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Lobectomy or Sublobar Resection? Evidence-Based and AI-Enhanced Strategies for Early-Stage Non-Small Cell Lung Cancer

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ABSTRACT

Background. Lobectomy has historically been the gold standard surgical treatment for early-stage non-small cell lung cancer (NSCLC). However, the role of sublobar resections, particularly segmentectomy, has been redefined over the past decade, with recent randomized trials challenging traditional paradigms. In parallel, artificial intelligence (AI) is emerging as a transformative tool in thoracic surgery, offering new opportunities for preoperative risk stratification, surgical planning, and individualized treatment selection.

This review synthesizes current evidence comparing sublobar resections and lobectomy in early-stage NSCLC, examining both oncologic and functional outcomes, and explores the potential of AI and real-world data to refine surgical decision-making.

Methods. A narrative review of key randomized controlled trials, meta-analyses, and recent literature on AI in thoracic oncology was performed, emphasizing patient selection, risk assessment, and integration of AI-derived tools.

Results. Trials such as JCOG0802/WJOG4607L and CALGB 140503 demonstrate non-inferior survival with anatomical segmentectomy for selected tumors ≤2 cm, though higher locoregional recurrence rates in specific subgroups underscore the importance of patient selection. Functional preservation after segmentectomy is modest and not universally superior to lobectomy. AI applications—ranging from radiomics-based tumor characterization to machine learning–driven risk prediction—offer promising avenues to support nuanced surgical decisions, but prospective validation and clinical integration remain limited.

Conclusions. Surgical decision-making for early-stage NSCLC is evolving from a one-size-fits-all model toward precision strategies integrating oncologic, functional, and patient-specific factors. AI has the potential to enhance this process by providing individualized prognostic and functional predictions. Future research should focus on prospective evaluation of AI-assisted decision pathways, addressing barriers to adoption, and aligning surgical strategies with personalized cancer care.

Keywords: Artificial intelligence, segmentectomy, lobectomy, lung cancer, surgical decision-making, personalized medicine.

Introduction

Lobectomy has long been considered the gold standard treatment for early-stage non-small cell lung cancer (NSCLC). In 1973, Jensik and colleagues [1] were the first to propose that a lesser resection, specifically, segmentectomy, could be an appropriate surgical option for early-stage NSCLC, challenging the prevailing belief at the time that lobectomy was the default treatment for all lung tumors. Since then, segmental resection has often been regarded by surgeons as a "compromise" procedure, typically reserved for patients with limited pulmonary function, offering the benefit of better postoperative lung function and reduced risk of complications.

More than 50 years later, the optimal surgical approach for early-stage NSCLC remains a subject of ongoing debate. In recent years, the discussion has expanded beyond typical segmentectomies and lobectomies to include atypical pulmonary resections as well.

In recent years, beyond purely oncological and surgical factors, greater emphasis has been placed on tailoring the type of resection to the patient. This is particularly important in elderly, frail individuals with significant comorbidities, mainly respiratory, who may not tolerate aggressive surgery. In such cases, limited resections can offer a safer, more personalized approach without compromising overall outcomes.

Moreover, the evolving landscape of lung cancer management introduces important temporal considerations: advancements in imaging techniques, the growing role of artificial intelligence (AI), emerging surgical technologies, novel medical therapies, and the increasing integration of personalized medicine must all be taken into account when applying the findings of earlier studies to current clinical practice.

In particular, AI is poised to become a key element across multiple phases of NSCLC management: from the preoperative risk-assessment and patient selection, to the surgical planning, and even in the postoperative phase, where it may play a crucial role in predicting the risk of relapse. [2–4] Despite the promising results of AI implementation in thoracic surgery, its widespread adoption is still far from being routine clinical practice.

This article aims to review the current literature surrounding the ongoing debate on the comparative outcomes of sublobar resections versus lobectomies in early-stage NSCLC. Specifically, this review seeks to identify the most appropriate surgical approach through a dual lens:

1. From an oncologic perspective, the goal is to assess which type of pulmonary resection provides the most significant benefit in terms of overall survival and cancer-specific outcomes.
2. From a functional perspective, the goal is to evaluate how to best balance oncological radicality with individual clinical factors such as comorbidities and pulmonary function.

Particular attention is given to how real-world data and AI-augmented tools can inform and refine individualized therapeutic strategies by integrating these complementary dimensions and addressing the multidimensional nature of patient selection, enhancing preoperative risk stratification [5].

