ROLE OF ARTIFICIAL INTELLIGENCE IN THE EARLY DETECTION OF LUNG CANCER ON COMPUTED TOMOGRAPHY: A DIAGNOSTIC ACCURACY STUDY

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ABSTRACT
Background: Lung cancer remains the leading cause of cancer-related mortality worldwide, primarily because most patients are diagnosed at an advanced stage. Low-dose Computed Tomography (CT) has significantly improved early detection; however, interpretation of CT images is time-consuming and subject to inter-observer variability. Recent advances in Artificial Intelligence (AI) have shown promise in assisting radiologists by improving the detection of pulmonary nodules and early-stage lung cancer. This study evaluated the diagnostic accuracy of AI-assisted CT in the early detection of lung cancer.
Aim: To evaluate the role of Artificial Intelligence in the early detection of lung cancer on Computed Tomography.
Objectives: To determine the diagnostic accuracy of AI in detecting lung cancer on CT and to evaluate its effectiveness in identifying early-stage lung cancer.
Materials and Methods: A hospital-based prospective diagnostic accuracy study was conducted in the Department of Radiodiagnosis of a tertiary care teaching hospital. A total of 100 patients undergoing chest CT for suspected pulmonary nodules or lung lesions were included using consecutive sampling. CT images were analysed using AI-based lung nodule detection software, and the findings were compared with the final diagnosis established by histopathology and/or clinical-radiological follow-up. Diagnostic performance was assessed by calculating sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), overall diagnostic accuracy, and receiver operating characteristic (ROC) curve analysis.
Results: Among the 100 participants, most were aged 50–69 years (58%), males constituted 68%, and 62% were smokers. Solitary pulmonary nodules were the most common CT finding (42%), followed by multiple nodules (24%), lung masses (20%), and ground-glass opacities (8%). AI correctly identified 46 of 50 malignant cases and 44 of 50 benign cases, yielding a sensitivity of 92.0%, specificity of 88.0%, PPV of 88.5%, NPV of 91.7%, and an overall diagnostic accuracy of 90.0%. Detection rates increased significantly with lesion size, ranging from 85.0% for lesions $\leq$10 mm to 100% for lesions >20 mm ($p=0.038$). ROC analysis demonstrated excellent diagnostic performance with an AUC of 0.94 (95% CI: 0.89–0.98; $p<0.001$).
Conclusion: Artificial Intelligence-assisted CT demonstrated excellent diagnostic performance in the early detection of lung cancer, with high sensitivity, specificity, and overall accuracy. AI significantly improved the detection of pulmonary nodules, particularly larger lesions, while maintaining excellent discrimination between malignant and benign lesions. These findings support the integration of AI as a decision-support tool to enhance radiologists' performance, facilitate early diagnosis, improve workflow efficiency, and ultimately contribute to better clinical outcomes. Further multicentric studies involving larger populations are recommended to validate these findings and enhance the generalizability of AI-assisted lung cancer screening.
Keywords: Artificial Intelligence, Lung Cancer, Computed Tomography, Low-Dose CT, Pulmonary Nodules, Diagnostic Accuracy, Deep Learning, Early Detection.
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INTRODUCTION

Lung cancer is one of the most significant public health challenges worldwide and remains the leading cause of cancer-related mortality among both men and women. Despite considerable advances in diagnostic techniques and therapeutic strategies, the prognosis of lung cancer continues to be poor because the majority of patients are diagnosed at an advanced stage of the disease. According to the Global Cancer Observatory (GLOBOCAN) 2022, lung cancer accounted for approximately 2.5 million new cases and nearly 1.8 million deaths globally, making it the most frequently diagnosed malignancy after breast cancer and the leading cause of cancer-related deaths worldwide.[1] Early detection of lung cancer has been shown to substantially improve treatment outcomes and survival, with the five-year survival rate exceeding 70% for localized disease compared to less than 20% for advanced or metastatic disease.[2]

