DOI: https://doi.org/10.17816/DD119870

Низкодозная компьютерная томография органов грудной клетки в диагностике COVID-19: обзор литературы

И.А. Блохин, Д.А. Румянцев, М.М. Сучилова, А.П. Гончар, О.В. Омелянская

Научно-практический клинический центр диагностики и телемедицинских технологий, Москва, Российская Федерация

АННОТАЦИЯ

Обоснование. Повышение числа исследований компьютерной томографии во время пандемии COVID-19 актуализировало задачу снижения лучевой нагрузки на пациента, так как воздействие радиационного излучения достоверно связано с повышением риска развития онкологических заболеваний. В работе отделений лучевой диагностики даже в условиях пандемии должен соблюдаться принцип минимальной дозы облучения при максимальном уровне качества диагностики — ALARA (as low as reasonably achievable), предложенный Международной комиссией по радиационной защите.

Цель — систематизация данных о возможностях снижения лучевой нагрузки при диагностике поражения лёгких при COVID-19 методом компьютерной томографии.

Материалы и методы. Проведён анализ релевантных отечественных и зарубежных источников литературы в научных библиотеках PubMed и eLIBRARY по запросам «low dose computed tomography COVID-19» и «низкодозная компьютерная томография COVID-19», опубликованных в период с 2020 по 2022 год. Публикации включались в обзор после оценки их соответствия теме обзора путём анализа названия и абстракта. Списки литературы также были проанализированы на предмет выявления пропущенных при поиске статей, попадающих под критерии включения.

Результаты. Изучение опубликованных результатов исследований позволило обобщить современные данные о лучевой диагностике поражения лёгких при COVID-19 и использовании компьютерной томографии, а также определить возможные варианты снижения дозы лучевой нагрузки.

Заключение. Представлены способы уменьшения лучевой нагрузки при компьютерной томографии органов грудной клетки и сохранения высокого качества диагностического изображения, потенциально достаточного для надёжного выявления признаков COVID-19. Снижение дозы облучения является оправданным подходом к получению актуальной диагностической информации, сохраняющим возможности внедрения технологий продвинутого компьютерного анализа в клиническую практику.

Ключевые слова: компьютерная томография; низкодозная компьютерная томография; обзор литературы; COVID-19; диагностика COVID-19.

Как цитировать
Блохин И.А., Румянцев Д.А., Сучилова М.М., Гончар А.П., Омелянская О.В. Низкодозная компьютерная томография органов грудной клетки в диагностике COVID-19: обзор литературы // *Digital Diagnostics.* 2023. Т. 4 № 1. С. 25–37. DOI: https://doi.org/10.17816/DD119870

Рукопись получена: 22.12.2022 **Рукопись одобрена:** 06.02.2023 **Опубликована:** 31.03.2023

DOI: https://doi.org/10.17816/DD119870

Low-dose computed tomography in COVID-19: systematic review

Ivan A. Blokhin, Denis A. Rumyantsev, Maria M. Suchilova, Anna P. Gonchar,
Olga V. Omelyanskaya

Moscow Center for Diagnostics and Telemedicine, Moscow, Russian Federation

ABSTRACT

BACKGROUND: The increased number of computed tomography scans during the COVID-19 pandemic has emphasized the task of decreasing radiation exposure of patients, since it is known to be associated with an elevated risk of cancer development. The ALARA (as low as reasonably achievable) principle, proposed by the International Commission on Radiation Protection, should be adhered to in the operation of radiation diagnostics departments, even during the pandemic.

AIM: To systematize data on the appropriateness and effectiveness of low-dose computed tomography in the diagnosis of lung lesions in COVID-19.

MATERIALS AND METHODS: Relevant national and foreign literature in scientific libraries PubMed and eLIBRARY, using English and Russian queries “low-dose computed tomography” and “COVID-19,” published between 2020 and 2022 were analyzed. Publications were evaluated after assessing the relevance to the review topic by title and abstract analysis. The references were further analyzed to identify articles omitted during the search that may meet the inclusion criteria.

RESULTS: Published studies summarized the current data on the imaging of COVID-19 lung lesions and the use of computed tomography scans and identified possible options for reducing the effective dose.

CONCLUSION: We present techniques to reduce radiation exposure during chest computed tomography and preserve high-quality diagnostic images potentially sufficient for reliable detection of COVID-19 signs. Reducing radiation dose is a valid approach to obtain relevant diagnostic information, preserving opportunities for the introduction of advanced computational analysis technologies in clinical practice.

Keywords: computed tomography; low-dose computed tomography; literature review; COVID-19; COVID-19 diagnosis.

