Systematic review and meta-analysis of factors predicting postoperative lung function after lung cancer resection

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KEY WORDS

computed tomography perfusion, computed tomography volume and density, lobectomy, lung cancer, postoperative pulmonary function

ABSTRACT

INTRODUCTION Lung resection continues to be the most effective treatment for early-stage lung cancer. Prediction of postoperative lung function is particularly important when evaluating patient eligibility for surgery, as it helps assess the likelihood of experiencing difficulty breathing after the operation.
AIM We aimed to identify the most common methods used to predict postoperative lung function in clinical practice and to compare their accuracy.
MATERIALS AND METHODS A systematic review and meta-analysis were performed to synthesize research focused on the prediction of postoperative lung function. A total of 10 studies were included in the analysis. The Cochrane risk of bias tool was utilized to evaluate the risk of bias in the studies. Additionally, a meta-analysis of the mean difference between the predicted and measured values of forced expiratory volume in 1 second (FEV_1) was conducted. The I^2 value was computed as a metric of coherence among studies, while funnel plots and the Begg test were used to evaluate the likelihood of publication bias.
RESULTS The analyzed studies had a low risk of bias. The meta-analysis showed that computed tomography (CT) volume and density measurement had the highest level of accuracy for predicting postoperative FEV_1, with a mean difference between the predicted and actual value of 83 ml (95% CI, 41–116).
CONCLUSIONS The results indicate that using CT volume and density is the optimal method for predicting postoperative FEV_1. Additional research is necessary to establish the connection between the type of surgical procedure, adopted thresholds, and outcomes reported by patients.

INTRODUCTION Non–small cell lung cancer (NSCLC) is a collective term that refers to several types of lung malignancies, such as squamous cell carcinoma and adenocarcinoma, which share comparable characteristics and behaviors.[1,2] The symptoms encompass chronic cough, respiratory distress, involuntary weight loss, and hemoptysis.[3] Primary therapeutic interventions include surgery, chemotherapy, and radiation treatment.[4] Surgical excision with curative intent is the recommended therapy for stage I and II NSCLC.[5] The 5-year survival rate for regional NSCLC that has spread to nearby tissues or lymph nodes is 35%. In contrast, the 5-year survival rate for metastatic NSCLC is 7%.[6] Patients referred for invasive treatment require a comprehensive preoperative assessment. It involves evaluation of the transfer factor for carbon monoxide (TL_{CO}), also known as diffusing capacity, which is a pulmonary function test that measures the capacity of the lung to absorb oxygen from breathed air,[7] and forced expiratory volume in 1 second (FEV_1), which refers to the greatest amount of air that an individual may forcibly exhale during the first second after taking a deep breath.[8] The predicted postoperative values of FEV_1 and TL_{CO} are also used to estimate the risk of mortality and impaired lung function after surgery, with a percentage of predicted value in the range of 30% to 60% indicating that a patient requires further evaluation to confirm their eligibility for surgery.[9,10]

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To date, the accuracy and precision of the many methods that are purported to predict postoperative lung function have not been systematically assessed. Prediction plays a crucial role in guiding important therapeutic decisions, such as whether to proceed with surgical resection or opt for other treatment methods (eg, chemotherapy or radiation). When curative medical therapies are insufficient, surgical resection remains the primary method of treatment for cancer patients. Its aim is to achieve a complete resection with secure margins by removing the affected tissue, a portion, or the entirety of an organ. Lung resection is a surgical procedure used to treat pulmonary infections, emphysema, bronchiectasis, or cancer by removing the entire lung or its portion. It can be performed using minimally invasive techniques or via open surgery. In contrast, chemotherapy employs cytotoxic pharmaceuticals administered intravenously to selectively eliminate cancer cells from various anatomical sites, whereas radiation therapy utilizes high-energy beams (eg, X-rays or proton therapy) to specifically target and eradicate cancer cells at the site of the tumor.[11,12] Patient counseling entails making predictions regarding the operative risk, and a comprehensive analysis has shown that a significant proportion of patients with resectable malignancies do not view resection as their preferred treatment option.[13,14] Moreover, predictions of a high operative risk might potentially lead to postponement of therapy in order to accommodate further investigations, such as evaluation of cardiopulmonary endurance.[15,16] Therefore, it is necessary to explicitly compare the methods used for prediction.

AIM The purpose of this study was to identify the optimal strategy for the prediction of postoperative lung function following lung cancer resection by a systematic review and meta-analysis of relevant observational studies[17-26] chosen based on predefined inclusion exclusion criteria.

