
Review

Evolving surgical standards in early-stage non-small cell lung cancer: A review of sublobar resections and future perspectives

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Abstract: Lung cancer remains the leading cause of cancer-related mortality globally, with surgical resection representing the cornerstone of curative treatment for early-stage NSCLC. Historically, lobectomy has been the gold standard, according to perceptions of oncologic efficacy. However, concerns regarding pulmonary preservation and perioperative morbidity have catalyzed renewed interest in sublobar resections, including wedge resection and segmentectomy. Early randomized trials, notably the Lung Cancer Study Group (LCSG) trial of 1995, demonstrated higher recurrence rates with sublobar resections, establishing lobectomy as the preferred approach. Nevertheless, advances in preoperative imaging, staging accuracy, and minimally invasive techniques—specifically video-assisted thoracoscopic surgery (VATS)—have prompted reconsideration of this standard. Recent landmark randomized trials, notably JCOG 0802 and CALGB 140503, provided pivotal evidence supporting sublobar resection as oncologically comparable with lobectomy for small (≤ 2 cm), peripheral tumors, with the added benefits of reduced morbidity and better preservation of pulmonary function. However, these studies also identified increased locoregional recurrence rates associated with sublobar resections. Current guidelines, including the NCCN recommendations, now support sublobar resections as a viable alternative in carefully selected patients. Despite these advancements, ongoing debates persist regarding the optimal patient selection criteria, appropriate application in central tumors, management of tumors larger than 2 cm, and the significance of tumor features such as tumor spread through airspaces (STAS) and the consolidation-to-tumor ratio (CTR). Further investigation is required to refine patient selection and surgical techniques, particularly to clarify whether segmentectomy confers advantages over wedge resection and to determine the necessity and extent of mediastinal lymph node staging. This review critically examines historical and contemporary evidence

informing the role of sublobar resections and highlights areas needing further research to optimize outcomes for early-stage NSCLC patients.

Keywords: lung cancer; early stage; wedge resection; segmentectomy; sublobar resection; survival

1. Introduction

Lung cancer remains a leading cause of cancer-related mortality worldwide, responsible for more deaths annually than breast, bladder, and colorectal cancers combined [1]. Despite advances in diagnosis and treatment, the prognosis for patients with lung cancer is often poor, with five-year survival rates significantly lower compared with other common malignancies [2]. For patients with early-stage disease, surgery remains the cornerstone of treatment, offering the best chance for long-term survival [3].

The primary objective of surgery in lung cancer is to achieve complete resection of the tumor while minimizing the risk of recurrence. Historically, this has involved lobectomy or pneumonectomy, depending on the tumor's size and location. However, these procedures come at the cost of significant morbidity, including impaired pulmonary function, prolonged recovery, and, in some cases, mortality. Therefore, a key challenge in lung cancer surgery is finding a balance between the extent of resection necessary to ensure oncologic efficacy and the morbidity associated with the operation. This issue is particularly pronounced in patients with limited pulmonary reserve or other comorbidities, who may be at higher risk of postoperative complications.

Another factor complicating surgical decision-making is the increased risk of second primary lung cancers in this patient population. As lung cancer patients often have underlying smoking-related lung disease, preserving lung volume for potential future treatments is a critical consideration. This has led to growing interest in sublobar resections, such as segmentectomy or wedge resection, as potentially less morbid alternatives to lobectomy in appropriately selected patients. While these approaches offer the advantage of lung preservation, questions remain about their long-term oncologic outcomes, specifically the risk of recurrence and overall survival compared with more extensive resections.

The surgical management of early-stage lung cancer, therefore, requires careful consideration of both immediate and long-term factors: The need to achieve an oncologically sound resection while preserving enough lung function for future treatments. This tension is at the heart of ongoing debates surrounding sublobar resection, especially in light of evolving evidence from landmark studies [4]. In the following sections, we review the history and development of sublobar resection as a treatment strategy for early-stage lung cancer, starting with the period before the pivotal 1995 Lung Cancer Study Group (LCSG) trial [5] and progressing through to the findings of more recent trials, including the JCOG 0802 and CALGB 140503 studies [6,7].