To cite this article

Blokhin IA, Rumyantsev DA, Suchilova MM, Gonchar AP, Omelyanskaya OV. Low-dose computed tomography in COVID-19: systematic review. *Digital Diagnostics*. 2023;4(1):25–37. DOI: https://doi.org/10.17816/DD119870

Received: 22.12.2022 **Accepted:** 06.02.2023 **Published:** 31.03.2023

DOI: https://doi.org/10.17816/DD119870

胸部低剂量计算机断层扫描在COVID-19诊断中的应用：系统综述

Ivan A. Blokhin, Denis A. Rumyantsev, Maria M. Suchilova, Anna P. Gonchar, Olga V. Omelyanskaya

Moscow Center for Diagnostics and Telemedicine, Moscow, Russian Federation

简评

论证。在COVID-19大流行期间，计算机断层扫描检查数量的增加使减少病人的辐射量的任务成为现实，因为暴露于辐射与增加癌症风险有着可靠的联系。国际放射防护委员会提出的在最高诊断质量下的最小辐射剂量原则——ALARA（as low as reasonably achievable），在辐射诊断部门的工作中应该得到遵守，即使在大流行的情况下。

目的是整理关于通过计算机断层扫描诊断COVID-19肺部病变时减少辐射暴露的潜力的数据。

材料和方法。对PubMed和eLIBRARY科学图书馆中2020年至2022年期间发表的的国内外相关文献进行了分析，搜索查询包括“low dose computed tomography COVID-19”和“низкодозная компьютерная томография COVID-19”（低剂量计算机断层扫描COVID-19）。通过分析标题和摘要评估其与综述主题的相关性后，将出版物纳入综述。还对参考文献列表进行了分析，以确定搜索中遗漏的符合纳入标准的文章。

结果。对已发表的研究进行了，研究已发表的科学著作允许总结关于目前COVID-19肺部病变的辐射诊断和计算机断层扫描的使用的数据，并确定减少辐射剂量的可能方法。

结论。介绍了在胸部计算机断层扫描过程中减少辐射量并保留高质量诊断图像的方法，这些图像可能足以可靠地检测COVID-19征候。减少辐射剂量是获得现实诊断信息的一种有道理的方法，保留将先进计算机化分析技术引入临床实践的可能性。

关键词：计算机断层扫描，低剂量计算机断层扫描，文献综述，COVID-19，COVID-19诊断。

To cite this article
Blokhin IA, Rumyantsev DA, Suchilova MM, Gonchar AP, Omelyanskaya OV. 胸部低剂量计算机断层扫描在COVID-19诊断中的应用：系统综述. *Digital Diagnostics*. 2023;4(1):25–37. DOI: https://doi.org/10.17816/DD119870

收到：22.12.2022 **接受：**06.02.2023 **发布日期：**31.03.2023

BACKGROUND

At the time of writing this paper (December 22, 2022), the number of coronavirus disease 2019 (COVID-19) cases reaches 650 million.[1] Spread of the disease and consequent mortality can be prevented and reduced with a combination of measures, including early diagnosis.[2]

The main method of laboratory diagnostics is reverse-transcription polymerase chain reaction (RT PCR). At the first peak of the coronavirus pandemic, disadvantages of this technique were revealed, such as a high rate of false-positive results, limited test availability, and long waiting time for results. [1] Moreover, computed tomography (CT) of the chest can also provide false-negative results in patients with signs of COVID-19. [2]

According to Russian [3] and international[3] guidelines, diagnostic radiology for COVID-19-associated pneumonia includes radiography and CT. Chest X-ray imaging has low sensitivity to viral pneumonia [4], so CT plays an important role in the diagnosis of COVID-19-associated pneumonia and its complications. [5]

The active use of CT during the pandemic leads to high radiation exposure to the population. [6, 7] To assess changes in patient condition during the hospital stay, 2–6 CTs are usually performed within a short period since a clear trend toward CT regression of abnormal changes is one of the criteria for patient discharge.[3] Patients with suspected COVID-19 may undergo 1–2 outpatient CT scans to detect signs of the disease. [8. 9]

Radiation exposure is significantly associated with the increased risk of developing cancer. [10] In radiology departments, even in a pandemic, the “as low as reasonably achievable” principle proposed by the International Commission of Radiological Protection [11] should be observed. In March 2020, Kang et al. proposed the use of low-dose CT (LDCT) as the first stage of radiation diagnosis in patients with COVID-19-associated pneumonia. [6] The important role of LDCT in COVID-19 was also highlighted by the webinar “*COVID-19 and Chest CT: Protocol and Dose Optimization,*” which was held in April 2020 and attended by 1633 people from 100 countries. During the video conference, it was found that 55%, 43%, and 2% of healthcare institutions use standard (CTDIvol 5–10 mGy), low-dose (CTDIvol <5 mGy), and high-dose protocols (CTDIvol >10 mGy). [12] However, even a superficial assessment of an X-ray workstation reveals a significant number of scan parameters that affect radiation exposure, [13], and the relationship between different protocol settings and radiation dose may not be obvious, especially considering the pathology examined.

This literature review aimed to systematize data on opportunities for reducing radiation exposure during lung CT in patients with COVID-19.

MATERIALS AND METHODS

Relevant Russian and foreign literature sources were reviewed in PubMed and eLIBRARY scientific libraries for search queries “low dose computed tomography COVID-19” and “низкодозная компьютерная томография COVID-19” for the period from 2020 to 2022.

