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ORIGINAL RESEARCH

Clinical Value of Low-Dose Spiral CT Combined with Serum CEA in the Differential Diagnosis of Early Lung Cancer

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Purpose: Early detection of lung cancer is critical to improving prognosis, yet current screening methods such as low-dose spiral CT and serum CEA each have diagnostic limitations. This study aims to analyze the clinical value of low-dose spiral CT combined with serum CEA in the differential diagnosis of early lung cancer.

Materials and Methods: In this retrospective study, 62 patients diagnosed with early lung cancer in our hospital from April 2022 to October 2023 were selected as the case group, and 50 patients diagnosed with benign pulmonary lesions during the same period were selected as the control group. Data from low-dose spiral CT and serum CEA levels were compared. The efficacy of low-dose spiral CT alone, serum CEA alone, and the combination of both in discriminating early lung cancer was assessed using ROC curves.

Results: Low-dose spiral CT showed a sensitivity of 77.42%, a specificity of 94.00%, and an AUC of 0.8571 (95% CI: 0.7832–0.9310) in detecting early lung cancer. Serum CEA levels were significantly higher in the case group compared to the control group ($P<0.05$). Serum CEA yielded an AUC of 0.8661 (95% CI: 0.7964–0.9359) in distinguishing early lung cancer ($P<0.0001$). Low-dose spiral CT combined with serum CEA detection achieved an AUC of 0.9137 (95% CI: 0.8624–0.9650), significantly increasing the early lung cancer detection rate from 82.26% to 95.16% ($P<0.05$).

Conclusion: Patients with early lung cancer show distinct alterations in low-dose spiral CT signs, and their serum CEA levels demonstrate a notable increase compared with those with benign pulmonary lesions. The combination of low-dose spiral CT with serum CEA can be considered in the discrimination of early lung cancer, which can markedly enhance the positive detection rate while maintaining a minimal rise in false-positive rates.

Keywords: low-dose spiral CT, serum carcinoembryonic antigen, early lung cancer, combined detection, discriminative value

Introduction

Statistics show that lung cancer is the leading cause of death from malignant tumors worldwide, posing a serious threat to human health.[1,2] The total number of new lung cancer patients worldwide reached 2.2 million in 2020, accounting for about 11.4% of the total incidence of malignant tumors, and the total number of patients who died from lung cancer in the same year was about 1.8 million, accounting for 18.0% of the total number of deaths, ranking it as the highest among all causes.[3,4] Scholars have analyzed that the reason for the high morbidity and mortality of lung cancer is related to the lack of specific clinical manifestations in the early stage of lung cancer, and most of the patients exhibiting clinical symptoms are already in the advanced stage of the disease, missing the optimal window for surgical resection, ultimately leading to an unfavorable prognosis.[5,6] Consequently, early differential diagnosis and positive treatment hold significant value in enhancing the prognosis of lung cancer patients and reducing mortality rates, and are of positive implications in improving the quality of life for individuals afflicted with lung cancer.[7]

In recent years, many countries have dedicated efforts to the early screening of lung cancer. As early as 2010, the United States advocated the National Lung Screening Trial, highlighting the efficacy of low-dose spiral CT scans and chest X-ray screenings in reducing mortality rates among lung cancer patients, while the US Preventive Services Task Force recommended annual low-dose spiral CT screenings for individuals aged over 55 years and those with a history of

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persistent smoking.[8,9] Compared with chest X-ray detection, low-dose spiral CT has the advantages of low radiation, convenient detection, and high sensitivity, especially higher detection rate for small lesions with diameter < 5 mm. However, repeated CT screening still presents limitations, such as a high false-positive rate and low repeatability.[10,11] These limitations reduce the effectiveness of low-dose spiral CT as a standalone screening tool, particularly in distinguishing early lung cancer from benign lesions.

Carcinoembryonic antigen (CEA) is a tumor-associated antigen, mostly found on the surface of cancer cells differentiated from endodermal cells. In previous studies, CEA is often used as a specific marker for rectal and colon cancers, but it has been pointed out in in recent practice that this factor also has a better value in the differentiation, diagnosis, and monitoring of other malignant tumors.[12] However, as a standalone biomarker, CEA demonstrates limited sensitivity in the early detection of lung cancer, which is potentially attributable to fluctuations in tumor marker levels caused by individual comorbidities, dietary factors, and medications. Several studies have reported that the sensitivity of CEA in diagnosing lung cancer ranges from approximately 30% to 70%, with a specificity of about 60% to 90%, indicating that CEA alone is insufficient to meet the clinical requirements for accurate differentiation of early lung cancer.