2. Pre-1995 studies on sublobar resection in early-stage lung cancer

Before the pivotal LCSG trial in 1995, evidence on the optimal surgical management of early-stage NSCLC was evolving. The role of sublobar resections, such as wedge resection or segmentectomy, was explored in a number of studies, although these procedures were often viewed as

less effective than lobectomy due to concerns about local recurrence. Although viewed as inferior, they were reserved for patients with prohibitive lung function.

In the 1980s, several studies examined the outcomes after surgical resection in early-stage lung cancer patients. Immerman et al. analyzed early Stage I or II lung cancer including T1-2, N0-1 patients to evaluate the likelihood and distribution of disease recurrence over 5 years [8]. Interestingly, distant recurrence was more frequently observed as the first site of recurrence in the node-negative patients. In the patients with node-positive disease, overall recurrence was higher but also more likely to be locoregional before systemic. Criticism of this study centered on whether the mediastinum was staged appropriately at the time of surgery. Another study by the Lung Cancer Study Group from 1984 focused on patients with Stage I NSCLC who underwent complete resection [9]. In this study, recurrence rates and sites of recurrence were analyzed, and they observed that even in patients with early-stage disease, the majority of recurrences involved distant sites, with the brain being the most common site of failure, regardless of the tumor stage or histology. This early work helped frame the understanding that disease recurrence, both locally and distant, was a significant concern even after ostensibly curative surgery, which drove many to conclude that more radical resection was preferred.

Others, however, questioned whether sublobar resections were as effective as lobectomy in preventing recurrence. Jensik et al. (1973) and others began advocating for segmentectomy as an alternative to lobectomy for patients with small, peripheral tumors, citing the theoretical advantages of preserving lung function [10,11]. However, many surgeons remained cautious, as it was unclear whether these smaller resections would result in higher local recurrence rates. As a result, wedge resection and segmental resection were often reserved for “poor-risk” patients. Interestingly, several of these studies noted no statistical difference in actuarial survival up to 6 years after surgery [12–15]. These pre-1995 studies laid the groundwork for the randomized trials that followed, culminating in the 1995 LCSG trial, which definitively compared lobectomy with sublobar resection in patients with early-stage lung cancer.

3. The Lung Cancer Study Group trial (1995)

The LCSG trial, published in 1995, was a landmark study that fundamentally shaped the surgical management of early-stage NSCLC [5]. The trial directly addressed the longstanding debate over whether sublobar resections, such as segmentectomy or wedge resection, could provide comparable oncologic outcomes to lobectomy, the gold standard at the time.

Prior to the LCSG trial, there had been anecdotal and observational evidence suggesting that sublobar resections might be as effective as lobectomy for small, peripheral tumors [10,11]. Advocates of limited resection argued that it could preserve lung function, reduce perioperative morbidity, and allow for future resections in patients at high risk for a second lung cancer. However, these advantages had to be weighed against the potential for increased locoregional recurrence and decreased long-term survival.

The LCSG trial was a prospective, multi-institutional randomized study designed to settle these questions. It enrolled 276 patients with peripheral T1 N0 NSCLC and randomized them to either lobectomy or sublobar resection (either wedge resection or segmentectomy). The primary endpoints included locoregional and distant recurrence rates, five-year survival, perioperative morbidity and mortality, and long-term pulmonary function.

