Original Article

Clinical analysis of incidental discovery of pulmonary nodules with computed tomography: a retrospective cohort study

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Background: The increasing use of computed tomography (CT) for screening has led to a rising number of incidental pulmonary nodule detections. The incidental pulmonary nodule detection rates are well-documented in Western populations, but large-scale data from Chinese cohorts remain limited. Understanding the clinical characteristics of these lesions is crucial for the early diagnosis and management of potential malignancies. This study aimed to determine the prevalence of incidentally detected pulmonary nodules in routine Chinese practice, their malignant potential based on radiological characteristics, and the diagnostic outcomes of high-risk nodules.

Methods: The study enrolled patients who underwent CT screening from February 2020 to February 2022, except for those with respiratory diseases or primary malignant tumors. Clinical and radiologic characteristics were retrospectively analyzed. Additionally, patients with high-risk lesions (noncalcified nodules ≥6 mm) were informed and followed up every 6 months until a clear pathological diagnosis was made.

Results: The cohort (n=120,623) comprised 25.2% of individuals aged >65 years with 49.9% males, identifying 52.9% CT-positive (diameter ≥4 mm) cases, with 5.1% high-risk lesions. Among 5,482 followed cases, 343 underwent surgery or invasive diagnostics, confirming lung cancer in 310 (93.9% adenocarcinoma) after a 30-month median follow-up.

Conclusions: CT screening demonstrates significant potential for incidental pulmonary nodule detection, with a subset exhibiting high malignancy risk. Our findings underscore the clinical value of targeted, risk-stratified screening over universal approaches in China.

Keywords: Pulmonary nodule; screening; coronavirus disease 2019 (COVID-19); computed tomography (CT)

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Introduction

According to Global Cancer Statistics 2022, among malignancies, lung cancer has the highest incidence and is the leading cause of cancer-related death worldwide (1). The survival rate of lung cancer varies greatly according to stage, with the 5-year overall survival ranging from approximately 7% in stage IVB to 82% for stage IA (2). Therefore, early diagnosis and treatment are crucial for improving the prognosis of patients with lung cancer. Computed tomography (CT) is an effective means of

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detecting lung cancer at an early stage. The National Lung Screening Trial (NLST) reported a 20.0% reduction in lung cancer mortality with regular screening via low-dose computed tomography (LDCT) compared to chest radiography (3). Subsequently, the Nederlands-Leuvens Longkanker Screenings Onderzoek (NELSON) study also demonstrated the value of CT screening in reducing the lung cancer mortality rate (4). In addition, a recent multicenter prospective cohort study conducted in China found that lung cancer mortality was 31% lower in the LDCT-screened group (5), suggesting potential benefits beyond current risk-stratified approaches. CT serves as a pivotal non-invasive imaging modality for pulmonary nodule assessment and early lung cancer detection, offering rapid comprehensive diagnostic information while minimizing patient discomfort (6). However, screening for lung cancer using a CT scan is associated with certain risks such as greater radiation exposure, a higher workload for radiologists, and higher costs. Most studies on this subject have only conducted CT screening in participants at high risk according to different criteria, including smoking history, age, and other factors (7,8). However, the incidence rate of lung cancer in low-risk participants without screening was reported to be 0.3% in a large-scale study, which is not particularly low (5). Therefore, the baseline situation of CT screening in the entire population needs to be examined in a study with a relatively larger sample size.

Highlight box

Key findings
- A total of 52.9% of screened patients had positive findings on chest computed tomography (CT).
- A total of 6,117 patients were classified as high risk due to noncalcified nodules ≥6 mm.
- A total of 310 cases of primary lung cancer were confirmed after follow-up and invasive procedures.

What is known and what is new?
- Pulmonary nodules are frequently detected in CT screenings, with existing guidelines focusing on high-risk populations.
- This study provides large-scale data on incidentally detected pulmonary nodules in an approximately healthy Chinese population.

What is the implication, and what should change now?
- Opportunistic CT screening can help detect early-stage lung cancer even in individuals not classified as high-risk according to traditional criteria.
- Enhanced follow-up strategies and risk assessment models are needed to optimize early lung cancer detection and management.