MATERIALS AND METHODS Following the guidelines defined in the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement,[27] this study encompassed a systematic review and meta-analysis of factors employed to predict postoperative lung function in patients undergoing lung cancer resection.

All procedures performed in the study were in accordance with the institutional and / or national research committee standards and with the 1964 Helsinki Declaration and its later amendments, or comparable ethical standards.

Search strategy and study selection The present meta-analysis was conducted following a comprehensive search of major databases, including Embase, PubMed, Scopus, and the Cochrane Library. The search approach incorporated key words related to lung surgery, lung function measurement, postoperative period, and prediction or correlation. The following search terms were used: *thoracic surgery*, *lung cancer*, *lung function*, *postoperative lung function*, *lung cancer resection*, *computed tomography* or *CT*, *CT volume and density*, *forced expiratory volume in 1 s* or *FEV$_1$*, *lobectomy*, *pneumonectomy*, *perfusion scintigraphy*, *CT perfusion*, *single photon emission computed tomography* or *SPECT*, *segment counting*, *mean difference*, *ventilation scintigraphy*, *meta-analysis*, and *systematic review and meta-analysis*. Following the Population, Intervention, Comparison, Outcomes and Study (PICOS) criteria, we identified and assessed the key words for their agreement in both the Embase and Medline databases (**TABLE 1**). The specified key words were entered into the title / abstract / keyword field during the Scopus search. In the Cochrane database, we searched for papers related to postoperative lung function, prediction techniques, and lung cancer resection.

Using predetermined search criteria, we aimed to identify studies that evaluated the accuracy of various predictive factors in assessing postoperative pulmonary function in patients diagnosed with lung cancer, as measured by the standard mean difference between the predicted and measured FEV$_1$ values. The criteria for study selection were based on the PICO framework[28] (Population referred to individuals diagnosed with lung cancer; Intervention referred to prediction methods; Comparison represented the control, and Outcomes referred to standard mean difference between the measured and projected FEV$_1$ value). Only observational studies were considered for analysis. There were no restrictions or limitations with respect to the language, date of publication, or any other study feature. To identify the pertinent publications, 2 investigators (LH and QZ) conducted a comprehensive individual review of the whole corpus of relevant scientific literature. The same 2 investigators conducted a separate analysis of titles and abstracts of the identified publications to find all that potentially met the criteria for inclusion, and independently assessed their whole content to ascertain suitability. Disputes over eligibility were resolved by consensus, with the inclusion of a third reviewer, if necessary. Studies that were assessed to have a minimal risk of bias were included in the meta-analysis.

Inclusion and exclusion criteria The inclusion criteria were as follows: 1) study population comprising adults with a suspected or confirmed diagnosis of primary lung cancer; 2) the procedure performed was lung resection with curative intent (pneumonectomy, lobectomy, segmentectomy, or wedge resection); and 3) lung function assessment was performed before and after the operation using at least 2 methods to predict postoperative lung function and evaluate the accuracy of the predictions. Studies that included both patients with benign and malignant tumors were considered suitable if a majority of the participants had primary lung cancer. Studies involving surgical procedures related to benign cancer,

