eISSN: 2234-2591
Open Access

Review

Ewha Med J 2025;48(2):e23
https://doi.org/10.12771/emj.2025.00052

Ewha Medical Journal

Impact of pulmonary tuberculosis on lung cancer screening: a narrative review

Jeong Uk Lim*

Division of Pulmonary and Critical Care Medicine, Department of Internal Medicine, Yeouido St. Mary's Hospital, College of Medicine, The Catholic University of Korea, Seoul, Korea

Lung cancer remains a leading cause of cancer-related mortality worldwide. Low-dose computed tomography (LDCT) screening has demonstrated efficacy in reducing lung cancer mortality by enabling early detection. In several countries, including Korea, LDCT-based screening for high-risk populations has been incorporated into national healthcare policies. However, in regions with a high tuberculosis (TB) burden, the effectiveness of LDCT screening for lung cancer may be influenced by TB-related pulmonary changes. Studies indicate that the screen-positive rate in TB-endemic areas differs from that in low-TB prevalence regions. A critical challenge is the differentiation between lung cancer lesions and TB-related abnormalities, which can contribute to false-positive findings and increase the likelihood of unnecessary invasive procedures. Additionally, structural lung damage from prior TB infections can alter LDCT interpretation, potentially reducing diagnostic accuracy. Nontuberculous mycobacterial infections further complicate this issue, as their radiologic features frequently overlap with those of TB and lung cancer, necessitating additional microbiologic confirmation. Future research incorporating artificial intelligence and biomarkers may enhance diagnostic precision and facilitate a more personalized approach to lung cancer screening in TB-endemic settings.

Keywords: Artificial intelligence; Biomarkers; Early detection of cancer; Lung neoplasms; Pulmonary tuberculosis

Introduction

Background

Lung cancer is a leading cause of cancer-related deaths globally [1]. In the United States, its 5-year age-adjusted incidence and mortality rates are recorded at 49.0 and 32.4 per 100,000, respectively [2]. One of the primary reasons for lung cancer's high mortality rate is that it is often diagnosed at an advanced stage when curative treatment option is limited [3]. The introduction of lung cancer screening (LCS) using low-dose computed tomography (LDCT) has been associated with a measurable decrease in lung cancer-related mortality [4,5].

LDCT plays a pivotal role in detecting lung lesions suspected of malignancy while maintaining low radiation exposure [6]. Individuals presenting with abnormal lung findings may require continued monitoring or definitive diagnostic procedures such as percutaneous needle aspiration, bronchoscopy, or surgical resection [7,8]. LDCT enables the early detection of lung cancer, which is often not detectable on routine chest X-rays [9]. In countries with a high tuberculosis (TB) burden, LCS with LDCT is especially crucial, as conventional chest X-rays often fail to clearly differentiate TB-related sequelae from malignant lesions. Among the various forms of TB sequelae, cavitary lesions and aspergillomas pose a significant challenge in distinguishing them from lung cancer [10]. This, in turn, contributes to improved patient survival by facilitating the diagnosis of lung cancer at an earlier stage [11]. Consequently, several global health organizations endorse LCS, leading to its integration into many national healthcare policies [12-14]. However, conditions such as TB and histoplasmosis can produce LDCT findings resembling malignancies, potentially resulting in unnecessary imaging and invasive testing, which may subject patients to procedural risks and psychological distress [15,16].

Pulmonary TB remains a critical public health concern [17], and presents a diagnostic challenge in differentiating it from malignancy, especially in patients with a past history of mycobacterial

*Corresponding email: cracovian@catholic.ac.kr
Received: February 16, 2025 Revised: March 14, 2025 Accepted: March 17, 2025

infection, a positive tuberculin skin test or interferon-gamma release assay [18,19], and concurrent radiographic pulmonary abnormalities. The diagnosis of lung cancer may be delayed when malignant lesions are mistaken for active TB [20,21].

Objectives

This review aims to examine how TB affects LCS and further explores what clinicians should know to distinguish between the 2 diseases.

Ethics statement

As this study is a literature review, it did not require institutional review board approval or individual consent.

Low-dose computed tomography screening for lung cancer

LDCT screening is linked to a substantial reduction in both lung cancer-related and overall mortality [22]. The National Lung Screening Trial, a randomized clinical study, demonstrated that LDCT reduced lung cancer-specific mortality by 20% and overall mortality by 6.7% compared to chest radiography [4,23]. A subsequent 10-year follow-up from the Dutch-Belgian lung cancer screening trial (NELSON) reaffirmed these findings, further supporting the expansion of LDCT-based screening programs [5]. Currently, the U.S. Preventive Services Task Force advises LCS for asymptomatic individuals aged 50 to 80 years who are either current smokers or former smokers who quit within the last 15 years, with a smoking history of at least 20 pack-years [12,24].

In 2015, a Korean multi-society collaborative committee issued LCS guidelines, advocating annual LDCT screening for individuals aged 55–74 years who are either current or former smokers (having quit within the past 15 years) with a history of at least 30 pack-years of smoking [25]. To implement a standardized screening protocol, a multidisciplinary expert committee developed the Korean Lung Cancer Screening Project (K-LUCAS), a population-based, single-arm trial focusing on high-risk individuals who meet these criteria. LDCT results within this initiative follow Lung Imaging Reporting and Data System (Lung-RADS) classification as recommended by the American Radiology Society [26].

Does tuberculosis affects lung cancer screening?

TB is a widespread infectious disease [27], affecting around 25% of the global population with *Mycobacterium tuberculosis* infection. Since 2000, an estimated 58 million individuals have survived the disease [28,29].

For risk-based LCS, age and tobacco use are key determinants; moreover, several lung cancer risk prediction models also consider chronic obstructive pulmonary disease (COPD) and a history of prior cancer [8,30,31], but other comorbidities, along with pulmonary TB is not included [32,33]. Furthermore, most trials on LCS were from regions with low TB prevalence [5,13,34]. In contrast, studies from TB-endemic areas have reported varying screen-positive rates, creating challenges for developing countries in implementing LCS programs [35-37]. It is important to understand key studies on the differences between low TB burden countries and those with a more significant burden.