Given the respective limitations of low-dose spiral CT and serum CEA when used individually, and considering their distinct diagnostic characteristics (low-dose spiral CT primarily evaluates anatomical tumor features, while CEA reflects biological characteristics), the combined use of these two modalities may theoretically provide complementary advantages and enhance the diagnostic accuracy for early lung cancer. However, current research on the combined use of low-dose spiral CT and CEA in early lung cancer screening remains limited. The synergistic diagnostic efficacy of this combined approach has not been fully evaluated, particularly regarding whether improvements in sensitivity are accompanied by a significant increase in false-positive rates. Further research is needed to validate these aspects.

Materials and Methods

General Data

Sixty-two patients diagnosed with early lung cancer in our hospital from April 2022 to October 2023 were retrospectively selected as the case group, and 50 patients diagnosed with benign pulmonary lesions in our hospital during the same period were selected as the control group. The case group comprised 33 males, accounting for 53.23% of the cases, aged between 46 and 73 years with an average age of (56.98±11.20) years. There were 19 smokers, accounting for 30.65% of the group. Pathological analysis revealed that 46 cases were diagnosed with lung adenocarcinoma, accounting for 74.19% of the cases, while 13 cases were diagnosed with squamous cell lung carcinoma, accounting for 20.97%, and the remaining cases consisted of 3 other pathological types, accounting for 4.84%. Among them, 50 cases presented with stage I lung cancer, accounting for 80.65%, whereas 12 cases were at stage II, accounting for 19.35%. The average lesion size was (1.35±0.51) cm. In the control group, there were 29 males, accounting for 58.00% of the group, aged between 50 and 67 years with an average age of (57.32±13.51) years; 12 cases of smokers, accounting for 24.00%. Gender, average age, and smoking habits were compared between the two groups, showing no significant differences (P>0.05). This study was approved by the Ethics Committee of First People's Hospital of Linping District (date: 02.15.2022, approval number: 2022–029) and complied with the Declaration of Helsinki. All patients signed an informed consent form.

Data Screening Requirements

The sample size for this study was estimated based on the primary objective of evaluating the diagnostic value of low-dose spiral CT combined with serum CEA detection for early lung cancer differentiation. According to previous reports,[6] the sensitivity of low-dose spiral CT alone for diagnosing early lung cancer is approximately 75%. We hypothesized that adding serum CEA detection would increase sensitivity to 90%. Using a paired comparison design, with a Type I error (α) of 0.05 (two-sided) and a Type II error (β) of 0.20 (corresponding to 80% statistical power), the required sample size was calculated via the McNemar test, resulting in a need for 68 early lung cancer cases. To account for potential data loss and analytical considerations, the sample size of the case group was increased to 92. The control group included 50 patients with benign pulmonary lesions to maintain analytical balance and ensure adequate specificity assessment.

Data were collected through the hospital information system from April 2022 to October 2023. A total of 92 patients with early lung cancer and 130 patients with benign lung lesions were gathered. Inclusion criteria of the case group: (1) definite pathological findings confirming the diagnosis of early lung cancer; (2) comprehensive data on age, gender, pathological type, and serum CEA level; (3) those who had not undergone radiotherapy and biotherapy. Exclusion criteria of the case group: (1) patients concurrently suffering from other malignant tumors; (2) patients diagnosed with advanced lung cancer. The inclusion criteria for the control group: (1) patients with definitive diagnosis of benign pulmonary lesions; (2) patients with detailed information of low-dose spiral CT scans and serum CEA detection results. Exclusion criteria for the control group were the same as for the case group. After screening by inclusion and exclusion criteria, 62 patients in the case group and 50 patients in the control group were enrolled.

Bias Control Measures

As a retrospective study, we implemented the following measures to minimize selection bias: (1) All eligible patients between April 2022 and October 2023 were identified via the hospital's electronic medical record system using a consecutive sampling method, rather than convenience sampling, to avoid arbitrary inclusion of specific patient groups; (2) Radiologists performed image evaluations blinded to clinical diagnoses, pathological results, and serum CEA levels to minimize expectation bias; (3) Evaluations were conducted based on established diagnostic criteria and thresholds to minimize subjective judgment.

Low-Dose Spiral CT Examination and Image Analysis

All patients underwent low-dose spiral CT scans using the same model scanner (Siemens SOMATOM Definition Flash dual-source CT, Germany). The scanning protocol strictly adhered to the technical parameters recommended in the China Guideline for the Screening and Early Detection of Lung Cancer (2021, Beijing): tube voltage of 120 kV, automatic tube current modulation (30–50 mAs), rotation time of 0.5 s, collimation of 64×0.625 mm, pitch of 0.9, and scan range extending from the lung apex to the base. The scan layer thickness was 5 mm, with a layer reconstruction thickness of 1 mm. Image reconstruction was performed using standard lung window settings (window width: 1500 HU; window level: –600 HU) and mediastinal window settings (window width: 400 HU; window level: 40 HU). To ensure consistency in image quality, all scans were conducted by a single radiologic technologist with over 10 years of experience, using the same CT scanner for all examinations.