The findings of the LCSG trial were unequivocal. Patients who underwent sublobar resection had a significantly higher locoregional recurrence rate compared with those who underwent lobectomy. Specifically, there was a 75% increase in recurrence rates, largely driven by a tripling of the local recurrence rate in the sublobar group ($p = 0.008$). Moreover, there was a 30% increase in overall mortality and a 50% increase in cancer-related death in the sublobar group, though these findings approached (but did not reach) statistical significance ($p = 0.08$ and $p = 0.09$, respectively) [5]. Importantly, sublobar resection did not confer any advantage in terms of perioperative morbidity, mortality, or late postoperative pulmonary function.

On the basis of these results, the LCSG concluded that lobectomy should remain the surgical standard for patients with peripheral T1 N0 NSCLC even though LCSG was designed to prove the equivalence of sublobar resection to lobar resection [5]. The LCSG confirmed that sublobar resection had a significantly higher chance of local recurrence and less chance of overall survival and disease-free survival, while both groups had no significant different postoperative complications. Meanwhile, the theoretical benefit of preserving pulmonary function in sublobar resection was not realized in the LCSG trial. This study firmly established lobectomy as the procedure of choice for early-stage lung cancer despite several notable limitations to the study. A key limitation of the LCSG trial was the usage of chest reoentgenograms (CXR) instead of computed tomography (CT) as the screening imaging of choice. CXRs offered limited anatomical details of the tumor's location within a specific segment of the lung. Patients probably would not be candidates for segmentectomy or wedge resection in later trials according to CT imaging but could be randomized to sublobar resection in this LCSG trial, which created a selection bias against sublobar resection.

4. Key studies and developments (1995–2009)

In the years following the LCSG trial, these findings were widely accepted and heavily influenced clinical practice [16]. However, questions persisted, particularly in light of advances in imaging, surgical techniques, and radiation therapy. The year 2011 was the first that the National Comprehensive Cancer Network (NCCN) Clinical Practice Guidelines in Oncology (NCCN Guidelines®) recommended thorax CT over chest X-rays for lung cancer screening [17]. Surgical management was centered on anatomic R0 resection and mediastinal staging, as recommended by the NCCN. The NCCN guidelines were updated in 2023 to provide specific indications for sublobar resection in NSCLC. Several observational studies in the late 1990s and early 2000s began to question its conclusions, particularly the necessity of lobectomy for all early-stage NSCLC patients. These studies primarily focused on small, peripheral tumors, suggesting that in carefully selected patients, sublobar resections, such as segmentectomy, might offer equivalent survival outcomes without the associated morbidity of more extensive resections.

4.1. Observational studies

Kodama et al. (2016) reported on 312 patients with clinical (c-) T1a N0 M0 NSCLC, detected as a part-solid ground-glass nodule or purely solid nodule [18]. Using propensity matching, their study found no significant difference in surgical approach, documenting similar 5-year and 10-year overall survival rates, as well as no significant difference in the overall survival ($p = 0.442$) or local-regional recurrence-free survival ($p = 0.717$) between the two groups. Okada et al. (2006) compared the

outcomes of nonrandomized patients with peripheral cT1N0M0 NSCLC of 2 cm or less who were able to tolerate a lobectomy [19]. In that study, 262 patients receiving sublobar resection demonstrated similar overall and disease-free survival to 305 patients receiving lobectomy (median follow-up of more than 5 years). Nakamura et al. (2005) performed a meta-analysis comparing the outcomes of segmentectomy versus lobectomy for Stage I NSCLC [20]. This meta-analysis found no significant differences in survival or local recurrence rates between the two surgical approaches, adding further support to the idea that sublobar resection could be a viable alternative for early-stage tumors in select patients. A similar systematic review and meta-analysis of sublobar resections versus lobectomy for NSCLC considered the patient selection process to compare “intentionally selected” and “compromised” patients who underwent sublobar resections versus lobectomies [21]. Their results suggested that segmentectomies were a “feasible alternative” for patients who could tolerate either procedure. However, the analysis highlighted the importance of patient selection and emphasized the need for further prospective randomized trials.