Surgical Decision Making

Surgical decision-making regarding the extent of pulmonary resection should not be guided solely by radiologic features or oncologic principles derived from clinical guidelines. Equally important are patient-specific, clinically relevant factors. Thus, a balanced approach is required, considering:

- tumor size, presence of spread through air spaces (STAS), and adequacy of surgical margins,
- pulmonary function and comorbidities,
- and the necessity to preserve pulmonary reserve whenever possible.

LESS IS MORE? REVISITING THE DEBATE ON SUBLOBAR RESECTION VERSUS LOBECTOMY IN EARLY-STAGE SOLID NSCLC

One of the earliest randomized controlled trials (RCTs), published in 1995 by the North American Lung Cancer Study Group, found that lobectomy was associated with better overall survival compared to both typical and atypical segmentectomies in early-stage NSCLC patients [6].

The currently available studies that allow for a meaningful comparison are limited in number and include only a few randomized controlled trials (RCTs), with a higher prevalence of retrospective studies (non-RCTs). These studies are all characterized by a high degree of heterogeneity in their findings, likely due to variability in surgical expertise, patient comorbidities, and tumor characteristics across different centers [7].

Lobectomy has traditionally been regarded as the standard surgical approach for early-stage lung cancer. However, the Japanese randomized controlled trial JCOG0802/WJOG4607L, published in 2022, was the first phase III study to report non-inferior overall survival (OS) outcomes with anatomical segmentectomy compared to lobectomy in patients with clinical T1aN0 2 cm or less in size [8]. Based on this conclusion, anatomical (typical) segmentectomy should become the standard surgical procedure for stage IA NSCLC as opposed to lobectomy.

Later, the CALGB 140503 trial demonstrated that, for peripheral NSCLC ≤ 2 cm and node-negative (N0), sublobar resection (including also non-anatomical resections) is non-inferior to lobectomy in terms of disease-free survival (DFS) and overall survival (OS). Anatomical segmentectomy emerges as the preferred option in lesions ≤2 cm, when technically feasible, whereas wedge resection should be reserved for very small tumors or medically fragile patients [9].

While overall survival (OS) and disease-free survival (DFS) are critical endpoints in evaluating surgical strategies for early-stage non-small cell lung cancer, locoregional control remains a key component of oncologic outcomes and should not be overlooked. In the CALGB 140503 trial, locoregional recurrence, defined as recurrence within the lung or hilar lymph nodes of the lobe, was reported in 13.4% of patients who underwent sublobar resection, compared to 10% in the lobectomy group. Although this difference did not reach statistical significance, it underscores the need for careful patient selection and thorough oncologic assessment when considering sublobar approaches.

In the post-hoc analysis of CALGB 140503, the authors found that disease-free and overall survival, the primary and secondary endpoints, were similar regardless of the extent of pulmonary resection, considering wedge resections (WR), segmental resections (SR), or lobar resections (LR) [10]. The difference in locoregional recurrence between wedge resections and segmental resections was neither statistically significant nor clinically meaningful. Freedom from loco-regional recurrence was 84.6% after SR and 82.7% after WR.

The results of this post-hoc analysis question the longstanding assumption that wedge resections are intrinsically inferior from an oncological standpoint. Their findings revealed no clinically significant differences between different resections in terms of survival outcomes or recurrence rates. Of course, there are substantial limitations to the results of this post-hoc analysis; for example, patients were not randomly assigned to the type of sublobar resection performed.

Accordingly, with this study, they make no recommendations for or against a specific type of sub-lobar resection but suggest that either modality is acceptable within the constraints defined by the trial (Table 1).

Table 1. Comparative summary of key randomized controlled trials on sublobar resection versus lobectomy in early-stage NSCLC. NSCLC = non-small cell lung cancer; OS = overall survival; DFS = disease-free survival.