Studies indicate that individuals with TB face an elevated risk of lung cancer compared to those without TB. A population-based cohort study conducted in Taiwan found that a history of TB was associated with a 1.76-fold increase in lung cancer risk. Multivariate analysis confirmed pulmonary TB as an independent risk factor for lung cancer [38]. A prospective cohort study in Korea found a significant link between pre-existing TB and a higher likelihood of developing lung cancer, with hazard ratios of 1.37 in men and 1.49 in women [39]. A meta-analysis including approximately 477,000 individuals from 44 studies showed that the lung cancer detection rate by LDCT for LCS was 0.94% in high TB-burden countries [40].

Korea is considered a TB-endemic region while providing a unique clinical environment for the advanced detection of 2 major lung diseases: pulmonary TB and lung cancer [41,42]. In 2022, Korea reported a total of 20,383 TB cases, corresponding to an incidence rate of 39.8 per 100,000 people [43]. A multicenter prospective study in Korea (K-LUCAS) involving 11,394 participants, of whom TB sequelae were identified in 13%, reported a 0.6% lung cancer diagnosis rate; the specificity of Lung-RADS was higher in participants without TB sequelae (85%) compared to those with sequelae (80%) ($P < 0.001$), while sensitivity remained unchanged between groups [36].

TB can influence lung cancer risk, particularly among populations eligible for LCS. Moon et al. [29] not only demonstrated an increased lung cancer risk in TB patients but also identified age over 60, smoking, and comorbid COPD or asthma as risk factors among TB survivors. In the COPD subgroup, a well-established risk factor for lung cancer [44], patients with a history of TB had a significantly higher risk of developing lung cancer compared to those without (hazard ratio [HR], 1.24; 95% confidence interval [CI], 1.03–1.50) [45].

Beyond its impact on lung cancer prevalence, concurrent pulmonary TB also influences lung cancer-related mortality. A retro-

spective study in China found that individuals with TB had significantly higher lung cancer mortality (25 vs. 3.1 per 1,000 person-years), with the highest risk observed within the first 5 years post-diagnosis (HR, 6.7–13). The increased risk remained at 5–9.9 years (HR, 3.4; 95% CI, 1.3–9.1) and persisted beyond 10 years (HR, 3.0; 95% CI, 1.3–7.3). This association remained significant even after adjusting for confounding factors [46] (Table 1).

Differentiation between pulmonary tuberculosis and lung cancer

In China, 45 out of 6,683 patients (0.7%) initially diagnosed with TB were later confirmed to have lung cancer, primarily due to radiologic suspicion and 27% having a positive sputum acid-fast stain [47].

Radiologic evaluation plays a important role in diagnosing TB, with early bronchogenic spread typically appearing as 2–4 mm centrilobular nodules and branching linear opacities on computed tomography (CT), corresponding to intrabronchiolar and peribronchiolar necrosis. As the disease advances, these nodules may coalesce into larger 5–8 mm lesions or form consolidated lobular opacities [48]. Following anti-TB treatment, residual structural changes, including bronchovascular distortion, bronchiectasis, fibrosis, and emphysema, may persist [49]. Miliary TB on CT often presents initially as ground-glass opacities with indistinct nodules, progressing to discrete miliary nodules measuring less than 3 cm [50]. The variability in pulmonary nodule size frequently complicates diagnosis, particularly when clinical symptoms are non-specific. In some cases, TB manifests as multiple well-defined nodules with partial fusion, further increasing the likelihood of misinterpretation [51]. Additionally, in patients with a history of TB or malignancy, imaging similarities between these diseases increase the risk of misdiagnosis [52].

Positron emission tomography (PET)/CT is an essential tool for lung mass characterization and offers higher accuracy than CT alone for mediastinal lymph node staging in malignancies [53]. However, false positives remain a concern due to increased fluo-

Table 1. Key studies on the influence of pulmonary tuberculosis on lung cancer screening

Study references	Design	Country	Patients	Key findings
[40]	Meta-analysis	Multinational	44 studies with 477,424 individuals	Screen-positive and lung cancer detection rates in high TB-burden countries compared to regions with lower TB incidence
[36]	Multicenter prospective study	Korea (K-LUCAS)	11,394 participants	Lung cancer diagnosis 0.6%; TB sequelae identified in 13%. Specificity of Lung-RADS was higher for participants without TB sequelae (85%) than for those with TB sequelae (80%) ($P<0.001$). Sensitivity was not different between groups.
[38]	Retrospective nationwide population-based cohort study	Taiwan	5657 pulmonary TB patients and 23,984 age- and sex-matched controls	Lung cancer incidence was higher in pulmonary TB patients (269 vs. 153 per 100,000 person-years; IRR, 1.76; 95% CI, 1.33–2.32; $P<0.001$). The risk remained elevated at 2–4 years (IRR, 1.98), 5–7 years (IRR, 1.42), and 8–12 years (IRR, 1.59) post-infection.
[46]	Retrospective study	China	42,422 participants from Xuanwei County	Lung cancer mortality was significantly higher in individuals with TB (25 vs. 3.1 per 1,000 person-years), especially within the first 5 years post-diagnosis (HR, 6.7–13). The risk remained elevated at 5–9.9 years (HR, 3.4; 95% CI, 1.3–9.1) and beyond 10 years (HR, 3.0; 95% CI, 1.3–7.3). The association was significant in the adjusted model.
[45]	Retrospective nationwide population study	Korea	13,165 Korean men and women with COPD	Compared to participants without a history of TB, the fully adjusted subdistribution HR (95% CI) for lung cancer in those with a pulmonary TB history was 1.24 (1.03–1.50).
[29]	Retrospective population study	Korea	75,467 TB survivors	The risk of developing lung cancer was 1.72 times higher in TB survivors compared to controls. Among them, current smokers with at least 20 pack-years had the greatest risk (adjusted HR, 6.78) relative to never-smokers without TB.