Publications were included in the review after assessing their relevance according to their titles and abstracts. The review included original studies and meta-analyses, and literature reviews, case reports, and congress abstracts were excluded. References were also reviewed for relevant studies on general principles of CT dose reduction that might have been published before 2020. When such articles were found, the most recent study was included in the review.

RESULTS AND DISCUSSION

In total, 45 foreign papers and five Russian papers were reviewed. The latest search date was December 22, 2022.

Methods for Reducing Radiation Exposure

Methods for reducing radiation exposure can be divided into hardware and software ones. Hardware methods are related to tube potential, tube current, pitch factor, and X-ray beam filter. Software methods are related to the reconstruction filter, slice thickness, and iterative reconstructions.

Hardware Methods. Tube potential (kVp) is nonlinearly related to radiation exposure. [14] Zarb et al. [15] showed that a decrease in tube potential by 14%–17% provides a radiation dose decrease by 32%–38%. In this case, reducing the tube potential increases the noise level while performing non-contrast-enhanced examinations. A phantom study showed that these parameters are interrelated via an exponent of –1.3. [16] Moreover, reducing the tube potential in contrast-enhanced examinations improves the quality of images by significantly reducing radiation exposure. [17]

Tube current (mAs) is linearly related to radiation exposure. [18] For example, a 50% decrease in tube current leads to a 50% decrease in the effective dose [17], while the signal-to-noise ratio is inversely proportional to the square root of the current. [19]

A pitch factor for multislice CT has almost no effect on radiation exposure. [20] As the pitch factor increases,

---

[1] World Health Organization. Novel Coronavirus (COVID-19) situation. Available at https://who.sprinklr.com.

[2] Centers for Disease Control and Prevention. Coronavirus 2019 disease (COVID-19). Available at https://www.cdc.gov/coronavirus/2019-ncov/index.html.

[3] World Health Organization. Use of chest imaging in COVID-19: A rapid advice guide [11 June 2020]. Available at https://apps.who.int/iris/handle/10665/332336.

the signal-to-noise ratio decreases, and the tomograph automatically increases the tube current to prevent deterioration of image quality. [21]

An X-ray beam filter is used to absorb low-energy photons that cannot pass through the patient tissues and do not reach the detectors. Therefore, the use of an additional tin filter can significantly reduce radiation exposure during CT [22] but requires additional costs for scanner modification.

Software Methods. The choice of the reconstruction filter (convolution kernel) does not affect radiation exposure but affects the signal-to-noise ratio, amplifying or smoothing out the difference between pixels of different organs or structures. [23]

A low slice thickness is associated with lower image quality but decreases the risk of missing small abnormal changes. Thus, slice thickness can be optimized. For example, for the examination of pulmonary nodes, this parameter may be 2 mm. [24]

The main way to reduce “noise” is iterative reconstructions, which allow CTs with lower radiation doses and a similar signal-to-noise ratio to the standard data reconstruction technique. [25] The use of artificial neural networks for image reconstruction is one of the promising methods. [26, 27]

Based on the literature review, reducing the tube current reduces radiation exposure, and the signal-to-noise ratio can be optimized using a reconstruction filter that smoothens the difference between adjacent pixels (soft tissue) and iterative reconstruction.

Low-dose CT in the diagnosis of COVID-19

In the literature review, a single, well-defined low-dose protocol is warranted for COVID-19 (Table 1 [28–54]). The reduced radiation exposure dose is achieved mainly by changing the tube potential, tube current, use of iterative reconstructions, and a tin filter. Some studies reviewed had shortcomings related to data presentation: dosimetric parameters (CTDI, DLP, SSDE, and effective dose) were not mentioned, and small sample sizes were used.

Interestingly, a parameter to be changed when optimizing the scanning protocol can be universal for various clinical tasks. Therefore, in LDCT for lung cancer screening, different groups of authors also changed the tube current [55, 56]. However, the development of a specialized LDCT protocol should be initiated with a study on a model object (phantom) to select the optimal method for reducing the exposure. For example, Gombolevsky et al. [57] developed the LDCT protocol for the diagnosis of COVID-19 using a phantom with thickening plates, while setting the automatic tube current control system (Sure Exposure 3D) to a sufficient level to detect ground-glass lesions with a maximum reduction in radiation exposure (SD = 36). A comparison of the protocol selected according to the results of the phantom study with standard CT and LDCT for lung cancer screening is shown in Fig. 1.

