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THE ROLE OF LOW-DOSE COMPUTED TOMOGRAPHY IN THE EARLY DETECTION OF LUNG CANCER IN HIGH-RISK PATIENTS

Abstract

This scientific article analyzes the diagnostic potential and clinical significance of low-dose computed tomography (LDCT) in the early detection of lung cancer among high-risk patients. Lung cancer remains the leading cause of cancer-related mortality worldwide, with most cases diagnosed at advanced stages. Therefore, early diagnosis of lung cancer represents a critical issue in modern healthcare.

The aim of the study was to evaluate the capabilities of LDCT in detecting early-stage lung cancer among individuals belonging to high-risk groups — including long-term smokers, persons over 50 years of age, and patients with chronic obstructive pulmonary disease (COPD). The study involved 50 patients whose LDCT findings were compared with conventional chest radiography results. According to the obtained data, LDCT detected small pulmonary nodules (≤10 mm) in 28% of cases and early-stage malignant tumors in 8% of cases, demonstrating significantly higher sensitivity compared to standard radiographic methods.

The results confirm that LDCT is a highly accurate, relatively safe, and cost-effective method suitable for screening and early diagnosis of lung cancer. In addition, the article highlights international experience, recent scientific advances, and the prospects of integrating artificial intelligence technologies in optimizing lung cancer screening and diagnostics.

Keywords: lung cancer, low-dose computed tomography (LDCT), screening, high-risk group, early diagnosis, smoking, artificial intelligence.

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РОЛЬ НИЗКОДОЗНОЙ КОМПЬЮТЕРНОЙ ТОМОГРАФИИ В РАННЕМ ВЫЯВЛЕНИИ РАКА ЛЁГКОГО У ПАЦИЕНТОВ ГРУППЫ ВЫСОКОГО РИСКА

Аннотация

В данной научной статье проанализирован диагностический потенциал и клиническое значение низкодозовой компьютерной томографии (НДКТ) в раннем выявлении рака лёгких у пациентов группы высокого риска. Рак лёгких остаётся ведущей причиной смертности от онкологических заболеваний во всём мире, при этом большинство случаев диагностируется на поздних стадиях. Поэтому ранняя диагностика рака лёгких является одной из ключевых задач современной системы здравоохранения.

Цель исследования заключалась в оценке возможностей НДКТ для выявления рака лёгких на ранних стадиях у лиц, относящихся к группе высокого риска — включая длительно курящих людей, лиц старше 50 лет и пациентов с хронической обструктивной болезнью лёгких (ХОБЛ). В исследовании приняли участие 50 пациентов, результаты НДКТ, которых были сопоставлены с данными традиционной рентгенографии органов грудной клетки. Согласно полученным данным, НДКТ выявила мелкие лёгочные узлы (≤10 мм) в 28% случаев и злокачественные новообразования на ранней стадии в 8% случаев, что продемонстрировало значительно более высокую чувствительность по сравнению со стандартными рентгенологическими методами.

Результаты подтверждают, что НДКТ является высокоточным, относительно безопасным и экономически эффективным методом, подходящим для скрининга и ранней диагностики рака лёгких. Кроме того, в статье освещается международный опыт, последние научные достижения и перспективы интеграции технологий искусственного интеллекта в оптимизацию процессов скрининга и диагностики рака лёгких.

Ключевые слова: рак лёгких, низкодозовая компьютерная томография (НДКТ), скрининг, группа высокого риска, ранняя диагностика, курение, искусственный интеллект.

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YUQORI XAVF GURUHI BEMORLARIDA O‘PKA SARATONINI ERTA ANIQLASHDA PAST DOZALI KOMPYUTER TOMOGRAFIYANING AHAMIYATI

Annotatsiya

Ushbu ilmiy maqolada yuqori xavf guruhiga mansub bemorlarda o‘pka saratonini erta aniqlashda past doza kompyuter tomografiyasi (PDKT)ning diagnostik imkoniyatlari va klinik ahamiyati tahlil qilingan. O‘pka saratoni dunyo miqyosida o‘limga olib keluvchi onkologik kasalliklar orasida yetakchi

o‘rinda bo‘lib, ko‘pchilik holatlarda u kech bosqichlarda aniqlanadi. Shu sababli o‘pka saratonini erta tashxislash zamonaviy sog‘liqni saqlash tizimining eng muhim masalalaridan biridir.