TB, tuberculosis; K-LUCAS, Korean Lung Cancer Screening Project; Lung-RADS, Lung Imaging Reporting and Data System; IRR, incidence rate ratio; CI, confidence interval; HR, hazard ratio; COPD, chronic obstructive pulmonary disease.

rodeoxyglucose (FDG) uptake in inflammatory and infectious conditions [54]. Lymph node TB, for example, often exhibits significant FDG uptake, which can be confused with malignancy in patients with multiple hypermetabolic lesions [55]. Therefore, when PET/CT shows increased FDG uptake in patients suspected of having metastases, tuberculous lymphadenopathy should be considered in the differential diagnosis. As the next step in differential diagnosis, pathological evaluation using endobronchial ultrasound-guided transbronchial needle aspiration can provide a more confirmative diagnosis.

When performing a pathologic diagnosis, granulomatous inflammation often occurs in infectious diseases such as TB, as well as in local inflammatory reactions in malignant tumors [56,57]. Hence, although biopsy pathology is important for distinguishing cancer from TB, it cannot be performed routinely due to procedure-related risks [58]. Microbiological confirmation is essential for the definitive diagnosis of pulmonary TB, with a positive sputum culture being a key diagnostic indicator [59]. Tumor markers cannot be specific indicators for differentiating between TB and metastasis [52].

Do nontuberculous mycobacteria affect lung cancer screening?

Nontuberculous mycobacteria (NTM) are widely present in the human environment and are closely associated with chronic pulmonary infections [60-62]. Among the various species, *Mycobacterium avium-intracellulare* complex is the leading cause of NTM-pulmonary disease (NTM-PD) worldwide [63,64]. Although the incidence and prevalence of NTM disease vary among different populations, both have been increasing over time [65-67]. Pulmonary TB and NTM-PD share a similarity in that both diseases often yield positive sputum AFB smears [68,69]. Furthermore, radiologic findings such as lung cavitary lesions, tree-in-bud patterns, and bronchogenic spread are observed in both diseases [68,70].

There are limited studies on the impact of NTM on LCS. However, given its radiologic similarity to pulmonary TB and its high incidence in certain countries, including Korea, the presence of pulmonary NTM is likely to influence LCS outcomes. In Korea, the annual prevalence of NTM diseases rose from 11.4 to 56.7 cases per 100,000 people between 2010 and 2021 [71]. This increasing trend suggests a growing health burden associated with NTM [72], potentially affecting LCS practices and outcomes.

A key distinction between NTM and TB is that, in most cases, pulmonary NTM is not airborne and therefore person-to-person transmission is not proven [73]. However, since LDCT findings alone cannot definitely differentiate between NTM and TB, microbiologic studies are essential along with routine imaging follow-up. However, even when microbiologic evidence confirms NTM, if serial imaging shows changes in lesion size or shape that raise suspicion of malignancy, more aggressive diagnostic measures, such as pathological confirmation, should be pursued.

In a retrospective study of 388 patients with NTM-PD, 14 suspected of having lung cancer were analyzed, with 3.6% presenting as solitary nodules or mass-like consolidations, often incidentally detected, showing poor contrast enhancement, internal calcifications, and strong PET/CT FDG uptake in those who underwent PET/CT [74].

TB is not the only lung infection linked to an increased risk of lung cancer [75-78], suggesting that NTM could also be a potential risk factor. Like TB, NTM infections may contribute to an increased risk of lung cancer by inducing chronic inflammation [79]. Chronic lung inflammation or scar tissue formation following respiratory infections may contribute to lung cancer development [80]. Although current evidence directly connecting NTM to lung cancer is limited, further research is necessary given the growing prevalence of NTM in many populations. For future studies, it will be necessary to analyze the lung cancer detection rate among NTM populations.

Future perspectives

A major challenge in detecting lung cancer in TB-endemic regions is distinguishing TB-related lesions from true malignancies to reduce unnecessary invasive procedures. Recent advancements in artificial intelligence are expected to play a crucial role by supporting clinicians in making informed decisions regarding the need for pathological diagnosis [81,82]. Furthermore, there is a significant need for biomarkers that can reliably differentiate benign lesions from early-stage cancers during imaging, whether in low-dose CT screening or incidentally detected nodules [83,84]. As imaging alone may not be adequate to distinguish between TB and lung cancer, future studies should investigate the potential of liquid biopsy techniques, such as circulating tumor cells, circulating tumor DNA, extracellular vesicles, and tumor-educated platelets, in cancer screening [85].

Conclusion

Pulmonary TB significantly complicates LCS by mimicking malignant lesions LDCT, potentially leading to misdiagnosis, delayed treatment, and unnecessary procedures. In TB-endemic regions, distinguishing TB sequelae from lung cancer remains a di-

agnostic challenge, increasing patient risks and psychological distress. While LDCT enhances early detection and reduces mortality, TB's presence elevates lung cancer risk and mortality, necessitating improved differentiation strategies. Future advancements in AI and biomarkers could refine LCS accuracy, optimizing outcomes in high-TB-burden areas.

ORCID

Jeong Uk Lim: https://orcid.org/0000-0001-8364-2380

Authors' contributions

All work was done by Jeong Uk Lim.

Conflict of interest

No potential conflict of interest relevant to this article was reported.

Funding

None.

Data availability

Not applicable.

Acknowledgments

None.

Supplementary materials

None.

