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Original Article

Meta-analysis of the changes in clinical features and characteristics of lung cancer under bronchoscopy

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Abstract: Objective: This study aims to summarize the clinical features and evolutionary changes of lung cancer under bronchoscopy. Methods: Relevant literature on the "clinical characteristics and evolving features of lung cancer observed under bronchoscopy" was retrieved from Chinese and English databases, including CNKI, Wanfang, VIP, PubMed, and Web of Science. Results: A total of 21 studies published between 2005 and 2023 were included, involving 8,892 patients, with 10 studies in English and 11 in Chinese. All studies were analyzed using a random-effects model with the Freeman-Tukey double arcsine transformation for meta-analysis of single proportions. The pooled estimate for the diagnostic accuracy of bronchoscopy in lung cancer was 2.22 (95% CI: 2.10-2.34; Q=42.21, P<0.01). Regarding pathological types, the pooled estimates were 1.20 for lung squamous cell carcinoma (95% CI: 0.90-1.50; Q=328.08, P<0.01), 0.77 for small cell lung cancer (95% CI: 0.62-0.93; Q=219.43, P<0.01), 0.67 for non-small cell lung cancer (95% CI: 0.49-0.86; Q=66.84, P<0.01), and 1.53 for lung adenocarcinoma (95% CI: 1.06-2.01; Q=2096.93, P<0.01). For age distribution, the pooled estimate was 1.45 for patients aged ≥60 years (95% CI: 0.91-1.99; Q=886.54, P<0.01) and 1.69 for patients aged <60 years (95% CI: 1.15-2.23; Q=886.54, P<0.01). The pooled estimates for male and female patients were 1.59 (95% CI: 1.17-2.02; Q=983.83, P<0.01) and 1.55 (95% CI: 1.12-1.97; Q=983.83, P<0.01), respectively. Regarding bronchoscopic morphological patterns, the pooled estimates were 1.50 for proliferative-type lung cancer (95% CI: 1.25-1.74; Q=180.64, P<0.01), 1.14 for infiltrative-type lung cancer (95% CI: 0.94-1.35; Q=225.58, P<0.01), and 0.83 for lung cancer with non-specific bronchoscopic changes (95% CI: 0.60-1.06; Q=498.02, P<0.01). Meta-regression analysis of lung adenocarcinoma indicated that publication year and study design were significant sources of heterogeneity among the included studies (P<0.01). Conclusion: Among lung cancers diagnosed by bronchoscopy, lung adenocarcinoma was the predominant pathological type, and the proliferative type was the most common bronchoscopic morphological pattern. Most patients were younger than 60 years, and the proportion of male patients was slightly higher than that of female patients.

Keywords: Lung cancer, bronchoscopy, clinical features, pathology, age

Introduction

Lung cancer is one of the major challenges in global public health and medical care, often resulting from the long-term progression of various pulmonary diseases such as pulmonary fibrosis, asthma, lung nodules, and chronic obstructive pulmonary disease (COPD) [1]. According to AI-based big data analysis, approximately 40% of patients undergoing chest CT examinations present with lung nodules, with detection rates reaching as high as 80% among men over the age of 50 [2, 3]. Meanwhile, the incidence and mortality rates of lung cancer remain persistently high due to the worsening impact of smoking, food safety issues, occupational exposure, and industrial pollution [4]. However, public awareness of lung cancer-related diseases and diagnostic and treatment knowledge remains insufficient. In clinical practice, delays and uncertainties in diagnosing and treating lung cancer frequently lead to missed or misdiagnosed cases in the early stages. Traditionally, imaging diagnostics for lung cancer have primarily relied on CT or MRI scans, which can clearly define tumor size, determine bone metastasis, and assess neurovascular invasion. However, these methods

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lack sampling capabilities and have relatively low accuracy in diagnosing small lesions within the bronchi [5].

Bronchoscopy is a minimally invasive diagnostic and therapeutic method that can be integrated with a TV system to perform sampling, lesion imaging and observation, dynamic recording, and even surgical procedures [6]. It not only enables precise localization of pulmonary and bronchial target lesions but also enhances the early diagnosis and treatment rates of lung cancer, thereby extending patients' survival and controlling the progression of related diseases [7]. However, with the decreasing age of lung cancer onset and the increasing complexity of its causes, the clinical characteristics and features of the disease have undergone certain changes. In the study by Biciuşcă V et al. [8], the incidence of bronchial abnormalities (such as stenosis and hyperplasia) caused by lung cancer was as high as 57.89%, while malignant lung atelectasis occurred in 42.10% of cases, predominantly affecting intrapulmonary bronchi, with adenocarcinoma being the most common pathological type. However, earlier studies [9, 10] indicated no significant differences in the incidence of bronchial lesions across different bronchial segments in lung cancer or other malignant respiratory tumors. To enhance the diagnostic and therapeutic value of bronchoscopy in lung cancer and improve the quality of life for lung cancer patients, this study conducts a meta-analysis of the clinical characteristics and evolving features of lung cancer as observed through bronchoscopy.

Materials and methods

Data sources

Following the PRISMA 2020 statement, relevant literature on the "clinical characteristics and evolving features of lung cancer under bronchoscopy" was retrieved from both Chinese and English databases, covering the period from 1990 to 2024. In Chinese databases, including CNKI, Wanfang, VIP, X-MOL Academic Platform, the Chinese Medical Association, and the National Science and Technology Library, search terms such aslung cancer, lung squamous cell carcinoma, bronchoscopy, characteristics of lung cancer, fiberoptic bronchoscopy, and bronchoscopy biopsy were used. In English databases, including Wiley InterScience, PubMed, Web of Science, Cochrane Library, and Springer Link, search terms such as "lung cancer", "lung squamous cell carcinoma", "bronchoscopy", "characteristics of lung cancer", "fiberoptic bronchoscopy", and "bronchoscopy biopsy" were applied.

Literature selection

Inclusion criteria: ① The publication years of the included literature range from 1990 to 2024. ② The study subjects were all diagnosed with lung cancer through medical history, CT or MRI scans, pulmonary function tests, blood tests, pathology, and other examinations. ③ The study subjects had undergone bronchoscopy (including rigid bronchoscopy, flexible bronchoscopy, etc.). ④ The included literature did not use any endoscopic examinations other than bronchoscopy and its associated systems. ⑤ The research methods and objectives of the included literature were closely related to "Clinical features and changes in characteristics of lung cancer under bronchoscopy". ⑥ The study subjects had no infectious diseases or severe psychiatric disorders. ⑦ The study subjects had no history of sedative or hypnotic drug abuse.