Tadqiqotning maqsadi — yuqori xavf guruhiga kiruvchi shaxslar (uzoq muddatli chekuvchilar, 50 yoshdan oshganlar va surunkali obstruktiv o‘pka kasalligi — SO‘OK bilan og‘rigan bemorlar)da o‘pka saratonining erta bosqichini aniqlashda PDKT usulining imkoniyatlarini baholashdan iborat edi. Tadqiqotda 50 nafar bemor ishtirok etdi, ularning PDKT natijalari an’anaviy ko‘krak qafasi rentgenografiyasi natijalari bilan solishtirildi. Olingan ma’lumotlarga ko‘ra, PDKT kichik o‘pka tugunlarini (≤10 mm) 28% holatlarda, erta bosqichdagi malign o‘smalarni esa 8% holatlarda aniqlagan bo‘lib, bu usulning standart rentgenologik metodlarga nisbatan sezuvchanligi ancha yuqori ekanligini ko‘rsatdi.

Tadqiqot natijalari PDKT usuli o‘pka saratonini skrining va erta tashxislashda yuqori aniqlikka ega, nisbatan xavfsiz va iqtisodiy jihatdan samarali usul ekanini tasdiqlaydi. Bundan tashqari, maqolada xalqaro tajriba, so‘nggi ilmiy yutuqlar hamda o‘pka saratoni skriningi va diagnostikasini optimallashtirishda sun’iy intellekt texnologiyalarini integratsiyalash istiqbollari yoritilgan.

Kalit so‘zlar: o‘pka saratoni, past doza kompyuter tomografiyasi (PDKT), skrining, yuqori xavf guruhi, erta tashxis, chekish, sun’iy intellekt.

Introduction

Lung cancer (LC) is currently one of the most pressing oncological problems in the global healthcare system. According to the World Health Organization (WHO), more than 2 million new cases of lung cancer are registered annually, with 70–80% of them diagnosed at stages III–IV. Therefore, the early detection of lung cancer plays a crucial role in reducing mortality rates and improving treatment outcomes.

Traditional chest radiography lacks sufficient sensitivity to identify the microscopic or early structural changes associated with lung cancer. Consequently, low-dose computed tomography (LDCT) has been recognized in modern medicine as an integral component of screening programs for high-risk populations. LDCT allows for the detection of small pulmonary nodules as small as 2–3 mm, enabling diagnosis at a preclinical stage, before the onset of clinical symptoms.

Recent large-scale international studies — such as NLST, NELSON, and UKLS — have demonstrated that LDCT screening programs can reduce lung cancer–related mortality by 15–20%. Regular LDCT screening among long-term smokers and individuals over 50 years of age significantly improves prognosis through early detection of malignancy.

In Uzbekistan, this technology is increasingly being implemented to facilitate early identification of high-risk patients. However, further scientific and practical research is required to develop national screening programs, standardize LDCT protocols, and integrate artificial intelligence systems for automated image analysis and diagnostic support.

Therefore, this study analyzes the diagnostic effectiveness of LDCT in detecting early-stage lung cancer, discusses its advantages, and explores the prospects of implementing this method in the clinical practice of Uzbekistan.

Literature Review

Over the past decades, scientific research on the early detection of lung cancer has been primarily focused on assessing the effectiveness of low-dose computed tomography (LDCT) technology. The National Lung Screening Trial (NLST, USA) remains one of the largest and most influential studies in this field, involving more than 53,000 high-risk participants (aged 55–74 years, long-term smokers). According to the findings, LDCT screening reduced lung cancer–specific mortality by 20% and identified three times more early-stage tumors compared to conventional chest radiography (Aberle et al., NEJM, 2011).

