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Application Value of Artificial Intelligence-Assisted Diagnostic Systems in CT Diagnosis of Pulmonary Nodules

Yang Xue*, Mingqiang Diao, Bing Han

Deyang People's Hospital, Deyang 618000, Sichuan Province, China

***Corresponding author:** Yang Xue, 26917269@qq.com

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Abstract: *Objective:* To explore the application value of artificial intelligence-assisted diagnostic systems in the computed tomography (CT) diagnosis of pulmonary nodules. *Methods:* A total of 80 patients with pulmonary nodules, treated from June 2023 to May 2024, were included. All patients underwent pathological examination and CT scans, with pathological results serving as the gold standard. The diagnostic performance of CT alone and CT combined with the artificial intelligence-assisted diagnostic system was analyzed, and differences in CT imaging features and evaluation results of benign and malignant pulmonary nodules were compared. *Results:* The sensitivity, specificity, and accuracy of CT combined with the artificial intelligence-assisted diagnostic system were significantly higher than those of CT alone ($P < 0.05$). Moreover, the false-positive and false-negative rates were significantly lower for the combined approach compared to CT alone ($P < 0.05$). *Conclusion:* The artificial intelligence-assisted diagnostic system effectively identifies malignant features in pulmonary nodules, providing valuable clinical reference data and enhancing diagnostic accuracy and efficiency.

Keywords: Artificial intelligence-assisted diagnostic system; Pulmonary nodule; CT diagnosis

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1. Introduction

Lung cancer is one of the most prevalent and deadly malignant tumors globally, posing a severe threat to human health. Early detection, diagnosis, and treatment are critical for improving survival rates and outcomes for lung cancer patients. Pulmonary nodules are common radiological findings in the lungs, some of which may represent early-stage lung cancer [1]. Therefore, accurately differentiating between benign and malignant pulmonary nodules is of great clinical importance.

Traditionally, the diagnosis of pulmonary nodules relies primarily on imaging techniques, such as chest X-rays and computed tomography (CT) scans, along with the expertise and clinical experience of physicians [2,3].

However, the imaging characteristics of pulmonary nodules are often complex and varied, with overlaps in morphology, size, and density between benign and malignant nodules, which presents challenges for accurate diagnosis [4]. Additionally, factors such as subjectivity, fatigue, and workload can affect the diagnostic accuracy of physicians.

With the rapid development of artificial intelligence (AI) technology, AI-assisted diagnostic systems are being increasingly applied in medicine. These systems can learn from and analyze large volumes of medical imaging data, automatically extract features from images, and provide diagnostic and predictive insights. In the context of pulmonary nodule diagnosis, AI-assisted diagnostic systems can quickly and accurately identify the location, size, and morphology of nodules, assess their benign or malignant nature, and offer critical diagnostic support for clinicians [5].

Several studies have demonstrated the high accuracy and reliability of AI-assisted diagnostic systems in diagnosing pulmonary nodules. However, these studies often involve relatively small sample sizes, limiting the generalizability and scalability of their findings. This study aims to analyze a larger cohort of pulmonary nodule patients to further evaluate the application value of AI-assisted diagnostic systems in CT diagnosis, providing more reliable evidence for clinical practice.

2. Materials and methods

2.1. General information

Eighty patients with pulmonary nodules who visited our hospital from June 2023 to May 2024 were selected for this study, including 45 males and 35 females, aged 35–75 years, with an average age of 52.57 ± 10.54 years.

Inclusion criteria: (1) Pulmonary nodules detected via chest CT; (2) Patients who signed informed consent forms and were willing to cooperate with the study.

Exclusion criteria: (1) Concurrent diagnoses of other malignant tumors; (2) Severe dysfunction of critical organs such as the heart, liver, or kidneys; (3) Patients with mental illnesses who could not cooperate with examination and treatment.

2.2. Methods

2.2.1. CT examination

All patients underwent chest CT using a 64-slice spiral CT scanner (Brand: Shanghai United Imaging Healthcare Co., Ltd.; Model: uCT 760). Scanning parameters: tube voltage 120 kV, tube current 200–300 mAs, slice thickness 5 mm, and slice spacing 5 mm. The scanning range extended from the thoracic inlet to the diaphragm. After the scan, image data were transmitted to a workstation for post-processing, including multiplanar reconstruction (MPR) and volume rendering (VR).