CT image analysis was conducted using a double-blind method, independently evaluated by two radiologists, each with a minimum of five years of experience in thoracic imaging. The radiologists were blinded to patients' clinical information, pathological results, and serum CEA levels. Prior to evaluation, both radiologists underwent standardized training to ensure consistency in interpretation criteria. In cases of disagreement (observed in 12 cases, approximately 11%), a third senior radiologist with over 15 years of experience rendered the final decision, based on the 2017 Fleischner Society Guidelines for Pulmonary Nodule Management and the standards of the International Association for the Study of Lung Cancer.[13]

Serum CEA Measurements

All serum CEA measurements were conducted at the Clinical Laboratory Center of our hospital. Blood samples were collected following a standardized protocol: after an 8-hour fast, 5 mL of peripheral venous blood was drawn using blood collection tubes (BD Vacutainer®, USA) by trained nurses. Within 30 minutes of collection, samples were centrifuged at $2000 \times g$ for 10 minutes to separate the serum. The serum was either analyzed immediately or stored at −80 °C for no longer than 24 hours. Serum CEA levels were determined using the electrochemiluminescence immunoassay (ECLIA) on the Roche Elecsys 2010 automated analyzer (Roche Diagnostics, Switzerland), with the corresponding CEA assay kit (Lot No. 2021–05-A, Roche Diagnostics). All procedures strictly followed the National Clinical Laboratory Operating Procedures (4th edition)[14] and the manufacturer's standard operating procedures. A CEA concentration <5 ng/mL was considered negative.

Observation Indices

The final pathologic findings were used as the gold standard, and the discriminative value of low-dose spiral CT, serum CEA, and combined detection in early lung cancer was calculated separately.

Statistical Methods

The gathered data were consolidated using EXCEL 2021 and analyzed using SPSS 22.0. Measurement data were expressed as mean ± standard deviation and examined using intergroup *t*-tests. Counting data were represented as rates, employing intergroup chi-square tests. $P<0.05$ was considered statistically significant differences.

Results

Comparison of Baseline Clinical Data Between the Case and Control Groups

The baseline clinical data of patients were collected through the hospital information system, and a total of 62 patients were enrolled in the case group after screening by inclusion and exclusion criteria. In the case group, there were 33 males, accounting for 53.23%, aged between 46 and 73 years with an average age of (56.98±11.20) years; there were 19 smokers, accounting for 30.65% of the group. Pathological analysis revealed that 46 cases were diagnosed with lung adenocarcinoma, accounting for 74.19%, 13 cases were diagnosed with squamous cell lung carcinoma, accounting for 20.97%, and the remaining cases consisted of 3 other pathological types, accounting for 4.84%. Among them, 50 cases presented with stage I lung cancer, accounting for 80.65%, whereas 12 cases were at stage II, accounting for 19.35%. The average lesion size was (1.35±0.51) cm. In the control group, there were 29 males, accounting for 58.00%, aged between 50 and 67 years with an average age of (57.32±13.51) years; 12 cases of smokers, accounting for 24.00%. Gender, average age, and smoking habits were compared between the two groups, showing no significant differences ($P>0.05$), as shown in Table 1 for details.

Analysis of the Discriminative Value of Low-Dose Spiral CT in Early Lung Cancer

Low-dose spiral CT in patients with benign lesions revealed a regular surface within the lesion area, devoid of lobulation, accompanied by fibrous cord-like alterations surrounding the lesion, as depicted in Figure 1. The malignant lesion exhibited irregular surfaces, obvious spiculated margins, and inhomogeneous density, along with obvious manifestations of pleural retraction or vascular penetration at the lesion site, and the above signs were helpful in identifying the nature of the lung lesion, as depicted in Figure 2. Based on the standards mentioned above, a blinded evaluation was conducted by two physicians. Among the 62 patients in the case group, 51 cases were positive, with a positivity rate of 82.26%. In contrast, among the 50 patients in the control group, 9 cases were positive, yielding a positivity rate of 18.00%. The difference in positivity rates between the two groups was statistically significant ($P<0.05$), as depicted in Table 2. Calculations showed that low-dose spiral CT had a sensitivity of 77.42%, a specificity of 94.00%, a positive predictive value of 94.12%, and a negative predictive value of 77.05% for the identification of early lung cancer, as shown in Table 3.

