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Exploration and Research on a New Model for Early Lung Cancer Screening

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Abstract: *Objective*: To explore scientifically feasible management models and methods for the assessment, screening, early diagnosis, and early treatment of individuals at high risk for lung cancer. *Methods*: Seven communities within the Jinyinshan area of our city, namely Xiliuwan, Ligongxiang, Huxingshan, Zhushan, Xiufeng, Jinyinshan, and Sanyantang, were selected as the screening regions for this project. The screening methods followed the "Technical Plan for Lung Cancer Screening in Hunan Province (2021 Edition)", involving low-dose spiral computed tomography (CT) and carcinoembryonic antigen (CEA) testing for clinical screening of high-risk individuals. The positive screening rate and lung cancer positive rate were calculated, and positive cases were subjected to stratified management and treatment. *Results*: From January 1, 2024, to December 31, 2024, a total of 2,626 individuals completed questionnaires, including 1,625 males and 1,001 females. Among them, 681 individuals were identified as being at high risk for lung cancer, accounting for 25.93% of the total screened population, with 456 males (66.96%) and 225 females (33.04%). The detection rate of suspected lung cancer was higher with combined testing (3.00%) compared to CT alone (2.00%) or CEA alone (1.60%), suggesting that combined testing improves diagnostic accuracy. A total of 500 cases underwent low-dose spiral CT combined with CEA testing, with 15 suspected cases of lung cancer identified, resulting in a detection rate of 2.20%. *Conclusion*: Early screening for lung cancer facilitates early detection, diagnosis, and treatment, reduces incidence and mortality rates, improves patients' quality of life, and alleviates societal burdens.

Keywords: Early screening for lung cancer; Positive rate; Low-dose spiral CT; CEA

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1. Introduction

Lung cancer, as one of the most prevalent malignant tumors globally, poses a severe threat to human health and life due to its high incidence and mortality rates. According to data from the International Agency for Research on Cancer (IARC) of the World Health Organization, lung cancer is the leading cause of cancer-related deaths worldwide, with over 2 million new cases and nearly 1.8 million deaths annually [1,2]. The situation of lung cancer in China is particularly grave; in 2015, it ranked first in both incidence and mortality among malignant tumors, with 787,000 new cases and 631,000 deaths, accounting for a quarter of all cancer-related deaths. These figures not only reflect the high prevalence of lung cancer in China but also underscore the immense pressure it places on the public health system [3,4]. Early screening plays an irreplaceable and crucial role in improving the cure rate of lung cancer and enhancing patient prognosis. For early-stage lung cancer, surgical treatment can significantly increase the five-year survival rate to over 90%, whereas the five-year survival rate for patients with advanced-stage lung cancer is only around 5% [5,6]. Early detection and intervention are key to improving lung cancer survival; however, traditional physical examinations often fail to detect early lesions, resulting in most patients being diagnosed at intermediate or advanced stages. Based on this, this study analyzes the exploration and research of new models for early lung cancer screening.

2. Subjects and methods

2.1. Subjects

Seven communities within the Jinyinshan area of our city were selected as the screening regions for this project: Xiliuwan, Ligongxiang, Huxingshan, Zhushan, Xiufeng, Jinyinshan, and Sanyantang.

Inclusion criteria: The project targets permanent residents who have continuously resided in the designated area for over three years, with ages ranging from 45 to 74 years old (based on the date of birth recorded on their ID cards).

Exclusion criteria: Individuals without a history of malignant tumors or severe dysfunction of the heart, brain, lungs, or kidneys, and those who voluntarily participate in the project.

2.2. Methods

The goal is to mobilize the public to participate in lung cancer screening to enhance the early diagnosis rate of lung cancer. Emphasis is placed on promoting the background and significance of the project, and understanding participants' lifestyle habits and medical histories through questionnaires. The questionnaire covers seven aspects, including basic information, diet, environment, lifestyle, medical history, family history, and female reproductive history. Trained personnel guide participants in completing the questionnaire to ensure quality, and the National Cancer Center's evaluation software is used to screen high-risk individuals. All participants in the lung cancer screening project must sign an informed consent form; the assessment of high-risk individuals and clinical screening should be conducted simultaneously, with a time interval of no more than 15 days. High-risk individuals identified through the assessment are required to visit our hospital for relevant clinical screenings within the agreed-upon timeframe. Clinical screening of initially identified high-risk individuals is conducted according to unified methods and standards, following the "Technical Plan for Lung Cancer Screening in Hunan Province" [7] (2021 edition). Screening technique selection: The screening process involves low-dose chest spiral CT scans combined with blood CEA tests.