References

1. Sung H, Ferlay J, Siegel RL, Laversanne M, Soerjomataram I, Jemal A, Bray F. Global Cancer Statistics 2020: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. CA Cancer J Clin 2021;71:209-249. https://doi.org/10.3322/caac.21660
2. National Cancer Institute, Surveillance Epidemiology, and End Results Program. All cancer sites combined recent trends in SEER age-adjusted incidence rates, 2000-2021 [Internet]. National Cancer Institute; 2024 [cited 2025 Feb 10]. Available from: https://seer.cancer.gov/statistics-network/explorer/
3. Howlader N, Noone AM, Krapcho M, Garshell J, Miller D, Altekruse SF, Kosary CL, Yu M, Ruhl J, Tatalovich Z, Mariotto A, Lewis DR, Chen HS, Feuer EJ, Cronin KA. SEER cancer statistics review, 1975-2012 [Internet]. National Cancer Institute; 2014 [cited 2025 Feb 10]. Available from: http://seer.cancer.gov/archive/csr/1975_2012/
4. National Lung Screening Trial Research Team; Aberle DR, Adams AM, Berg CD, Black WC, Clapp JD, Fagerstrom RM, Gareen IF, Gatsonis C, Marcus PM, Sicks JD. Reduced lung-cancer mortality with low-dose computed tomographic screening. N Engl J Med 2011;365:395-409. https://doi.org/10.1056/NEJMoa1102873
5. de Koning HJ, van der Aalst CM, de Jong PA, Scholten ET, Nackaerts K, Heuvelmans MA, Lammers JJ, Weenink C, Yousaf-Khan U, Horeweg N, van 't Westeinde S, Prokop M, Mali WP, Mohamed Hoesein FA, van Ooijen PM, Aerts JG, den Bakker MA, Thunnissen E, Verschakelen J, Vliegenthart R, Walter JE, Ten Haaf K, Groen HJ, Oudkerk M. Reduced lung-cancer mortality with volume CT screening in a randomized trial. N Engl J Med 2020;382:503-513. https://doi.org/10.1056/NEJMoa1911793
6. Silva M, Picozzi G, Sverzellati N, Anglesio S, Bartolucci M, Cavigli E, Deliperi A, Falchini M, Falaschi F, Ghio D, Gollini P, Larici AR, Marchiano AV, Palmucci S, Preda L, Romei C, Tessa C, Rampinelli C, Mascalchi M. Low-dose CT for lung cancer screening: position paper from the Italian College of Thoracic Radiology. Radiol Med 2022;127:543-559. https://doi.org/10.1007/s11547-022-01471-y
7. Kim SH, Kim MH, Lee MK, Eom JS. Problems in the pathologic diagnosis of suspected lung cancer. Tuberc Respir Dis (Seoul) 2023;86:176-182. https://doi.org/10.4046/trd.2022.0142
8. Park D. Advanced bronchoscopic diagnostic techniques in lung cancer. Tuberc Respir Dis (Seoul) 2024;87:282-291. https://doi.org/10.4046/trd.2023.0147
9. Hanna WC, Paul NS, Darling GE, Moshonov H, Allison F, Waddell TK, Cypel M, de Perrot ME, Yasufuku K, Keshavjee S, Pierre AF. Minimal-dose computed tomography is superior to chest X-ray for the follow-up and treatment of patients with resected lung cancer. J Thorac Cardiovasc Surg 2014;147:30-33. https://doi.org/10.1016/j.jtcvs.2013.08.060
10. Bandoh S, Fujita J, Fukunaga Y, Yokota K, Ueda Y, Okada H, Takahara J. Cavitary lung cancer with an aspergilloma-like shadow. Lung Cancer 1999;26:195-198. https://doi.org/10.1016/s0169-5002(99)00080-x
11. Kim MH, Kim SH, Lee MK, Eom JS. Recent advances in adjuvant therapy for non-small-cell lung cancer. Tuberc Respir Dis (Seoul) 2024;87:31-39. https://doi.org/10.4046/trd.2023.0085
12. US Preventive Services Task Force; Krist AH, Davidson KW, Mangione CM, Barry MJ, Cabana M, Caughey AB, Davis EM, Donahue KE, Doubeni CA, Kubik M, Landefeld CS, Li L, Ogedegbe G, Owens DK, Pbert L, Silverstein M, Stevermer J, Tseng