Exclusion criteria: ① The study subjects had other respiratory system diseases, such as obstructive sleep apnea syndrome, primary nasopharyngeal carcinoma, etc.; ② The literature was unpublished, retracted by the journal, or involved academic copyright disputes; ③ The literature had incomplete information, such as missing volume, issue, and page numbers, vague research content, absence of an abstract, inability to access the full text, unclear treatment methods, missing data, or unknown authors; ④ The literature was a duplicate report; ⑤ The literature contained data errors, significant statistical method errors, or flaws in research design; ⑥ The literature was a systematic review, quantitative analysis, network pharmacology analysis, survey report, descriptive study, case study, theoretical review, personal experience.

Outcome indicators: The factors considered in the study include: ① lymphatic metastasis, ② positive predictive value/sensitivity, ③ negative predictive value/specificity, ④ accuracy, ⑤ tumor size, ⑥ pathological type, ⑦ bronchial abnormalities, ⑧ gender, ⑨ positive rate, ⑩ respiratory symptoms, ⑪ missed diagnosis rate, ⑫ smoking history, ⑬ tumor resection rate, ⑭ age (≥60 years and <60 years), ⑮ bronchoscopic type, and ⑯ major CT findings.

Literature screening and data extraction

Relevant literature was retrieved using search terms in both Chinese and English databases, and the titles of the retrieved articles were imported into the "NoteExpress 3.2 Literature Retrieval and Management" system for duplicate checking. After the duplication check, the titles and abstracts were carefully reviewed, and low-quality or irrelevant articles were excluded. Two researchers independently screened the literature according to the inclusion and exclusion criteria and extracted the information for summarization. In case of disagreements, a third-party expert with more clinical experience or a higher professional title was invited to make the final judgment. The extracted information included: ① basic information such as the first author, publication year, journal, country, etc.; ② source of study subjects, gender, age, number of cases completed in the study, disease type, etc.; ③ study type, examination methods and tools, research content and objectives, intervention methods, outcome indicators, research results, etc.; ④ key factors influencing the bias risk assessment.

Literature quality assessment

The quality of the finally included literature was assessed using the Methodological Index for Non-Randomized Studies (MINORS) tool [11]. The evaluation criteria included: ① A clear research objective, with the proposed question being precise and supported by the literature; ② All included patients meeting the inclusion and exclusion criteria; ③ Data from prospective studies being collected before the start of the study; ④ Appropriate evaluations, observations, main indicators, or criteria for assessing the study outcomes; ⑤ Use of single-blind or double-blind methods or providing reasons if blinding was not used; ⑥ Whether follow-up was conducted, whether the purpose of the follow-up aligned with the research objectives, the follow-up duration, and the follow-up endpoints; ⑦ Loss to follow-up rate being less than 5%; ⑧ Prospective calculation of sample size, considering the expected event rate, effect size, 95% confidence interval, significance level, and power. Each item was scored from 0 to 2, where 0 indicated no reporting, 1 indicated partial reporting with incomplete information, and 2 indicated full reporting with complete information.

Statistical analysis

Data processing was performed using the meta-analysis module in Stata 17.0. Since this study aimed to systematically describe the clinical characteristics and evolving features of lung cancer under bronchoscopy without a control group, a single-arm proportion meta-analysis was conducted using the Freeman-Tukey (FT) double arcsine transformation. A random-effects model was primarily applied to pool the effect sizes from the included studies, and the pooled estimates with 95% confidence intervals (95% CIs) and prediction intervals were calculated. Heterogeneity among the pooled data was assessed using the Q test and quantitatively evaluated using the I^2 statistic. Forest plots were generated to visually present the pooled results. Meta-regression analysis was performed using the outcome indicator with the largest number of pooled studies among pathological types or bronchoscopic morphological types to explore the presence and potential sources of heterogeneity among the included studies. A *P* value <0.05 was considered statistically significant for the pooled estimates.

Results

Literature search flow

After searching the database using both Chinese and English keywords, a total of 2,489 relevant articles on "Clinical features and changes in characteristics of lung cancer under bronchoscopy" were identified. The titles of the articles were imported into the "NoteExpress 3.2 Literature Retrieval and Management" system for duplicate checking, resulting in the removal of 1,783 articles, leaving 706 articles. The titles and abstracts were then reviewed for a second round of screening, and 534 articles with low relevance or poor quality were excluded, leaving 172 articles. Following the inclusion and exclusion criteria, another 151 articles were excluded, leaving a final total

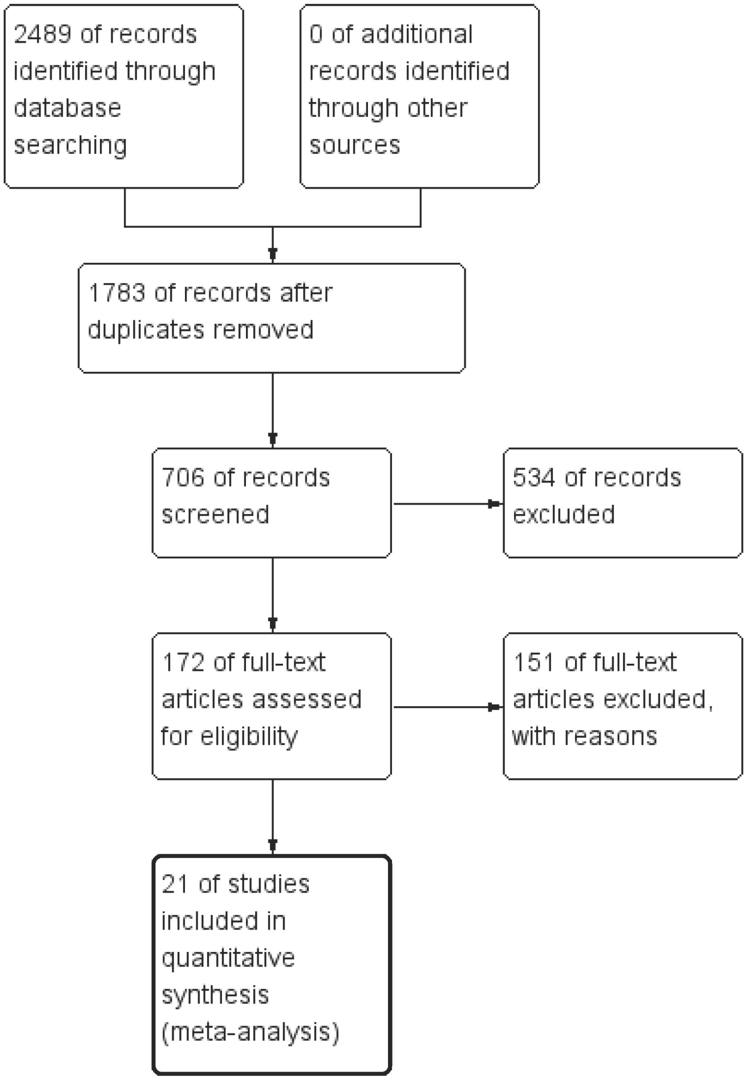

Figure 1. Literature search flow.

of 21 articles. The literature retrieval process is shown in **Figure 1**.