4.2. Advances in imaging and staging

During the early 2000s, the introduction of high-resolution computed tomography (CT) and positron emission tomography (PET) significantly improved preoperative staging accuracy [22]. This advancement allowed for better identification of early-stage tumors and more precise selection of patients who might benefit from lung-sparing surgery, potentially reducing the risk of local recurrence following sublobar resection. By identifying patients with truly localized disease and smaller tumors, surgeons could more confidently opt for sublobar resections in specific cases. The landmark the National Lung Screening Trial (NLST) from the United States confirmed that screening with low-dose CT reduces mortality from lung cancer [23]. This finding was confirmed again in the NELSON trial from the Netherlands. CT imaging was established as the diagnostic imaging of choice for lung cancer [24]. These studies established the platform for contemporary lung screening protocols.

4.3. Emergence of video-assisted thoracoscopic surgery

The development and widespread adoption of video-assisted thoracoscopic surgery (VATS) in the 2000s played a significant role in changing the surgical landscape for early-stage lung cancer. VATS allowed for minimally invasive sublobar resections, potentially reducing the morbidity associated with open thoracotomy and accelerating postoperative recovery. As VATS gained traction, it became a preferred method for performing both lobectomies and sublobar resections in appropriately selected patients [25]. This technological advancement likely contributed to the increased interest in and acceptance of sublobar resection as a viable treatment option for small, peripheral tumors. The VIOLET trial is a more contemporary prospective trial which demonstrated the improved recovery of physical function using VATS surgery with equivalent oncologic outcomes [26].

4.4. Groundwork for new trials

By the mid-2000s, accumulating evidence from observational studies, meta-analyses, and prospective trials suggested that sublobar resection might be appropriate for select patients with small, peripheral tumors [27–30]. Advances in imaging and surgical techniques, particularly with the

emergence of VATS, allowed surgeons to perform less invasive procedures while maintaining oncologic control. This shift in thinking set the stage for the design and initiation of new randomized controlled trials, including the Japanese Japan Clinical Oncology Group (JCOG) 0802 and the North American CALGB 140503 trials, which aimed to definitively compare lobectomy with sublobar resection in early-stage NSCLC.

5. JCOG 0802 and CALGB 140503: Defining the role of sublobar resection

The accumulating evidence from observational studies and smaller trials prompted the design of two large, randomized controlled trials aimed at definitively comparing lobectomy with sublobar resection for early-stage NSCLC: The Japanese JCOG 0802 trial and the North American CALGB 140503 trial. These trials sought to challenge the conclusions of the 1995 LCSG trial, which had established lobectomy as the standard of care.

5.1. JCOG 0802

The JCOG 0802 trial was a multi-institutional Phase III randomized controlled trial conducted in Japan. It enrolled patients with Stage IA NSCLC (tumors ≤ 2 cm in diameter; consolidation-to-tumor ratio >0.5 ; located in the outer third of the pulmonary parenchyma) and randomized them to either lobectomy or segmentectomy [7]. The study protocol used thin-section CT to determine anatomical eligibility. In addition, intraoperative frozen section examinations of the mediastinal lymph nodes were mandated. The primary objective of the trial was to compare overall survival between the two groups, while secondary endpoints included postoperative respiratory function (up to 12 months), local recurrence rates, and postoperative morbidity.

