DIAGNOSTIC ADVANTAGES OF LOW-DOSE MSCT IN THE EARLY DETECTION OF LUNG PATHOLOGIES

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Abstract. Background. *Early detection of pulmonary pathologies is one of the most critical tasks of modern diagnostic radiology. Multislice computed tomography (MSCT) provides high spatial resolution and enables detection of minimal morphological changes in lung parenchyma. However, routine MSCT protocols involve ionizing radiation, which is a significant concern, particularly for patients requiring repeated examinations.* ***Objective.*** *To evaluate the diagnostic advantages of low-dose MSCT (LDCT) in the early detection of pulmonary pathologies compared to standard MSCT protocols, with emphasis on radiation safety.* ***Methods.*** *A prospective observational study was conducted involving 115 patients (aged 18–45) treated for COVID-19 (n = 109; 94.7%) or community-acquired pneumonia (n = 6; 5.3%) between 2023 and 2026 at Department of Pulmonology and Internal Medicine of the Central Military Clinical Hospital of the Republic of Uzbekistan. Patients were divided into two groups: standard MSCT (n = 57; 120–130 kV, 180–250 mAs, effective dose 4.5–6.0 mSv) and LDCT (n = 58; 100 kV, 50 mAs, effective dose 1.2 mSv) using a GE Revolution EVO 64-slice tomograph with iterative reconstruction algorithms (ADMIRE and ASIR-V). Lung involvement was graded CT-0 to CT-4.* ***Results.*** *LDCT protocols reduced the effective radiation dose by approximately 73% compared to standard MSCT (1.2 mSv vs. 4.5–6.0 mSv) while maintaining high diagnostic image quality. The use of iterative reconstruction algorithms (ADMIRE, ASIR-V) effectively suppressed noise in low-dose images. LDCT demonstrated sufficient diagnostic accuracy for detecting ground-glass opacities, consolidation, infiltrative and interstitial changes in both COVID-19 and community-acquired pneumonia cases.* ***Conclusion.*** *Low-dose MSCT is an effective, safe, and promising method for the early diagnosis of pulmonary pathologies. Its implementation in clinical practice, based on the ALARA principle, allows significant reduction of radiation exposure while maintaining diagnostic quality, particularly for patients requiring repeated examinations.*

Keywords: *low-dose MSCT, lung pathologies, early diagnosis, radiation safety, ALARA principle, computed tomography, diagnostic optimization.*

Introduction. Lung diseases are among the most common pathologies in modern medicine, and their early detection and timely treatment are crucial for improving patients' quality of life. Respiratory system diseases, including pneumonia, bronchopulmonary inflammatory processes, interstitial changes, lung tissue damage, and other pathological conditions, can often present with minimal clinical signs in their early stages. Therefore, using modern, high-precision diagnostic methods is a pressing issue [1, 2, 3].

Radiation diagnostic methods, particularly computed tomography (CT), play a crucial role in identifying pathologies of the thoracic organs. With the development of multislice computed tomography (MSCT) technology, it is now possible to evaluate structural changes in lung tissue with high precision, detect small pathological foci, and accurately determine the extent of the disease process [4, 5, 6, 7].

MSCT offers higher sensitivity and specificity than traditional radiological examinations, enabling the early detection of minimal changes in the lung parenchyma, infiltrative processes, nodular formations, fibrotic changes, and other pathological conditions. This is of significant diagnostic importance, particularly in identifying diseases at stages where clinical symptoms have not yet become apparent [8, 9].

However, alongside the widespread use of MSCT examinations, concerns related to the effects of ionizing radiation remain a pressing issue. The radiation dose a patient receives during computed tomography depends on the examination protocol, technical parameters, and the device's capabilities. Therefore, reducing the radiation dose while maintaining diagnostic effectiveness is one of the primary tasks of modern radiology [10, 11, 12].

In this context, the development and practical implementation of low-dose MSCT (LDCT) technologies are of great significance. Low-dose MSCT makes it possible to reduce the amount of ionizing radiation exposure to the patient while maintaining sufficient image quality. This approach is particularly important for patients who require screening, dynamic monitoring, and repeated diagnostic examinations [13, 14, 15].

The effectiveness of low-dose MSCT protocols is increased by optimizing examination parameters, adjusting X-ray tube voltage and current, utilizing automatic exposure control systems, and applying modern iterative reconstruction algorithms. These technologies make it possible to reduce the radiation dose while maintaining diagnostic image quality [16, 17, 18].

Thus, the use of low-dose MSCT is a promising approach for the early detection of pulmonary pathologies, expanding diagnostic capabilities, and ensuring radiation safety. This article examines the diagnostic advantages of low-dose MSCT in identifying pulmonary pathologies and explores its significance in modern radiology [19, 20, 21].