Basic characteristics of the included studies

The 21 included articles were published between 2005 and 2023, involving a total of 8,892 patients. Among them, 10 articles were in English [12-15, 17-22] and 11 articles were in Chinese [16, 23-32]. Of these, 4 articles [12, 13, 20, 22] were prospective studies, 1 article [14] was a prospective, multicenter study, 10 articles [15, 16, 18, 19, 23, 24, 26, 27, 29, 32] were retrospective studies, 5 articles [17, 25, 28, 30, 31] were single-arm studies, and 1 article [21] was an observational study. The MINORS scores ranged from 12 to 17, with an average score of 13.52, as detailed in **Table 1**.

Meta-analysis of main indicators

Meta-analysis of accuracy rate: Eight articles [12, 17, 18, 20, 22, 24, 30, 31] reported the accuracy of bronchoscopic examination for lung cancer, involving a total of 1,908 patients. Significant heterogeneity was observed across studies (I^2=85.56%), and a random-effects model was applied for the single-arm proportion meta-analysis. The pooled effect estimate for diagnostic accuracy was 2.22 (95% CI: 2.10-2.34; Q=42.21, P<0.01). In the subgroup analyses, the highest effect estimate was observed in studies published in 2018 among the publication-year subgroups, in single-arm studies among the study-type subgroups, and in studies using endobronchoscopy (EB) among the examination-method subgroups. Significant differences in effect estimates were observed among different publication years and examination methods (P<0.01). The detailed results are shown in **Figure 2**.

Meta-analysis of pathological types: Eight articles [23, 24, 26-29, 31, 32] reported the pathological types of lung cancer, involving a total of 5,014 patients. Substantial heterogeneity was observed among the studies (I^2> 50%, P<0.01); therefore, a random-effects model was applied for the single-arm proportion meta-analysis. For lung squamous cell carcinoma, the pooled effect estimate was 1.20 (95% CI: 0.90-1.50; Q=328.08, P<0.01). In subgroup analyses, the highest effect estimate was observed in studies published in 2005 among the publication-year subgroups, in retrospective studies among the study-type subgroups, and in studies using fiberoptic bronchoscopy (FB) among the examination-method subgroups. Significant differences in effect

Table 1. Basic characteristics of the included studies

Author	Year	n	Type	Disease	Inspection method	Outcome indicators	MINORS score
Hwangbo B et al. [12]	2010	143	Prospective study	Lung cancer	Bronchoscopy + ultrasound	①②③④	12
Oki Mde et al. [13]	2014	146	Prospective study	NSCLC	Bronchoscopy + ultrasound	①②③	14
Ye T et al. [14]	2021	615	Prospective, multi-center study	Lung cancer	FB	⑤⑥⑦⑧	12
Li D et al. [15]	2022	380	Retrospective study	Lung cancer	FB	⑤⑦⑨⑩	14
Wang RR et al. [16]	2014	100	Retrospective study	Lung cancer	AFB	⑨⑩⑪	12
Liam CK et al. [17]	2007	503	Single arm research	Lung cancer	FB	②③④	13
Gaddam M et al. [18]	2020	311	Retrospective study	Malignant tumor of thoracic cavity	Bronchoscopy + ultrasound	③④⑨⑩	15
Marie MM et al. [19]	2023	800	Retrospective study	NSCLC, SCLC	FB	⑦⑨⑩⑫	13
Lam B et al. [20]	2009	181	Prospective study	Lung cancer	Sputum cytology + Bronchoscopy	②④⑨	14
Yutaka Y et al. [21]	2022	80	Observational study	Small lung lesions	Electromagnetic navigation bronchoscopy	⑬	12
van der Drift MA et al. [22]	2005	221	Prospective study	Lung cancer	FB	③④⑧⑨⑭	14
Zhu CY et al. [23]	2005	151	Retrospective study	Lung cancer	FB	⑥⑧⑭⑮	13
Zhong LX et al. [24]	2013	176	Retrospective study	Lung cancer	FB	④⑥⑧⑭⑮	15
Feng F et al. [25]	2016	98	Single arm research	bronchogenic carcinoma	Bronchoscopy	⑧⑭⑮	13
Zhao LJ et al. [26]	2009	2670	Retrospective study	Lung cancer	FB	⑥⑮	14
Zhou CL et al. [27]	2009	1200	Retrospective study	Lung cancer	Bronchoscopy	⑥⑧⑫⑭⑮	12
Li LY et al. [28]	2012	239	Single arm research	Lung cancer	Bronchoscopy	⑥⑧⑫⑭⑮	15
Yang YY et al. [29]	2023	172	Retrospective study	Lung cancer	FB+CT	⑥⑧⑫⑭⑮⑯	16
Liu Y et al. [30]	2021	300	Single arm research	Peripheral lung cancer	EB+cytology	②③④⑯	14
Wang JH et al. [31]	2018	73	Single arm research	lung cancer	EB	④⑥⑧⑭⑮	15
Liu YN et al. [32]	2019	333	Retrospective study	Peripheral lung cancer	Bronchoscopy	⑤⑥⑧⑫⑭⑯	17

Note: NSCLC refers to non-small cell lung cancer, and SCLC refers to small cell lung cancer. FB stands for flexible bronchoscope, AFB refers to fluorescence bronchoscopy, and EB refers to electronic bronchoscopy. The factors considered include ① lymphatic metastasis, ② positive predictive value/sensitivity, ③ negative predictive value/specificity, ④ accuracy, ⑤ tumor size, ⑥ pathological type, ⑦ bronchial abnormalities, ⑧ gender, ⑨ positive rate, ⑩ respiratory symptoms, ⑪ missed diagnosis rate, ⑫ smoking history, ⑬ tumor resection rate, ⑭ age (≥60 years and <60 years), ⑮ bronchoscopic type, and ⑯ major CT findings.

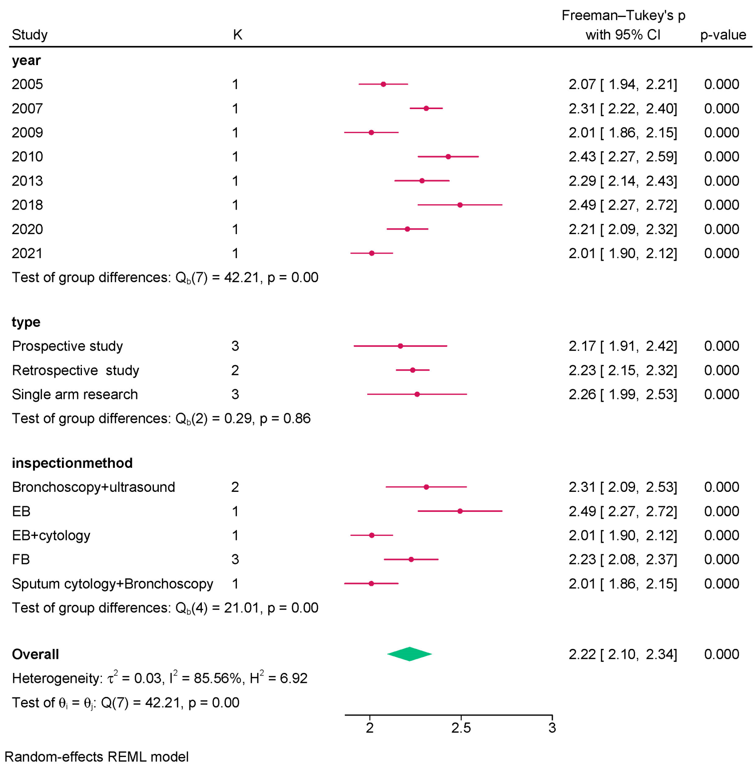

Figure 2. Meta-analysis of accuracy.