2.3. Index detection

Clinical screening evaluation criteria:

(1) Low-dose spiral CT: Assess nodule size (suspicious if > 6 mm), nodule shape (suspicious if irregular), density (higher CT values suggest a higher likelihood of malignancy), nodule location, nodule growth, nodule margins (rough or blurred margins suggest malignancy), and nodule count.

(2) Blood CEA: The normal range is 0–5 μg/L.

2.4. Statistical analysis

Statistical analysis was performed using SPSS 26.0 software. Continuous data are presented as mean ± standard deviation (SD), with comparisons between groups made using independent sample t-tests and comparisons within groups made using paired *t*-tests. Categorical data are expressed as percentages, with comparisons between groups made using the chi-square (χ^2) test. A *P*-value of < 0.05 indicates statistical significance.

3. Results

3.1. Comparison of gender and age distribution among high-risk populations

As shown in **Table 1**, from January 1, 2024, to December 31, 2024, a total of 2,626 questionnaires were completed. Among the respondents, there were 1,625 males and 1,001 females. A total of 681 individuals were identified as being at high risk for lung cancer, accounting for 25.93% of the total screened population. This included 456 males (66.96%) and 225 females (33.04%). The average age of the high-risk population was (53.36 ± 7.85) years old. In terms of age distribution, the majority were concentrated in the 45–49 and 50–54 age groups, accounting for 21.29% and 26.58%, respectively.

Table 1. Comparison of gender and age distribution among high-risk populations

Group		**Number of Cases (*n* = 681)**	Percentage (%)
Gender	Male	456	66.96
	Female	225	33.04
Age	40–44	70	10.28
	45–49	145	21.29
	50–54	181	26.58
	55–59	101	14.83
	60–64	86	12.63
	65–69	68	9.99
	70–74	30	4.41
Total		681	100.00

3.2. Results of low-dose spiral CT and CEA tests

As shown in **Table 2**, out of the 681 high-risk individuals, 500 underwent screening, resulting in a screening rate of 73.42%. Low-dose spiral CT (LDCT), CEA tests, and combined tests were conducted on these 500 individuals at high risk for lung cancer, with the following results: Single test results: LDCT had the highest detection rates for small airway lesions (17.80%), positive nodules (12.40%), and emphysema (6.40%). The positive rate for CEA tests was generally low, with the highest rates observed for small airway lesions (12.20%) and positive nodules (9.40%). Advantages of combined testing: Combined testing significantly improved specificity while maintaining high sensitivity. For positive nodule detection, the combined detection rate (25.80%) was higher than that of single CEA testing (9.40%) or LDCT testing (12.40%), demonstrating better specificity. For the detection of suspected lung cancer, the combined test (3.00%) yielded higher results than CT (2.00%) or CEA (1.60%) alone, suggesting that combined testing can enhance diagnostic accuracy.

Table 2. Results of low-dose spiral CT, CEA tests, and combined tests

Examination findings	Low-dose spiral CT detection	CEA test	Low-dose spiral CT combined with CEA test
Emphysema	32 (6.40)	27 (5.40)	109 (21.80)
Pulmonary Cyst	10 (2.00)	8 (1.60)	54 (10.80)
Small Airway Disease	89 (17.80)	61 (12.20)	143 (28.60)
Interstitial Lung Disease	18 (3.60)	15 (3.00)	41 (8.20)
Pulmonary Fibrotic Scar	15 (3.00)	12 (2.40)	75 (15.00)
Atelectasis	7 (1.40)	6 (1.20)	28 (5.60)
Positive Nodule	62 (12.40)	47 (9.40)	129 (25.80)
Suspected Lung Cancer	10 (2.00)	8 (1.60)	15 (3.00)

3.3. Lung cancer detection rates across age groups

As shown in **Table 3**, when comparing different age groups, the lung cancer detection rate increased with age, demonstrating a statistically significant difference ($P < 0.05$).