Table 1 Comparison of Baseline Clinical Data Between the Case and Control Groups (Mean ± SD)/[n (%)]

Group	Number of Cases	Gender (Male/Female)	Average Age (Years)	Smoking
Case group	62	33/29	56.98±11.20	19 (30.65)
Control group	50	29/21	57.32±13.51	12 (24.00)
t/χ2	–	0.255	0.146	0.435
P	–	0.613	0.884	0.611

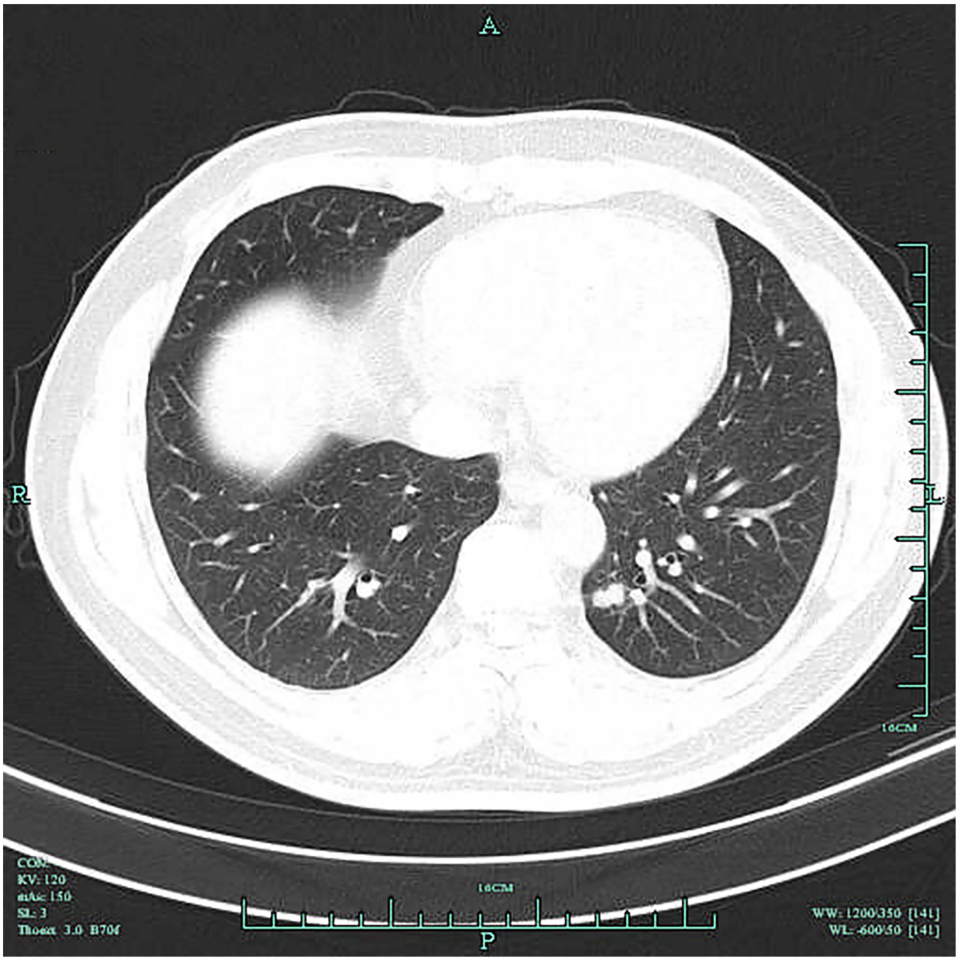

Figure 1 CT signs of low-dose spiral CT in patients with benign lesions.

Analysis of the Discriminative Value of Serum CEA Level in Early Lung Cancer

Serum CEA detection results of patients in the case and control groups were collected based on the hospital information system. The calculation showed that the serum CEA level of the patients in the case group was significantly higher than that of the patients in the control group (P<0.05), as shown in Table 4 and Figure 3.

Analysis of the Discriminative Value of Serum CEA in Early Lung Cancer

The differential diagnostic value of serum CEA levels in early lung cancer was calculated using a plotted ROC curve, which showed an AUC of 0.8661 (95% CI=0.7964–0.9359) (P<0.0001), as shown in Figure 4.

Analysis of the Discriminative Value of Low-Dose Spiral CT, Serum CEA and Combined Detection for Early Lung Cancer

A parallel approach was used to calculate the discriminative value of low-dose spiral CT and serum CEA for early lung cancer, and the results showed that compared with low-dose spiral CT alone, the combined detection of low-dose spiral CT and serum CEA increased the positivity rate of early lung cancer screening from 82.26% to 95.16%, showing significant differences (P<0.05). However, the detection rate of early lung cancer was not significantly improved by combined detection compared with CEA detection alone (87.10% vs 95.16%) (P>0.05). In terms of detection rate of benign lesions, the combined detection did not notably increase the false-positive rate, exhibiting no significant differences compared with the CT detection alone or CEA detection alone (P>0.05), as shown in Table 5 and Figure 5.