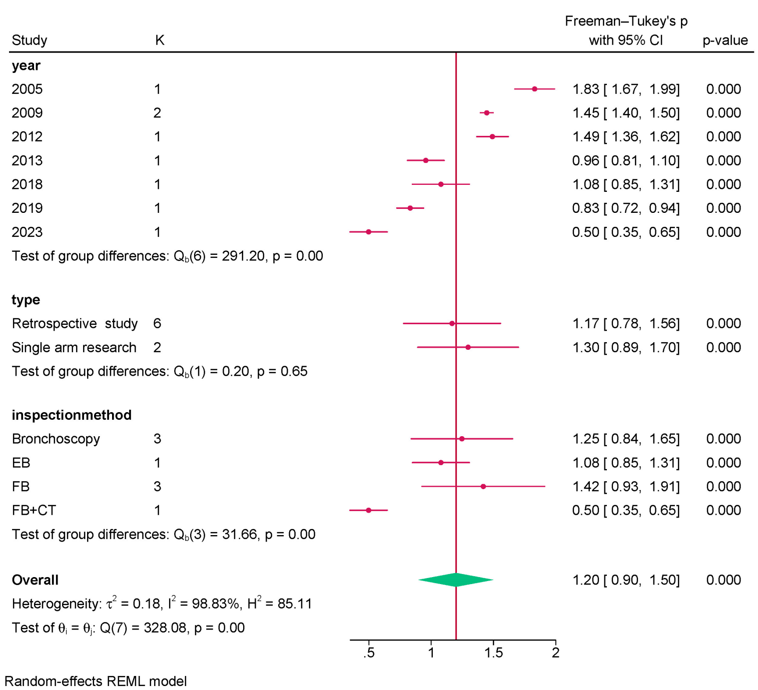

Figure 3. Meta-analysis of squamous cell lung cancer.

estimates were observed among different publication years and examination methods (P<0.01). The detailed results are shown in **Figure 3**.

For small cell lung cancer, the pooled effect estimate was 0.77 (95% CI: 0.62-0.93; Q=219.43, P<0.01). In the subgroup analyses, the highest effect estimate was observed in studies published in 2009 among the publication-year subgroups, in retrospective studies among the study-type subgroups, and in studies using bronchoscopy among the examination-method subgroups. Significant differences in effect estimates were observed among different publication years (P<0.01). The detailed results are shown in **Figure 4**.

For non-small cell lung cancer, the pooled effect estimate was 0.67 (95% CI: 0.49-0.86; Q=66.84, P<0.01). In the subgroup analyses, the highest effect estimate was observed in studies published in 2018 among the publication-year subgroups, in single-arm studies among the study-type subgroups, and in studies using endobronchoscopy (EB) among the examination-method subgroups. Significant differences in effect estimates were observed among different publication years and examination methods (P<0.01). The detailed results are shown in **Figure 5**.

Nine articles [14, 23, 24, 26-29, 31, 32] reported on adenocarcinoma of the lung, involving a total of 5,629 patients. Significant heterogeneity was observed across studies (I^2=99.62%, P<0.01), and a random-effects model was applied for the single-arm proportion meta-analysis. The pooled effect estimate for lung adenocarcinoma was 1.53 (95%

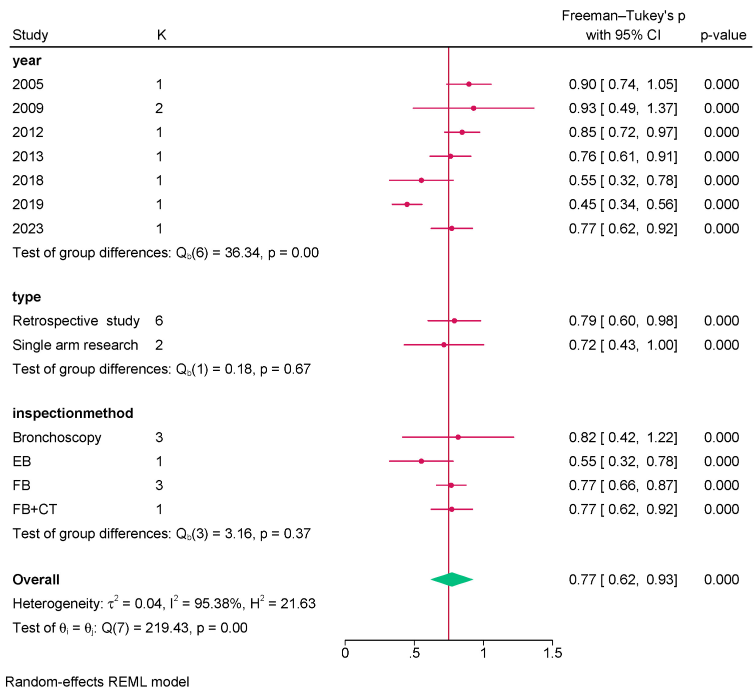

Figure 4. Meta-analysis of small cell lung cancer.

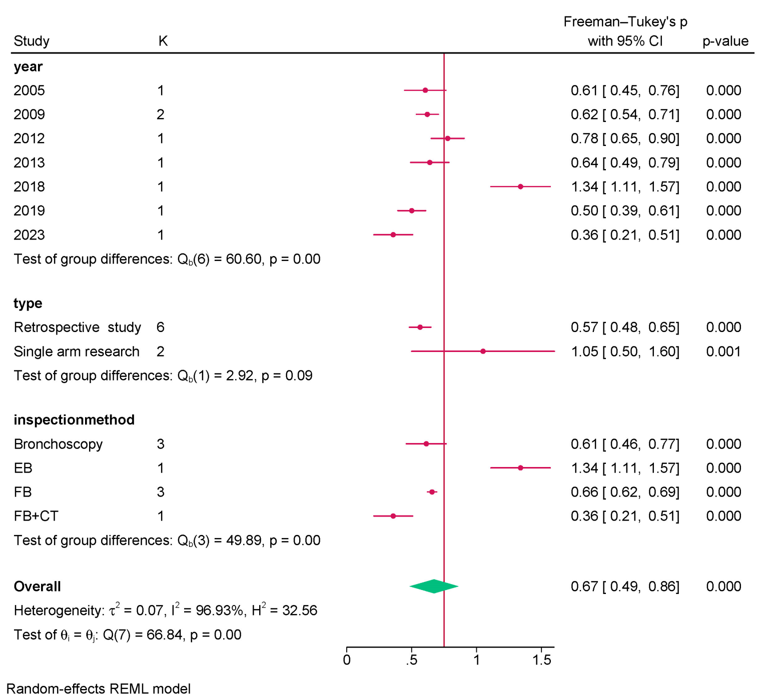

Figure 5. Meta-analysis of non-small cell lung cancer.