Any special low-dose protocols require clinical validation and comparison with the gold standard. Therefore, clinical trials of the developed LDCT protocol for COVID-19 used

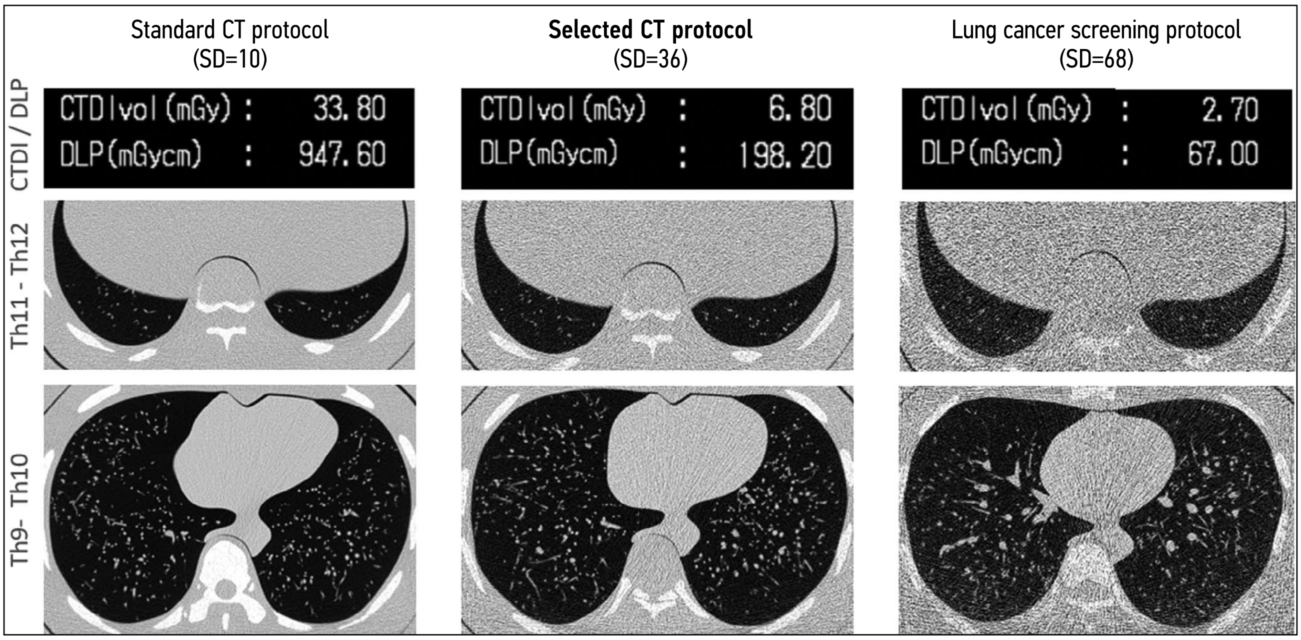

Figure 1. Comparison of a dedicated low-dose computed tomography protocol for COVID-19 (SD = 36) with standard and low-dose computed tomography for lung cancer screening. Data on radiation exposure and axial tomograms of the phantom at the level of the lower and middle zones of the lungs. Low-dose computed tomography for lung cancer screening was developed considering the need for radiation exposure limitation as preventive measures according to SanPin (disease control and prevention standards) and has the lowest signal-to-noise ratio. The proposed protocol for low-dose computed tomography for COVID-19 considers the densitometric characteristics of ground-glass lesions with a significant reduction in radiation exposure.

Table 1. Parameters of low-dose computed tomography for diagnosis of COVID-19 based on the literature review

Author, year, link	Tube potential (kV)	Tube current, mA	Average radiation dose (mSv)	Slice thickness (mm)	Reconstruction filter	Use of Iterative Reconstruction
Blokhin et al. (2022) [28]	120	10–500, noise level 36 (SD)	3	1	FC51, FC07	No
Filatova et al. (2020) [29]	100/110	40–120	1,27	1	-	Yes
Afshar et al. (2022) [30]	110	20	1–1,5	2	D40s	-
Fukumoto et al. (2022) [31]	120	20–25	CTDI 1.3 mGy	5	Lung and soft tissue	-
Bieba et al. (2022) [32]	Depending on weight	Depending on weight	-	1 and 3	-	-
Barrio et al. (2022) [33]	100/150	Anthropomorphic current modulation system	-	1	Br32 Bl60	-
Thieß et al. (2022) [34]	100	10–100	0,53	0,5 b 0,625	Fc01 Fc85	Yes
Greffier et al. (2021) [35]	100/120	10	0,2	1	I30f, mediastinal, I50f, lung images	Yes
Karakaş et al. (2021), [36]	80	40	0,18	5	lung	Yes
Julie et al. (2021) [37]	120	45	-	1,2	-	-
Desmet et al. (2021) [38]	80–140	20–30	0,64	0,6	-	-
Aslan et al. (2021) [39]	80	35–50	0,2856	3	lung	Yes
Stoleriu et al. (2021) [40]	120	40–113	35–100 mGy×cm 0.78–2.91 mGy	1,25	Medium Soft	Yes
Bai et al. (2021) [41]	120	120–380	1,21±0,10	1,25	Standard	Yes
Agostini et al. (2021) [42]	100	95	0,39	1,5	Sharp	Yes
Zali et al. (2021) [43]	100–120	50–100	-	1-3	-	-
Argentieri et al. (2021) [44]	80	20	0,219	2	Sharp	-
Leger et al. (2020) [45]	120	45	0,49	1,2	-	-
Hamper et al. (2020) [46]	100	20–120	0,5	0,625–1	Lung	Yes
Li et al. (2020) [47]	120	30	1,22±0,14	1	-	Yes
Dangis et al. (2020) [48]	100	20	0,56	1	Lung (150f)	Yes
Radpour et al. (2020) [49]	100–120	50–100	-	1–3	-	-
Kang et al. (2020) [6]	80–100	10–25	0,203	0,6	-	Yes
Tofighi et al. (2020) [50]	100	40	2,03	-	-	No
Tabatabaei et al. (2020) [51]	120	30	1,8	3	-	-
Schulze-Hagen et al. (2020) [52]	80	35	1,7	1 and 3	170f 130f	-
Zhao Yue et al. (2020) [53]	100	50	1,5	1	-	-
Castelli et al. (2020) [54]	120	45	0,47	1,2	-	-