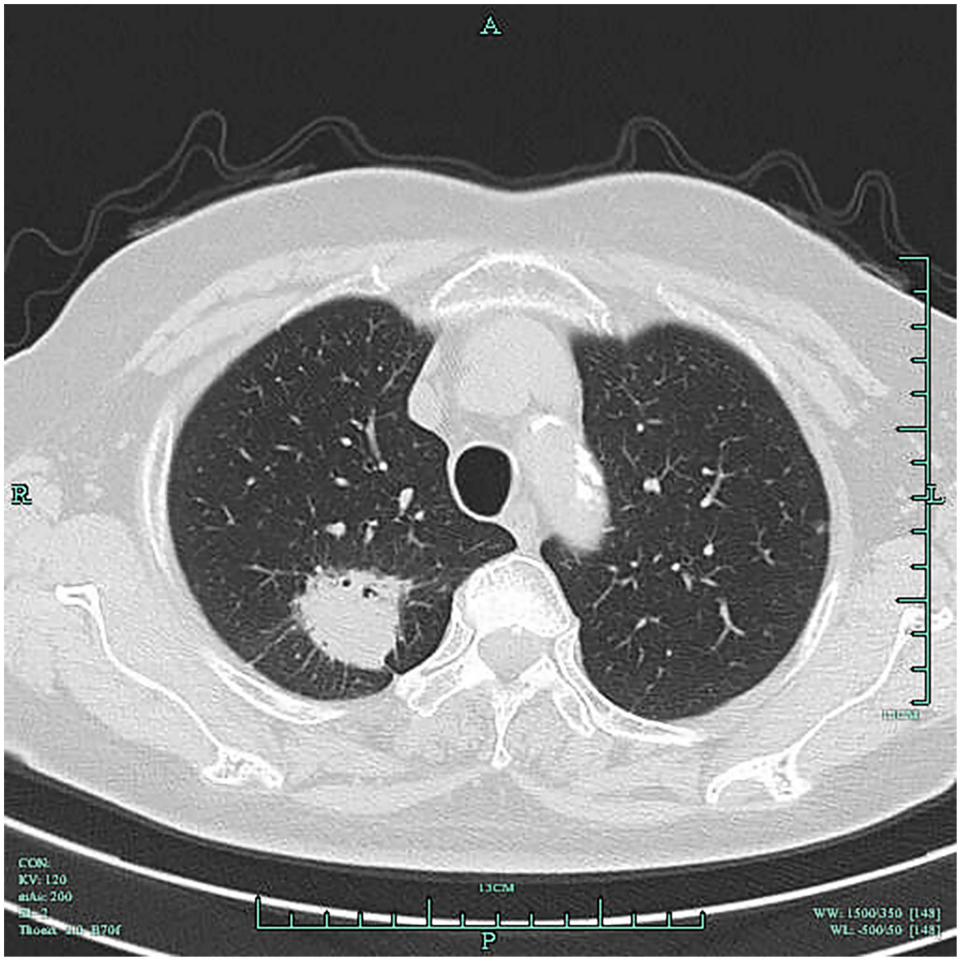

Figure 2 CT signs of low-dose spiral CT in patients with malignant lesions.

Comparison of the Diagnostic Sensitivity of Detection Methods in Tumor Size Subgroups

Subgroup analysis based on tumor size revealed an increasing trend in diagnostic sensitivity for both low-dose spiral CT and serum CEA as tumor diameter increased (Table 6). For small lesions measuring ≤1.0 cm (n=14), the sensitivity of low-dose spiral CT was 57.14% (8/14), and that of serum CEA was 50.00% (7/14). Notably, the combined detection approach significantly improved sensitivity to 78.57% (11/14) (P=0.038). For lesions measuring 1.1–2.0 cm (n=36), the

Table 2 Analysis of the Discriminative Value of Low-Dose Spiral CT in Early Lung Cancer

Group	Number of Cases	Number of Positive	Positive Rate (%)	$\chi 2$	P
Case group Control group	62 50	51 9	82.26 18.00	45.949	<0.001

Table 3 Diagnostic Value of Low-Dose Spiral CT in Early Lung Cancer

Item	Sensitivity	Specificity	Positive Predictive Value	Negative Predictive Value	AUC
Low-dose spiral CT	77.42 (65.36–86.97)	94.00 (83.45–98.75)	94.12 (84.82–98.44)	77.05 (64.50–86.85)	0.8571 (0.7832–0.9310)

Table 4 Comparison of Serum CEA Level Between the Case and Control Groups (Mean ± SD)

Group	Number of Cases	CEA Level (ng/mL)	t	P
Case group	62	15.11±5.10	10.519	<0.001
Control group	50	8.46±2.60		

Abbreviation: CEA, carcinoembryonic antigen.

sensitivity of low-dose spiral CT (80.56%) was higher than that of serum CEA (69.44%), and combined detection further increased sensitivity to 97.22% (35/36) (P=0.012). For lesions measuring 2.1–3.0 cm (n=12), the sensitivity of low-dose spiral CT and serum CEA alone was 91.67% and 83.33%, respectively, with the combined approach achieving 100% sensitivity (P=0.157). These findings suggest that the combined detection method offers particular significant diagnostic value for small and medium-sized lesions (Table 6).