CW, Wong JB. Screening for lung cancer: US Preventive Services Task Force recommendation statement. JAMA 2021;325:962-970. https://doi.org/10.1001/jama.2021.1117
13. Kauczor HU, Baird AM, Blum TG, Bonomo L, Bostantzoglou C, Burghuber O, Cepicka B, Comanescu A, Couraud S, Devaraj A, Jespersen V, Morozov S, Agmon IN, Peled N, Powell P, Prosch H, Ravara S, Rawlinson J, Revel MP, Silva M, Snoeckx A, van Ginneken B, van Meerbeeck JP, Vardavas C, von Stackelberg O, Gaga M; European Society of Radiology (ESR) and the European Respiratory Society (ERS). ESR/ERS statement paper on lung cancer screening. Eur Radiol 2020;30:3277-3294. https://doi.org/10.1007/s00330-020-06727-7
14. Lee J, Kim Y, Kim HY, Goo JM, Lim J, Lee CT, Jang SH, Lee WC, Lee CW, Choi KS, Park B, Lee DH. Feasibility of implementing a national lung cancer screening program: interim results from the Korean Lung Cancer Screening Project (K-LUCAS). Transl Lung Cancer Res 2021;10:723-736. https://doi.org/10.21037/tlcr-20-700
15. Balekian AA, Tanner NT, Fisher JM, Silvestri GA, Gould MK. Factors associated with a positive baseline screening exam result in the National Lung Screening Trial. Ann Am Thorac Soc 2016;13:1568-1574. https://doi.org/10.1513/AnnalsATS.201602-091OC
16. Shankar A, Saini D, Dubey A, Roy S, Bharati SJ, Singh N, Khanna M, Prasad CP, Singh M, Kumar S, Sirohi B, Seth T, Rinki M, Mohan A, Guleria R, Rath GK. Feasibility of lung cancer screening in developing countries: challenges, opportunities and way forward. Transl Lung Cancer Res 2019;8(Suppl 1):S106-S121. https://doi.org/10.21037/tlcr.2019.03.03
17. World Health Organization. Global tuberculosis report 2017. World Health Organization; 2017.
18. Kang SW, Lee J, Kim SM, Kang D, Chang E, Bae S, Jung J, Kim MJ, Chong YP, Lee SO, Choi SH, Kim YS, Kim SH. Quantitative interferon-gamma releasing assay in predicting tuberculosis in South Korean military: a retrospective cohort study. Clin Microbiol Infect 2024;30:1284-1290. https://doi.org/10.1016/j.cmi.2024.04.014
19. Swensen SJ, Viggiano RW, Midthun DE, Muller NL, Sherrick A, Yamashita K, Naidich DP, Patz EF, Hartman TE, Muhm JR, Weaver AL. Lung nodule enhancement at CT: multicenter study. Radiology 2000;214:73-80. https://doi.org/10.1148/radiology.214.1.r00ja1473
20. Parker CS, Siracuse CG, Litle VR. Identifying lung cancer in patients with active pulmonary tuberculosis. J Thorac Dis 2018;10(Suppl 28):S3392-S3397. https://doi.org/10.21037/jtd.2018.07.11
21. Scott C, Kirking HL, Jeffries C, Price SF, Pratt R; Centers for Disease Control and Prevention (CDC). Tuberculosis trends: United States, 2014. MMWR Morb Mortal Wkly Rep 2015;64:265-269.
22. Li N, Tan F, Chen W, Dai M, Wang F, Shen S, Tang W, Li J, Yu Y, Cao W, Xu Y, Qin C, Zhao L, Zhu M, Guo L, Wu Z, Yang Z, Zheng Y, Chen H, Liu Y, Wei D, Dong D, Cao J, Zhang S, Yan S, Wang N, Du L, Shen H, Wu N, He J; National Lung Cancer Screening programme group. One-off low-dose CT for lung cancer screening in China: a multicentre, population-based, prospective cohort study. Lancet Respir Med 2022;10:378-391. https://doi.org/10.1016/S2213-2600(21)00560-9
23. National Lung Screening Trial Research Team; Aberle DR, Berg CD, Black WC, Church TR, Fagerstrom RM, Galen B, Gareen IF, Gatsonis C, Goldin J, Gohagan JK, Hillman B, Jaffe C, Kramer BS, Lynch D, Marcus PM, Schnall M, Sullivan DC, Sullivan D, Zylak CJ. The National Lung Screening Trial: overview and study design. Radiology 2011;258:243-253. https://doi.org/10.1148/radiol.10091808
24. Wolf AM, Oeffinger KC, Shih TY, Walter LC, Church TR, Fontham ET, Elkin EB, Etzioni RD, Guerra CE, Perkins RB, Kondo KK, Kratzer TB, Manassaram-Baptiste D, Dahut WL, Smith RA. Screening for lung cancer: 2023 guideline update from the American Cancer Society. CA Cancer J Clin 2024;74:50-81. https://doi.org/10.3322/caac.21811
25. Kim HY. Lung cancer screening: update. J Korean Soc Radiol 2015;73:137-146. https://doi.org/10.3348/jksr.2015.73.3.137
26. Lee J, Lim J, Kim Y, Kim HY, Goo JM, Lee CT, Jang SH, Lee WC, Lee CW, An JY, Ko KD, Lee MK, Choi KS, Park B, Lee DH. Development of protocol for Korean Lung Cancer Screening Project (K-LUCAS) to evaluate effectiveness and feasibility to implement national cancer screening program. Cancer Res Treat 2019;51:1285-1294. https://doi.org/10.4143/crt.2018.464
27. World Health Organization. Global tuberculosis report 2013. World Health Organization; 2013.
28. Allwood BW, van der Zalm MM, Amaral AF, Byrne A, Datta S, Egere U, Evans CA, Evans D, Gray DM, Hoddinott G, Ivanova O, Jones R, Makanda G, Marx FM, Meghji J, Mpagama S, Pasipanodya JG, Rachow A, Schoeman I, Shaw J, Stek C, van Kampen S, von Delft D, Walker NF, Wallis RS, Mortimer K. Post-tuberculosis lung health: perspectives from the First International Symposium. Int J Tuberc Lung Dis 2020;24:820-828. https://doi.org/10.5588/ijtld.20.0067
29. Moon SM, Choi H, Kim SH, Kang HK, Park DW, Jung JH, Han K, Shin DW, Lee H. Increased lung cancer risk and associated risk factors in tuberculosis survivors: a Korean population-based study. Clin Infect Dis 2023;77:1329-1339. https://