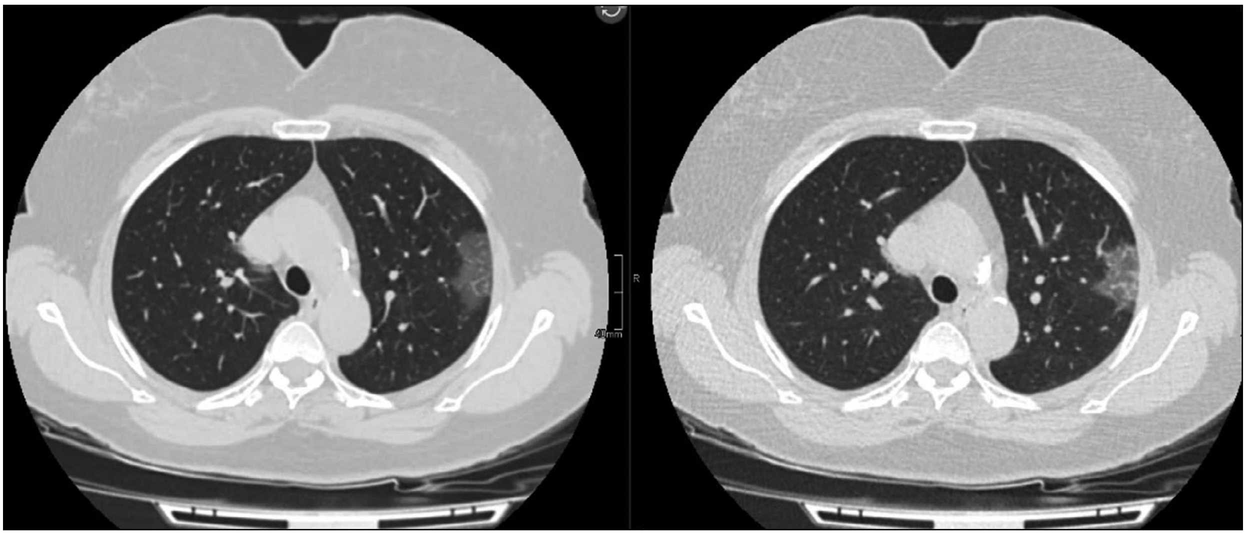

Figure 2. Radiation exposure is reduced by 5 times. Patient, 59 y. o., BMI 29 kg/m^2. Computed tomography with a soft tissue filter (effective dose: 9.7 mSv), low-dose computed tomography with a soft tissue filter (effective dose: 2.1 mSv). In the upper lobe of the left lung, there was a peripheral ground-glass lesion.