Discussion

Lung cancer is the malignant tumor with the highest morbidity and mortality rate worldwide, posing a serious threat to human health and life safety. The World Health Organization (WHO) has issued information showing that lung cancer is the leading cause of death from malignant tumors in men and ranks second in cancer mortality in women.[15,16] China is affected by many factors such as population aging, environmental pollution, and accelerated pace of life, leading to the increasing prevalence of lung cancer year by year, and the number of lung cancer patients now accounts for the first place in the world.[17,18] Although surgery, radiotherapy, and targeted therapy can reduce the mortality rate of patients with advanced lung cancer to a certain extent, there are still a majority of patients whose symptoms are not relieved or even worsen after receiving standard first- or second-line treatment.[19] Therefore, early screening, diagnosis, and treatment are particularly important, and early detection and timely treatment are of great significance in saving the lives of lung cancer patients.

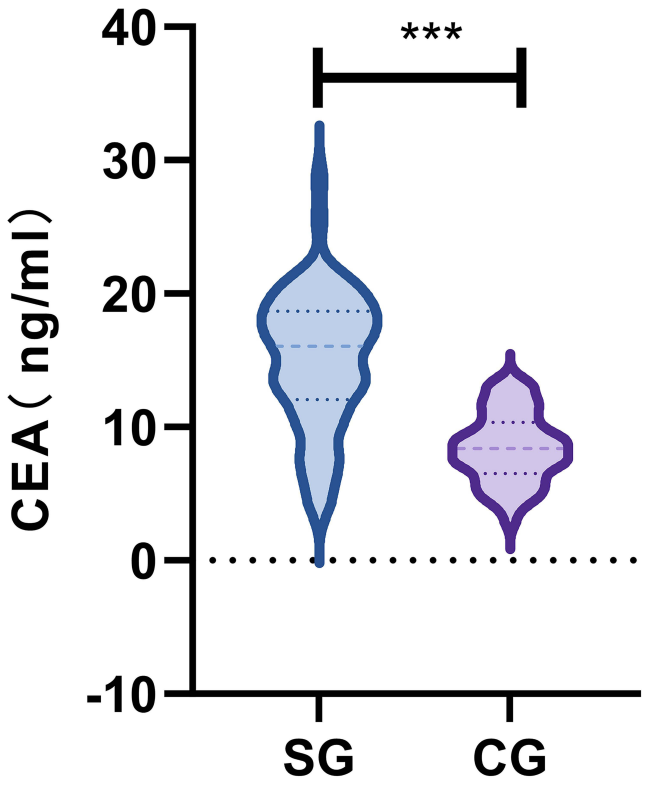

Figure 3 Comparison of serum CEA level between the case and control groups.

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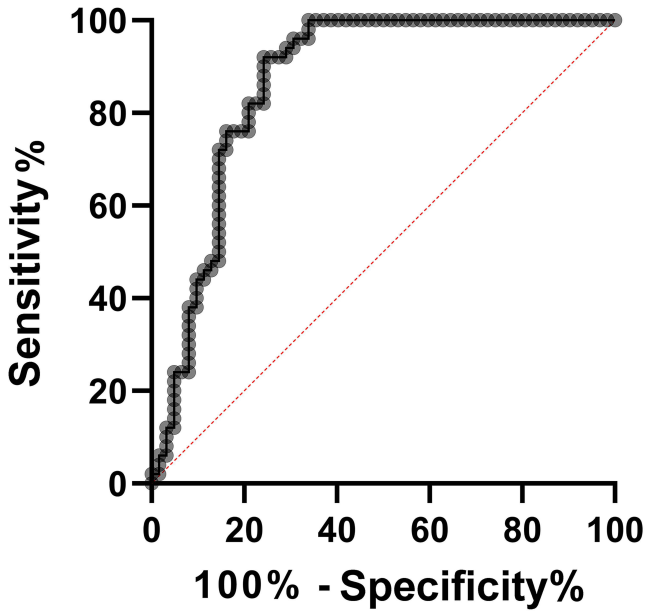

Figure 4 Analysis of the discriminative value of serum CEA in early lung cancer. The AUC of serum CEA for early lung cancer identification was 0.8661 (95% CI=0.7964–0.9359) (P<0.0001).

