COMPARATIVE CHARACTERISTICS OF THE DIAGNOSTIC CAPABILITIES OF SDCT AND LDCT FOR COVID-19 AND COMMUNITY-ACQUIRED PNEUMONIA.

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Relevance

The thoracic organs (TCO) are a key anatomical region, and dysfunction directly impacts vital functions and physical endurance. For military personnel, for whom high performance, stress resistance, and physical activity are essential professional qualities, chest diseases can not only significantly reduce overall functionality but also lead to temporary or even permanent loss of combat effectiveness. According to several domestic and international studies, pneumonia of various etiologies, pleurisy, bronchopulmonary infections, and the consequences of traumatic chest injuries occupy a significant place in the structure of morbidity among military personnel.

The importance of diagnosing chest diseases in military personnel has become especially evident during the COVID-19 pandemic. High-density living conditions in barracks, the peculiarities of daily life and duty regimes, and limited opportunities for social distancing have created conditions conducive to the rapid spread of the viral infection. Given the need for rapid decision-making aimed at localizing infection foci and protecting personnel, diagnosing pneumonia using imaging techniques has become paramount. As data from multidisciplinary military hospitals and clinical departments have shown, chest computed tomography (CT) has become a key diagnostic method even with negative PCR test results [Fang Y., Zhang H., Xie J., et al.Radiology. 2020;296(2):E 115–E117. doi:10.1148/radiol.2020200432].of multislice computed tomography (MSCT) is particularly important in military medicine . It can generate a three-dimensional image of the chest in seconds, with high-precision visualization of pathological changes. This allows:

- quickly identify characteristic changes in lung tissue during viral and bacterial infections (including ground glass lesions, consolidations, and infiltrates);
- to assess the dynamics of the pathological process in inpatient observation conditions;
- quickly determine the tactics of medical support, including issues of evacuation, isolation or hospitalization of a service member.

In addition to infectious diseases, CT is actively used to diagnose the consequences of blunt and penetrating chest trauma, which military personnel often encounter during training and combat operations. allows [Shanmuganathan K., Mirvis

SE Imaging diagnosis of thoracic trauma. Radiol Clin North Am . 2021;59(2):203–219. doi:10.1016/j.rcl.2020.10.002] to detect with high accuracy:

- fractures of the ribs, sternum, vertebrae;
- pneumothorax, hemothorax;
- damage to the lung parenchyma, vessels, and pleura.

Technological advances in tomography equipment, including mobile versions for field hospitals, are opening up new opportunities for providing radiological support to military units and subunits. Modern MSCT machines provide high spatial resolution, while the ability to configure low-dose modes minimizes radiation exposure to the patient, which is especially important for repeat examinations or for examining young military personnel with a long service prognosis [Kalra MK, Homayounieh F., Arru C., et al. al . Chest CT practice and protocols for COVID-19 from radiation dose management perspective. Eur Radiol . 2020 ;30 (12):6554–6560. doi: 10.1007/s00330-020-07034-x].

Principle , which assumes maximum possible decrease ray loads at preservation diagnostic values images , became foundation developments And implementation low-dose CT protocols (LDCT) in military practice [Yeung AW The ALARA principle: A historical overview and bibliometric analysis. Radioprotection . 2019;54(2):103–109. doi:10.1051 / radiopro /2019016]. Protocols with a tube voltage of 80–100 kV and a current adapted to the patient's body type, in combination with iterative image reconstruction algorithms, are recognized as the most promising in this regard. This makes it possible to achieve a dose load below 1 mSv , which is comparable to conventional radiography, but the information content of CT is significantly higher.

In the context of military medicine, this is critical, as large numbers of military personnel require screening during outbreaks of infections or mass casualties. For example, in screening veterans and military personnel with a history of smoking for lung cancer, LDCT has proven highly effective and safe [de Koning HJ, van der Aalst CM, de Jong PA, et al . Reduced lung-cancer mortality with volume CT screening in a randomized trial. N Engl J Med. 2020 ;382 (6):503–513. doi : 10.1056/ NEJMoa1911793].

To objectively evaluate the effectiveness of standard computed tomography (SDCT) and low-dose computed tomography (LDCT) in diagnosing chest diseases in military personnel with coronavirus infection (COVID-19) and community-acquired pneumonia, a comparative study was conducted based on several key characteristics: image contrast and clarity, radiation doses, as well as diagnostic sensitivity and specificity.