TABLE 1 Database search strategy

Database	Search strategy
Scopus	1 *Thoracic surgery* OR *lung cancer* OR *lung function* OR *postoperative lung function* OR *lung cancer resection* OR *computed tomography* OR *CT* OR *CT volume and density* OR *forced expiratory volume in 1 s* OR FEV_1 OR *lobectomy* OR *pneumonectomy* OR *perfusion scintigraphy* OR *CT perfusion*
	2 *Single photon emission computed tomography* OR *SPECT* OR *segment counting* OR *mean difference* OR *ventilation scintigraphy* OR *meta-analysis* OR *systematic review and meta-analysis*
	3 #1 AND #2
PubMed	1 *Thoracic surgery* OR *lung cancer* OR *postoperative lung function* (MeSH terms) OR *lung function* OR *lung cancer resection* OR *computed tomography* OR *CT* (all fields) OR *CT volume and density* OR *forced expiratory volume in 1 s* (all fields) OR FEV_1 OR *lobectomy* (all fields) OR *pneumonectomy* (all fields) OR *perfusion scintigraphy* (all fields) OR *CT perfusion* (all fields)
	2 *Single photon emission computed tomography* OR *SPECT* OR *segment counting* (MeSH terms) OR *mean difference* OR *systematic review and meta-analysis* OR *meta-analysis* (all fields)
	3 #1 AND #2
Embase	1 *Thoracic surgery*/exp OR *lung cancer*/ exp OR *postoperative lung function*/exp OR *lung function*/exp OR *lung cancer resection*/exp OR *computed tomography*/exp OR *CT* /exp OR *CT volume and density*/exp OR *forced expiratory volume in 1 s*/exp OR FEV_1/exp OR *lobectomy*/exp OR *pneumonectomy*/exp OR *Perfusion scintigraphy*/exp OR *CT perfusion*/exp
	2 *Single photon emission computed tomography*/exp OR *SPECT*/exp OR *segment counting*/exp OR *mean difference*/exp OR *meta--analysis*/exp OR *systematic review and meta-analysis*
	3 #1 AND #2
Cochrane library	1 *Thoracic surgery*: ti, ab, kw OR *lung cancer*: ti, ab, kw OR *postoperative lung function*: ti, ab, kw OR *lung function*: ti, ab, kw OR *lung cancer resection*: ti, ab, kw OR *computed tomography* OR *CT volume and density*: ti, ab, kw OR *forced expiratory volume in 1 s*: OR FEV_1: ti, ab, kw OR *lobectomy*: ti, ab, kw OR *pneumonectomy*: ti, ab, kw OR *perfusion scintigraphy*: ti, ab, kw OR *CT perfusion* (word variations have been searched)
	2 *Single photon emission computed tomography*: ti, ab, kw OR *SPECT*: ti, ab, kw OR *segment counting*: ti, ab, kw or *mean difference*: ti, ab, kw OR *meta-analysis*: ti, ab, kw OR *systematic review and meta-analysis* (word variations have been searched)
	3 #1 AND #2

Abbreviations: exp, explosion in Emtree—searching of selected subject terms and related subjects; MeSH, Medical Subject Headings; ti, ab, kw, title, abstract, or key word field

palliative care, diagnostic purposes, emergencies, and bronchoscopy alone were excluded.

Risk of bias evaluation The assessment of bias was conducted using a Cochrane Collaboration approach outlined in the Cochrane Handbook (version 5.3).[29] The instrument has 7 components, including one that evaluates bias resulting from confounding. This study analyzed the following types of bias: measurement bias in assessing exposure, bias in selecting participants for the study, bias resulting from treatments after exposure, bias due to missing data, measurement bias in assessing the outcome, and bias in selecting the reported results. Two reviewers (LH and QZ) undertook an impartial evaluation to detect any potential bias. WL, who served as an arbitrator, was responsible for resolving any outstanding issues. Ultimately, the possible bias was assessed and categorized as either "uncertain risk," "high risk," or "low risk."

Data management and evidence synthesis For the purpose of documenting extracted data from eligible studies and risk of bias assessment, a predesigned electronic form was utilized. The extracted information comprised the following: study authors and year of publication, publishing journal, country where the study was conducted, total participant count, sample size, participant age and sex, procedure type, predictive factors, time to postoperative lung function assessment, primary outcomes, and statistical analysis. One investigator performed independent data extraction, while a second one verified the data. Any inconsistencies were handled by consensus with a third investigator, if needed. The primary summary measurements included the mean difference between measured and predicted postoperative lung function and the standard deviation of the mean difference. Meta-analysis of standard mean difference was performed using the generic inverse variance method in RevMan software, version 5.4,[30] and forest plots[31] were created to evaluate the influence of outcome drivers. The I^2 value[32] was calculated as a measure of consistency across studies, and funnel plots[33] and the Begg test[34] were used to assess the risk of publication bias.

RESULTS **Included studies** The search was conducted via inclusive computer-aided scanning of numerous databases, yielding 112 publications that met the PICOS inclusion-exclusion criteria. A total of 25 items were excluded due to duplication, leaving 87 articles. Subsequently, 28 items were removed owing to irrelevant titles and abstracts, whereas 59 articles were further examined. Following screening, 35 records were assessed for eligibility. Of them, 24 were removed because they did not meet the inclusion criteria, had insufficient data to enable generation of 2 × 2 tables, or lacked important outcome measures. Finally, 10 observational studies published between 2000 and 2023 were included in the meta-analysis