This study employed grouping and comparison method to analyze the clinical value of low-dose spiral CT and serum CEA in early lung cancer screening. The findings revealed that low-dose spiral CT exhibited a sensitivity of 77.42%, a specificity of 94.00%, a positive predictive value of 94.12%, and a negative predictive value of 77.05% in distinguishing early lung cancer, which were similar to findings from other scholarly research.[20] Various routes have been tried in early lung cancer screening in the past, among which chest X-ray, although of some value, is highly radioactive, has low repeatability and low accuracy; in contrast, low-dose spiral CT does not have significant radiation risks and has lower medical costs, and thus has been considered for application in early lung cancer screening.[21] There are several authoritative guidelines stating that annual screening with low-dose spiral CT of the chest can help improve lung cancer detection rates, especially in patients with stage I lung cancer.[22] However, with the popularization and application of this technology, its shortcomings have been gradually exposed. On the one hand, although the radiation dose is low, repeated screening still causes radiation accumulation in patients and increases the risk of radiation-related cancers, and on the other hand, the false-positive rate and the high cost of screening have limited the popularization of this technology in primary care settings.

Table 5 Analysis of the Discriminative Value of Low-Dose Spiral CT, Serum CEA and Combined Detection for Early Lung Cancer

Item	Case Group (n=62)		Control Group (n=50)		P
	Positive	Negative	Positive	Negative	
Low-dose spiral CT	51	11	9	41	<0.001
Serum CEA	54	8	15	35	<0.001
Combined detection	59	3	16	34	<0.001
P1	0.023		0.105		
P2	0.114		0.829		

Notes: P1: P value between combined detection and low-dose spiral CT; P2: P value between combined detection and serum CEA;
Abbreviation: CEA, carcinoembryonic antigen.

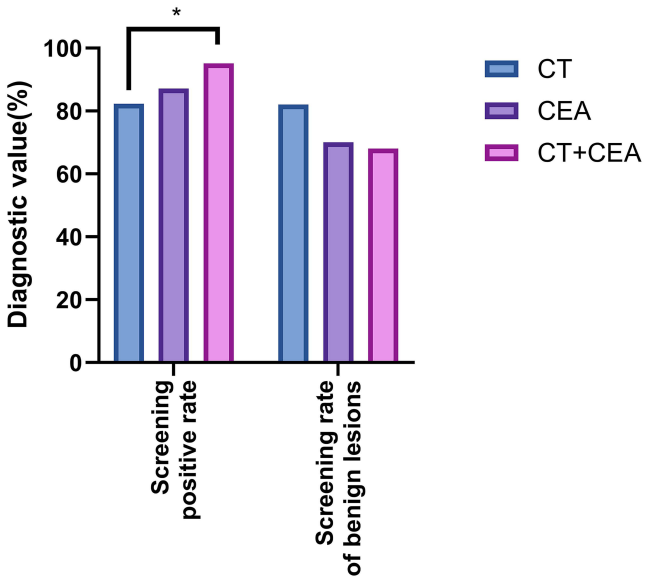

Figure 5 Analysis of the discriminative value of low-dose spiral CT, serum CEA and combined detection for early lung cancer. *represents P<0.05.

The subgroup analysis in this study further highlighted the clinical value and target population characteristics of combining low-dose spiral CT with serum CEA detection. Stratification by tumor size revealed that for small lesions measuring ≤1.0 cm, the combined detection method yielded the most significant improvement in diagnostic sensitivity compared to either modality alone, a finding of considerable clinical importance. Previous studies have shown that early detection and intervention for subcentimeter lung cancers (≤1.0 cm) can markedly improve patient survival rates. However, traditional imaging techniques often lack sufficient sensitivity for such small lesions, and serum biomarkers alone demonstrate limited diagnostic performance. Our findings affirm the clinical value of the combined detection strategy. In particular, for subcentimeter lung cancers, this approach significantly improves detection rates and may facilitate earlier intervention.

The screening value of serum CEA in early lung cancer was further analyzed in this study, and the results showed that the serum CEA level in patients with early lung cancer was significantly higher than that in patients with benign lung lesions, and the plotted ROC curve showed that its diagnostic AUC was 0.8661, with high diagnostic efficacy, which was also similar to the results of other studies.[23] Tumor factor belongs to the tumor detection markers with better prospects. Tumor factor represented by CEA is often able to intuitively reflect the state of the tumor, and has unique advantages compared with other detection methods, such as good repeatability, higher accuracy, etc., which have led to the increasing widespread application of tumor factor in malignant tumor screening in recent years. In a study conducted on 90 patients with suspected lung cancer, the accuracy of serum CEA in identifying lung cancer was 88.10%, which indicated that serum CEA helps in the early detection of malignant lesions in the lungs, and provides a reference for early clinical intervention in lung cancer patients.[24] The authors of this study posit that the carcinogenic process involves the