Trial	Population	Inclusion Criteria	Intervention	Comparator	Primary Endpoint(s)	Key Findings
North American Lung Cancer Study Group (1995)	247 patients	T1N0 NSCLC	Sublobar resection (segmentectomy or wedge)	Lobectomy	Overall survival	Lobectomy superior for OS; sublobar resection had higher local recurrence rates.
JCOG0802/WJOG4607L (2022)	1,106 patients	Clinical T1aN0 ≤2 cm, predominantly solid tumors	Anatomical segmentectomy	Lobectomy	Overall survival	Segmentectomy non-inferior, with OS benefit in some subgroups; slightly higher locoregional recurrence; no major functional benefit at 1 year.
CALGB 140503 (Alliance) (2023)	697 patients	Peripheral NSCLC ≤2 cm, node-negative	Sublobar resection (segmentectomy or wedge)	Lobectomy	Disease-free survival (DFS), overall survival (OS)	Sublobar resection non-inferior for DFS and OS; no significant difference in locoregional recurrence; wedge resection outcomes comparable to segmentectomy in post-hoc analysis.

While the results of two randomized trials designed for non-inferiority suggest that segmentectomy is superior, the presence of moderate heterogeneity among randomized controlled trials, the different techniques of performing segmentectomies with particular attention paid to complex resection, functional aspects, local recurrence, and long-term cancer-specific survival, are at this time points that need further discussion [11].

INFLUENCE OF PATIENT DEMOGRAPHICS ON TYPE OF RESECTION

Patient demographics significantly influence the type of resection chosen for early-stage non-small cell lung cancer (NSCLC). Key demographic factors include:

- Age: Older patients may not tolerate extensive surgery (e.g., lobectomy). In elderly patients, less invasive resections (like segmentectomy or wedge resection) are often preferred to preserve lung function and reduce surgical risk.
- Frailty and performance status: Patients with poor functional status or general frailty are less likely to benefit from extensive resections and may experience major postoperative complications and mortality.
- Comorbidities: Especially respiratory or cardiovascular comorbidities. Limited resections are often selected for patients with chronic obstructive pulmonary disease (COPD), heart disease, or other conditions that compromise lung or systemic function.
- Pulmonary reserve: Lower baseline lung function (e.g., FEV1, DLCO) may lead surgeons to opt for sublobar resections rather than lobectomy.

In summary, the choice of resection is increasingly patient-centered, balancing oncologic efficacy with the patient's ability to tolerate surgery and recover effectively.

The post-hoc analysis of the JCOG0802/WJOG4607L trial [12] was conducted to explore the underlying factors contributing to the improved overall survival (OS) observed with segmentectomy compared to lobectomy.

Age and gender emerged as significant factors influencing survival outcomes. Improved overall survival following segmentectomy was generally observed in subgroups characterized by male sex, age ≥70 years, and non-adenocarcinoma histology. In contrast, relapse-free survival appeared to favor lobectomy, particularly among patients younger than 70 years and females.

In addition, the proportion of patients who had a locoregional recurrence after segmentectomy was significantly higher than after lobectomy among patients younger than 70 years or who were female; these associations were not seen among patients aged 70 years or older or males.

Therefore, thoracic surgeons must establish clinically meaningful indications for segmentectomy in patients with radiologically pure-solid NSCLC, carefully balancing the benefits of reduced surgical invasiveness with the need for effective oncologic control.

LUNG FUNCTION VS. ONCOLOGIC RADICALITY: DOES THE PATIENT PROFILE TIP THE BALANCE?

In addition to demographic characteristics, other variables that may influence the clinical decision regarding the most appropriate type of pulmonary resection include comorbidities and the patient's functional status.

Many lung cancer patients have a history of smoking, which predisposes them to additional conditions such as COPD and coronary artery disease, factors that elevate surgical risks. In some cases, a limited respiratory reserve may lead to poor postoperative quality of life. Therefore, clinicians must carefully assess the feasibility and risks of lung resection in patients facing multiple complicating factors [13].

A comprehensive preoperative assessment is crucial to determine surgical candidacy, anticipate potential complications, and optimize clinical outcomes. Although several techniques have been proposed to estimate postoperative lung function [14], a definitive quantitative validation of their accuracy and reliability remains lacking. Nevertheless, such estimations are integral to clinical decision-making, aiding in the selection between surgical resection and alternative treatment strategies [15].

The degree of pulmonary function loss is determined not only by the extent of the surgical resection but also by the functional status of the residual lung parenchyma [16].

The rationale behind recommending segmentectomy (anatomical or non-anatomical) in frail patients with early-stage NSCLC should primarily be the preservation of pulmonary function.