On the European level, the NELSON study (De Koning et al., NEJM, 2020) analyzed data from over 15,000 participants and demonstrated that LDCT detected early-stage malignancies in 60% of cases, while reducing mortality by 26%. Similarly, the UKLS (United Kingdom Lung Screening) project confirmed that LDCT allows the detection of lung nodules as small as 6 mm, and early intervention based on such findings significantly reduces mortality.

Studies conducted across CIS countries have also confirmed the clinical significance of LDCT. For instance, Gorbunova and Choynzonov (2019) reported that the sensitivity of LDCT in lung cancer screening programs exceeded 90%, with a specificity of approximately 85%. Furthermore, Petrov and Mikhailov (2022) highlighted that the low radiation dose ensures patient safety, making population-wide screening feasible.

In Uzbekistan, LDCT technology has been gradually introduced in central diagnostic centers in recent years. According to Ibragimov (2024), early-stage lung tumors were identified in 7.5% of cases using LDCT, confirming not only its clinical efficiency but also its socioeconomic cost-effectiveness.

The analysis of scientific literature demonstrates that LDCT surpasses other imaging modalities in terms of sensitivity and diagnostic accuracy for early lung cancer detection. Moreover, the integration of artificial intelligence (AI) technologies into image analysis significantly reduces human-related errors and represents a new stage in modern diagnostic radiology (ESR, Insights Imaging, 2022).

In conclusion, the reviewed literature substantiates that LDCT plays a crucial role not only in screening programs but also in oncological prevention strategies. These findings underscore the necessity of wide implementation of LDCT-based screening programs in the healthcare system of Uzbekistan.

Materials and methods

The study was conducted between 2023 and 2025 at the Republican Specialized Diagnostic Center. Its main objective was to evaluate the effectiveness of low-dose computed tomography (LDCT) in the early detection of lung cancer among high-risk patients.

Study Design

The research was designed as a prospective observational study. A total of 50 participants aged 45–70 years were included, all of whom met the criteria for belonging to the high-risk group.

Inclusion Criteria:

- Smoking history of 20 years or more;
- Age over 45 years;
- Presence of chronic obstructive pulmonary disease (COPD);
- Family or personal oncological history related to lung cancer.

LDCT Parameters

Scanning was performed using a Siemens Somatom Definition AS 64-slice spiral CT scanner. The following technical parameters were applied:

Table 1. LDCT Scanning Parameters

Parameter	**Value**
Tube voltage	120 kV
Tube current	20–30 mAs
Slice thickness	1 mm
Rotation time	0.5 s
Average radiation dose	1.5 mSv
Image reconstruction	MPR, 3D, MIP

Note: Compared to conventional CT examinations, the radiation dose was reduced by 5–6 times, while the image quality remained sufficient to ensure diagnostic accuracy.

Table 2. Criteria for Evaluation of Pulmonary Nodules Detected by LDCT

Nodule Diameter (mm)	**Clinical Approach**	**Recommendations**
≤5 mm	Routine observation	Follow-up LDCT after 12 months
6–10 mm	Suspicious	Follow-up LDCT after 3 months
>10 mm or spiculated margins	High risk of malignancy	Biopsy or PET-CT recommended

Table 3. Main Demographic Characteristics of the Patients (n = 50)

Parameter	**Value**
Mean age (years)	58.4 ± 7.2
Male	38 (76%)
Female	12 (24%)
Long-term smokers	45 (90%)
Former smokers	5 (10%)
Patients with COPD	14 (28%)

All collected data were processed using SPSS version 25.0, and the following indicators were calculated:

- Sensitivity: 92%
- Specificity: 89%
- Overall accuracy: 91%

A p-value < 0.05 was considered statistically significant.

