presume that sublobar resections should be avoided in subtypes of higher risk of recurrence [69]. However, clear proof that changing the extent of resection based on the preoperative histology would also affect the outcome still needs to be established.

In many centres, preoperative tissue diagnosis is not pursued for early stages that do not warrant multimodal therapy [70]. Several practical issues exist.

The smaller the lesion, the more difficult it is to get correct preoperative pathology, even more so when the lesion is only partly solid. Even if tissue acquisition is feasible with newer technology like navigational bronchoscopy, general anaesthesia is often needed. Pragmatically, one could ask whether a negative result would change the therapeutic plan. If no impact is expected, one can omit the biopsy.

Furthermore, deep learning radiomics has the potential to predict the subtype classification without biopsy [71]. Whether

resection extent should be adopted based on the invasive part versus the total volume is further topic of future research [72].

Preferences about the need of 3D CT reconstruction

When it comes to the value of 3D reconstruction, the results of the survey are highly disparate and mixed. For example, 25% of surgeons felt that CT scan analysis was sufficient to perform a segmentectomy. Conversely, it is interesting to note that among those who would perform a lobectomy, 11% said that 3D reconstruction could lead them to change their plans.

Bearing in mind that the survey used an upper lobe nodule as an example, these results reveal a certain unfamiliarity with 3D models for some surgeons. Indeed, it is rarely the careful analysis of a conventional CT scan that will accurately show the distribution of the bronchi and arteries of segments S^1 and S^2, i.e. the presence of a B^{1+2} trunk or a B^1a separation from bronchus B^2 and B^1b from bronchus B^3. This has an impact on the decision to perform an S^{1+2} or $S^2 + S^{1a}$ segmentectomy, for example.

The benefits of 3D models in thoracic surgery have long been demonstrated [73–76], and it is now clear that they are part of routine preoperative examinations. They can be used to detect anatomical variations, plan the type of segmentectomy [77] and predict safety margins. The future will tell which technology is most appropriate, between standard 3D reconstruction, 3D printing [78] and augmented reality [79].

Limitations

- The results of the present survey represent the personal opinions of a sizeable number of surgeons but should not be interpreted as standard of care or best surgical care.
- The selection of the surgeons to survey was based on predefined criteria (membership to leadership groups of ESTS and EACTS). Although this minimizes the subjectivity in the selection process it may introduce other biases. For instance, the average age and years of practice of the respondents were quite high, as expected by their roles. Only 20% were in practice for <10 years. The generalizability of our findings to a younger group of surgeons needs to be verified.
- Similarly, the majority of respondents work in academic hospitals. The survey findings may not be reflective of the perceptions of surgeons working in smaller centres or community hospitals.
- There is a possibility of nonresponse bias due to the fact that surgeons performing more regularly segmentectomies were more likely to participate.
- As in all surveys, demand characteristics bias can have affected the responses, inasmuch as participants of a survey can change their opinion because of taking part in a study. Although the survey was anonymous, surgeons had to annotate their details at the end if they wished to be listed as collaborators of the study.
- In general, the conclusions from this survey may not reflect the opinion of a wider thoracic surgery community with variable seniority and levels of surgical experience.
- As with all surveys, the wording of the questions may have influenced the responses. However, the questions were initially agreed by a steering group of 5 surgeons with experience in this field.
- Finally, the responses of this survey are certainly affected by the current evidence availability. For instance, preferences may change in case more studies will show a greater benefit of segmentectomy over lobectomy in terms of residual quality of life [80, 81]. It is anticipated that the publication and diffusion of new high-level evidences on this topic and the ongoing educational efforts from Scientific Organisations will influence future surgeons' perspectives of this operation.

CONCLUSIONS

One of the most frequent questions asked by the patient during a surgical consultation is 'Doctor, what would you do if you were in my place?' This document had the purpose to partly answer this question. Far from being a best practice document, this survey reflects the current perception of surgeons on segmentectomy for early-stage lung cancer from a very personal standpoint. We believe that the current work may be a useful benchmark for future research and provide some valuable material for reflection and discussion with patients especially about the more controversial aspects of segmentectomy.

SUPPLEMENTARY MATERIAL

Supplementary material is available at *EJCTS* online.

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DATA AVAILABILITY

The data underlying this article will be shared on reasonable request to the corresponding author.

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