The results of the JCOG 0802 trial, published in 2022, showed that a total of 1106 patients were enrolled, in which 554 patients were randomly assigned to the lobectomy group and 552 patients to the segmentectomy group [7]. The 5-year overall survival was 94.3% for segmentectomy and 91.1% for lobectomy (hazard ratio (HR), 0.663; 95% confidence interval (CI), 0.474–0.927, $p < 0.0001$ for noninferiority, $p = 0.0082$ for superiority). In fact, segmentectomy was associated with a slight but statistically significant improvement in overall survival compared with lobectomy. This surprising finding challenged the longstanding belief that lobectomy was superior for oncologic control. However, the study also found that segmentectomy was associated with a significantly higher locoregional recurrence rate compared with lobectomy (11% vs 5%, $p = 0.0018$), although this did not translate into worse survival outcomes. The 5-year relapse-free survival was similar in the segmentectomy and lobectomy groups (88% vs 87.9%; HR, 0.998; CI, 0.753–1.323). Both groups had similar immediate postoperative complications. Additionally, segmentectomy patients experienced better postoperative pulmonary function, consistent with the lung-sparing advantage of this approach. The pulmonary function was measured in terms of the reduction in Forced Expiratory Volume in 1 Second (FEV1) at 6 months and 12 months. The segmentectomy group had less reduction in FEV1 at 6 and 12 months compared with the lobectomy group. However, the difference between the groups did not reach statistical significance.

The JCOG 0802 trial was pivotal in showing that for patients with small, peripheral NSCLC, segmentectomy could provide similar survival outcomes to lobectomy, with the added benefit of lung

preservation [7]. These results reinforced the notion that, in carefully selected patients, sublobar resection could be a reasonable alternative to lobectomy.

5.2. CALGB 140503 (*Alliance for Clinical Trials in Oncology*)

The CALGB 140503 trial, conducted in the United States, Canada, and Australia, was another multi-center Phase III randomized controlled trial designed to compare lobectomy with sublobar resection (either segmentectomy or wedge resection) in patients with small (≤ 2 cm) peripheral NSCLC [6]. The primary endpoint was to evaluate disease-free survival, with secondary outcomes focused on overall survival, recurrence patterns, pulmonary function, and quality of life.

Like JCOG 0802, the CALGB 140503 trial was designed in response to the growing body of evidence suggesting that sublobar resection might be appropriate for select patients [6]. However, the trial had broader inclusion criteria, as it allowed both segmentectomy and wedge resection as the sublobar options. CALGB 140503 was able to recruit 697 patients, in which 340 patients were randomized to sublobar resection and 357 to lobectomy. Among the 340 patients in the sublobar resection arm, 201 (59.1%) underwent wedge resection and 129 (37.9%) underwent segmentectomy. Intraoperative frozen sections of mediastinal lymph nodes were also mandated to confirm the N0 status.

The results of CALGB 140503, published in 2023, showed no significant difference in disease-free survival or overall survival between patients who underwent lobectomy and those who underwent sublobar resection [6]. The 5-year disease-free survival was 63.6% after sublobar resection and 64.1% after lobectomy (HR, 0.99; 90% CI, 0.80–1.21). The 5-year overall survival was 80.3% after sublobar resection and 78.9% after lobectomy. The disease recurrence rate was 30.4% after sublobar resection and 29.3% after lobectomy (HR, 1.05; 95% CI, 0.80–1.39). Locoregional recurrence was 13.4% after sublobar resection and 10% after lobectomy. As in the JCOG 0802 trial, there was a slight increase in locoregional recurrence in the sublobar group, but this difference was not statistically significant. The study also confirmed that sublobar resection preserved pulmonary function better than lobectomy in terms of preserving postoperative FEV1 and Forced Vital Capacity (FVC) on pulmonary function test. Patients who underwent sublobar resection experienced fewer postoperative complications and shorter hospital stays.

5.3. *Implications of JCOG 0802 and CALGB 140503*

The combined findings of JCOG 0802 and CALGB 140503 have shifted the paradigm in the surgical management of early-stage NSCLC. These trials provide high-level evidence that sublobar resection can achieve survival outcomes equivalent to lobectomy in patients with small, peripheral tumors, while offering the added benefits of lung preservation and reduced postoperative morbidity. However, both trials also highlighted the increased risk of locoregional recurrence with sublobar resection, underscoring the need for careful patient selection.