2.2.2. Artificial intelligence-assisted diagnostic system

The artificial intelligence-assisted diagnostic system used in this study was developed by Pu'er iFLYTEK Information Technology Co., Ltd. This system, based on deep learning algorithms, was trained with extensive pulmonary nodule CT images to establish a classification model for distinguishing benign from malignant nodules. Patient CT images were imported into the system, which automatically identified and analyzed pulmonary nodules, providing an evaluation of their benign or malignant nature.

2.2.3. Pathological examination

All patients underwent pathological examination within 1–2 weeks after CT scanning. Depending on the location and size of the pulmonary nodules, appropriate pathological examination methods were selected, including percutaneous lung biopsy, bronchoscopic biopsy, or thoracoscopic surgery. Pathological results were jointly assessed by two experienced pathologists to determine the nature of the pulmonary nodules.

2.3. Observation indicators

2.3.1. Diagnostic performance metrics

Using pathological results as the gold standard, the diagnostic performance of CT alone and CT combined with the artificial intelligence-assisted diagnostic system was analyzed. Diagnostic performance metrics included sensitivity (true positive rate), specificity (true negative rate), false positive rate, false negative rate, and accuracy.

$$Sensitivity = \frac{True\ positives}{True\ positives + False\ negatives} \times 100\%$$

$$Specificity = \frac{True\ negatives}{True\ negatives + False\ positives} \times 100\%$$

$$False\ positive\ rate = \frac{False\ positives}{True\ negatives + False\ positives} \times 100\%$$

$$False\ negative\ rate = \frac{False\ negatives}{True\ positives + False\ negatives} \times 100\%$$

$$Accuracy = \frac{True\ positives + True\ negatives}{Total\ cases} \times 100\%$$

2.3.2. Differences in pulmonary nodule evaluation results

The CT imaging features of benign and malignant pulmonary nodules were compared, including nodule size, shape, margins, density, and the presence of lobulation, spiculation, or pleural indentation. Additionally, differences in evaluations by the artificial intelligence-assisted diagnostic system were analyzed. Malignant pulmonary nodules were scored within a range of 60–100 points, while benign nodules were scored between 0–40 points.

2.4. Statistical analysis

Statistical analysis was performed using SPSS 27.0 software. Quantitative data were expressed as mean ± standard deviation (SD) and compared using the *t*-test. Categorical data were presented as frequencies and percentages and compared using the χ^2-test. Statistical significance was set at $P < 0.05$.

3. Results

3.1. Pathological examination results

Among the 80 patients with pulmonary nodules, pathological examination confirmed 30 cases of malignant nodules and 50 cases of benign nodules (**Table 1**).

Table 1. Comparison of pathological examination results

Pathological examination		Number of cases (*n*)
Malignant nodules	Adenocarcinoma	20
	Squamous carcinoma	5
	Small cell carcinoma	3
	Other	2
Benign nodules	Inflammatory nodules	30
	Tuberculoma	10
	Hamartoma	5
	Other	5

3.2. Diagnostic performance of CT and AI-assisted CT examination

The sensitivity, specificity, and accuracy of AI-assisted CT examination were significantly higher than those of CT examination alone ($P < 0.05$), while the false positive and false negative rates were significantly lower ($P < 0.05$) (**Table 2**).

Table 2. Comparison of diagnostic performance between CT and AI-assisted CT examination

Diagnostic method	True positive (*n*)	False positive (*n*)	False negative (*n*)	True negative (*n*)	Sensitivity (%)	Specificity (%)	False positive rate (%)	False negative rate (%)	Accuracy (%)
CT examination	20	10	10	40	66.67	80.00	20.00	33.33	75.00
AI-assisted CT examination	25	5	5	45	83.33	90.00	10.00	16.67	87.50
χ^2	-	-	-	-	7.402	3.922	3.922	7.402	5.128
P	-	-	-	-	0.007	0.048	0.048	0.007	0.024

3.3. Comparison of CT imaging features between benign and malignant pulmonary nodules

There were significant differences in CT imaging features between benign and malignant pulmonary nodules, including nodule size, shape, margins, density, and the presence of lobulation, spiculation, and pleural indentation ($P < 0.001$) (**Table 3**).