Given the aforementioned concerns with chest CT screening, it is impractical to conduct it on a large scale for a relatively healthy population in daily clinical work. However, the coronavirus disease 2019 (COVID-19) pandemic represented a unique opportunity. During this period, all emergency patients and outpatients ready to be admitted to the wards were asked to accept chest CT scanning and viral tests to exclude COVID-19 pneumonia. Except for those individuals who accepted chest CT scanning due to related respiratory diseases and a history of malignant tumors, others could be defined as approximately healthy individuals who did not require chest CT examination in actual clinical practice. Thus, this study focused on this segment of patients, the imaging features of unexpectedly discovered lung lesions were analyzed, patients with high-risk lesions were informed of their condition, and follow-up was conducted to characterize the baseline CT screening in the entire population. This accidental screening cohort provides unique insights into true population-level nodule prevalence, malignancy rates without selection bias, and practical challenges of large-scale CT implementation. We present this article in accordance with the STROBE reporting checklist (available at https://jtd.amegroups.com/article/view/10.21037/jtd-2025-577/rc).

Methods

Patients

According to patients' medical records or CT application forms, all patients underwent chest CT scans in Xuanwu Hospital, Capital Medical University from February 1, 2020 to February 1, 2022, except those who received CT scans due to respiratory system diseases or a history of malignant tumor, were included in this study. These patients were considered to be approximately healthy individuals who underwent CT scans only to exclude infection of COVID-19. This study was conducted in accordance with the Declaration of Helsinki and its subsequent amendments. This study was approved by the Institutional Review Board of Xuanwu Hospital, Capital Medical University (approval No. KS2022057; approved on April 20, 2022). Individual consent for this retrospective analysis was waived.

Chest CT scan

Spiral CT images were obtained using a 64-detector CT row scanner (Brilliance, Philips Healthcare, Best, the Netherlands) and were reconstructed in overlapping contiguous 5-mm increments, with a pitch of 1.25 (9). A window level of –700 Hounsfield units (HU) and a window width of 1,500 HU was defined as the lung window, while the mediastinal window was defined as a window level of 40 HU and a window width of 350 HU. The maximum diameter of the nodule was measured on the lung window. At least two senior radiologists read the original images and wrote reports. Positive findings were defined as any nodule with a diameter ≥4 mm. The pulmonary nodules were further differentiated into solid nodules, part-solid nodules, and ground-glass (non-solid) nodules (GGNs). A solid nodule has a homogeneous soft-tissue attenuation, a GGN has hazy increased attenuation that does not obscure the bronchial and vascular margins, and a part-solid nodule has elements of both solid and GGNs (10).

The definition of high-risk patients and follow-up procedures

Patients with noncalcified nodules ≥6 mm identified by CT screening are defined as high risk. We informed these patients of their CT scan results over the telephone and recommended they undergo reexamination or directly receive invasive procedures to confirm the pathologic diagnosis according to the National Comprehensive Cancer Network (NCCN) lung cancer screening guidelines (10). For these patients, follow-up was conducted every 6 months via CT or immediate biopsy until a clear pathological diagnosis was made. The final follow-up date was June 30, 2024. The stage of lung cancer was decided based on the ninth edition of the TNM classification of lung cancer (2).

Statistical analysis

SPSS 26 (IBM Corp., Armonk, NY, USA) was used for all statistical analyses. Categorical variables are reported as numbers and percentages. Their differences were analyzed with the Pearson χ^2 test or the Fisher exact test. Statistical significance was defined as a two-sided P value <0.01 to account for increased type I error risk due to the large sample size.