doi.org/10.1093/cid/ciad373
30. Lansdorp-Vogelaar I, Gulati R, Mariotto AB, Schechter CB, de Carvalho TM, Knudsen AB, van Ravesteyn NT, Heijnsdijk EA, Pabiniak C, van Ballegooijen M, Rutter CM, Kuntz KM, Feuer EJ, Etzioni R, de Koning HJ, Zauber AG, Mandelblatt JS. Personalizing age of cancer screening cessation based on comorbid conditions: model estimates of harms and benefits. Ann Intern Med 2014;161:104-112. https://doi.org/10.7326/M13-2867
31. Terret C, Castel-Kremer E, Albrand G, Droz JP. Effects of comorbidity on screening and early diagnosis of cancer in elderly people. Lancet Oncol 2009;10:80-87. https://doi.org/10.1016/S1470-2045(08)70336-X
32. Gendarme S, Irajizad E, Long JP, Fahrmann JF, Dennison JB, Ghasemi SM, Dou R, Volk RJ, Meza R, Toumazis I, Canoui-Poitrine F, Hanash SM, Ostrin EJ. Impact of comorbidities on the mortality benefits of lung cancer screening: a post-hoc analysis of the PLCO and NLST trials. J Thorac Oncol 2025 Jan 9 [Epub]. https://doi.org/10.1016/j.jtho.2025.01.003
33. Kovalchik SA, Tammemagi M, Berg CD, Caporaso NE, Riley TL, Korch M, Silvestri GA, Chaturvedi AK, Katki HA. Targeting of low-dose CT screening according to the risk of lung-cancer death. N Engl J Med 2013;369:245-254. https://doi.org/10.1056/NEJMoa1301851
34. Henschke CI, McCauley DI, Yankelevitz DF, Naidich DP, McGuinness G, Miettinen OS, Libby DM, Pasmantier MW, Koizumi J, Altorki NK, Smith JP. Early Lung Cancer Action Project: overall design and findings from baseline screening. Lancet 1999;354:99-105. https://doi.org/10.1016/S0140-6736(99)06093-6
35. dos Santos RS, Franceschini JP, Chate RC, Ghefter MC, Kay F, Trajano AL, Pereira JR, Succi JE, Fernando HC, Junior RS. Do current lung cancer screening guidelines apply for populations with high prevalence of granulomatous disease?: results from the First Brazilian Lung Cancer Screening Trial (BRELT1). Ann Thorac Surg 2016;101:481-488. https://doi.org/10.1016/j.athoracsur.2015.07.013
36. Kim H, Kim HY, Goo JM, Kim Y. Lung cancer CT screening and lung-RADS in a tuberculosis-endemic country: the Korean Lung Cancer Screening Project (K-LUCAS). Radiology 2020;296:181-188. https://doi.org/10.1148/radiol.2020192283
37. Damaraju V, Singh N, Garg M, Kathirvel S, Basher RK, Grover S, Kalra N, Prasad KT. Effect of prior pulmonary TB on low-dose computed tomography during lung cancer screening. Int J Tuberc Lung Dis 2023;27:223-225. https://doi.org/10.5588/ijtld.22.0560
38. Wu CY, Hu HY, Pu CY, Huang N, Shen HC, Li CP, Chou YJ. Pulmonary tuberculosis increases the risk of lung cancer: a population-based cohort study. Cancer 2011;117:618-624. https://doi.org/10.1002/cncr.25616
39. Hong S, Mok Y, Jeon C, Jee SH, Samet JM. Tuberculosis, smoking and risk for lung cancer incidence and mortality. Int J Cancer 2016;139:2447-2455. https://doi.org/10.1002/ijc.30384
40. Damaraju V, Krushna Karri JK, Gandrakota G, Marimuthu Y, Ravindra AG, Aravindakshan R, Singh N. Low dose computed tomography for lung cancer screening in tuberculosis endemic countries: a systematic review and meta-analysis. J Thorac Oncol 2025;20:296-310. https://doi.org/10.1016/j.jtho.2024.11.020
41. Min J, Jeong Y, Kim HW, Kim JS. Tuberculosis notification and incidence: Republic of Korea, 2022. Tuberc Respir Dis (Seoul) 2024;87:411-413. https://doi.org/10.4046/trd.2024.0018
42. Lee JG, Kim HC, Choi CM. Recent trends of lung cancer in Korea. Tuberc Respir Dis (Seoul) 2021;84:89-95. https://doi.org/10.4046/trd.2020.0134
43. Korea Disease Control and Prevention Agency. Annual report on the notified tuberculosis in Korea: 2022. Korea Disease Control and Prevention Agency; 2023.
44. Parris BA, O'Farrell HE, Fong KM, Yang IA. Chronic obstructive pulmonary disease (COPD) and lung cancer: common pathways for pathogenesis. J Thorac Dis 2019;11(Suppl 17):S2155-S2172. https://doi.org/10.21037/jtd.2019.10.54
45. Park HY, Kang D, Shin SH, Choi H, Jang SH, Lee CH, Kim H, Kwon OJ, Rhee CK, Cho J. Pulmonary tuberculosis and the incidence of lung cancer among patients with chronic obstructive pulmonary disease. Ann Am Thorac Soc 2022;19:640-648. https://doi.org/10.1513/AnnalsATS.202010-1240OC
46. Engels EA, Shen M, Chapman RS, Pfeiffer RM, Yu YY, He X, Lan Q. Tuberculosis and subsequent risk of lung cancer in Xuanwei, China. Int J Cancer 2009;124:1183-1187. https://doi.org/10.1002/ijc.24042
47. Shu CC, Chang SC, Lai YC, Chang CY, Wei YF, Chen CY. Factors for the early revision of misdiagnosed tuberculosis to lung cancer: a multicenter study in a tuberculosis-prevalent area. J Clin Med 2019;8:700. https://doi.org/10.3390/jcm8050700
48. Skoura E, Zumla A, Bomanji J. Imaging in tuberculosis. Int J Infect Dis 2015;32:87-93. https://doi.org/10.1016/j.ijid.2014.12.007
49. Im JG, Itoh H, Shim YS, Lee JH, Ahn J, Han MC, Noma S. Pulmonary tuberculosis: CT findings: early active disease and sequential change with antituberculous therapy. Radiology 1993;186:653-660. https://doi.org/10.1148/radiology.186.3.8430169
50. Setio AA, Traverso A, de Bel T, Berens MS, Bogaard CV, Cerello P, Chen H, Dou Q, Fantacci ME, Geurts B, Gugten

RV, Heng PA, Jansen B, de Kaste MM, Kotov V, Lin JY, Manders JT, Sonora-Mengana A, Garcia-Naranjo JC, Papavasileiou E, Prokop M, Saletta M, Schaefer-Prokop CM, Scholten ET, Scholten L, Snoeren MM, Torres EL, Vandemeulebroucke J, Walasek N, Zuidhof GC, Ginneken BV, Jacobs C. Validation, comparison, and combination of algorithms for automatic detection of pulmonary nodules in computed tomography images: the LUNA16 challenge. Med Image Anal 2017;42:1-13. https://doi.org/10.1016/j.media.2017.06.015