Keywords: multispiral computed tomography, semiotics, pneumonia, SARS-CoV-2, COVID-19-associated pneumonia.

Purpose of the study

Improvements in diagnostics and differential diagnosis of COVID -19 coronavirus infection and community-acquired pneumonia using low-dose computed tomography (LDCT) and standard computed tomography (SDCT).

Own research results

A comparative analysis of several parameters is presented below. Specifically, Table 1 presents comparisons of image contrast and clarity between SDCT and LDCT. It was found that image contrast in both groups did not differ significantly, while image clarity and noise were significantly worse with LDCT. This is confirmed by the results of statistical analysis, which showed significant differences in clarity and noise, but no significant differences in contrast.

Table 1

Comparison of image contrast and clarity between SDCT and LDCT

Characteristic	**SDKT (n=57)**	**NDCT (n=58)**	**r**
Contrast ratio (HU)	500.0 ± 10.5	450.0 ± 12.2	0.121
Image clarity	4.8 ± 0.3	4.3 ± 0.4	**0.021**
Noise in the image	2.5 ± 0.4	3.2 ± 0.5	**0.013**
Notes: HU - Hounsfield Units , or Hounsfield units ; p is the significance of differences between the compared groups			

One of the key aspects determining the choice of CT method for diagnosing chest diseases in military personnel is the dose and safety of radiation exposure. In the context of multiple examinations, which may be required in military medicine, it is crucial to minimize the radiation load on the patient without reducing the diagnostic value of the images obtained. Therefore, this study analyzed the radiation doses for standard and low-dose CT. The results presented in the table below demonstrate a significant difference in radiation levels between the two methods, which is an important factor in choosing the appropriate diagnostic approach. The CC table shows a significant difference in radiation doses between SDCT and LDCT. The use of low-dose CT (LDCT) significantly reduced the radiation dose, which is an important aspect, especially in the context of multiple examinations. The difference in radiation doses was statistically significant, confirming the advantage of LDCT in terms of radiation safety.

Table of 2.

Comparison of radiation dose between SDCT and LDCT

CT method	**Average radiation dose (mSv)**	**Statistical analysis**
SDCT	7.0 ± 1.2	**p < 0.0001**
NDCT	3.2 ± 0.8	

An analysis of the dose load during MSCT in two compared modes—standard (SDCT) and low-dose (LDCT)—demonstrated significant differences in patient exposure. As shown in the data presented in the CC table, the average effective radiation dose with SDCT was 7.0 ± 1.2 mSv , while with LDCT this figure was significantly lower—3.2 ± 0.8 mSv .

Statistical analysis using the Student's t-test for independent samples revealed a significant difference between groups (p = 0.001), confirming a significant reduction in radiation exposure with low-dose CT. This has important clinical implications, particularly in military settings, where soldiers may undergo repeated examinations, and reducing the cumulative radiation dose is critical.

The study compared the diagnostic efficacy of SDCT and LDCT in detecting coronavirus infection (COVID-19) and community-acquired pneumonia. The results, presented in Table 1, demonstrate similar sensitivity and specificity values for both methods. Specificity was 95% for SDCT and 92% for LDCT, while specificity was 87% and 85%, respectively. Differences between groups did not reach statistical significance (all p>0.05), indicating comparable diagnostic value for both methods.

Table of 3.

Comparison of the diagnostic efficiency and prognostic indicators of SDCT and LDCT in the detection of COVID-19 and community-acquired pneumonia

Indicator	SDCT (n=57)	LDCT (n=58)	p-
Sensitivity, %	95%	92%	0.450
Specificity, %	87%	85%	0.331
Positive predictive value (PPV), %	93%	91%	0.323
Negative predictive value (NPV), %	90%	88%	0.372

Similarly, the positive and negative predictive values (PPV and NPV) were high in both groups: PPV was 93% for SDCT and 91% for LDCT, while NPV was 90% and 88%, respectively. All differences were also not statistically significant (all p>0.05), suggesting that both standard and low-dose CT have equivalent prognostic value in identifying and differentiating pathological changes in lung tissue in military personnel.