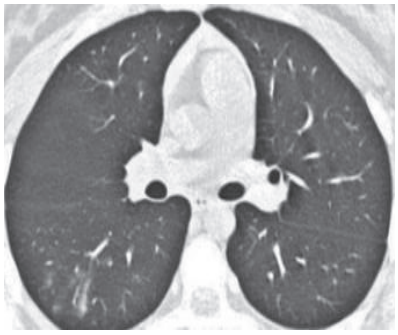


Figure 1A



Figure 1B

Fig. 1. Low-dose chest CT of a 23-year-old patient (X) with COVID-19.
A — with model-based iterative reconstruction;
B — low-dose CT without model-based iterative reconstruction.



Figure 2A

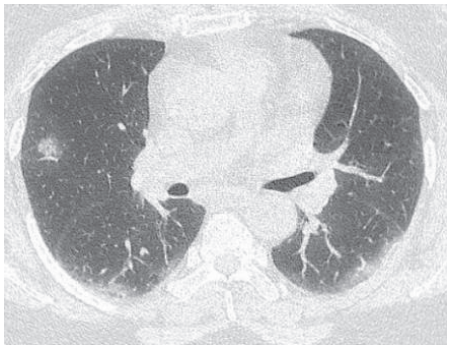


Figure 2B

Fig. 2. Standard chest CT scan of a 28-year-old patient S. with COVID-19.
A — with model-based iterative reconstruction;
B — standard CT without model-based iterative reconstruction.

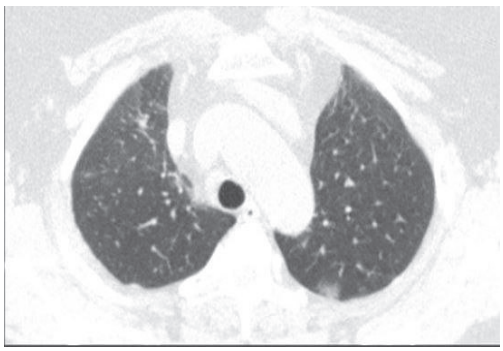


Figure 3A

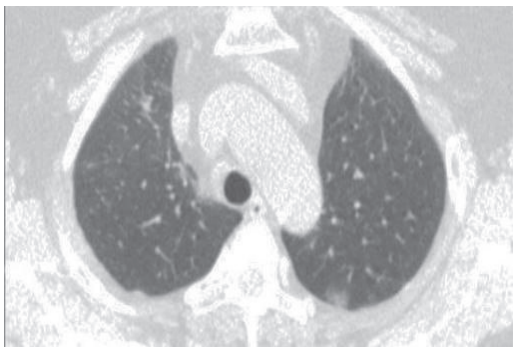


Figure 3B

Fig. 3. MSCT of the chest of a 35-year-old patient M. with COVID-19. A — normal contrast; B — low contrast.

Materials and methods.

Ethics statement: This study was approved by the Local Ethics Committee of Tashkent State Medical University (Protocol No. ___/2023). All participants provided voluntary written informed consent prior to inclusion in the study. The study was conducted in accordance with the principles of the Declaration of Helsinki (2013).

Study design and patient population.

A prospective observational study was conducted involving 115 patients aged 18 to 45 years who were treated for COVID-19 or community-acquired pneumonia between 2023 and 2026 at the clinics of Tashkent State Medical University. Patients were divided into two diagnostic groups based on CT protocol: standard MSCT (n = 57) and low-dose CT, LDCT (n = 58). By diagnosis, 109 patients (94.7%) had confirmed COVID-19 and 6 patients (5.3%) had community-acquired pneumonia.

Inclusion criteria: age 18–45 years; confirmed diagnosis of COVID-19 or community-acquired pneumonia; presence of clinical indications for chest CT; voluntary informed consent. Exclusion criteria: pregnancy; decompensated chronic diseases; allergy to contrast agent.

CT examination protocol.

All CT examinations were performed on a GE Revolution EVO 64-slice tomograph. The standard MSCT protocol used a tube voltage of 120–130 kV, a tube current of 180–250 mAs, and a slice thickness of 1.0 mm; the mean effective radiation dose was 4.5–6.0 mSv. The low-dose LDCT protocol used a tube voltage of 100 kV, an average tube current of 50 mAs, and a slice thickness of 1.25 mm; the effective dose was 1.2 mSv. Iterative reconstruction algorithms (ADMIRE and ASIR-V) were applied in all LDCT examinations to reduce image noise while maintaining diagnostic quality [16, 17, 18].

In image analysis, ground-glass opacities, consolidation, infiltrative changes, and focal densities within the lung parenchyma were assessed, along with the volume of lung involvement. The extent of damage was determined on a scale from CT-0 (no pathological changes) to CT-4 (≥75% involvement): CT-1 — ≤25%; CT-2 — 25–50%; CT-3 — 50–75%; CT-4 — ≥75%.

Clinical and laboratory analyses.

The patients' overall condition, disease severity, and progression were evaluated using clinical indicators: body temperature, blood oxygen saturation (SpO_2), and respiratory rate (RR). Laboratory tests included measurement of C-reactive protein (CRP) as an acute-phase inflammatory marker, and assessment of leukocyte and lymphocyte dynamics in the complete blood count.

Literature analysis.