Results

Between February 1, 2020 and February 1, 2022, a total of 211,759 patients underwent chest CT scans in our institution. Of these, 91,136 were excluded from the study because they received thoracic CT scans due to respiratory diseases or a history of malignant tumors. The remaining 120,623 patients underwent CT only to rule out pneumonia and were therefore included in the study. Among these patients, 63,775 (52.9%) were identified with positive results. Subsequently, the images of all patients with positive results were reviewed by senior thoracic surgeons, and a total of 6,117 patients were identified as having high-risk lesions. Subsequently, all high-risk patients were informed of their CT screening results by telephone and were advised to undergo follow-up examinations or invasive procedures to confirm the pathological diagnosis following the NCCN lung cancer screening guidelines. A total of 635 patients were excluded from follow-up due to death, loss of contact, advanced age, or other serious illnesses, while follow-up data were successfully obtained from the remaining 5,482 patients. After a median follow-up of 30 months, 343 patients received invasive procedures, and a total of 310 lung cancer and 4 metastatic carcinoma cases were ultimately confirmed by pathology. The flowchart for the whole study is shown in *Figure 1*.

Among the entire screening population, the proportion of individuals with positive results was 52.9% (63,775/120,623). The incidence of positive findings did not differ significantly between genders but increased with age (*Table 1*, *Figure 2*). Subsequently, based on the definition of high-risk patients as those with noncalcified nodules ≥6 mm, a total of 6,117 cases were placed in the high-risk group, while the other 57,658 participants were placed in the low-risk group. The specific characteristics of all patients with positive results and the comparison between the high- and low-risk groups are shown in *Table 2*. We found that compared with the low-risk cases, high-risk cases were older, with a higher proportion of females, a higher proportion of family history of cancer, and a higher proportion of GGNs or partially solid nodules as compared to solid nodules. However, there was no significant difference in the history of heavy smoking between the two groups of patients.

According to the NCCN guidelines, we recommended regular follow-up or invasive diagnosis for the 6,117 patients classified as high-risk. A total of 635 cases declined to participate, while the other 5,482 agreed to participate. During a median follow-up period of 30 months, 343 patients received invasive diagnostic procedures. A total of 314 patients were diagnosed with malignant lesions, of which 310 were primary lung cancer and 4 were metastatic lesions. We further analyzed the characteristics of