CI: 1.06-2.01; Q=2096.93, P<0.01). In the subgroup analyses, the highest effect estimate was observed in studies published in 2021 among the publication-year subgroups, in prospective multicenter studies among the study-type subgroups, and in studies using FB+CT among the examination-method subgroups. Significant differences in effect estimates were observed among different publication years, study types, and examination methods (P<0.01). The detailed results are shown in **Figure 6**.

Meta-analysis of age: Nine articles [22-25, 27-29, 31, 32] reported the age distribution of patients undergoing bronchoscopy, involving a total of 2,263 patients. Significant heterogeneity was observed across studies (I^2>50%, P<0.01), and a random-effects model was applied for the single-arm proportion meta-analysis. For patients aged ≥60 years, the pooled effect estimate was 1.45 (95% CI: 0.91-1.99; Q=886.54, P<0.01). In the subgroup analyses, the highest effect estimate was observed in studies published in 2005 among the publication-year subgroups, in single-arm studies among the study-type subgroups, and in studies using FB among the examination-method subgroups. Significant differences in effect estimates were observed among different publication years, study types, and examination methods (P<0.01). The detailed results are shown in **Figure 7**.

For patients aged <60 years, the pooled effect estimate was 1.69 (95% CI: 1.15-2.23; Q=886.54, P<0.01). In the subgroup analyses, the highest effect estimate was observed in studies published in 2023 among the publication-year subgroups, in prospective studies among the study-type subgroups, and in studies using

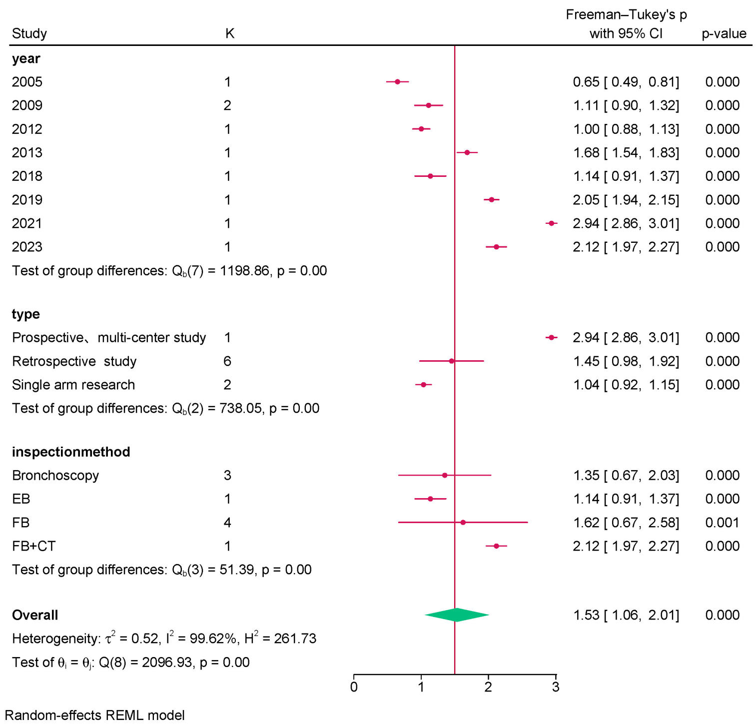

Figure 6. Meta-analysis of adenocarcinoma of the lung.

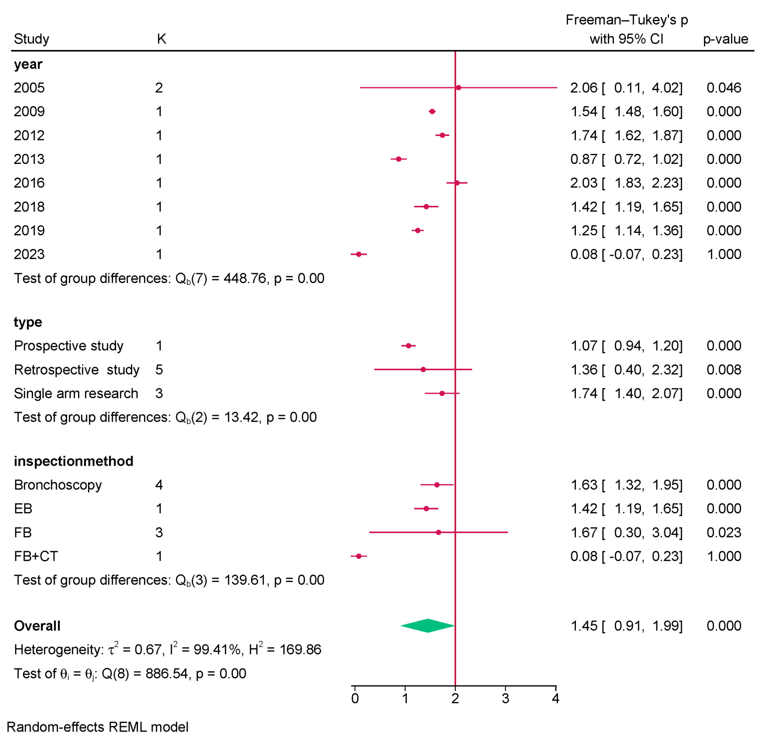

Figure 7. Meta-analysis of age ≥60.

FB+CT among the examination-method subgroups. Significant differences in effect estimates were observed among different publication years, study types, and examination methods (P<0.01). The detailed results are shown in **Figure 8**.

Meta-analysis of gender: Ten articles [14, 22-25, 27-29, 31, 32] reported on gender, involving a total of 3,278 patients. Significant heterogeneity was observed across studies (I^2> 50%, P<0.01), and a random-effects model was applied for the single-arm proportion meta-analysis. For male patients, the pooled effect estimate was 1.59 (95% CI: 1.17-2.02; Q=983.83, P<0.01). In the subgroup analyses, the highest effect estimate was observed in studies published in 2012 among the publication-year subgroups, in single-arm studies among the study-type subgroups, and in studies using bronchoscopy among the examination-method subgroups. Significant differences in effect estimates were observed among different publication years, study types, and examination methods (P< 0.01). The detailed results are shown in **Figure 9**.