Due to the limited regenerative capacity of the adult lung, postoperative pulmonary function largely depends on the volume of lung parenchyma resected. While lobectomy induces anatomical displacement and compensatory expansion of the remaining lobes, it is generally associated with a greater reduction in FEV_1, reflecting increased airway resistance. In contrast, segmentectomy tends to preserve ventilatory mechanics better, as it spares more lung tissue. Similarly, changes in forced vital capacity (FVC) are proportionate to the volume of resection, with the residual lung partially compensating through expansion. Notably, segmentectomy is associated with a smaller decline in diffusing capacity of the lung for carbon monoxide (DLCO), suggesting superior preservation of alveolar-capillary surface area and overall pulmonary function compared to lobectomy [17].

On the other hand, the JCOG0802/WJOG4607L trial did not find the expected evidence of superiority in postoperative respiratory function in segmentectomies. Consequently, less lung parenchyma excision would not necessarily result in improved function preservation, which could be caused by less acceptable re-expansion of the residual lobe following segmentectomy [8].

The post-hoc analysis of CALGB 14050310 shows that at 6 months postoperatively, the median reduction in % FEV1 was 5% after WR and 3% after SR (p=0.930), with no significant difference in the decrease in FEV1.
Therefore, it is too early to define segmentectomy as the standard of care before we know how segmentectomies would benefit which subsets of patients [18].

Where Could Artificial Intelligence Improve the Patient's Preoperative Evaluation?

The preoperative assessment in thoracic surgery is undergoing a significant transformation, fueled by advancements in imaging modalities, pulmonary function testing, and perioperative management. In recent years, rapid progress in AI has led to its successful integration across multiple clinical domains, with a particularly notable impact in the diagnosis and management of lung cancer. AI contributes not only to enhancing diagnostic accuracy and efficiency but also to supporting clinical decision-making and optimizing patient care pathways [19].

IMAGING EVALUATION: LUNG CANCER SCREENING AND NODULE DETECTION

Recent advancements in imaging technologies and software have enabled high-resolution anatomical and functional assessments that were previously unattainable. AI is increasingly transforming medical imaging by streamlining workflows, improving diagnostic precision, and generating quantitative insights that surpass the limits of human interpretation [20].

With the continuous development of imaging and computer technology, X-ray computed tomography (CT) has been widely used in clinical practice, and population-based lung cancer screening has demonstrated high cost-effectiveness and significant value for early prediction in the community [19].

For example, within lung cancer screening, while a large number of manual image readings can lead to missed diagnoses, AI can be applied not only for automatic detection, but also for patient selection and the reconstruction of low-dose CT scans [21] Kim et al. [22] demonstrated that AI-based tools can enhance the diagnostic performance of radiologists and pulmonologists in estimating the malignancy risk of indeterminate pulmonary nodules on chest CT scans. Additionally, AI applications capable of predicting the likelihood of benign versus malignant nodules have also been developed [23]. Nevertheless, further studies are needed to validate the clinical utility and diagnostic impact of these AI-driven tools in the evaluation of indeterminate pulmonary nodules [24].

AI-ASSISTED SURGERY

Within the imaging field, AI algorithms can segment lung regions on CT scans with high precision and quantify emphysema, fibrosis, and tumor burden automatically [25].

Airway segmentation in volumetric CT scans is among the most challenging tasks in medical image processing. Yun et al. [26] explored the applicability of the deep learning technique to airway segmentation. Deep learning is expected to improve the diagnostic accuracy of radiologists by delivering a quantitative analysis of suspicious lesions. It also provides automatic report generation and voice recognition, both of which will benefit the clinical workflow and shorten the reading time.

Upon completion of airway segmentation, a range of quantitative assessments becomes feasible, including the evaluation of emphysema severity through low-attenuation area analysis, measurement of airway wall thickness to assess airflow obstruction, and calculation of total lung and vascular volumes. These imaging-derived biomarkers hold significant potential for predicting postoperative pulmonary function in patients with lung cancer [27].

3D reconstruction technology, increasingly used in AI-assisted surgery, enables detailed visualization of thoracic lesions and surrounding structures by generating 3D images from various modalities such as CT, MRI, or PET-CT data. This enhances reconstructions for preoperative planning and supports more accurate and confident surgical decision-making [19].

AI-driven reconstruction enables surgeons to achieve a high level of accuracy in identifying anatomical patterns within a short period, which has practical value in surgical planning for segmentectomy. By providing clear, patient-specific anatomical guidance, considering all the possible anatomic variations, this technology can help simplify technically demanding procedures, such as segmentectomy, making them more accessible and manageable compared to traditional approaches like lobectomy.