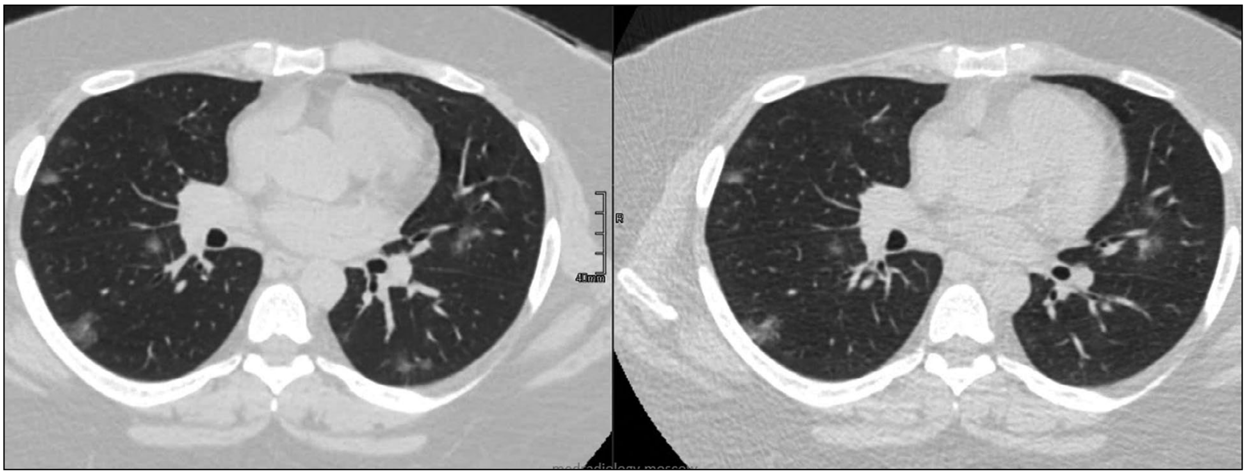

Figure 3. Radiation exposure is reduced by 1.5 times. Patient, 44 y. o., BMI 46 kg/m^2. Computed tomography with a soft tissue filter (effective dose: 15.3 mSv), low-dose computed tomography with a soft tissue filter (effective dose: 10.5 mSv). Bilateral peripheral ground-glass lesions.

standard CT as a reference technique. [28] Some of the clinical images obtained using the developed protocol are shown in Figs. 2 and 3.

Limitations of LDCT

Kim et al. [58] showed that obesity (body mass index > 25) appears to limit the use of chest LDCT in routine practice due to X-ray absorption by adipose tissue. However, studies on the inter-expert agreement of COVID-19 examinations indicate the opposite. [59]

In addition, LDCT empirically appears to be related to the negative effect of increased image noise on the operation of AI systems, including the calculation of an emphysema index in densitometric analysis, [60] and the radiomic analysis of subsolid pulmonary nodules. [61] Effect of a scanning protocol on the results of a quantitative analysis can be reduced using relative parameters, for example, the percentage of affected lung tissue in COVID-19, [62] or by normalizing the obtained data with special algorithms. [63]

CONCLUSION

Methods are presented to reduce radiation exposure during chest CT and maintain high-quality diagnostic images that are hypothetically sufficient to reliably detect signs of COVID-19. Although there is no single way to optimize scan protocols, dose reduction provides relevant diagnostic information and retains the ability to incorporate advanced computer-assisted technologies into clinical pathways.

ADDITIONAL INFORMATION

Funding source. This article was prepared by a team of authors as part of the research work (EGISU number: AAAA-A20-120071090058-7) in accordance with the Program of the Moscow Department of Health "Scientific support of metropolitan health" for 2020-2022.

Competing interests. The authors declare that they have no competing interests.

Authors' contribution. All authors made a substantial contribution to the conception of the work, acquisition, analysis, interpretation of data for the work, drafting and revising the work, final approval of the version to be published and agree to be accountable for all aspects of the work. The largest contributions were distributed as follows: I.A. Blokhin — editing and approval of the final manuscript text, advisory support; D.A. Rumyantsev — data analysis, article text writing; M.M. Suchilova, A.P. Gonchar — editing and approval of the final manuscript text; O.V. Omelyanskaya — study concept and design.

REFERENCES

1. Yang Y, Yang M, Shen C, et al. Evaluating the accuracy of different respiratory specimens in the laboratory diagnosis and monitoring the viral shedding of 2019-nCoV infections. *medRxiv*. 2020. doi: 10.1101/2020.02.11.20021493

2. Rubin GD, Ryerson CJ, Haramati LB, et al. The role of chest imaging in patient management during the COVID-19 pandemic: A multinational consensus statement from the fleischner society. *Radiology*. 2020;296(1):172–180. doi: 10.1148/radiol.2020201365

3. Temporary methodological recommendations prevention, diagnosis and treatment of new coronavirus infection (COVID-19). Version 12 (09/21/2021). Moscow; 2021. 232 p.

4. Ng M, Lee EY, Yang J, et al. Imaging profile of the COVID-19 infection: Radiologic findings and literature review. *Radiology: Cardiothoracic Imaging*. 2020;2(1):e200034. doi: 10.1148/ryct.2020200034

5. Ai T, Yang Z, Hou H, et al. Correlation of chest CT and RT-PCR testing for coronavirus disease 2019 (COVID-19) in China: A report of 1014 cases. *Radiology*. 2020;296(2):E32–E40. doi: 10.1148/radiol.2020200642

6. Kang Z, Li X, Zhou S. Recommendation of low-dose CT in the detection and management of COVID-2019. *Eur Radiolohy*. 2020;30(8):4356–4357. doi: 10.1007/s00330-020-06809-6

7. Morozov SP, Kuzmina ES, Ledekhova NV, et al. Mobilization of the scientific and practical potential of the radiation diagnostics service of Moscow in the COVID-19 pandemic. *Digital Diagnostics*. 2020;1(1):5–12. (In Russ). doi: 10.17816/DD51043

8. Pan F, Ye T, Sun P, et al. Time course of lung changes on chest CT during recovery from 2019 novel coronavirus (COVID-19) pneumonia. *Radiology*. 2020;295(3):715–721. doi: 10.1148/radiol.2020200370