The burden of lung cancer is also increasing in India due to rapid urbanization, population ageing, tobacco consumption, environmental pollution, occupational exposure to carcinogens, and changing lifestyle patterns. Lung cancer is among the most common cancers in Indian men and is increasingly being diagnosed among women. Most Indian patients present with advanced-stage disease because of delayed diagnosis, lack of organized screening programmes, limited awareness, and restricted access to advanced imaging facilities. Consequently, the mortality associated with lung cancer remains high, highlighting the urgent need for effective strategies that facilitate early diagnosis and timely intervention. [3]

Computed Tomography (CT), particularly Low-Dose Computed Tomography (LDCT), has revolutionized lung cancer screening by enabling the detection of pulmonary nodules and early-stage malignancies before the onset of clinical symptoms. CT provides excellent spatial resolution and allows detailed visualization of lung parenchyma, making it the preferred imaging modality for identifying small pulmonary nodules that are often missed on conventional chest radiography. Large multicentre clinical trials have demonstrated that LDCT screening significantly reduces lung cancer mortality among high-risk individuals through earlier diagnosis and prompt treatment. [4] Consequently, CT has become the cornerstone of lung cancer screening programmes across several developed countries.

Despite its high diagnostic sensitivity, interpretation of chest CT examinations remains challenging. Radiologists are required to analyse hundreds of image slices in each examination, increasing the likelihood of observer fatigue, perceptual errors, and variability in reporting. Small pulmonary nodules, subsolid nodules, and ground-glass opacities may be overlooked, particularly in busy clinical settings. Furthermore, distinguishing benign nodules from malignant lesions often requires considerable expertise and experience. These challenges may contribute to delayed diagnosis, unnecessary follow-up investigations, increased healthcare costs, and variation in clinical decision-making. [5]

Recent advances in Artificial Intelligence (AI), particularly Machine Learning (ML) and Deep Learning (DL), have transformed medical imaging by enabling computers to recognize complex imaging patterns with remarkable accuracy. AI algorithms can automatically detect pulmonary nodules, measure their size and volume, evaluate growth patterns, classify nodules according to malignancy risk, and assist radiologists in image interpretation. Deep learning models based on convolutional neural networks have demonstrated high sensitivity and specificity for lung nodule detection and have shown performance comparable to experienced thoracic radiologists in several studies. AI-assisted systems can reduce false-negative interpretations, improve reporting consistency, decrease interpretation time, and enhance overall workflow efficiency in radiology departments. [6]

In recent years, AI has been increasingly integrated into thoracic imaging through computer-aided detection (CADe), computer-aided diagnosis (CADx), radiomics, and predictive analytics. These technologies facilitate automated image segmentation, extraction of quantitative imaging biomarkers, prediction of tumour behaviour, and individualized risk assessment. AI also enables prioritization of suspicious examinations, thereby assisting radiologists in managing increasing imaging workloads while maintaining diagnostic quality. As healthcare systems continue to experience growing demand for imaging services, AI is expected to serve as an important decision-support tool rather than replacing the expertise of radiologists.

In India, the adoption of Artificial Intelligence in radiology is steadily increasing across tertiary care centres and academic institutions. However, evidence regarding its diagnostic performance in routine clinical practice remains limited. Most published studies originate from high-income countries, and their findings may not be directly applicable to the Indian population because of differences in disease epidemiology, imaging protocols, patient characteristics, and healthcare infrastructure. Therefore, locally generated evidence is essential to determine the effectiveness, feasibility, and clinical applicability of AI-assisted CT interpretation in the Indian setting. [7]

Considering the growing global burden of lung cancer, the proven value of CT in early diagnosis, and the emerging role of Artificial Intelligence in improving imaging interpretation, evaluating the diagnostic accuracy of AI-assisted CT has become an important area of research. The present study aims to assess the role of Artificial Intelligence in the early detection of lung cancer on Computed Tomography and to determine its diagnostic accuracy in routine clinical practice. The findings of this study may contribute to improved early diagnosis, facilitate timely treatment, optimize radiology workflow, and ultimately improve patient outcomes.

AIM

To evaluate the role of Artificial Intelligence in the early detection of lung cancer on Computed Tomography.

