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Diagnostic Performance of Radiomics Analysis for Pulmonary Cancer Airway Spread: A Systematic Review and Meta-Analysis

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ADMINISTRATIVE INFORMATION

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Review Stage at time of this submission - Completed but not published.

Conflicts of interest - None declared.

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Amendments - This protocol was registered with the International Platform of Registered Systematic Review and Meta-Analysis Protocols (INPLASY) on 24 October 2024 and was last updated on 24 October 2024.

INTRODUCTION

Review question / Objective Spread through air spaces (STAS) is a unique metastatic pattern of pulmonary cancer closely associated with patient prognosis. This study aims to evaluate the application of radiomics in the diagnosis of pulmonary cancer STAS through meta-analysis and explore its clinical significance and potential limitations.

Condition being studied Radiomics employs both machine learning (ML) and deep learning (DL) methods to quantitatively analyze lung cancer images and extract rich hidden information. This includes hand-crafted features such as shape, greyscale, texture, and wavelet, as well as features derived from deep radiomics techniques. By integrating these diverse features, radiomics provides more comprehensive, objective, and accurate information for the early diagnosis of lung cancer, as well as for staging and prognostic assessment.

This study explores the performance of radiomics analysis in the diagnosis of lung cancer spread through air spaces (STAS) through a systematic review and meta-analysis, providing reliable evidence-based support for clinical practice.

Analysing lung cancer images using radiomics analysis can significantly improve the accuracy and sensitivity of diagnosis, and can even detect tiny STAS lesions.

METHODS

Participant or population As this meta-analysis did not involve human or animal participants.

Intervention n/a.

Comparator n/a.

Study designs to be included a cohort study or case-control study.

Eligibility criteria Based on the PICOS (Population, Intervention, Comparator, Outcome, Study design) principle, studies meeting the following criteria were included: 1) the study population comprised patients with lung cancer; 2) the intervention involved AI-assisted radiomics; 3) histopathology was used as the reference standard; 4) the primary outcome was pulmonary cancer airway spread; and 5) the study design was either a cohort study or case-control study. Studies meeting the following criteria were excluded: 1) irrelevant study types, such as animal studies, case reports or conference papers; 2) studies with incomplete data; and 3) studies that did not report predefined outcomes or did not adhere to the intervention and control settings.

Information sources PubMed, Embase and the Cochrane Central Register of Controlled Trialsdatabases.

Main outcome(s) 1) regardless of whether it was in the development or validation cohorts, radiomics showed good sensitivity and specificity in diagnosing lung cancer STAS; 2) radiomics demonstrated good discriminative ability for diagnosing lung cancer STAS, accurately distinguishing between two patient groups; and 3) no significant publication bias was found in the included studies, although methodological quality assessment indicated uncertain risk of bias in some studies.

Quality assessment / Risk of bias analysis Understanding risk of bias is crucial for evaluating the reliability of study findings. Bias can be introduced at various stages of a study, including patient selection, index test application and reference standards. High or unclear risk of bias can affect the internal validity and generalisability of the study results.
The methodological quality of the 18 included studies is detailed in Figure 2. One study was at high risk of bias in the 'patient selection' domain due to a case-control study design, and another study had an unclear risk due to insufficient description. Additionally, 12 studies had unclear risks of bias in the 'index test' and 'reference standard' domains due to unreported blinding. Notably, all studies had low risks in the 'flow and timing' domain and overall showed few concerns.

Strategy of data synthesis Data analysis in this study was performed using RevMan 5.4 and Stata SE 15.0 software. Sensitivity and specificity were calculated based on 2×2 table data and presented graphically, with squares representing values and horizontal lines representing corresponding confidence intervals (CIs). Summary receiver operating characteristic curves were used to represent the performance of diagnostic tests. The approximate classification criteria for area under the curve (AUC) values were as follows: 0.50–0.60=inadequate, 0.60–0.70=poor, 0.70–0.80=fair, 0.80–0.90=good and 0.90–1=excellent. Additionally, summary statistics of positive likelihood ratio, negative likelihood ratio and diagnostic odds ratio, along with their 95%CIs, were calculated. Heterogeneity of results was assessed using Cochran's Q test and the I2 statistic test, and meta-analysis was conducted using either fixed-effects or random-effects models accordingly. The possibility of publication bias was assessed using Deeks' funnel plot analysis, and sensitivity analysis was performed to evaluate the stability of the results. Fagan's nomogram was used to evaluate the clinical utility of radiomics and calculate the post-test probability of STAS.

Subgroup analysis Data analysis in this study was performed using RevMan 5.4 and Stata SE 15.0 software. Sensitivity and specificity were calculated based on 2×2 table data and presented graphically, with squares representing values and horizontal lines representing corresponding confidence intervals (CIs). Summary receiver operating characteristic curves were used to represent the performance of diagnostic tests. The approximate classification criteria for area under the curve (AUC) values were as follows: 0.50–0.60=inadequate, 0.60–0.70=poor, 0.70–0.80=fair, 0.80–0.90=good and 0.90–1=excellent. Additionally, summary statistics of positive likelihood ratio, negative likelihood ratio and diagnostic odds ratio, along with their 95%CIs, were calculated. Heterogeneity of results was assessed using Cochran's Q test and the I2 statistic test, and meta-analysis was conducted using either fixed-effects or random-effects models accordingly. The possibility of publication bias was assessed using Deeks' funnel plot analysis, and sensitivity analysis was performed to evaluate the stability of the results. Fagan's nomogram was used to evaluate the clinical utility of radiomics and calculate the post-test probability of STAS.

Sensitivity analysis Publication bias occurs when the outcome of the research influences the decision whether to publish it. This can lead to an overestimation of the effect in published studies.

Sensitivity analysis assesses how the results vary with changes in the data or analytical methods. Both publication bias analysis and sensitivity analysis are critical for understanding the robustness and reliability of the meta-analysis findings.
Deeks' funnel plot analysis revealed no significant publication bias in either cohort (P=0.963 and 0.106, respectively), as shown in Figure 5. Sensitivity analysis indicated that the exclusion of individual studies did not significantly affect the pooled results, indicating the stability of the study findings.

Country(ies) involved China.

Keywords Lung cancer, Spread through air spaces, Radiomics, Computed tomography, Meta-analysis.

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