9. Lei DP, Fan B, Mao J, et al. The progression of computed tomographic (CT) images in patients with coronavirus disease (COVID-19) pneumonia: Running title: the CT progression of COVID-19 pneumonia. *J Infect*. 2020;80(6):e30–e31. doi: 10.1016/j.jinf.2020.03.020

10. Power SP, Moloney F, Twomey M, et al. Computed tomography and patient risk: Facts, perceptions and uncertainties. *World J Radiol*. 2016;8(12):902–915. doi: 10.4329/wjr.v8.i12.902

11. Yeung AW. The "As low as reasonably achievable" (ALARA) principle: A brief historical overview and a bibliometric analysis of the most cited publications. *Radioprotection.* 2019;54(2):103–109. doi: 10.1051/radiopro/2019016

12. Kalra MK, Homayounieh F, Arru C, et 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

13. Krasnov AS, Kabanov DO, Tereshchenko GV. Fundamentals of dosimetry and dose load optimization during multispiral computed tomography. *Issues Hematology Oncology Immunopathology Pediatrics*. 2018;17(3):127–132. (In Russ).

14. Singh S, Kalra MK, Thrall JH, Mahesh M. CT radiation dose reduction by modifying primary factors. *J Am Coll Radiol*. 2011;8(5):369–372. doi: 10.1016/j.jacr.2011.02.001

15. Zarb F, Rainford L, McEntee MF. Developing optimized CT scan protocols: Phantom measurements of image quality. *Radiography*. 2011;17(2):109–114. doi: 10.1016/j.radi.2010.10.004

16. Hilts M, Duzenli C. Image noise in X-ray CT polymer gel dosimetry. *J Physics: Conference Series*. 2004;3(1):252. doi: 10.1088/1742-6596/3/1/040

17. Lira D, Padole A, Kalra MK, Singh S. Tube potential and CT radiation dose optimization. *Am J Roentgenol*. 2015;204(1):W4–W10. doi: 10.2214/AJR.14.13281

18. Reid J, Gamberoni J, Dong F, Davros W. Optimization of kVp and mAs for pediatric low-dose simulated abdominal CT: Is it best to base parameter selection on object circumference? *AJR Am J Roentgenol*. 2010;195(4):1015–1020. doi: 10.2214/AJR.09.3862

19. Khoramian D, Sistani S, Firouzjah RA. Assessment and comparison of radiation dose and image quality in multi-detector CT scanners in non-contrast head and neck examinations. *Paul J Radiol*. 2019;84:61–67. doi: 10.5114/pjr.2019.82743

20. Mahesh M, Scatarige JC, Cooper J, Fishman EK. Dose and pitch relationship for a particular multislice CT scanner. *AJR Am J Roentgenol*. 20011;77(6):1273–1275. doi: 10.2214/ajr.177.6.1771273

21. Tack D, Gevenois PA, Abada H. Radiation dose from adult and pediatric multidetector computed tomography. *Springer*. 2007. doi: 10.1007/978-3-540-68575-3

22. Greffier J, Pereira F, Hamard A, et al. Effect of tin filter-based spectral shaping CT on image quality and radiation dose for routine use on ultralow-dose CT protocols: A phantom study. *Diagnostic Interventional Imaging*. 2020;101(6):373–381. doi: 10.1016/j.diii.2020.01.002

23. Paul J, Krauss B, Banckwitz R, et al. Relationships of clinical protocols and reconstruction kernels with image quality and radiation dose in a 128-slice CT scanner: Study with an anthropomorphic and water phantom // *Eur J Radiology*. 2012;81(5):e699–e703. doi: 10.1016/j.ejrad.2011.01.078

24. Hashemi S, Mehrez H, Cobbold RS, Paul NS. Optimal image reconstruction for detection and characterization of small pulmonary nodules during low-dose CT. *Eur Radiol*. 2014;24(6):1239–1250. doi: 10.1007/s00330-014-3142-9

25. Beister M, Kolditz D, Kalender WA. Iterative reconstruction methods in X-ray CT. *Physica Medica*. 2012;28(2):94–108. doi: 10.1016/j.ejmp.2012.01.003

26. Shiri I, Akhavanallaf A, Sanaat A, et al. Ultra-low-dose chest CT imaging of COVID-19 patients using a deep residual neural network. *Eur Radiology*. 2021;31(3):1420–1431. doi: 10.1007/s00330-020-07225-6

27. Shan H, Padole A, Homayounieh F, et al. Competitive performance of a modularized deep neural network compared to commercial algorithms for low-dose CT image reconstruction. *Nat Machine Intelligence*. 2019;1(6):269–276. doi: 10.1038/s42256-019-0057-9

28. Blokhin I, Gombolevskiy V, Chernina V, et al. Inter-observer agreement between low-dose and standard-dose CT with soft and sharp convolution kernels in COVID-19 pneumonia. *J Clin Med*. 2022;11:669. doi: 10.3390/jcm11030669