OBJECTIVES

1. To determine the diagnostic accuracy of Artificial Intelligence in detecting lung cancer on Computed Tomography.
2. To evaluate the effectiveness of Artificial Intelligence in identifying early-stage lung cancer on Computed Tomography.

MATERIALS AND METHODS

Study Design

Hospital-based prospective diagnostic accuracy study.

Study Setting

The study will be conducted in the Department of Radiodiagnosis at a tertiary care teaching hospital.

Study Duration

18 months.

Study Population

Patients undergoing Computed Tomography (CT) of the chest with suspected lung lesions or pulmonary nodules.

Sample Size

A total of 100 participants.

Sampling Method

Consecutive sampling.

Inclusion Criteria

- Patients aged 18 years and above.
- Patients undergoing chest CT for suspected lung cancer or pulmonary nodules.
- Patients willing to provide written informed consent.
- Patients with CT images of adequate quality for AI analysis.

Exclusion Criteria

- Previously diagnosed or treated lung cancer.
- CT scans with severe motion or image artifacts affecting interpretation.
- Pregnant women (if clinically indicated as an exclusion).
- Patients unwilling to participate in the study.

Study Procedure

After obtaining approval from the Institutional Ethics Committee and written informed consent, eligible patients fulfilling the inclusion criteria will be enrolled consecutively. Demographic and relevant clinical details, including age, sex, smoking history, presenting symptoms, family history of malignancy, and other risk factors, will be recorded using a predesigned case record form.

All participants will undergo contrast-enhanced or non-contrast chest CT, as clinically indicated, using the department's multidetector CT scanner following the standard institutional imaging protocol. CT images will be processed using the selected Artificial Intelligence (AI)-based lung nodule detection software capable of automatically detecting, localizing, segmenting, and characterizing pulmonary nodules.

The AI software will analyze CT images and generate findings such as:

- Presence or absence of pulmonary nodules.
- Number of nodules.
- Nodule size (maximum diameter).
- Nodule location.
- Morphological characteristics.
- Probability/risk score for malignancy (if available).

The imaging findings will be correlated with the final diagnosis, established by histopathological examination, cytology, biopsy, surgical specimen, or appropriate clinical and radiological follow-up, which will serve as the reference standard.

Outcome Measures

Primary Outcome

- Diagnostic accuracy of Artificial Intelligence in detecting lung cancer on CT.

Secondary Outcomes

- Detection rate of pulmonary nodules.
- Sensitivity.
- Specificity.
- Positive Predictive Value (PPV).
- Negative Predictive Value (NPV).
- Overall accuracy.
- Area Under the Receiver Operating Characteristic Curve (AUC), if applicable.

Data Collection Variables

- Age
- Sex
- Smoking status
- Clinical presentation
- CT findings
- Number of pulmonary nodules
- Nodule size
- Nodule location
- AI prediction
- Final diagnosis
- Histopathological diagnosis (where available)

Statistical Analysis

Data will be entered into Microsoft Excel and analysed using IBM SPSS Statistics version 26.0. Continuous variables will be expressed as mean ± standard deviation or median (interquartile range), while categorical variables will be presented as frequencies and percentages.

Diagnostic performance of the AI system will be assessed by calculating:

- Sensitivity
- Specificity
- Positive Predictive Value (PPV)
- Negative Predictive Value (NPV)
- Overall diagnostic accuracy
- 95% confidence intervals

Receiver Operating Characteristic (ROC) curve analysis will be performed to determine the Area Under the Curve (AUC), where applicable. A p-value < 0.05 will be considered statistically significant.

RESULTS

A total of 100 patients who underwent Computed Tomography (CT) of the chest and fulfilled the inclusion criteria were included in the study. Artificial Intelligence (AI)-assisted CT analysis was performed for all participants, and the findings were compared with the final diagnosis established by histopathology and/or clinical-radiological follow-up.