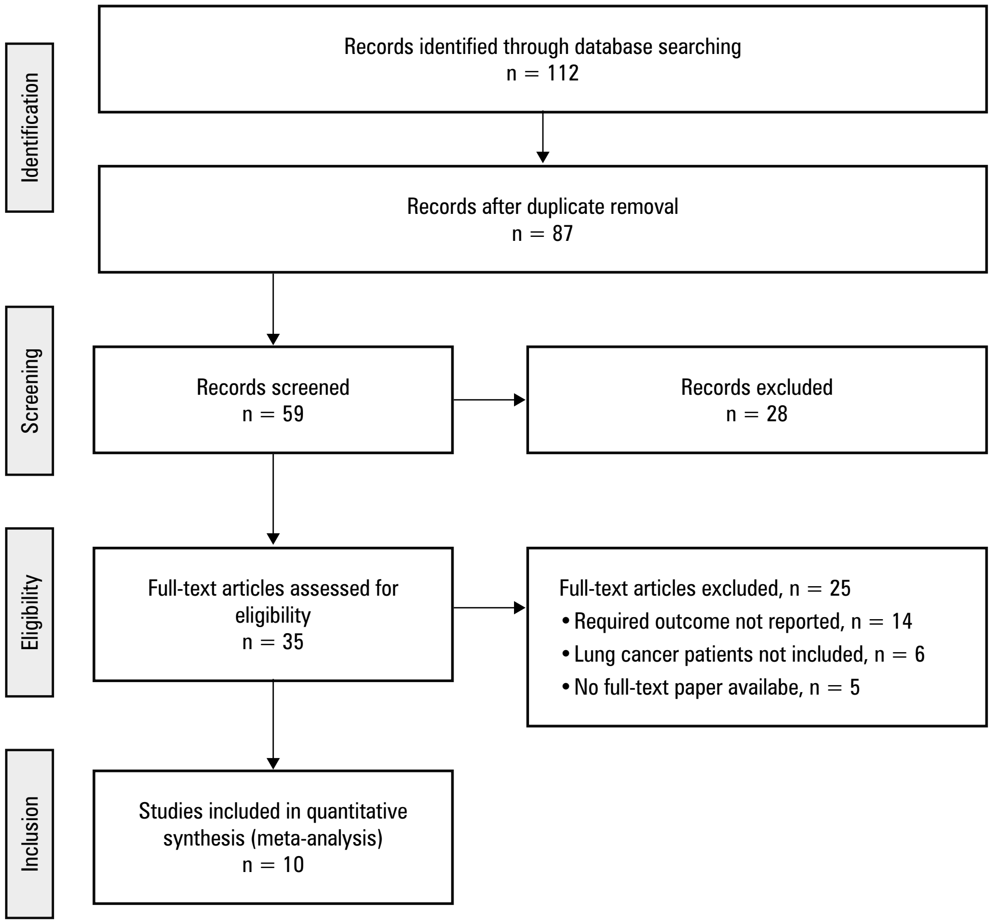

FIGURE 1 Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) study flow diagram

(**FIGURE 1**). All of them were performed on lung cancer patients of various ages. Main characteristics of the included studies are shown in **TABLE 2**.

Risk of bias assessment The studies included were assessed for potential risk of bias using a predesigned questionnaire. The overall risk of bias was evaluated as low (**FIGURES 2** and **3**). Among the 10 observational studies analyzed, 7 were found to have a low risk of bias, while 2 were identified as having a moderate risk of bias related to the measurement of exposure[18] or postexposure interventions.[23] Only 1 study[22] was found to have a high risk of bias due to confounding factors. Minimal risk of publication bias was further confirmed by the symmetrical funnel plot shown in **FIGURE 4** and the *P* value of the Begg test indicating a lack of significance ($P = 0.2$).

Quantitative synthesis: meta-analysis of mean difference between predicted and observed postoperative lung function The meta-analysis presents the findings of studies in which postoperative FEV_1 value was predicted using various methods. The results are shown in **TABLE 3**, and the related forest plots are displayed in **FIGURE 5**. The approach involving measurement of computed tomography volume and density (CT-VD) demonstrated the highest accuracy, with a mean FEV_1 difference of 83 ml (95% CI, 41–116). The precise threshold for the minimum clinically significant change in FEV_1 following surgery is not exactly known; however, it has been determined to be 100 ml in the context of chronic obstructive pulmonary disease.[35,36] Therefore, any difference in FEV_1 between the predicted actual values that is smaller than 100 ml should not be perceptible from a clinical standpoint.[37,38] Hence, the data indicate that CT-VD is the preferred method for predicting postoperative FEV_1. The level of heterogeneity was low for CT-VD, moderate for SPECT-CT and CT perfusion imaging, and high for segment counting, subsegment counting, and perfusion scintigraphy (**TABLE 3**).