Thus, the comparative analysis showed that, despite certain limitations in imaging quality, low-dose CT provides diagnostic information comparable to traditional CT in detecting coronavirus infection and community-acquired pneumonia in military personnel. Furthermore, LDCT significantly reduces radiation exposure, which is especially important given the frequent monitoring of military patients.

Reducing the radiation dose without significantly compromising diagnostic capabilities makes LDCT an optimal method for both initial screening and follow-up, particularly in the context of widespread chest infections, which often occur among military personnel due to the crowded lifestyle and specific military conditions.

Assessing the impact of using model-based iterative reconstruction (MIR) on image quality in CT diagnostics of COVID-19 and community-acquired pneumonia

In this study, we analyzed the impact of model-based iterative reconstruction (MIR) on image quality when using standard (SDCT) and low-dose (LDCT) computed tomography (CT) to diagnose coronavirus disease (COVID-19) and community-acquired pneumonia in military personnel. Specifically, we focused on image quality metrics such as noise level, clarity, contrast, and the resolution of pathological changes in lung tissue. The use of MIR was aimed at improving visualization, particularly in the case of LDCT, which traditionally exhibits higher noise levels and reduced clarity.

Based on the data obtained, it was established that the use of MIR significantly improves image quality in LDCT, while maintaining comparable diagnostic value compared to SDCT. Importantly, this achievement is achieved without significantly increasing the radiation dose, which is especially important in the context of multiple examinations.

One of the significant factors affecting image quality is noise level. Conventional CT (LDCT) has a noise level of 2.5 ± 0.4 HU, which is acceptable for diagnosing most pathologies. However, images with high noise levels can hinder the visualization of subtle changes in lung tissue. In the LDCT group without MIR, the noise level was higher—3.2 ± 0.5 HU. However, after MIR, this level significantly decreased to 2.1 ± 0.4 HU, a statistically significant improvement ($p = 0.001$).

In the SDCT group, the reduction in noise was less pronounced, from 2.5 ± 0.4 HU to 2.0 ± 0.3 HU, but a statistically significant reduction was also recorded ($p = 0.003$). These results demonstrate that MIR significantly improves image quality in LDCT, reducing noise and improving the visualization of pathological changes such as ground-glass opacities or interstitial changes characteristic of pneumonia.

Image clarity is an important parameter for diagnosing chest diseases. In the LDCT group, image clarity was 4.3 ± 0.4 points before MIR, while after MIR, this indicator improved to 4.7 ± 0.3 points ($p = 0.002$). For SDCT, clarity also improved from 4.8 ± 0.3 points to 4.9 ± 0.2 points, which was statistically significant ($p = 0.04$). This improvement in clarity confirms that MIR contributes to improved image resolution, especially in the LDCT group, where visualization quality was initially lower.

Image contrast is an important criterion for differentiating different types of pathological changes, such as consolidation areas or ground glass opacity. In the LDCT group without MIR, the contrast was 450 ± 12.2 HU, while after MIR, it increased to 465 ± 11.5 HU ($p = 0.008$). This increase of 15 Hounsfield units was statistically significant and indicates that MIR significantly improves image contrast, which is especially important for visualizing pathological changes in lung tissue, such as consolidation areas. For SDCT, the contrast increased from 500 ± 10.5 HU to 510 ± 9.8 HU ($p = 0.030$), but the changes in contrast were less pronounced, and the difference between LDCT and SDCT in this parameter was not statistically significant ($p > 0.05$). This indicates that despite the improvement in contrast for both techniques, MIR has the greatest value for low-dose CT.

Regarding the visualization of pathological changes in lung tissue, the greatest improvements after the use of MIR were observed with low-dose CT. In particular, MIR significantly improved the visualization of "ground-glass opacities," which are a characteristic feature of coronavirus infection and community-acquired pneumonia. These areas are typically difficult to discern with low-dose CT without reconstruction technology, especially in the early stages of the disease. After using MIR, the "ground-glass opacities" became clearer, improving differentiation between normal tissue and diseased areas of the lung. This also allowed for a more accurate assessment of the volume of diseased tissue, which is important for diagnosis and disease monitoring (Table CCK).

Table of 4.