Table 3. Lung cancer detection rates across age groups

Age group (years old)	Positive detected	Negative detected	Detection rate (%)	χ^2 value	*P* value
40-49	3	195	1.53		
50-59	5	203	2.46	12.034	0.001
60-69	7	102	6.86		

4. Discussion

Among the various factors contributing to cancer-related deaths in China, lung cancer holds a significant position. Despite a gradual decline in the smoking population and notable improvements in urban air quality in recent years, the long development cycle of cancer, often requiring years from exposure to onset, suggests that China will continue to face a substantial lung cancer burden in the coming decades [8].

Chest X-rays and CT scans are commonly used for early lung cancer screening. Chest X-rays, being simple and low-cost, utilize X-rays to observe changes in the lungs and are widely applied [9,10]. However, due to their limited resolution, chest X-rays struggle to detect small, low-density early-stage lung cancer lesions, resulting in low sensitivity and specificity. In contrast, CT scans, through multi-slice scanning and reconstruction techniques, offer higher spatial and density resolution, significantly enhancing the detection rate of early-stage lung cancer [11,12]. In particular, low-dose CT (LDCT) maintains high diagnostic accuracy while reducing radiation exposure, making it one of the primary methods for lung cancer screening today [13,14]. The results of this study reveal that among the respondents, there were 1,625 males and 1,001 females, with a total of 681 individuals identified as being at high risk for lung cancer, accounting for 25.93% of the total screened population. This included 456 males (66.96%) and 225 females (33.04%). The average age of the high-risk population was (53.36 ± 7.85) years old, with the majority concentrated in the 45–49 and 50–54 age groups, accounting for 21.29% and 26.58%, respectively. An analysis of the reasons reveals that males constitute over 60% of the high-risk population for lung cancer, with a male prevalence rate of 66.96%, significantly higher than that of females. This may be attributed to several factors: smoking is a major risk factor for lung cancer, and the higher smoking rate among males increases their risk of lung diseases. Additionally, males working in industries such as coal, metals, and chemicals are prone to lung cancer due to occupational exposure. Middle-aged individuals constitute nearly half of the high-risk group. As age increases, organ function declines, immunity weakens, and the stress of middle-aged life, combined with unhealthy habits (such as smoking and drinking) and environmental pollution, increases the risk of lung cancer.

The study also found that for single test results, LDCT had the highest detection rates for small airway lesions (17.80%), positive nodules (12.40%), and emphysema (6.40%). CEA test positivity rates were generally low, with the highest rates observed for small airway lesions (12.20%) and positive nodules (9.40%). In the detection of positive nodules, the combined detection rate (25.80%) was higher than that of single CEA testing (9.40%) or LDCT testing (12.40%), demonstrating better specificity. For the detection of suspected lung cancer, the combined test (3.00%) yielded higher results than CT (2.00%) or CEA (1.60%) alone, suggesting that combined testing can enhance diagnostic accuracy. When comparing different age groups, the lung cancer detection rate increased with age. An analysis of the reasons reveals that LDCT enables early detection of lung cancer, while CEA offers high specificity. Combining both tests leverages their complementary advantages, improving diagnostic accuracy. High-risk elderly individuals should prioritize screening, as single tests have limitations, and combined testing is more effective.

5. Conclusion

In conclusion, promoting the widespread adoption of screening technologies for high-risk lung cancer populations, enhancing early detection and treatment rates, can improve patient survival rates, reduce mortality risks, optimize patients' quality of life, and alleviate the social and familial burdens associated with cancer. Due to time constraints and various other factors, this study had a limited sample size, which may have affected the analysis results. Future research should increase the sample size, conduct in-depth analyses of patient prognoses, and incorporate additional variables to enhance the precision of the results and provide accurate data and theoretical support for clinical practice.

Disclosure statement

The authors declare no conflict of interest.

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