DISCUSSION Maintaining optimal lung function postsurgery is crucial, and fortifying the respiratory muscles both before and after the procedure can effectively lower the likelihood of contracting a pulmonary infection by 50%, as well as mitigate the danger of other complications, such as lung collapse, diminished lung capacity, and impaired mucus clearance from the respiratory system.[39,40] Multiple variables influence the restoration of pulmonary function following lung cancer surgery.[41,42] The selected surgical technique and the extent of lung tissue removal are significant determinants of pulmonary function loss. Due to

TABLE 2 Brief summary of the included studies

Study	Journal of publication	Country of study	Total number of participants	Sample size, n	Age of participants, y	Sex (M/F)	Procedure	Prediction technique	Time to postoperative lung function assessment, mo	Primary outcomes	Statistical analysis
Beccaria et al[17]	*Chest*	Italy	93	62	62	77/16	Lobectomy & pneumonectomy	Segment counting, CT-VD	6	FEV_1	MD, correlation
Chae et al[18]	*Investigative Radiology*	Korea	67	51	64	48/16	Lobectomy & pneumonectomy	Perfusion scintigraphy, CT perfusion, CT-VD	6	FEV_1	MD, correlation
Fourdrain et al[19]	*Journal of Thoracic Disease*	France	37	23	61	32/5	Lobectomy & pneumonectomy	Segment counting, subsegment counting. perfusion scintigraphy, ventilation scintigraphy, CT-VD	3	FEV_1	MD, correlation
Ohno et al[20]	*Journal of Magnetic Resonance Imaging*	Japan	60	60	70	30/30	Lobectomy & pneumonectomy	Perfusion scintigraphy, ventilation scintigraphy, SPECT, SPECT/CT	6	FEV_1	MD, correlation
Sudoh et al[21]	*Journal of Thoracic and Cardiovascular Surgery*	Japan	22	22	71	19/3	Lobectomy & segmentectomy	Subsegment counting, SPECT/CT	4	FEV_1	MD, correlation
Wu et al[22]	*American Journal of Roentgenology*	Taiwan	52	34	69	42/10	Lobectomy & segmentectomy	Perfusion scintigraphy, CT-VD	3	FEV_1	MD, correlation
Wang et al[23]	*Chest*	Canada	57	28	65	35/22	Segmentectomy, lobectomy & pneumonectomy	Segment counting, CT-VD	12	FEV_1	MD, correlation
Yanagita et al[24]	*Japanese Journal of Radiology*	Japan	34	30	70	20/10	Lobectomy & pneumonectomy	SPECT, CT	6	FEV_1	MD, correlation
Yamashita et al[25]	*Academic Radiology*	Canada	25	14	65	37/28	Lobectomy & pneumonectomy	Perfusion scintigraphy, CT perfusion, CT-VD	3	FEV_1	MD, correlation
Yabuuchi et al[26]	*European Journal of Radiology*	Japan	49	49	67	26/23	Lobectomy	Subsegment counting, CT volumetry, CT-VD	6	FEV_1	MD, correlation

Abbreviations: CT, computed tomography; CT-VD, computed tomography volume and density; F, female; FEV_1, forced expiratory volume in 1 second; M, male; MD, mean difference; SPECT, single photon emission computed tomography