To evaluate the diagnostic capabilities of low-dose MSCT in the early detection of pulmonary pathologies, this study analyzed peer-reviewed scientific literature on modern radiological diagnostic

methods, MSCT protocols, and radiation safety principles [4, 13, 14, 5]. The study evaluated the potential of MSCT to detect minimal pathological changes in the lung parenchyma and to diagnose diseases in their early stages [6, 7, 8, 9]. Methods aimed at reducing radiation exposure while preserving image quality—including optimization of scan parameters, automatic exposure control, and iterative reconstruction technologies—were also analyzed [16, 15, 18, 17].

An approach based on the ALARA principle (As Low As Reasonably Achievable) was used to assess radiation safety, entailing minimization of the ionizing radiation dose to the patient as much as reasonably achievable while preserving diagnostic information [19, 20, 21]. The obtained data were summarized using analytical and comparative methods [13, 8].

Results and discussion.

The results of the study demonstrated that low-dose MSCT (LDCT) is a highly informative method for the early detection of pulmonary pathologies. LDCT effectively identified minor structural changes in the pulmonary parenchyma and allowed assessment of the localization and extent of pathological processes in both COVID-19 and community-acquired pneumonia [4, 5, 6, 7].

One of the primary advantages of MSCT is its high spatial resolution, which enables the detection of minimal changes in lung tissue—infiltrative processes, ground-glass opacities, consolidation foci—in the early stages of disease. This contributes to timely diagnosis and increases the effectiveness of treatment [8, 9].

In the LDCT group (n = 58), the effective radiation dose was 1.2 mSv, representing a reduction of approximately 73% compared to the standard MSCT group (n = 57), in which the mean effective dose was 4.5–6.0 mSv. This result is consistent with previously published data demonstrating that low-dose protocols can reduce radiation exposure by 60–80% without significant loss of diagnostic information [13, 14, 16].

The use of iterative reconstruction algorithms (ADMIRE in standard MSCT and ASIR-V in LDCT) significantly reduced noise levels in low-dose images, thereby improving diagnostic quality. Consequently, this enhanced the ability to obtain high-resolution images while ensuring patient safety [16, 17, 18].

In the COVID-19 patient group, LDCT reliably identified bilateral multifocal ground-glass opacities, consolidation, and interstitial changes characteristic of SARS-CoV-2 pneumonia. The CT severity grade (CT-1 to CT-4) correlated with the clinical course of the disease. In cases of community-acquired pneumonia (n = 6), LDCT demonstrated lobar or segmental consolidation foci with inflammatory infiltration, consistent with standard MSCT findings.

Low-dose MSCT is particularly important for detecting pulmonary pathologies in cases requiring repeated examinations—including patients undergoing dynamic monitoring—and for groups under regular medical supervision, such as military personnel. This approach helps reduce cumulative radiation exposure while maintaining diagnostic efficacy, in full accordance with the ALARA principle [19, 20, 21].

Thus, low-dose MSCT is an effective, safe, and promising diagnostic method for the early detection of lung diseases, which expands clinical capabilities while upholding the principles of radiation protection in modern radiology [18, 19].

Conclusion.

Based on the analyses conducted, it is evident that low-dose multislice computed tomography (LDCT) is a modern examination method with high diagnostic efficacy for the early detection of pulmonary pathologies. The high spatial resolution and multiplanar reconstruction capabilities of LDCT enable the identification of minimal pathological changes in the lung parenchyma, assessment of the extent of disease, and an increase in diagnostic accuracy [4, 5, 6, 7, 8].

The study revealed that using low-dose MSCT protocols reduces radiation exposure by approximately 73% compared to standard MSCT while preserving the quality of diagnostic information. With low-dose protocols, ground-glass opacity syndrome, infiltrative and interstitial

changes, consolidation foci, and other pathological signs in lung tissue can be identified with high accuracy. This approach is particularly important for ensuring patient safety in cases requiring repeated examinations [13, 14, 15].

The study results indicated that the effectiveness of LDCT protocols is directly linked to the proper selection of examination parameters, optimization of X-ray tube voltage and current, use of automatic exposure control systems, and application of modern iterative reconstruction algorithms (ADMIRE, ASIR-V). By employing these technologies, it is possible to significantly reduce the radiation dose while maintaining image quality [16, 17, 18, 22].

Approaches based on the ALARA principle are a key criterion for ensuring radiation safety in MSCT examinations. This principle entails minimizing the patient's radiation dose as much as reasonably achievable, while maintaining the clinical justification for the examination, an individualized approach, and diagnostic effectiveness [19, 20, 21].

The use of low-dose MSCT is particularly important for patients who may require repeated medical examinations. Reducing radiation risk while ensuring the early detection of pulmonary pathologies is therefore one of the key objectives of modern diagnostics [23, 24].

In general, low-dose MSCT is an effective, safe, and promising method for the early diagnosis of pulmonary pathologies. Its application expands the opportunities for detecting diseases in their initial stages, determining the correct treatment strategy, and preventing complications. The refinement of modern MSCT technologies based on the ALARA principle ensures an optimal balance between diagnostic quality and radiation safety [18, 19, 21].

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