The results of these trials have led to a re-evaluation of the role of lobectomy as the default surgical approach for early-stage lung cancer [31,32]. In patients with small (≤ 2 cm), peripheral tumors, particularly those with limited pulmonary reserve, sublobar resection is now considered a viable alternative. The improved quality of life and pulmonary function, combined with comparable long-term survival, make sublobar resection an attractive option for select patients. The NCCN

guidelines for NSCLC now recommend that sublobar resection (segmentectomy and wedge resection) should be “strongly considered” for peripheral T1ab N0 tumors [33].

6. Unanswered questions

The question of whether wedge resection or segmentectomy is superior in managing early-stage NSCLC remains unresolved. Both techniques have been shown to provide comparable long-term survival when compared with lobectomy, as demonstrated in recent trials such as JCOG 0802 and CALGB 140503 [6,7]. However, a 2024 study by Towe et al. using data from the Society of Thoracic Surgeons (STS) database found no significant difference in overall survival between wedge resection and segmentectomy in patients with Stage IA NSCLC [33]. These findings were similar to a post hoc analysis of the CALGB 140503 study [34]. Importantly, wedge resection was associated with lower perioperative morbidity, making it a potentially safer option for high-risk patients.

Despite previous studies suggesting better locoregional control with segmentectomy, the findings from Towe et al. challenge this view by demonstrating comparable outcomes between the two approaches [35]. However, the risk of nodal metastasis was higher in segmentectomy, reflecting more extensive nodal dissection. While these results suggest that wedge resection may be favorable in selected patients, the choice between the two techniques should be individualized, considering factors such as tumor location, patient comorbidities, and the need for thorough nodal evaluation.

Many authors have focused on identifying higher risk patients with small, peripheral Stage IA NSCLC who would benefit more from lobectomy than sublobar resection. Tumor spread through airspaces (STAS) was a histologic feature associated with high recurrence. Li et al. performed a meta-analysis using 13 articles with 5947 pooled patients to study the disease-free survival and overall survival in patients with Stage I NSCLC and STAS after lobectomy and sublobar resection. Sublobar resection had significantly worsened recurrence-free survival and overall survival compared with lobectomy in this patient population (recurrence-free survival: HR, 2.59; 95% CI, 1.99–3.37, $p < 0.001$; overall survival: HR, 2.78; 95% CI, 1.92–4.02; $p < 0.001$) [36]. Eguchi et al. performed a propensity score-matched analysis in their retrospective study to compare sublobar resection with lobectomy in pT1N0M0 adenocarcinoma [37]. They found a significantly higher risk of recurrence and incidence of death after sublobar resection than lobectomy in patients with STAS. In patients without STAS, the recurrence rate and incidence of death were comparable after sublobar resection and lobectomy. Shiono et al. found similar results in their retrospective analysis. In Stage IA NSCLC after sublobar resection, STAS predicted significantly worsened recurrence-free survival and overall survival. In lobectomy patients, STAS did not reduce recurrence-free survival or overall survival [38].

Another tumor factor of interest is the consolidation-to-tumor ratio (CTR). Tumors dominated by ground-glass opacity (GGO) generally indicate a more favorable prognosis compared with solid-dominant tumors, which tend to behave more aggressively and have a higher rate of lymph node metastasis. This has led to a preference for more extensive resections, such as lobectomy, in managing solid-dominant tumors. A 2024 meta-analysis pooled data from 26 studies, encompassing 12,667 patients with T1 NSCLC, and examined two groups: tumors with a CTR of 1 and those with a CTR between 0.5 and 1 [39]. For tumors with a CTR between 0.5 and 1, there was no significant difference in overall survival between patients undergoing sublobar resection and lobectomy, although recurrence-free survival was lower after sublobar resection, consistent with the findings from the

CALGB and JCOG trials. However, for tumors with a CTR of 1, both overall survival and recurrence-free survival were significantly worse after sublobar resection compared with lobectomy.