51. Ringshausen FC, Tannapfel A, Nicolas V, Weber A, Duchna HW, Schultze-Werninghaus G, Rohde G. A fatal case of spinal tuberculosis mistaken for metastatic lung cancer: recalling ancient Pott's disease. Ann Clin Microbiol Antimicrob 2009;8:32. https://doi.org/10.1186/1476-0711-8-32
52. Xiang Y, Huang C, He Y, Zhang Q. Cancer or tuberculosis: a comprehensive review of the clinical and imaging features in diagnosis of the confusing mass. Front Oncol 2021;11:644150. https://doi.org/10.3389/fonc.2021.644150
53. Boland GW, Dwamena BA, Jagtiani Sangwaiya M, Goehler AG, Blake MA, Hahn PF, Scott JA, Kalra MK. Characterization of adrenal masses by using FDG PET: a systematic review and meta-analysis of diagnostic test performance. Radiology 2011;259:117-126. https://doi.org/10.1148/radiol.11100569
54. Chang JM, Lee HJ, Goo JM, Lee HY, Lee JJ, Chung JK, Im JG. False positive and false negative FDG-PET scans in various thoracic diseases. Korean J Radiol 2006;7:57-69. https://doi.org/10.3348/kjr.2006.7.1.57
55. Lee S, Woo SU, Kim WY, Lee JB, Eo JS. Lymphadenopathy by tuberculosis seemed like metastasis on FDG PET/CT in patients with breast carcinoma. Breast J 2019;25:723-725. https://doi.org/10.1111/tbj.13248
56. Trinchieri G. Cancer and inflammation: an old intuition with rapidly evolving new concepts. Annu Rev Immunol 2012;30:677-706. https://doi.org/10.1146/annurev-immunol-020711-075008
57. Candido J, Hagemann T. Cancer-related inflammation. J Clin Immunol 2013;33 Suppl 1:S79-S84. https://doi.org/10.1007/s10875-012-9847-0
58. Sa YJ, Kim JJ, Du Kim Y, Sim SB, Moon SW. A new protocol for concomitant needle aspiration biopsy and localization of solitary pulmonary nodules. J Cardiothorac Surg 2015;10:104. https://doi.org/10.1186/s13019-015-0312-z
59. Ryu YJ. Diagnosis of pulmonary tuberculosis: recent advances and diagnostic algorithms. Tuberc Respir Dis (Seoul) 2015;78:64-71. https://doi.org/10.4046/trd.2015.78.2.64
60. Griffith DE, Aksamit T, Brown-Elliott BA, Catanzaro A, Daley C, Gordin F, Holland SM, Horsburgh R, Huitt G, Iademarco MF, Iseman M, Olivier K, Ruoss S, von Reyn CF, Wallace RJ Jr, Winthrop K; ATS Mycobacterial Diseases Subcommittee; American Thoracic Society; Infectious Disease Society of America. An official ATS/IDSA statement: diagnosis, treatment, and prevention of nontuberculous mycobacterial diseases. Am J Respir Crit Care Med 2007;175:367-416. https://doi.org/10.1164/rccm.200604-571ST
61. Honda JR, Virdi R, Chan ED. Global environmental nontuberculous mycobacteria and their contemporaneous man-made and natural niches. Front Microbiol 2018;9:2029. https://doi.org/10.3389/fmicb.2018.02029
62. Zhang L, Lin TY, Liu WT, Ling F. Toward characterizing environmental sources of non-tuberculous mycobacteria (NTM) at the species level: a tutorial review of NTM phylogeny and phylogenetic classification. ACS Environ Au 2024;4:127-141. https://doi.org/10.1021/acsenvironau.3c00074
63. Koh WJ, Kwon OJ, Lee KS. Nontuberculous mycobacterial pulmonary diseases in immunocompetent patients. Korean J Radiol 2002;3:145-157. https://doi.org/10.3348/kjr.2002.3.3.145
64. Taiwo B, Glassroth J. Nontuberculous mycobacterial lung diseases. Infect Dis Clin North Am 2010;24:769-789. https://doi.org/10.1016/j.idc.2010.04.008
65. Namkoong H, Kurashima A, Morimoto K, Hoshino Y, Hasegawa N, Ato M, Mitarai S. Epidemiology of pulmonary nontuberculous mycobacterial disease, Japan. Emerg Infect Dis 2016;22:1116-1117. https://doi.org/10.3201/eid2206.151086
66. Marras TK, Chedore P, Ying AM, Jamieson F. Isolation prevalence of pulmonary non-tuberculous mycobacteria in Ontario, 1997-2003. Thorax 2007;62:661-666. https://doi.org/10.1136/thx.2006.070797
67. Andrejak C, Thomsen VO, Johansen IS, Riis A, Benfield TL, Duhaut P, Sorensen HT, Lescure FX, Thomsen RW. Nontuberculous pulmonary mycobacteriosis in Denmark: incidence and prognostic factors. Am J Respir Crit Care Med 2010;181:514-521. https://doi.org/10.1164/rccm.200905-0778OC
68. Kim C, Park SH, Oh SY, Kim SS, Jo KW, Shim TS, Kim MY. Comparison of chest CT findings in nontuberculous mycobacterial diseases vs. Mycobacterium tuberculosis lung disease in HIV-negative patients with cavities. PLoS One 2017;12:e0174240. https://doi.org/10.1371/journal.pone.0174240
69. Abbew ET, Lorent N, Mesic A, Wachinou AP, Obiri-Yeboah D, Decroo T, Rigouts L, Lynen L. Challenges and knowledge gaps in the management of non-tuberculous mycobacterial pulmonary disease in sub-Saharan African countries with a high tuberculosis burden: a scoping review. BMJ Open 2024;14:e078818. https://doi.org/10.1136/bmjopen-2023-078818
70. O'Connell ML, Birkenkamp KE, Kleiner DE, Folio LR, Hol-

land SM, Olivier KN. Lung manifestations in an autopsy-based series of pulmonary or disseminated nontuberculous mycobacterial disease. Chest 2012;141:1203-1209. https://doi.org/10.1378/chest.11-0425