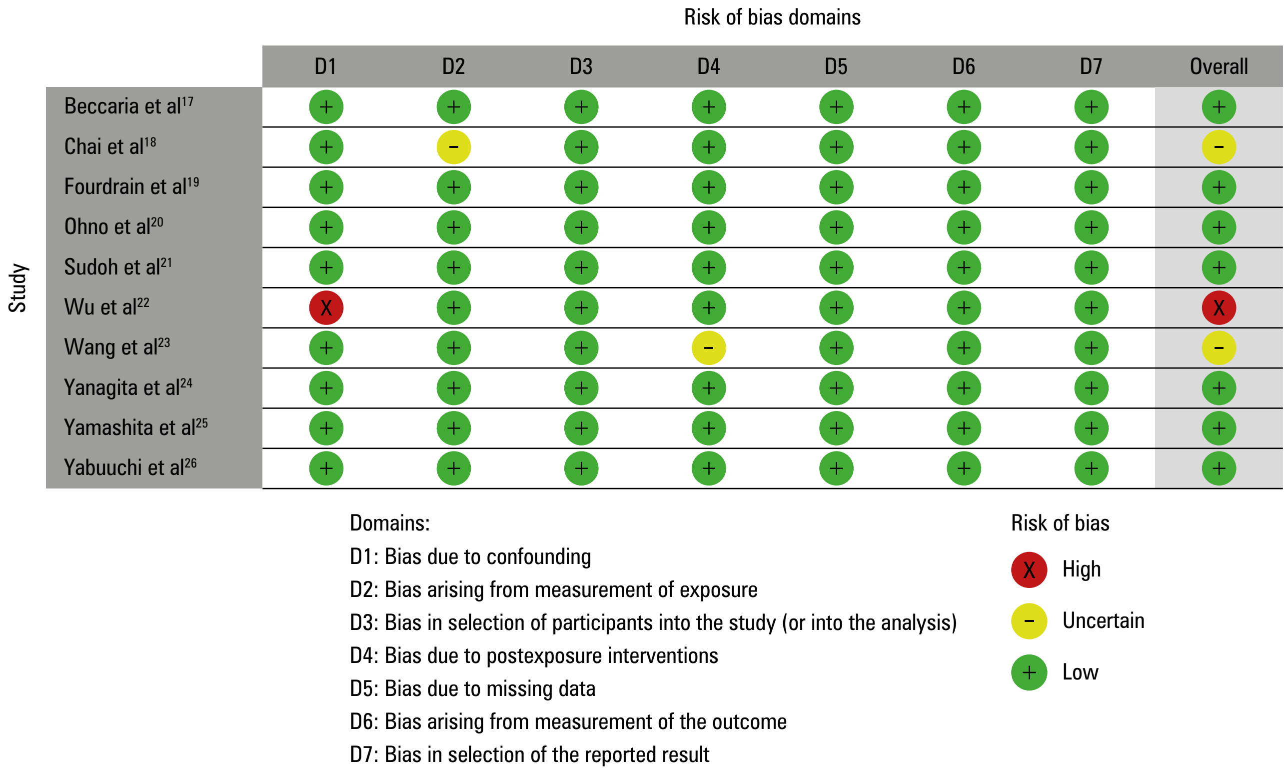

FIGURE 2 Traffic light plot for risk of bias assessment

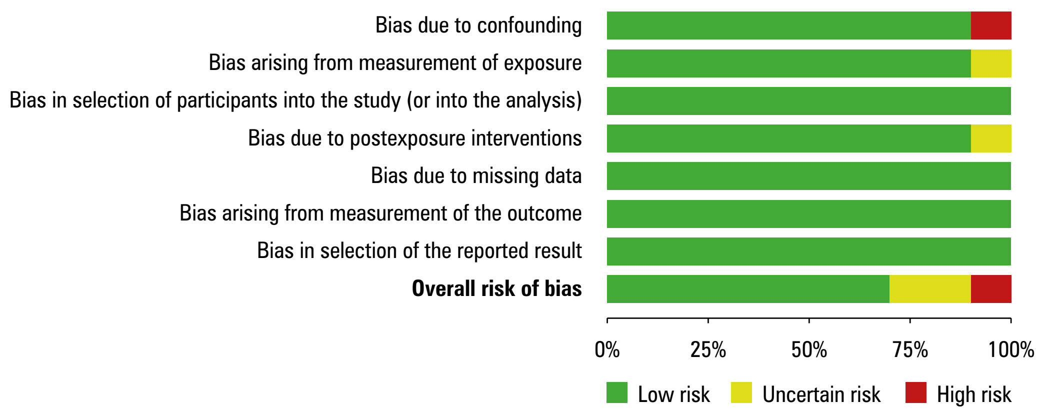

FIGURE 3 Risk of bias summary plot

TABLE 3 Meta-analysis of factors predicting postoperative lung function

Prediction technique	Number of studies	SMD[a], ml	95% CI	*P* value	Heterogeneity (I^2)
CT-VD	7	83	41–116	0.01	21
Perfusion scintigraphy	5	124	9–237	0.02	78
SPECT/CT	3	117	17–214	0.015	41
CT perfusion	2	165	67–264	0.024	34
Segment counting	3	210	135–330	0.035	71
Subsegment counting	3	223	132–305	0.014	67
CT volumetry	1	98	14–211	0.001	–
Ventilation scintigraphy	1	175	87–245	0.021	–

a Difference between predicted and measured value of forced expiratory volume in 1 second

Abbreviations: SMD, standard mean difference; others, see **TABLE 2**

the requirement for larger incisions and extended hospital stay, open surgery is commonly considered less favorable than a minimally invasive approach in certain surgical fields, such as colon and pulmonary surgery.[43-45] The benefits of minimally invasive surgical techniques include

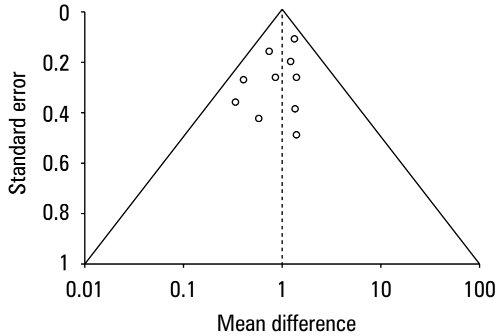

FIGURE 4 Funnel plot for publication bias

less discomfort, accelerated recovery, and faster resumption of work. Minimally invasive techniques eliminate the need for extensive tissue removal by utilizing tiny devices and cameras, and result in reduced discomfort and faster healing, with reduced duration of postsurgery suffering and pain.[46]