In patients with T1 NSCLC, overall survival and recurrence-free survival were comparable between segmentectomy and lobectomy, consistent with the JCOG 0802 trial [39]. However, wedge resection was associated with significantly lower recurrence-free survival for tumors smaller than 2 cm, and reduced overall survival and recurrence-free survival for tumors between 2 and 3 cm. A further subgroup analysis suggested that in patients aged over 75, wedge resection had similar overall and recurrence-free survival compared with lobectomy. This meta-analysis, as well as other similar studies, highlights CTR as a potential high-risk indicator that may support recommending lobectomy over sublobar resection [40,41].

Several other unanswered and controversial questions remain following the JCOG 0802 and CALGB 140503 trials, particularly regarding the nuances of patient selection and surgical technique.

1. Extent of invasive mediastinal staging: CALGB 140503 mandated intraoperative frozen section analysis of mediastinal lymph nodes to confirm the N0 status, raising questions about the necessity and extent of invasive staging. The requirement for thorough nodal assessment, particularly in sublobar resections, remains debated. There is concern that less aggressive staging might increase the risk of understaging and lead to higher recurrence rates, particularly with wedge resections, which typically involve less nodal dissection than segmentectomies. Complete mediastinal staging remains the standard in lung cancer resection, despite trends in increasing sublobar resection, until more data are available.

2. Sublobar resection for central tumors: Another unresolved issue is the appropriateness of sublobar resection for centrally located tumors. Both JCOG 0802 and CALGB 140503 focused on small, peripheral tumors, leaving open the question of whether sublobar resections, especially segmentectomy, could be safely extended to central tumors without compromising the oncologic outcomes. This is particularly relevant, as segmentectomy may allow better preservation of lung function than lobectomy, but central tumors may require more extensive resections to achieve negative margins.

3. Tumors larger than 2 cm: The trials focused on tumors 2 cm or smaller, but the applicability of sublobar resection to larger tumors remains unclear. The outcomes of patients with tumors between 2 and 3 cm, or even larger, are less well defined, and there is a need for further studies to determine whether sublobar resections provide acceptable oncologic outcomes in this population.

4. Tumor STAS: As mentioned above, the significance of STAS in determining the extent of resection—particularly whether lobectomy is necessary for tumors exhibiting this characteristic—is a growing area of concern, and the current guidelines do not provide clear recommendations on how to manage these cases. Evidence from retrospective data suggested that lobectomy should be the operation of choice in Stage IA NSCLC with STAS. Prospective data are needed to further define the extent of resection in this patient population.

5. Segmentectomy vs wedge resection: Retrospective data show conflicting results for patients after segmentectomy and wedge resection. Many authors argued that segmentectomies offered better lymphadenectomy, which led to superior oncological outcomes. On the other hand, segmentectomies were technically more challenging than wedge resection, leading to higher postoperative complications. Currently, there is no randomized clinical trial directly comparing these two surgical techniques. Until then, the sublobar technique should be individualized and based on the surgeons' experience.

7. Conclusions

We have reached an exciting era where robust randomized clinical trial data support sublobar resection as an oncologically sound alternative to lobectomy in selected patients. The issues mentioned above still highlight that there remain many areas requiring further investigation to refine patient selection and improve the surgical outcomes. The decision for surgical techniques should be an integral part of the treatment discussion between surgeons and patients, and ideally should be part of a multidisciplinary tumor board discussion as well. Continued medical education of the medical community beyond thoracic surgeons on this issue is paramount to ensure that patients receive the state-of-the-art treatment.

Author contributions

Boxiang Jiang, Jock Thacker and Christopher W. Towe: Conceptualization and study design; Literature search and data curation; Manuscript drafting; Critical review and editing; Approval of final manuscript; Accountability for all aspects of the work.

Use of AI tools declaration

The authors declare they have not used artificial intelligence (AI) tools in the creation of this article.

Conflict of interest

The authors declare no conflicts of interest.

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