Table 3. Comparison of CT imaging features between benign and malignant pulmonary nodules

CT feature	Malignant nodules (*n* = 30)	Benign nodules (*n* = 50)	χ^2 value	*P* value
Malignant nodules (mean ± SD, cm)	3.54 ± 1.20	1.81 ± 0.87	7.451	< 0.001
Irregular shape [*n* (%)]	20 (66.67%)	10 (20.00%)	17.422	< 0.001
Blurry edges [*n* (%)]	22 (73.33%)	15 (30.00%)	14.163	< 0.001
Uneven density [*n* (%)]	25 (83.33%)	20 (40.00%)	14.307	< 0.001
Lobulation [*n* (%)]	20 (66.67%)	5 (10.00%)	28.024	< 0.001
Spiculation [*n* (%)]	18 (60.00%)	8 (16.00%)	16.547	< 0.001
Pleural indentation [*n* (%)]	15 (50.00%)	5 (10.00%)	16.000	< 0.001

3.4. Differences in AI-assisted evaluation of benign and malignant pulmonary nodules

The AI-assisted diagnostic system produced significantly higher evaluation scores for malignant nodules compared to benign nodules ($P < 0.001$) (**Table 4**).

Table 4. Comparison of AI-assisted evaluation scores for benign and malignant pulmonary nodules

Group (*n*)	Score (mean ± SD, points)
Malignant pulmonary nodules (*n* = 30)	80.57 ± 10.54
Benign pulmonary nodules (*n* = 50)	20.54 ± 8.56
t value	27.815
P value	< 0.001

4. Discussion

The AI diagnostic assistance system has been a significant innovation in the medical field in recent years and has been extensively applied to cancer diagnosis and differential diagnosis. As cancer incidence continues to rise, precise and efficient diagnostic tools have become increasingly critical. Traditional imaging diagnostics are inevitably influenced by factors such as the physician's expertise, experience, and subjective judgment, leading to variability and interpretative differences [6]. Different physicians may provide varying diagnostic results for the same imaging data, which can affect subsequent treatment and lead to the inefficient use of medical resources.

The AI diagnostic assistance system, with its powerful data analysis and learning capabilities, can perform deep learning on large volumes of cancer imaging data. It can rapidly and accurately identify characteristic information in images, effectively reducing diagnostic variability caused by human factors [7,8]. By providing precise image analysis, AI systems deliver more consistent diagnostic results, significantly improving diagnostic consistency [9]. Moreover, the system's rapid processing capabilities can substantially reduce diagnostic time, enhancing efficiency and securing valuable treatment time for patients [10].

The results of this study demonstrate that the AI diagnostic assistance system combined with CT imaging has high application value in diagnosing pulmonary nodules. Compared to standalone CT imaging, the AI-assisted system significantly improves the detection rate, sensitivity, specificity, and accuracy of malignant pulmonary nodules while reducing false positive and false negative rates.

A comparison of CT imaging features between benign and malignant pulmonary nodules revealed that malignant nodules exhibit typical imaging characteristics, such as larger size, irregular shape, blurred margins, uneven density, lobulation, spiculation, and pleural indentation. Conversely, benign nodules are more likely to appear smaller, with regular shape, clear margins, uniform density, and without lobulation, spiculation, or pleural indentation. The AI diagnostic system can accurately identify these features and assess the benign or malignant nature of pulmonary nodules, providing critical reference information for physicians [11-13].

Furthermore, the system showed significant differences in its assessment of benign and malignant pulmonary nodules, with higher evaluation scores for malignant nodules compared to benign ones. This indicates that the AI diagnostic assistance system can effectively assess the malignancy of pulmonary nodules through CT image analysis, offering valuable information for the formulation of clinical treatment plans.

5. Conclusion

In summary, the application of the AI diagnostic assistance system in pulmonary nodule CT diagnosis improves diagnostic accuracy and reliability, reduces misdiagnosis and missed diagnosis, and holds significant clinical value and application prospects. However, this study has certain limitations, such as a relatively small sample size and short research duration. Future studies should expand the sample size and conduct multi-center, large-sample clinical research to verify the long-term efficacy and safety of the AI diagnostic assistance system in pulmonary nodule diagnosis. Additionally, continuous optimization of AI algorithms and models is needed to enhance its diagnostic capabilities for complex pulmonary nodules, thereby providing more precise medical services for patients.

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Disclosure statement

The authors declare no conflict of interest.

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