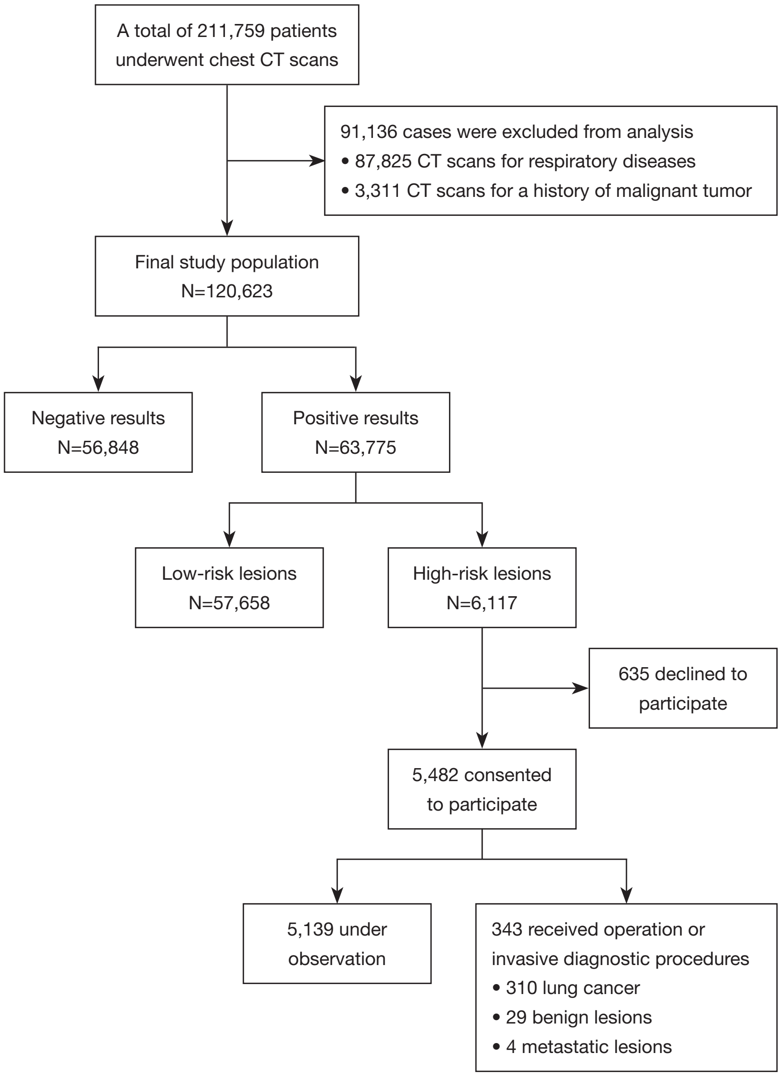

Figure 1 Flowchart of the study. CT, computed tomography.

Table 1 The demographic characteristics of the entire screening population

Characteristic	Overall (N=120,623)	Negative results (N=56,848)	Positive results (N=63,775)	P value
Age (years)				<0.001
≤18	3,182 (2.6)	2,596 (4.6)	586 (0.9)	
19–40	31,719 (26.3)	20,712 (36.4)	11,007 (17.3)	
41–65	55,405 (45.9)	23,870 (42.0)	31,535 (49.4)	
>65	30,317 (25.2)	9,670 (17.0)	20,647 (32.4)	
Sex				0.02
Male	60,200 (49.9)	28,573 (50.3)	31,627 (49.6)	
Female	60,423 (50.1)	28,275 (49.7)	32,148 (50.4)	

Data are presented as n (%).

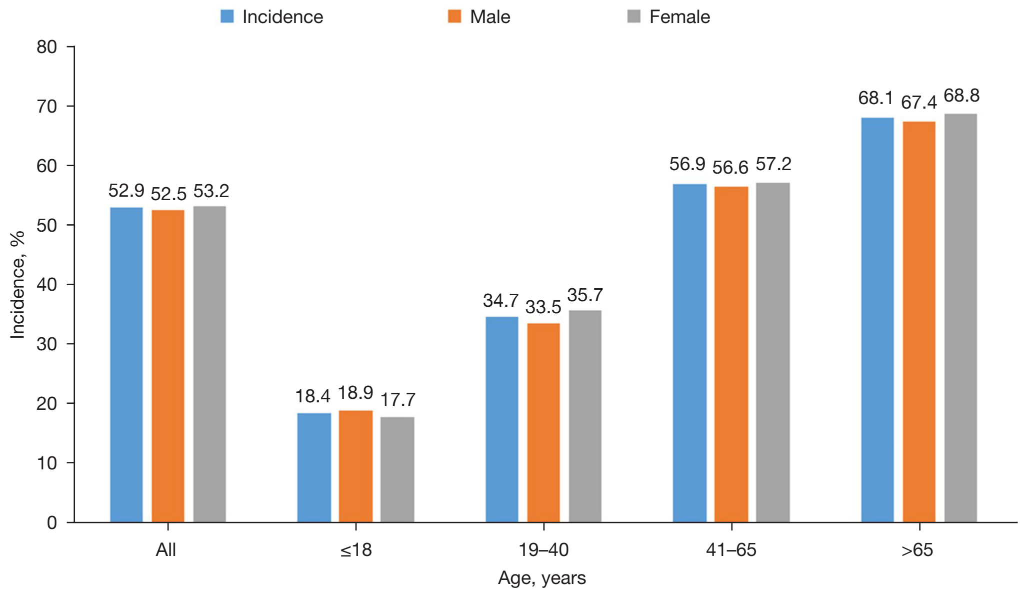

Figure 2 The detection rate of positive results by age and gender.