71. Lee G, Kim S, Chang S, Sohn H, Kang YA, Park Y. Epidemiological characteristics of nontuberculous mycobacterial pulmonary disease in South Korea: a meta-analysis of individual participant data. Tuberc Respir Dis (Seoul) 2024;87:386-397. https://doi.org/10.4046/trd.2023.0193
72. Kwak N, Choi H, Jeon D, Jhun BW, Jo KW, Kang YA, Kwon YS, Lee M, Mok J, Shim TS, Shin HJ, Whang J, Yim JJ. Protocol of a nationwide observational study among patients with nontuberculous mycobacterium pulmonary disease in South Korea (NTM-KOREA). Tuberc Respir Dis (Seoul) 2020;83:141-146. https://doi.org/10.4046/trd.2019.0077
73. Kendall BA, Varley CD, Choi D, Cassidy PM, Hedberg K, Ware MA, Winthrop KL. Distinguishing tuberculosis from nontuberculous mycobacteria lung disease, Oregon, USA. Emerg Infect Dis 2011;17:506-509. https://doi.org/10.3201/eid1703.101164
74. Hong SJ, Kim TJ, Lee JH, Park JS. Nontuberculous mycobacterial pulmonary disease mimicking lung cancer: clinicoradiologic features and diagnostic implications. Medicine (Baltimore) 2016;95:e3978. https://doi.org/10.1097/MD.0000000000003978
75. Lin TY, Huang WY, Lin JC, Lin CL, Sung FC, Kao CH, Yeh JJ. Increased lung cancer risk among patients with pneumococcal pneumonia: a nationwide population-based cohort study. Lung 2014;192:159-165. https://doi.org/10.1007/s00408-013-9523-z
76. Brenner DR, Boffetta P, Duell EJ, Bickeboller H, Rosenberger A, McCormack V, Muscat JE, Yang P, Wichmann HE, Brueske-Hohlfeld I, Schwartz AG, Cote ML, Tjonneland A, Friis S, Le Marchand L, Zhang ZF, Morgenstern H, Szeszenia-Dabrowska N, Lissowska J, Zaridze D, Rudnai P, Fabianova E, Foretova L, Janout V, Bencko V, Schejbalova M, Brennan P, Mates IN, Lazarus P, Field JK, Raji O, McLaughlin JR, Liu G, Wiencke J, Neri M, Ugolini D, Andrew AS, Lan Q, Hu W, Orlow I, Park BJ, Hung RJ. Previous lung diseases and lung cancer risk: a pooled analysis from the International Lung Cancer Consortium. Am J Epidemiol 2012;176:573-585. https://doi.org/10.1093/aje/kws151
77. Marcus JL, Leyden WA, Chao CR, Horberg MA, Klein DB, Quesenberry CP Jr, Towner WJ, Silverberg MJ. Immunodeficiency, AIDS-related pneumonia, and risk of lung cancer among HIV-infected individuals. AIDS 2017;31:989-993. https://doi.org/10.1097/QAD.0000000000001434
78. Zifodya JS, Crothers K. Tuberculosis, chronic obstructive lung disease, and lung cancer: the holey upper lobe trinity? Ann Am Thorac Soc 2022;19:540-542. https://doi.org/10.1513/AnnalsATS.202201-009ED
79. Kusumoto T, Asakura T, Suzuki S, Okamori S, Namkoong H, Fujiwara H, Yagi K, Kamata H, Ishii M, Betsuyaku T, Hasegawa N. Development of lung cancer in patients with nontuberculous mycobacterial lung disease. Respir Investig 2019;57:157-164. https://doi.org/10.1016/j.resinv.2018.11.004
80. Bobba RK, Holly JS, Loy T, Perry MC. Scar carcinoma of the lung: a historical perspective. Clin Lung Cancer 2011;12:148-154. https://doi.org/10.1016/j.cllc.2011.03.011
81. Lim WH, Kim H. Application of artificial intelligence in thoracic radiology: a narrative review (application of AI in thoracic radiology). Tuberc Respir Dis (Seoul) 2024 Dec 17 [Epub]. https://doi.org/10.4046/trd.2024.0062
82. Choi YR, Yoon SH, Kim J, Yoo JY, Kim H, Jin KN. Chest radiography of tuberculosis: determination of activity using deep learning algorithm. Tuberc Respir Dis (Seoul) 2023;86:226-233. https://doi.org/10.4046/trd.2023.0020
83. Ostrin EJ, Sidransky D, Spira A, Hanash SM. Biomarkers for lung cancer screening and detection. Cancer Epidemiol Biomarkers Prev 2020;29:2411-2415. https://doi.org/10.1158/1055-9965.EPI-20-0865
84. Vykoukal J, Fahrmann JF, Patel N, Shimizu M, Ostrin EJ, Dennison JB, Ivan C, Goodman GE, Thornquist MD, Barnett MJ, Feng Z, Calin GA, Hanash SM. Contributions of circulating microRNAs for early detection of lung cancer. Cancers (Basel) 2022;14:4221. https://doi.org/10.3390/cancers14174221
85. Wang X, Wang L, Lin H, Zhu Y, Huang D, Lai M, Xi X, Huang J, Zhang W, Zhong T. Research progress of CTC, ctDNA, and EVs in cancer liquid biopsy. Front Oncol 2024;14:1303335. https://doi.org/10.3389/fonc.2024.1303335