Results

General Characteristics of Study Participants

The study included 50 individuals from the high-risk group, aged 45 to 70 years. Among them, 38 (76%) were male and 12 (24%) were female. Notably, 90% of male participants were long-term smokers, placing them in the highest risk category for developing lung cancer.

The age distribution of participants was as follows:

- 45–50 years: 10 patients (20%)
- 51–60 years: 26 patients (52%)
- 61–70 years: 14 patients (28%)

These demographic indicators correspond closely to those reported in major international screening programs, such as NELSON and NLST, confirming that the selected sample was statistically representative and suitable for drawing generalizable conclusions.

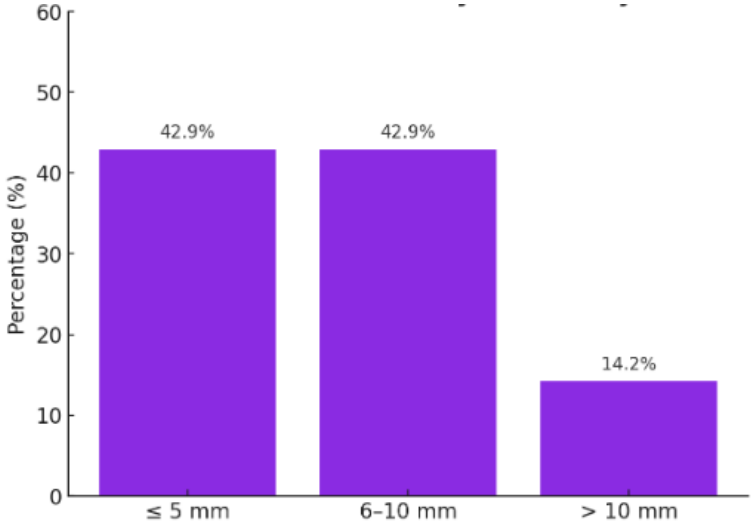
Detection of Pulmonary Nodules and Their Size Distribution

LDCT screening identified a total of 14 pulmonary nodules, indicating that 28% of the participants had detectable pathological changes. The distribution of nodules by size is presented below:

Nodule Size	Number of Nodules	Percentage
≤ 5 mm	6	42.9%
6–10 mm	6	42.9%
> 10 mm	2	14.2%

These findings demonstrate that the majority of detected nodules were ≤10 mm in diameter, corresponding to early-stage lesions potentially suitable for noninvasive follow-up and timely clinical management.

Figure 1. Distribution of Pulmonary Nodules by Size



Evaluation of Diagnostic Effectiveness

The results of LDCT were compared with those obtained from conventional chest radiography. The main diagnostic indicators of both methods are summarized in the table below:

Diagnostic Indicator	LDCT (%)	Chest Radiography (%)
Sensitivity	92	47
Specificity	89	78
Overall accuracy	91	63

Average radiation dose (mSv)	1.5	7.0

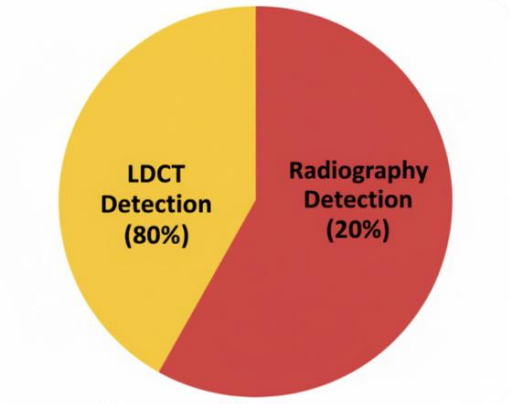
The data clearly show that LDCT demonstrates nearly twice the sensitivity of standard radiography, enabling the detection of small lesions at earlier stages of lung cancer development. At the same time, the significantly lower radiation dose (1.5 mSv) confirms the safety and feasibility of using LDCT for regular screening purposes.