Beyond aiding surgical planning, these technologies also promote the use of minimally invasive techniques like VATS, enhancing the safety and feasibility of complex segmentectomies via a thoracoscopic approach, which is more convenient for both the surgeon and the patient, reducing surgical time.

Li et al. developed an AI-based 3D reconstruction system based on 3D CNNs, which significantly reduced operative time for both lobectomy and segmentectomy (by 24.5 min and 20 min, respectively), as well as reconstruction time compared to a manual reconstruction model [28].

With ongoing advances in AI, the future may see the emergence of AI-guided robotic surgery systems, AI-assisted biopsy and treatment platforms, and fully automated robotic procedures for lung cancer management.

PERSONALIZED TREATMENT PLANS

Surgical resection, radiation therapy, chemotherapy, and the developing immunotherapy are common treatment approaches for lung cancer. Despite having similar clinical characteristics, patients can exhibit significant individual differences in their response to the same treatment strategy.

These differences are, of course, attributable to patient-related characteristics and tumor-related features. AI-assisted preoperative assessment could help to evaluate and predict the treatment efficacy early for various treatment strategies.

AI models demonstrated radiologist-level performance in predicting visceral pleural invasion [29] and identifying early-stage lung adenocarcinoma suitable for sublobar resection [30].

For example, Yoshiyasu et al. 30 used a radiomics approach to investigate the efficiency of voxel-based histogram analysis of 3D computed tomography images for detecting less-invasive lesions suitable for sublobar resection. This method can highlight the radiological characteristics of individual tumors, such as the percentage of solid, skewness, and entropy, which cannot be distinguished by visual inspection, assisting physicians in decision-making and treatment planning.

PREOPERATIVE EVALUATION AND RISK-ASSESSMENT

Lobectomies for primary non-small cell lung cancer have a mortality rate of 2.3% compared with pneumonectomies, where it increased to 6.8% in specialized centers with high volume activity [31].

Consequently, proper preoperative evaluation is essential to assess surgical risk in candidates for lung resection. While the 2009 ESTS/ERS (European Society of Thoracic Surgeons/European Respiratory Society) and ATS (American Thoracic Society) guidelines provide recommendations for cardiopulmonary assessment [32], they do not fully address other comorbidities, such as diabetes, smoking history, or prior medical conditions, that may significantly affect postoperative outcomes.

AI has gained increasing attention in the field of preoperative risk assessment, leading to the development of numerous machine learning (ML) algorithms aimed at predicting major postoperative complications and mortality [33]. In addition, AI systems may support surgical decision-making by integrating both tumor-related factors and patient-specific characteristics to help determine the most appropriate type of resection. Prognostic insights are critical in surgical planning, as they inform both the appropriateness of the proposed intervention and its anticipated impact on short- and long-term patient outcomes.

In this context, AI-based tools have shown promising results, supporting clinical decision-making and contributing to the generation of integrated risk scores [34–36].

The first to try to find models to estimate postoperative prognosis following lung resection and to predict cardiopulmonary morbidity after pulmonary resection for NSCLC were Esteva et al. [35] and shortly thereafter, Santos-García et al. [36].

The use of innovative methodologies, such as Surgical Data Science (SDS), based on AI, could help extract knowledge from clinical data and overcome limitations inherent in medical registry analysis. Building on this, Salati et al. developed an ML model able to predict cardiopulmonary complications after lung resection (80.7% lobectomy) based on 50 patient characteristics (including demographic data, clinical data, laboratory tests, and surgical data) [37].

They have included in the same analysis several clinical features that have been poorly studied in the past for their association with postoperative complications, for example, BMI, Hb preop, TLC, pack-years, RV, PaO2, and PaCO2.

A key advantage of this AI-based approach is its ability to generate outcome predictions even when some preoperative variables are missing. While incomplete data may affect the model's reliability, prediction remains feasible, unlike traditional statistical models, which typically cannot produce results in the presence of missing inputs.

Chang et al. [38] examined pre-anesthetic consultations within the context of increasing digitalization in clinical practice. Their study highlights the potential of AI to utilize historical medical data for accurate, non-invasive risk prediction. The proposed AI-assisted model enables integrated risk assessment while allowing manual input from clinicians, ensuring adaptability to dynamic and diverse patient data.