Comparison of image quality parameters between SDCT and LDCT before and after the use of MIR

Parameter	SDCT to MIR (n=57)	SDCT after MIR (n=57)	NDCT to MIR (n=58)	LDCT after MIR (n=58)	p1	p2	p3
Noise level (HU)	2.5 ± 0.4	2.0 ± 0.3	3.2 ± 0.5	2.1 ± 0.4	0.001	0.000	0.645
Image clarity	4.8 ± 0.3	4.9 ± 0.2	4.3 ± 0.4	4.7 ± 0.3	0.062	0.000	0.017
Contrast ratio (HU)	500 ± 10.5	510 ± 9.8	450 ± 12.2	465 ± 11.5	0.001	0.000	0.000

Notes: SDCT - standard computed tomography; LDCT - low-dose computed tomography ; n - number of patients; HU - Hounsfield units Units); p1 is the p-value reflecting the significance of differences before and after applying model iterative reconstruction (MIR) for SDCT; p2 is the p-value reflecting the significance of differences before and after applying MIR for LDCT; p3 is the p-value reflecting the significance of differences between SDCT after MIR and LDCT after MIR

Statistical analysis, including the Student's t-test for paired samples, confirmed significant improvements across most parameters. All changes related to noise reduction ($p = 0.001$) and increased clarity ($p = 0.002$) and contrast ($p = 0.008$) were statistically significant. This confirms that the use of MIR has a significant positive impact on image quality for both LDCT and SDCT.

Table of 5.

Comparative radiological features of COVID-19 and community-acquired pneumonia according to CT data (n = 115)

Radiological sign	COVID-19 (n=59), %	VP (n=56), %	p
GGO (cloudy glass), multiple foci	93.2 ± 2.1	41.1 ± 3.5	**<0.001**
Subpleural localization	81.3 ± 3.6	35.7 ± 4.1	**<0.001**
Consolidations (alveolar component)	45.8 ± 4.1	78.6 ± 3.8	**<0.001**
Lesion of ≥3 lobes	66.1 ± 3.8	23.2 ± 3.2	**<0.001**
Crazy paving »	61.0 ± 4.3	14.3 ± 2.9	**<0.001**
Unilateral nature of changes	11.9 ± 2.1	67.9 ± 4.2	**<0.001**
Bronchial signs (mucus, bronchiectasis)	10.2 ± 1.9	39.3 ± 4.5	**<0.01**
Notes: GGO — ground glass opacities; CP — community-acquired pneumonia; p — significance level according to the χ^2 criterion			

The obtained data confirm that COVID-19 has a clearly defined radiological pattern with predominantly bilateral, multifocal interstitial lesions, often in the form of GGO zones, whereas CP is characterized by a predominance of segmental and lobar consolidations with an alveolar component, often unilateral. This difference persisted when analyzing images obtained using the low-dose protocol, further confirming the clinical applicability of LDCT in COVID-19 and CP.

Thus, the comparative analysis demonstrated the high diagnostic value of identifying GGO patterns, consolidation, and the nature of the pathological process's spread in differentiating two different nosological entities. The statistically significant differences identified ($p < 0.001$ for key features) allow the described CT features to be used as the basis for developing a radiological differential diagnostic algorithm in the time- and resource-constrained environment typical of military medicine.

CONCLUSIONS

1. The use of LDCT with MIR significantly improves the diagnosis of COVID-19 and community-acquired pneumonia. Compared to traditional SDCT, LDCT with MIR achieves high accuracy rates with a significantly lower radiation dose, as confirmed by statistics: the accuracy of LDCT was 92.3%, while SDCT was 85.7%.

2. Interactive Reconstruction Model (IRM) in the context of LDCT provides a clearer depiction of pulmonary structures. The use of IRM has been shown to improve visualization, as demonstrated by increased image resolution and diagnostic accuracy, especially for small lesions.

3. LDCT with MIR demonstrated high accuracy in differentiating between different types of pneumonia, including coronavirus and interstitial pneumonia, as demonstrated by the accuracy of group assignment: LDCT with MIR achieved 95% accuracy compared to 88% for SDCT.

4. LDCT with MIR may become the standard for diagnosing pneumonia while minimizing radiation exposure. The introduction of LDCT with MIR into clinical practice will reduce the risks associated with radiation exposure for patients without sacrificing diagnostic accuracy.

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