Table 2 Baseline features of the positive population

Characteristic	Overall (N=63,775)	High risk (N=6,117)	Low risk (N=57,658)	P value
Age (years)				<0.001
≤18	586 (0.9)	19 (0.3)	567 (1.0)	
19–40	11,007 (17.2)	527 (8.6)	10,480 (18.2)	
41–65	31,535 (49.4)	3,492 (57.1)	28,043 (48.6)	
>65	20,647 (32.5)	2,079 (34.0)	18,568 (32.2)	
Sex				<0.001
Male	31,627 (49.6)	2,615 (42.7)	29,012 (50.3)	
Female	32,148 (50.4)	3,502 (57.3)	28,646 (49.7)	
Smoking history				0.92
≥20 pack-years	5,977 (9.4)	571 (9.3)	5,406 (9.4)	
<20 pack-years	57,798 (90.6)	5,546 (90.7)	52,252 (90.6)	
Family history of cancer				<0.001
Yes	7,124 (11.2)	829 (13.6)	6,295 (10.9)	
No	56,651 (88.8)	5,288 (86.4)	51,363 (89.1)	
Density of lesion				<0.001
Solid	46,971 (73.7)	1,077 (17.6)	45,894 (79.6)	
Part-solid	5,096 (8.0)	1,392 (22.8)	3,704 (6.4)	
Ground-glass	11,708 (18.3)	3,648 (59.6)	8,060 (14.0)	

Data are presented as n (%).

Table 3 Characteristics of patients confirmed as lung cancer

Characteristic	Overall (N=310)
Age (years)	
≤18	0
19–40	27 (8.7)
41–65	159 (51.3)
>65	124 (40.0)
Sex	
Male	121 (39.0)
Female	189 (61.0)
Smoking history	
≥20 pack-years	26 (8.4)
<20 pack-years	284 (91.6)
Family history of cancer	
Yes	53 (17.1)
No	257 (82.9)
Density of lesion	
Solid	21 (6.8)
Part-solid	64 (20.6)
Ground-glass	225 (72.6)
Size of lesion (mm)	
>6 & ≤10	213 (68.7)
>10 & ≤20	68 (21.9)
>20 & ≤30	20 (6.5)
>30	9 (2.9)
Pathology	
Adenocarcinoma	291 (93.9)
Squamous-cell carcinoma	16 (5.2)
Small-cell carcinoma	3 (0.9)
Stage	
0–I	252 (81.3)
II	43 (13.9)
III	11 (3.5)
IV	4(1.3)

Data are presented as n (%).

patients confirmed with primary lung cancer (*Table 3*). We discovered that a higher proportion of lung cancer patients were female, with the vast majority having early-stage lung adenocarcinoma.

Discussion

Chest CT screening has been confirmed to significantly reduce lung-cancer-related death in high-risk patients (3,5). However, the criteria for high-risk populations varies across different guidelines, such as the NCCN, International Early Lung Cancer Action Program (I-ELCAP), the United States Preventive Services Task Force (USPSTF), and China Guideline for the Screening and Early Detection of Lung Cancer (CGSL) (10-12). Therefore, large-scale CT screening studies targeting the entire population would be highly valuable, and the special circumstances surrounding the COVID-19 pandemic provided a unique opportunity. Our study provides insight drawn from opportunistic CT screening for approximately healthy individuals and may help refine inclusion criteria in the future.

Given the development of lung cancer in the population with negative initial screening results during follow-up and the refusal of cases with high-risk results, the incidence of lung cancer in our cohort was similar to the results of previous large-scale studies conducted in China (5,13). Our results indicated that among patients confirmed with lung cancer, the proportion of females was higher, and the vast majority of lesions on imaging were GGNs, which is consistent with the results of previous studies (14,15). This association may stem from exposure to second-hand smoke (SHS) and polycyclic aromatic hydrocarbons, as noted in prior research (16). Moreover, other research has suggested there to be higher malignancy in GGNs as compared to solid nodules, despite their slow progression (17). Therefore, female individuals in whom GGNs are detected may require greater clinical attention.

Within the cohort, adenocarcinoma was the predominant histological type of lung cancer, accounting for 93.9% (291 out of 310) of all patients. This result aligns with the findings of other clinical trials, with the percentage ranging from 60.6% to 91.3% (4,5,18). Correspondingly, the detection rate (5.3%) of squamous-cell carcinomas (SCCs), accounting for the majority of centrally located tumors, was lower than expected in our study or previous researches (3-5,18,19). This may be related to the fact that patients with central SCCs often present symptoms such as cough, sputum, or hemoptysis and thus seek advice from the respiratory department. In our study, this tendency is more pronounced precisely because we excluded this group of patients.