For female patients, the pooled effect estimate was 1.55 (95% CI: 1.12-1.97; Q=983.83, P<0.01). In the subgroup analyses, the highest effect estimate was observed in studies published in 2013 among the publication-year subgroups, in prospective studies among the study-type subgroups, and in studies using FB among the examination-method subgroups. Significant differences in effect estimates were observed among different publication years, study types, and examination methods (P<0.01). The detailed results are shown in **Figure 10**.

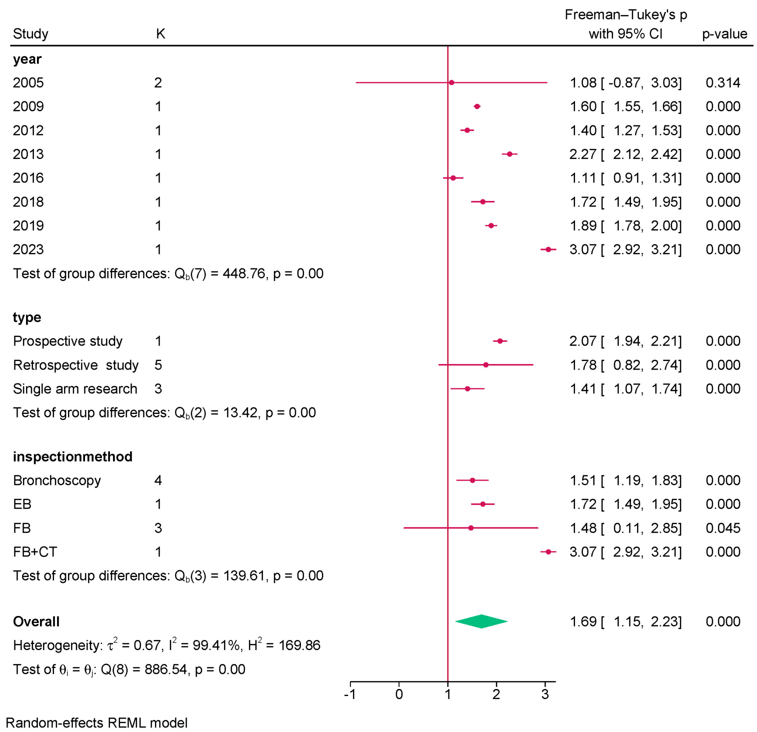

Figure 8. Meta-analysis of age <60.

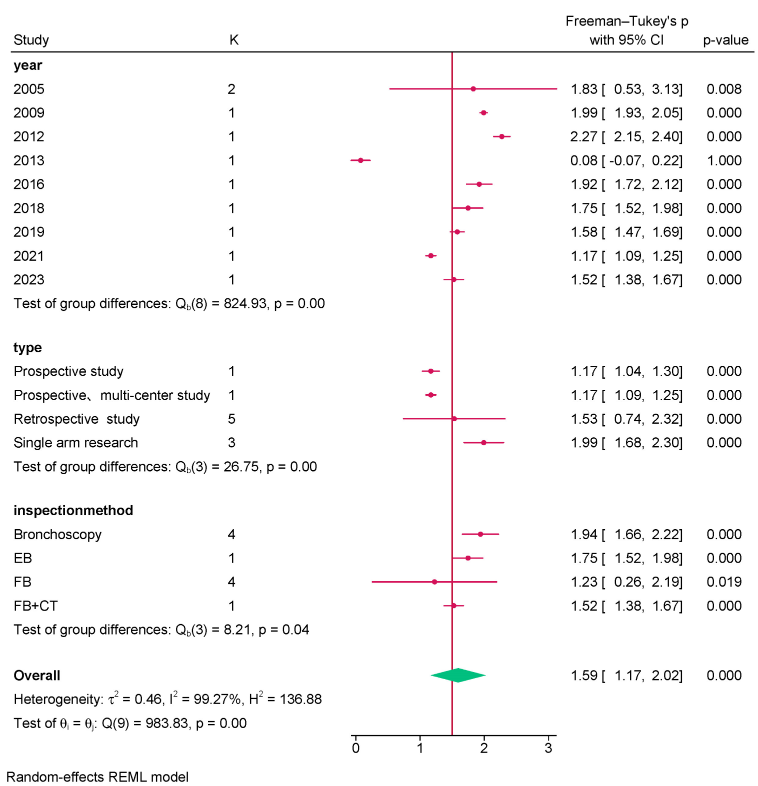

Figure 9. Meta-analysis of male incidence rate.

Meta-analysis of bronchoscopic types: Eight articles [23-29, 31] reported the bronchoscopic types of lung cancer, involving a total of 4,779 patients. Significant heterogeneity was observed across studies (I^2> 50%, P<0.01), and a random-effects model was applied for the single-arm proportion meta-analysis. For proliferative lung cancer, the pooled effect estimate was 1.50 (95% CI: 1.25-1.74; Q=180.64, P<0.01). In the subgroup analyses, the highest effect estimate was observed in studies published in 2012 among the publication-year subgroups, in single-arm studies among the study-type subgroups, and in studies using EB among the examination-method subgroups. Significant differences in effect estimates were observed among different publication years and examination methods (P< 0.01). The detailed results are shown in **Figure 11**.

For invasive lung cancer, the pooled effect estimate was 1.14 (95% CI: 0.94-1.35; Q= 225.58, P<0.01). In the subgroup analyses, the highest effect estimate was observed in studies published in 2013 among the publication-year subgroups, in retrospective studies among the study-type subgroups, and in studies using EB among the examination-method subgroups. Significant differences in effect estimates were observed among different publication years and examination methods (P<0.01). The detailed results are shown in **Figure 12**.

For lung cancer with non-specific changes, the pooled effect estimate was 0.83 (95%

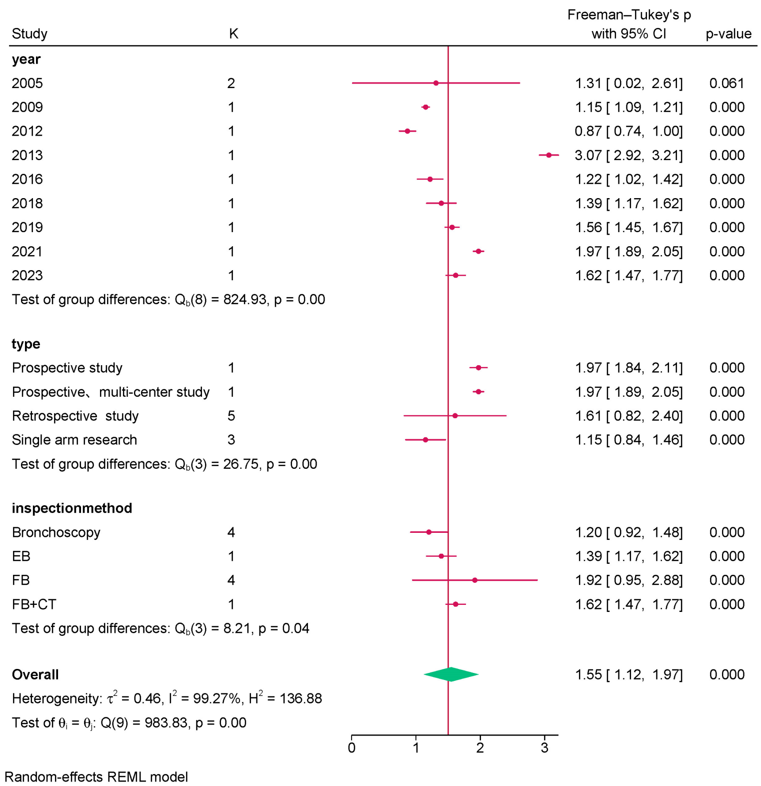

Figure 10. Meta-analysis of female incidence rate.