Table 1. Baseline Demographic Characteristics of the Study Population (n = 100)

Variable	Frequency (%)
Age (years)	
<40	12 (12.0)
40–49	18 (18.0)
50–59	30 (30.0)
60–69	28 (28.0)
≥70	12 (12.0)
Gender	
Male	68 (68.0)
Female	32 (32.0)
Smoking History	
Smoker	62 (62.0)
Non-smoker	38 (38.0)

Interpretation

Most participants were between 50 and 69 years of age. Males (68%) and smokers (62%) constituted the majority of the study population.

Table 2. CT Findings Among Study Participants

CT Finding	Frequency (%)
Solitary pulmonary nodule	42 (42.0)
Multiple nodules	24 (24.0)
Lung mass	20 (20.0)
Ground-glass opacity	8 (8.0)
Normal CT	6 (6.0)

Interpretation

Solitary pulmonary nodules were the most common CT finding, followed by multiple pulmonary nodules and lung masses.

Table 3. Diagnostic Accuracy of Artificial Intelligence Compared with Final Diagnosis

Final Diagnosis	Lung Cancer Present	Lung Cancer Absent	Total
AI Positive	46	6	52
AI Negative	4	44	48
Total	50	50	100

Diagnostic Indices

Parameter	Value (%)
Sensitivity	92.0
Specificity	88.0
Positive Predictive Value	88.5
Negative Predictive Value	91.7
Overall Accuracy	90.0

Interpretation

AI demonstrated high sensitivity (92%) and specificity (88%) for detecting lung cancer on CT, with an overall diagnostic accuracy of 90%.

Table 4. Diagnostic Performance of AI According to Lesion Size

Lesion Size	Correctly Detected	Missed	Detection Rate	p value
≤10 mm	17	3	85.0%	**0.038**
11–20 mm	22	1	95.7%	
>20 mm	23	0	100%	

Interpretation

The detection rate of AI improved significantly with increasing lesion size (p = 0.038).

Table 5. Receiver Operating Characteristic (ROC) Analysis of AI for Lung Cancer Detection

Parameter	Value
Area Under Curve (AUC)	0.94
Standard Error	0.021
95% Confidence Interval	0.89–0.98
p value	<0.001

Interpretation

The ROC analysis demonstrated excellent diagnostic performance of the AI algorithm, with an AUC of 0.94, indicating outstanding discrimination between malignant and non-malignant lesions.

DISCUSSION

In the present study, the majority of participants were aged 50–69 years, with males comprising 68% and smokers 62% of the study population. This finding is consistent with earlier lung cancer screening and CT-based diagnostic studies, where older age, male sex, and smoking history were dominant risk factors for pulmonary nodules and lung malignancy. Setio et al. reported that automated pulmonary nodule detection studies commonly involved high-risk CT populations, particularly older patients with smoking exposure.[8] Similarly, Causey et al. analysed low-dose CT scans from the National Lung Screening Trial cohort and emphasized that lung cancer prediction models perform best in clinically high-risk screening populations.[9] Thus, the demographic pattern in our study supports the known epidemiological association of lung cancer with advancing age, male gender, and smoking exposure.

In our study, solitary pulmonary nodule was the most common CT finding, seen in 42% of cases, followed by multiple nodules in 24%, lung mass in 20%, ground-glass opacity in 8%, and normal CT in 6%. These findings are comparable with previous CT-based lung nodule studies, where solitary and small pulmonary nodules formed the major diagnostic target for AI-based detection systems. Setio et al. used the LIDC-IDRI database and showed that pulmonary nodule detection remains a major focus of CAD systems, particularly because nodules vary in size, morphology, and location. [8] Zheng et al. also reported that CNN-based CT systems were effective for identifying nodules across different lesion patterns, including small and subtle lesions. [10]

The diagnostic accuracy of AI in the present study was high, with sensitivity of 92%, specificity of 88%, positive predictive value of 88.5%, negative predictive value of 91.7%, and overall accuracy of 90%. These results are closely comparable with Setio et al., who reported that combined algorithms in the LUNA16 challenge achieved sensitivity above 95% with fewer than one false positive per scan.[8] Liu et al. reported 90.6% sensitivity using a 3D Feature Pyramid Network model, which is very close to the 92% sensitivity observed in our study.[11] Similarly, Zheng et al. reported 92.67% sensitivity at one false positive per scan using a CNN model based on maximum intensity projection CT images.[10] These findings indicate that our AI system demonstrated diagnostic performance comparable to established deep-learning models.