Etienne et al. [34] focused on thoracic surgery, particularly lobectomies and pneumonectomies for non-small cell lung cancer. Their exploration of AI as a decision-making aid in surgical risk assessment and prognosis aligns with Change et al.'s emphasis on individualized medicine.

Topalovic et al. [39] demonstrated that AI outperformed pulmonologists in interpreting pulmonary function tests (PFTs) in a multicentre, non-interventional study involving 120 pulmonologists across 16 hospitals in five European countries. While guideline-concordant pattern recognition by pulmonologists occurred in $74.4 \pm 5.9\%$ of cases, and diagnostic accuracy was $44.6 \pm 8.7\%$, AI achieved 100% concordance in pattern interpretation and 82% diagnostic accuracy. These findings underscore the potential of AI to enhance clinical practice.

Overall, machine learning algorithms have demonstrated effectiveness in personalizing risk assessment, enhancing the accuracy of pre-anesthetic evaluations, supporting appropriate therapeutic and surgical planning, and improving the influence of patient-related characteristics on surgical decision-making. However, broader adoption will depend on AI's ability to address complex clinical scenarios, including the integration of comorbidities into decision-making.

Future Directions

Although the implementation of AI-based technologies in the operating room remains limited to date, their potential to enhance surgical precision, support intraoperative decision-making, and predict postoperative outcomes is promising [40]. Over the past two decades, surgical robotics has experienced significant growth, with minimally invasive techniques demonstrating reduced hospital stays and postoperative complications, and now serving as a cornerstone of enhanced recovery programs.

It is essential to distinguish that, despite often being associated with AI, robotic-assisted surgery is not inherently AI-based and requires continuous supervision by the surgeon. The scope of robot-assisted thoracic procedures has expanded to include lobectomies, mediastinal tumor resections, and esophagectomies. Among available platforms, the Da Vinci Robotic Surgical System (Intuitive Surgical Inc., Sunnyvale, CA, USA) is the most widely used. Robotic tele-manipulators provide surgeons with three-dimensional, magnified visualization and flexible instruments offering extensive freedom of movement, thereby improving surgical dexterity [41].

However, the absence of tactile feedback remains a significant limitation, potentially affecting surgical outcomes by causing suture breakage or failure, or because of the needing of a more assisted robotic procedure by the bedside surgeon. To address this, Dai et al. developed a biaxial haptic feedback system that alerts the surgeon when tension approaches the suture's failure threshold [42]. Machine learning models have also been applied to improve contactless gesture-recognition interfaces, reducing contamination risk in the surgical environment [43].

Additionally, the application of AI could facilitate the advancement of precision surgery and surgical training. ML algorithms have been proposed to accurately assess surgical skills, thereby providing feedback during learning curves and periodic evaluations [44].

Conclusions

The debate surrounding the most appropriate type of pulmonary resection for early-stage NSCLC remains open, reflecting the complexity of balancing oncological efficacy with patient-specific functional considerations. However, current advancements offer new opportunities to refine surgical decision-making. In particular, AI has emerged as a valuable tool capable of supporting clinicians across various phases of care, from preoperative risk stratification to postoperative outcome prediction. As demonstrated by the studies reviewed, AI holds the potential to enhance the individualization of surgical strategies by integrating a wide range of clinical variables, including comorbidities, pulmonary function, and patient frailty.

Traditionally, surgical decision-making has relied on hypothetical-deductive reasoning, heuristics, and individual clinical judgment, processes that, while essential, are susceptible to cognitive bias, error, and variability. Existing predictive tools and decision-support systems are often limited by their dependency on manual data input and modest predictive accuracy. In contrast, AI-driven models offer a promising alternative. These systems can automate data synthesis, improve predictive precision, and reduce clinician workload.

Nonetheless, successful integration of AI into surgical workflows will require overcoming essential challenges, including data standardization, improvements in model transparency and interpretability, and the development of ethical frameworks to address algorithmic bias and accountability. Crucially, AI must be viewed not as a replacement for clinical expertise but as a complement to it, enhancing, rather than substituting, the human elements of judgment, experience, and bedside assessment.

By responsibly incorporating AI into the decision-making process, thoracic surgeons can move toward a more precise, efficient, and patient-centered model of care, one that better aligns surgical interventions with both oncological goals and individual patient needs.

Conflict Of Interest Statement

The authors have no conflicts of interest to declare.

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