Predicting postoperative lung function is crucial during preoperative assessment of patients diagnosed with lung cancer. In order to thoroughly evaluate the risk of mortality and breathing difficulties following surgery, a full preoperative examination is conducted, which includes an evaluation of the predicted postoperative FEV_1.[47,48] This parameter reflects the maximum quantity of air that a person can forcefully exhale within the first second after taking a deep breath.[49] If the predicted value falls between 30% and 60%, it indicates the need for additional patient evaluation.[50]

Various methods can be used to assess the average difference in FEV_1 for predicting postoperative lung function, including CT techniques such as volume and density analysis, perfusion scintigraphy, SPECT-CT, CT perfusion, segment and subsegment counting, CT volumetry, and ventilation scintigraphy.[51-54] The observational studies included in this analysis compared various prediction methods and presented their respective findings. For instance, Beccaria et al[17] found that a predicted postoperative FEV_1 value of 40% or more may effectively identify individuals that do not need additional testing and are not at a risk of long-term respiratory dysfunction.

Chae et al[18] used the Bland–Altman plots to determine the limits of agreement between the measured the projected postoperative FEV_1 values. They showed that for scintigraphy, the limits of agreement ranged from −29.3% to 26.9%, while for CT, the range was from −28.9% to 17.3%. The error rate of CT was similar to that of scintigraphy (15.4% vs 17.8%). Dual-energy perfusion CT demonstrated superior accuracy, as compared with perfusion scintigraphy, in predicting postoperative lung function. According to Fourdrain et al,[19] quantitative CT imaging seems to be an acceptable technique for evaluating the predicted postoperative FEV_1. It also appears to be more dependable than other methods. The estimation of predicted postoperative FEV_1 value, as a component of the preoperative evaluation, does not require any further morphologic examinations, namely scintigraphy. This approach has the potential to become the standard way for evaluating predicted postoperative FEV_1.

Ohno et al[20] concluded that SPECT-CT using ^{81m}krypton- and ^{99m}technetium-labeled macroaggregated albumin demonstrated superior reproducibility and accuracy in predicting postoperative lung function, as compared with SPECT and planar imaging. Sudoh et al[21] reported that combining SPECT-CT images acquired during breath-holding enables precise estimation of postoperative pulmonary function. However, this approach did not demonstrate statistical advantage over

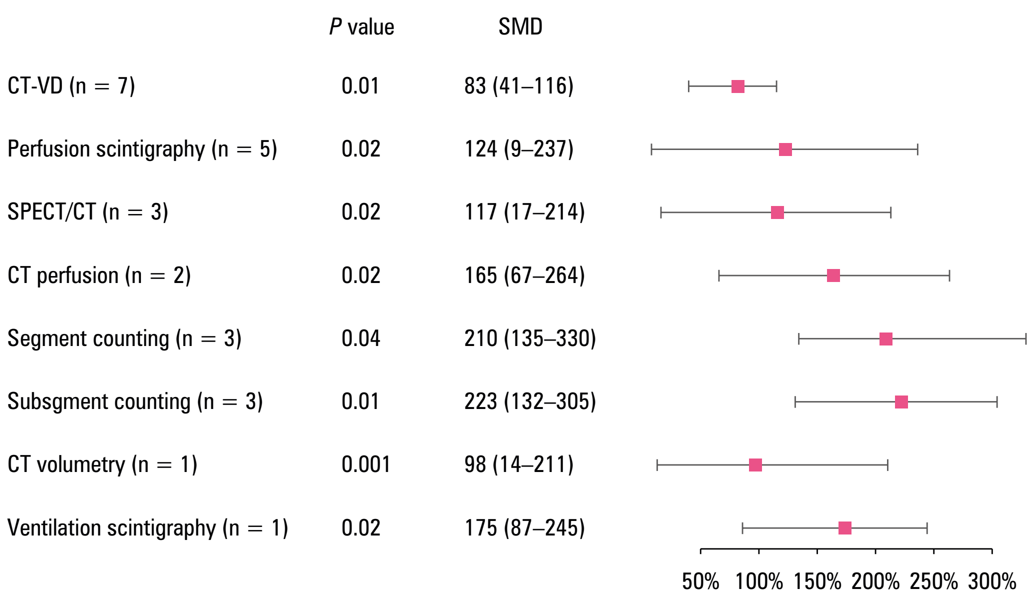

FIGURE 5 Forest plot for standard mean difference (SMD) between predicted and measured values of forced expiratory volume in 1 second assessed using different prediction methods
Abbreviations: see TABLES 2 and 3