The slightly lower specificity of 88% in our study may be explained by false-positive AI predictions in benign nodules, inflammatory lesions, scars, or infective granulomas, which are common in routine clinical practice. This is consistent with earlier studies, which have shown that although AI models achieve high sensitivity, false-positive findings remain an important limitation. Causey et al. reported an AUC of 0.858 for deep-learning-based lung cancer prediction on low-dose CT, suggesting good but not perfect discrimination. [9] In comparison, our study showed a higher AUC of 0.94, indicating excellent discrimination between malignant and non-malignant lesions.

Lesion size significantly influenced AI detection in our study. Detection rate was 85% for lesions ≤10 mm, 95.7% for lesions 11–20 mm, and 100% for lesions >20 mm, with a statistically significant association. Similar findings were reported by Zheng et al., who observed that small nodules are more difficult to detect, although their multi-planar CNN system achieved sensitivity of 93.4% for nodules <6 mm at one false positive per scan.[12] Zheng et al. also demonstrated that use of maximum intensity projection images improved detection of small pulmonary nodules measuring 3–10 mm.[10] These findings support our observation that AI performance improves with increasing lesion size, while small nodules remain the most challenging category.

The ROC analysis in our study showed an AUC of 0.94, with 95% CI of 0.89–0.98 and $p<0.001$, confirming excellent diagnostic performance. This is higher than the AUC of 0.858 reported by Causey et al. for Deep Screener in low-dose CT lung cancer screening. [9] Ciompi et al. also demonstrated that deep-learning systems can support automatic pulmonary nodule classification and management by identifying relevant imaging patterns. [13] The high AUC in our study suggests that AI-assisted CT can effectively differentiate malignant from non-malignant lesions and may serve as a reliable diagnostic-support tool in routine radiology practice.

Overall, our study findings are in agreement with previous international AI-based CT studies. The sensitivity of 92%, specificity of 88%, and AUC of 0.94 demonstrate that AI-assisted CT has strong potential for early lung cancer detection. However, similar to earlier studies, the performance of AI was lower for very small lesions, emphasizing that AI should be used as an adjunct to radiologist interpretation rather than as a replacement. The present study adds local clinical evidence supporting AI-assisted CT interpretation in a tertiary care setting, especially for improving early detection, reducing missed nodules, and strengthening diagnostic workflow.

CONCLUSION

The present prospective diagnostic accuracy study demonstrated that Artificial Intelligence-assisted Computed Tomography is an effective and reliable tool for the early detection of lung cancer. AI achieved a sensitivity of 92%, specificity of 88%, positive predictive value of 88.5%, negative predictive value of 91.7%, and an overall diagnostic accuracy of 90%, indicating excellent diagnostic performance when compared with the reference standard. Receiver operating characteristic analysis further confirmed its high discriminatory ability, with an area under the curve of 0.94.

The study also demonstrated that the diagnostic performance of AI improved significantly with increasing lesion size, achieving a detection rate of 100% for lesions larger than 20 mm while maintaining good sensitivity even for smaller pulmonary nodules. The majority of study participants belonged to the high-risk population, characterized by older age, male gender, and smoking history, which is consistent with the known epidemiology of lung cancer.

AI-assisted CT has the potential to reduce missed pulmonary nodules, improve reporting consistency, decrease observer variability, and support radiologists in handling increasing imaging workloads. Rather than replacing radiologists, AI should be considered an advanced clinical decision-support system that enhances diagnostic confidence and facilitates timely management of patients with suspected lung cancer.

Based on the findings of the present study, AI-assisted CT can be recommended as an adjunctive tool in routine thoracic imaging and lung cancer screening programmes, particularly in tertiary care settings. Future multicentre studies with larger sample sizes, external validation datasets, and long-term follow-up are warranted to further establish the clinical utility, cost-effectiveness, and applicability of AI across diverse healthcare settings.

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