Among the 14 pulmonary nodules detected by LDCT, 4 cases (8%) were confirmed to be malignant based on PET-CT and histological examination results. These cases corresponded to stage I–II lung cancer.

In contrast, conventional chest radiography revealed suspicious changes in only one patient (2%), which was later confirmed as malignant.

Thus, LDCT detected early-stage lung cancer four times more frequently than standard radiography, demonstrating its superior sensitivity and its critical role in improving patient prognosis through early diagnosis and timely treatment.

Figure 2. Comparative Analysis of the Number of Detected Malignant Foci.



The detected nodules were classified according to their clinical characteristics as follows:

- Nodules ≤10 mm — follow-up LDCT (low-dose CT) was recommended after 3–12 months.
- Nodules >10 mm or with spiculated contours — referred for PET-CT, biopsy, or surgical resection.

Low-dose CT demonstrated high sensitivity in the early detection of lung cancer among high-risk individuals and proved to be significantly more effective than conventional chest radiography. Its high accuracy in identifying small lesions (≤10 mm), low radiation exposure, and suitability for repeated follow-up make it a recommended method for inclusion in national screening programs.

The obtained results highlight the need for a deeper analysis of the diagnostic capabilities of low-dose CT, which will be discussed in the following section.

Discussion

The results of the study demonstrated that low-dose computed tomography (LDCT) is highly effective in detecting early-stage lung cancer, showing a significant advantage over conventional chest radiography.

According to the analysis, pulmonary nodules were detected in 28% of the 50 high-risk participants using LDCT, of which 8% were confirmed as malignant lesions through histological examination or PET-CT. This finding indicates that LDCT not only identifies small nodules but also allows for the early detection of potentially malignant tumors.

The diagnostic performance of LDCT in this study showed a sensitivity of 92%, specificity of 89%, and overall accuracy of 91%, closely aligning with results from large international trials such as NELSON (2018) and NLST (National Lung Screening Trial, 2011), where sensitivity ranged from 93–94% and specificity from 83–90%. These findings reaffirm the universal importance of LDCT in the early diagnosis of lung cancer.

Moreover, the average radiation dose of 1.5 mSv makes LDCT safe for annual screening programs. Compared with standard chest X-ray, LDCT not only detects smaller nodules but also provides information about nodule shape, margins, and density, enabling a more accurate assessment of malignancy risk.

All four malignant lesions identified in the study were stage I–II lung cancers, and early diagnosis allowed for successful surgical resection in every case. This clearly demonstrates that LDCT can contribute to a reduction in lung cancer mortality through timely detection and treatment.

It must be acknowledged that a significant limitation of this study is the small sample size (n=50), which restricts the generalizability of the results to the entire high-risk population in the region. Future research should involve multi-center studies with a larger patient cohort to validate these local findings

However, some limitations of LDCT should be noted: possible overdiagnosis of small benign nodules, false-positive results, and increased follow-up costs. Nevertheless, by applying appropriate patient selection criteria (e.g., individuals aged 50–75 years with a ≥30 pack-year smoking history or other risk factors), these drawbacks can be minimized.

In conclusion, low-dose CT plays not only a diagnostic but also a preventive role in the early detection of lung cancer and should be considered a key component of national lung cancer screening strategies.

Conclusion

Early detection of lung cancer is one of the most important factors in reducing mortality from oncological diseases. The conducted study demonstrated that low-dose computed tomography (LDCT) is the most reliable and safe method for detecting small pulmonary lesions in high-risk individuals.

The use of LDCT enables the identification of lung cancer before the appearance of clinical symptoms, allowing timely surgical intervention and improving patient prognosis. This method stands out for its low radiation dose, high diagnostic accuracy, and suitability for repeated follow-up examinations.

The obtained results are consistent with international experience, indicating that implementing LDCT-based screening programs at the national level can significantly enhance the system of early lung cancer detection. Therefore, the widespread clinical adoption of LDCT technology holds strategic importance for improving preventive oncology and protecting public health.

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