Table 6 Comparison of Diagnostic Sensitivity of Different Detection Methods in Tumor Size Subgroups

Tumor Size	N	Low-Dose Spiral CT	Serum CEA	Combined Detection	P
≤1.0cm	14	8(57.14)	7(50.00)	11(78.57)	0.038
1.1–2.0cm	36	29(80.56)	25(69.44)	35(97.22)	0.012
2.1–3.0cm	12	11(91.67)	10(83.33)	12(100.00)	0.157
Total	62	48(77.42)	42(67.74)	58(93.55)	0.003

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participation of multiple immune systems, and during the malignant transformation, the individual's humoral immune system might experience a dysregulation, consequently leading to dramatic fluctuations in certain factor levels. All these have laid the foundation for CEA in the screening of early lung cancer from the theoretical level. However, it is also important to recognize that serum CEA levels also have certain shortcomings in early lung cancer screening, as they are susceptible to influences from drugs and other diseases, resulting in a notably elevated false-positive rate.[25] In this study, the serum CEA positivity rate in the control group was 30%, indicating a relatively high false-positive rate. The potential reasons are as follows: (1) The control group consisted of patients with benign pulmonary lesions rather than healthy volunteers. Some of these patients may have had active inflammatory conditions, which could have led to elevated CEA levels; (2) The cutoff value for CEA used in this study was based on standard reference values for the general population, which may not be fully applicable to a hospital-based population with specific clinical conditions. Future studies will consider increasing the cutoff to 7.5 ng/mL.

In order to find the optimal indicator for early lung cancer identification, this study attempted to employ low-dose spiral CT and serum CEA jointly in the discrimination of early lung cancer. The results showed that the screening positivity rate of the combined detection was 95.16%, significantly higher than that of low-dose spiral CT alone (82.26%), but the combined detection did not make the false-positive rate increase significantly, merely elevating the false-positive rate of serum CEA from 30.00% to 32.00%, without a significant change, which suggests that the combined detection improves the screening rate of early lung cancer, but does not significantly improve the false-positive rate. The authors of this study analyzed that the result is exactly what medical workers aspire to witness. The serum CEA screening, to a certain extent, compensates for the deficiencies of low-dose spiral CT. Factors such as its favorable repeatability, minimal trauma, and absence of radiation accumulation render serum CEA screening advantageous. Meanwhile, low-dose spiral CT can serve as a subsequent examination for patients with positive serum CEA in preliminary screening. Through their combined application, the detection rate for early lung cancer is heightened, which provide valuable insights for subsequent treatment.[26]

The innovations of this study are primarily reflected in the following aspects: (1) It provides specific performance parameters for the combined use of low-dose spiral CT and serum CEA in early lung cancer screening among the Chinese population, offering evidence to support the development of localized screening strategies; (2) Through tumor size-based subgroup analysis, it clearly demonstrates that the diagnostic value of combined detection is most pronounced for small lesions (≤1.0 cm), addressing a gap in previous research; (3) It confirms that the combined approach can significantly improve diagnostic sensitivity without markedly increasing the false-positive rate, thereby addressing a key challenge in clinical practice. These findings have clear translational significance and may assist clinicians in more precisely applying combined detection strategies in early lung cancer screening.

This study has several limitations: (1) The retrospective case-control design inherently carries a risk of selection bias. Both case and control groups were drawn from a single-center patient population, which may not fully represent the broader target population; (2) In retrospective studies, researchers are aware of patients' final diagnoses. Although blinded assessments were employed, the potential influence of the study design on the interpretation of imaging features cannot be completely excluded; (3) The diagnostic criteria used in this study, especially the interpretation of CT imaging features, were based on current clinical guidelines but still involved a degree of subjectivity. Such subjectivity is more difficult to control in retrospective studies and may consequently result in an overestimation of diagnostic accuracy; (4) The study did not include multivariable analysis, limiting the ability to adequately control for potential confounders such as age, sex, and smoking status, which may have influenced the evaluation of the combined detection strategy; (5) The sample size was relatively limited, especially in tumor size subgroups, where small subgroup sizes may have affected the statistical stability and generalizability of the findings.

Conclusions

In summary, patients with early lung cancer show distinct alterations in low-dose spiral CT signs, and their serum CEA levels demonstrate a notable increase compared with those with benign pulmonary lesions. The combination of low-dose spiral CT with serum CEA can be considered in the discrimination of early lung cancer, which can markedly enhance the positive detection rate while maintaining a minimal rise in false-positive rates.

Data Sharing Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Ethics Approval and Informed Consent

This study was approved by the Ethics Committee of First People's Hospital of Linping District (date: 02.15.2022, approval number: 2022-029) and complied with the Declaration of Helsinki. All patients signed an informed consent form.

Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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Disclosure

The authors of this work report no conflicts of interest.

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