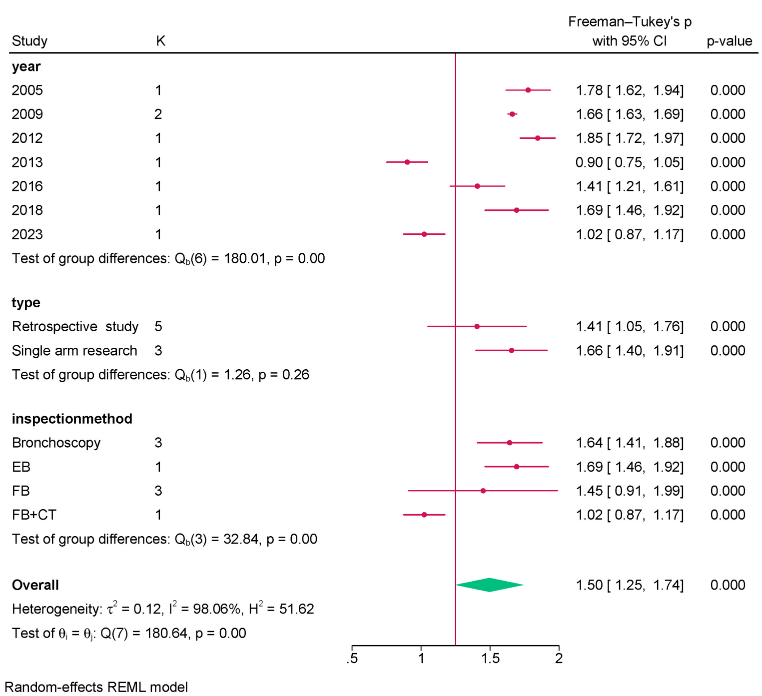

Figure 11. Meta-analysis of proliferative lung cancer.

CI: 0.60-1.06; Q=498.02, P<0.01). In the subgroup analyses, the highest effect estimate was observed in studies published in 2013 among the publication-year subgroups, in single-arm studies among the study-type subgroups, and in studies using FB among the examination-method subgroups. Significant differences in effect estimates were observed among different publication years (P<0.01). The detailed results are shown in **Figure 13**.

Meta-regression analysis: A meta-regression analysis was performed based on nine articles reporting lung adenocarcinoma. The results indicated that publication year and study type were significant sources of heterogeneity among the included studies (P<0.01). The detailed results are presented in **Table 2**.

Other indicators: The number of articles available for indicators ① ② ③ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩ ⑪ ⑫ ⑯ was insufficient for quantitative synthesis. Moreover, assessment of small-study effects is mainly applicable to randomized controlled trials and diagnostic accuracy meta-analyses. For single-arm proportion meta-analyses, the interpretation of funnel plots lacks standardized criteria. Therefore, funnel plot analysis and small-study effect assessment were not performed in this study.

Discussion

Lung cancer is a malignant tumor that develops from the mucosa or glands of the trachea and bronchi. Risk factors include advanced age, smoking, chronic lung diseases, and respiratory irritants. Patients often present with symptoms such as shortness of breath, cough, and bronchial ab-

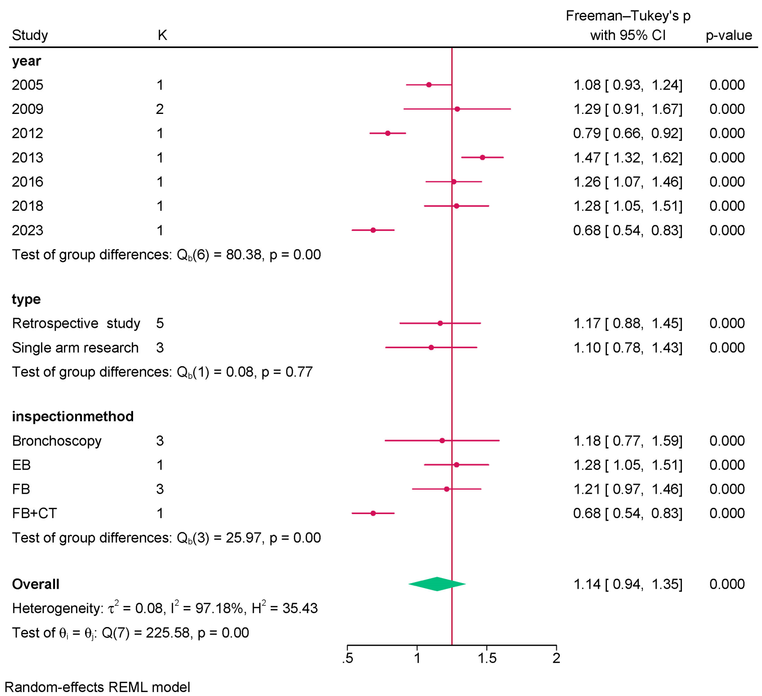

Figure 12. Meta-analysis of infiltrative lung cancer.