The rate of early-stage lung cancer (stage I or earlier) in our study was relatively high at 81.3%, surpassing the rate reported in the NLST (63%), NELSON trial (58.6%), and Li *et al.*'s study (62.7%) (3-5); meanwhile, it was similar to the results of Tang *et al.*'s and Zhang *et al.*'s studies (18,20). Moreover, the rate of stage IV lung cancer was very low (1.3%) in our study. Considering the high diagnostic rate of stage IV lung cancer in the non-screening group reported previously (2), we have reason to believe that CT screening provides survival benefits to patients, even if long-term follow-up is not conducted after a pathological diagnosis.

In our study, senior thoracic surgeons reviewed all patients' imaging and simply defined all noncalcified nodules ≥6 mm as high risk, but this was not sufficiently accurate and extremely time-consuming. More and more studies confirmed that novel techniques such as artificial intelligence (AI) provide value for applications in lung nodules and lung cancer in fields such as automated detection, noninvasive characterization of nodules, lung cancer risk assessment, and prediction of prognosis (6,21-24). Therefore, we believe the application of these techniques may hold substantial potential in fostering the implementation of lung cancer screening.

Our findings demonstrate that CT screening detects early-stage lung cancer in the Chinese cohort, but routine population-wide screening remains impractical due to high false-positive rates (47.1% benign nodules) and resource constraints. Instead, we advocate for prioritizing high-risk groups while integrating incidental CT scans. The high proportion of adenocarcinoma (93.9%) and early-stage cancers supports refining risk models for Asian populations, incorporating environmental and familial factors. Future efforts should optimize follow-up protocols for 4–6 mm nodules. These data reinforce targeted screening over universal approaches, balancing early diagnosis with overdiagnosis risks.

Several limitations should be acknowledged in our study. First, all patients enrolled in the study were patients seeking medical treatment and were not volunteers. Therefore, they cannot be fully recognized as healthy individuals. Although we excluded patients with respiratory symptoms or a history of malignant tumors, subclinical or resolved COVID-19-related lung changes might have contributed to false-positive nodule identifications in some asymptomatic individuals. This could lead to a modest overestimation of pulmonary nodule prevalence compared to non-pandemic screening cohorts. However, our stringent adherence to Lung Imaging Reporting and Data System (Lung-RADS) criteria for malignancy-predictive features and longitudinal growth assessment likely mitigated this bias for high-risk lesions. Moreover, the proportion of individuals who refused to participate in our follow-up was relatively high due to factors such as advanced age, presence of severe primary diseases, and lack of trust. Moreover, the use of telephone follow-up might have introduced bias. In addition, we did not follow up on cases with negative screening results and low-risk lesions, so we could not determine the incidence of lung cancer in this group of patients during the same follow-up period. Furthermore, we did not continue to follow up with patients confirmed with lung cancer to obtain the long-term prognosis.

Conclusions

Based on the chest CT screening data of a relatively large asymptomatic population, there is a high probability of the accidental discovery of pulmonary nodules. A considerable number of lesions were suspected of malignancy; therefore, regular follow-up and close monitoring were necessary.

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None.

Footnote

Reporting Checklist: The authors have completed the STROBE reporting checklist. Available at https://jtd.amegroups.com/article/view/10.21037/jtd-2025-577/rc

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Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://jtd.amegroups.com/article/view/10.21037/jtd-2025-577/coif). The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. This study was conducted in accordance with the Declaration of Helsinki and its subsequent amendments. This study was approved by the Institutional Review Board of Xuanwu Hospital, Capital Medical University (approval No. KS2022057; approved on April 20, 2022). Individual consent for this retrospective analysis was waived. The study was registered in the National Health Security Information Platform/Medical Research Registration and Filing System (www.medicalresearch.org.cn) (No. MR-11-22-005037).

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