the simpler segment-counting method. According to Wu et al,[22] both quantitative CT and perfusion scintigraphy accurately predicted postoperative FEV_1 value in patients undergoing pneumonectomy (n = 28; r = 0.88 vs r = 0.86, respectively; $P < 0.001$) and lobectomy (n = 16; r = 0.9 vs r = 0.8, respectively; $P < 0.001$). The Bland–Altman plot indicated a high level of concordance between the 2 methods. Quantitative CT is commonly utilized for predicting postoperative FEV_1 evaluation due to its simplicity. In a study by Wang et al,[23] a notable decrease in FEV_1 values evaluated with this method was found after lung resection.

Yanagita et al[24] noted a substantial difference between the predicted and actual values of vital capacity, forced vital capacity, and FEV_1 (R^2 = 0.56–0.77; $P < 0.001$), as determined using CT volumetry imaging. In turn, Yamashita et al[25] showed that CT subtraction imaging is as precise as radioisotope perfusion scintigraphy in predicting postoperative lung function. This finding is particularly relevant for the preoperative evaluation of resectable lung cancer in high-risk patients. In their study, Yabuuchi et al[26] discovered that analyzing the volume of the lungs using inspiratory / expiratory CT data can be a valuable method for predicting postoperative pulmonary function following lobectomy for primary lung cancer.

The latest British recommendations published in 2017[55] indicate that patients should have a CT scan performed at least twice before resection. This includes an initial diagnostic scan and a second one performed for staging. Positron emission tomography / CT is an attractive approach toward predicting postoperative lung function since it uses real-time imaging without the need for additional sessions and delays.[56] Moreover, CT densitometry has demonstrated superiority over spirometry in the prediction of pulmonary problems, such as extended air leak following lung resection, as well as in identification of individuals who are at a higher risk of experiencing these difficulties.[57-59] Patients are eligible for resection without the need for additional evaluation if their FEV_1 and TL_{CO} values are greater than or equal to 60% of the predicted values, as per the guidelines established by the American College of Chest Physicians.[5] Furthermore, quantitative measures of lung volume and density acquired from preoperative CT scans correlate with pulmonary function test results, enabling the prediction of pulmonary function in patients diagnosed with lung cancer and identification of individuals who are amenable to surgical resection.[60] In a similar vein, our meta-analysis showed that prediction of FEV_1 after lung resection is the most accurate and precise when performed based on combined CT-VD, and the accuracy of other evaluated methods for predicting postoperative FEV_1 is low. These findings are especially pertinent to future guidelines for the evaluation of eligibility for lung cancer surgery. A consolidated CT-based risk assessment that predicts both postoperative pulmonary function and the likelihood of postoperative pulmonary problems would be a useful tool for clinicians.

Strengths and limitations This systematic review and meta-analysis aimed to identify the most effective method for predicting postoperative lung function following lung cancer resection. Precise search criteria were adopted to allow for identification of studies investigating postoperative lung function, prediction techniques, and lung cancer resection across several databases. A notable advantage is that our findings have worldwide relevance, as the included studies were conducted in different countries and covered a wide variety of clinical settings. They were also heterogenous with respect to the surgical procedures, time of follow-up lung function evaluation, and specific features of the prediction method. Nevertheless, it is crucial to acknowledge certain limitations. Firstly, only a small proportion of the identified studies were included in the final analysis, which may have led to biased results. Moreover, due to a limited number of patients in each of the included studies, further investigation is necessary to establish a precise correlation between the type of surgical procedure, FEV_1 thresholds used, and patient outcomes.

CONCLUSIONS

In conclusion, CT-VD is the most precise and accurate method for predicting postoperative FEV_1. Nevertheless, further investigations involving a greater number of studies are required to substantiate these findings, establish a correlation between the surgical methods, adopted thresholds, and patient-reported outcomes, and strengthen the existing body of evidence.

ARTICLE INFORMATION

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CONTRIBUTION STATEMENT HW and LH conceived and designed the study; GX analyzed the data and drafted the manuscript; XH collected the data and participated in data analysis, proofreading, and final editing, along with being the guarantor of the manuscript. All authors read and approved the final version of the manuscript.

CONFLICT OF INTEREST None declared.

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