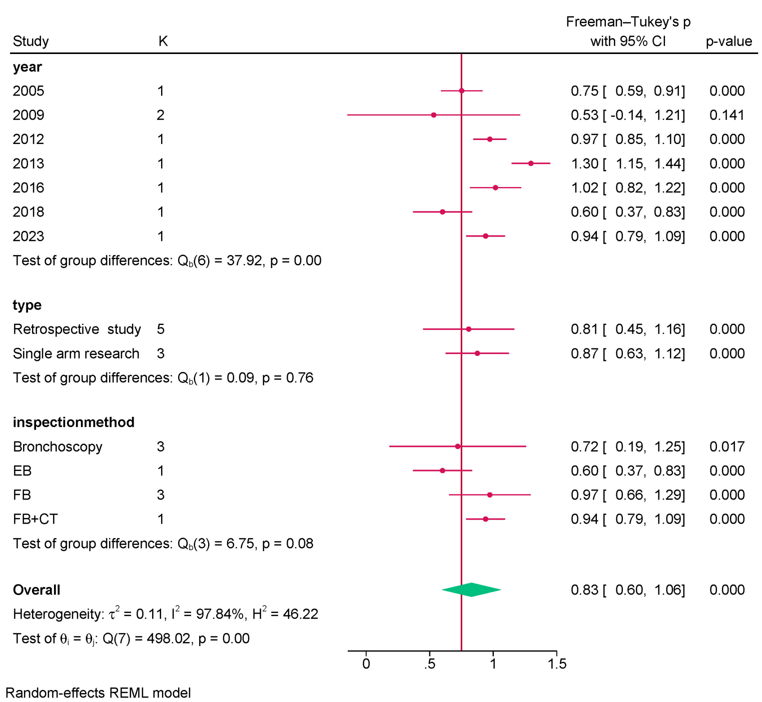

Figure 13. Meta-analysis of non-specific lung cancer changes.

normalities [33]. However, with the increasing prevalence of lung cancer and related complications, challenges including limited accuracy of early diagnosis and difficulties in tumor classification have severely impacted the quality of treatment for this disease [34, 35]. Shimoda M et al. [36] confirmed in their study that, compared to 2021, the incidence of lung abscesses after bronchoscopy for lung cancer patients was lower in 2013 (3.7% vs. 0.8%). This was not significantly related to age, smoking, or whether the tumor affected the bronchi. It is clear that, aside from common characteristics of lung cancer, clinical practice requires more scientific and reasonable examination methods to clarify its features and improve diagnostic accuracy, thus ensuring better early diagnosis and treatment outcomes. Therefore, this study analyzed the clinical data of 8,892 lung cancer patients and found that the pooled summary estimate for the accuracy of bronchoscopy in diagnosing this disease was 2.22. Among the different bronchoscopic approaches, the pooled effect sizes of "Bronchoscopy + ultrasound", "FB", and "EB" were all greater than 2. This is because bronchial examination using electronic devices or ultrasound has become a routine diagnostic procedure in bronchoscopy. For example, using FB can significantly reduce the stimulation to the respiratory tract and bronchi from interventional procedures, thereby reducing mucosal damage [37]. "Bronchoscopy + ultrasound" or "EB" not only has high diagnostic value and sensitivity in assessing mediastinal lymph node metastasis of lung cancer, but also helps to accurately diagnose early peripheral lung lesions and their nature by using miniature radial ultrasound probes and guiding sheaths to enter smaller tissue spaces [38, 39].

Table 2. Meta-regression analysis

Variable	β	SE	P	DOR	95% CI
year	0.092	0.019	<0.001	4.92	0.056-0.129
n	0	0.001	0.868	0.17	0-0.0002
type	-0.611	0.197	0.002	-3.10	-0.997--0.225
Disease	-0.113	0.175	0.519	-0.64	-0.457-0.230
Inspection method	-0.058	0.091	0.524	-0.64	-0.235-0.120
cons	-183.187	37.946	<0.001	-4.83	-257.560--108.813

Some studies [40, 41] suggest that the peak incidence of lung cancer occurs between the ages of 60 and 70, with a gradual decline after the age of 70. However, according to the meta-analysis of age, this study found that the majority of lung cancer cases were concentrated in patients under 60 years old (a pooled effect estimate of 1.69). This indicates a trend of decreasing age of onset for lung cancer in China. Moreover, in the subgroup analyses of examination methods stratified by age (≥60 years and <60 years), FB showed the highest pooled effect estimate in patients aged ≥60 years (1.67) and the lowest pooled effect estimate in patients aged <60 years (1.48). This shows that FB may be more frequently selected for elderly patients during lung cancer diagnosis and may provide better safety and therapeutic value. This is consistent with the findings of Mineshita M et al. [42]. Previous studies have generally reported that lung cancer occurs more frequently in men, which is also consistent with the findings of the present study. However, with changes in modern lifestyles, the impact of gender differences on lung cancer incidence has gradually decreased, while the risk factors for lung cancer in women (such as smoking and respiratory diseases) are increasing [43]. A report on lung cancer incidence in Hungary [44] states that in most age groups, the incidence rate in men has decreased by 2-11%, while the incidence rate in women over 60 years old has increased by 1-3%, and in contrast to Western countries, the incidence rate in the younger population has reached its peak. Zhang SW et al. [45] also pointed out in their study on the trend of lung cancer age of onset that the annual increase in the incidence rate for women was greater than for men (4.5% vs. 3.5%).

In addition, due to factors such as genetics, region, occupation, and the environment, the characteristics of lung cancer onset can vary significantly. For example, in the United States, the lung cancer mortality rate in women is higher than that of breast cancer; in France, although the incidence and mortality rates of lung cancer in women continue to rise, they are still lower than those in men (with a 1:2 incidence ratio) [46]. In this study, lung adenocarcinoma showed the highest pooled effect size among pathological types, followed by lung squamous cell carcinoma. Regarding bronchoscopic appearances, proliferative lung cancer had the highest pooled effect size, whereas non-specific bronchoscopic changes had the lowest. It is evident that simple pathological or bronchoscopic examinations are no longer sufficient to meet clinical diagnostic needs. Nadig TR et al. [47], after analyzing 126 studies, also concluded that while bronchoscopic technology has developed significantly, its diagnostic value remains limited. On the other hand, Kops SEP et al. [48] suggested that adding advanced imaging or (and) robotic navigation techniques to bronchoscopy can significantly improve this limitation. Furthermore, the diagnostic performance of different examination methods varies among different pathological or bronchoscopic types. For example, in lung adenocarcinoma, the subgroup effect size of the “FB+CT” approach was 2.12, whereas it was only 0.50 in lung squamous cell carcinoma. The subgroup effect size of “EB” was 1.69 for proliferative lung cancer, 1.28 for infiltrative lung cancer, and 1.34 for lung cancer with non-specific bronchoscopic changes. This suggests that different types of lung cancer require different diagnostic methods, and in clinical practice, flexible selection of bronchoscopy and navigation techniques should be employed.

Conclusion

Bronchoscopic examination of lung cancer has considerable advantages, with lung adenocarcinoma being the predominant pathological type and proliferative lung cancer being the main bronchoscopic type. Most patients diagnosed with lung cancer by bronchoscopy were younger than 60 years, and the proportion of males was slightly higher than that of females. Among the various diagnostic methods, flexible bronchoscopy (FB) holds significant value in lung cancer detection. However, this study was based on a single-arm proportion meta-analysis, with a relatively limited analytical scope, and did not perform detailed subgroup analyses according to language or country, which may introduce potential language bias. Future studies should further clarify the optimal diagnostic techniques for different lung cancer subtypes according to specific clinical contexts, thereby improving the diagnostic performance of bronchoscopy and expanding the breadth and depth of research.

Disclosure of conflict of interest

None.

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