29. Filatova DA, Sinitsyn VE, Mershina EA. The possibilities of reducing radiation exposure during computed tomography to assess changes in the lungs characteristic of COVID-19: The use of adaptive statistical iterative reconstruction. *Digital Diagnostics*. 2021;2(2):94–104. (In Russ). doi: 10.17816/DD62477

30. Afshar P, Rafiee MJ, Naderkhani F, et al. Human-level COVID-19 diagnosis from low-dose CT scans using a two-stage time-distributed capsule network. *Sci Rep*. 2022;12(1):4827. doi: 10.1038/s41598-022-08796-8

31. Fukumoto W, Nakamura Y, Yoshimura K, et al. Triaging of COVID-19 patients using low dose chest CT: Incidence and factor analysis of lung involvement on CT images. *J Infect Chemother*. 2022;28(6):797–801. doi: 10.1016/j.jiac.2022.02.025

32. Bieba CM, Desmet JN, Dubbeldam A, et al. Radiological findings in low-dose CT for COVID-19 pneumonia in 182 patients: Correlation of signs and severity with patient outcome. *Medicine (Baltimore)*. 2022;101(9):e28950. doi: 10.1097/MD.0000000000028950

33. Piqueras BM, Casajús EA, Iriarte UC, et al. Low-dose chest CT for preoperative screening for SARS-CoV-2 infection. *Radiologia (Engl Ed)*. 2022;64(4):317–323. doi: 10.1016/j.rxeng.2021.11.004

34. Thieß HM, Bressem KK, Adams L, et al. Do submillisievert-chest CT protocols impact diagnostic quality in suspected COVID-19 patients? *Acta Radiol Open*. 2022;11(1):20584601211073864. doi: 10.1177/20584601211073864

35. Greffier J, Hoballah A, Sadate A, et al. Ultra-low-dose chest CT performance for the detection of viral pneumonia patterns during the COVID-19 outbreak period: A monocentric experience. *Quant Imaging Med Surg*. 2021;11(7):3190–3199. doi: 10.21037/qims-20-1176

36. Karakaş HM, Yıldırım G, Çiçek ED. The reliability of low-dose chest CT for the initial imaging of COVID-19: Comparison of structured findings, categorical diagnoses and dose levels. *Diagn Interv Radiol*. 2021;27(5):607–614. doi: 10.5152/dir.2021.20802

37. Finance J, Zieleskewicz L, Habert P, et al. Low dose chest CT and lung ultrasound for the diagnosis and management of COVID-19. *J Clinic Med*. 2021;10(10):2196. doi: 10.3390/jcm10102196

38. Desmet J, Biebaû C, De Wever W, et al. Performance of low-dose chest CT as a triage tool for suspected COVID-19 patients. *J Belgian Society Radiology*. 2021;105(1):9. doi: 10.5334/jbsr.2319

39. Aslan S, Bekçi T, Çakır İM, et al. Diagnostic performance of low-dose chest CT to detect COVID-19: A Turkish population study. *Diagn Interv Radiol*. 2021;27(2):181–187. doi: 10.5152/dir.2020.20350

40. Stoleriu MG, Gerckens M, Obereisenbuchner F, et al. Automated quantitative thin slice volumetric low dose CT analysis predicts disease severity in COVID-19 patients. *Clin Imaging*. 2021;79:96–101. doi: 10.1016/j.clinimag.2021.04.008

41. Bai L, Zhou J, Shen C, et al. Assessment of radiation doses and image quality of multiple low-dose CT exams in COVID-19 clinical management. *Chin J Acad Radiol*. 2021;4(4):257–261. doi: 10.1007/s42058-021-00083-1

42. Agostini A, Borgheresi A, Carotti M, et al. Third-generation iterative reconstruction on a dual-source, high-pitch, low-dose chest CT protocol with tin filter for spectral shaping at 100 kV: A study on a small series of COVID-19 patients. *Radiol Med*. 2021;126(3):388–398. doi: 10.1007/s11547-020-01298-5

43. Zali A, Sohrabi MR, Mahdavi A, et al. Correlation between low-dose chest computed tomography and RT-PCR results for the diagnosis of COVID-19: A report of 27,824 cases in Tehran, Iran. *Acad Radiol*. 2021;28(12):1654–1661. doi: 10.1016/j.acra.2020.09.003

44. Argentieri G, Bellesi L, Pagnamenta A, et al. Diagnostic yield, safety, and advantages of ultra-low dose chest CT compared to chest radiography in early stage suspected SARS-CoV-2 pneumonia: A retrospective observational study. *Medicine (Baltimore)*. 2021;100(21):e26034. doi: 10.1097/MD.0000000000026034

45. Leger T, Jacquier A, Barral PA, et al. Low-dose chest CT for diagnosing and assessing the extent of lung involvement of SARS-CoV-2 pneumonia using a semi quantitative score. *PLoS One*. 2020;15(11):e0241407. doi: 10.1371/journal.pone.0241407

46. Hamper CM, Fleckenstein FN, Büttner L, et al. Submillisievert chest CT in patients with COVID-19: experiences of a German Level-I center. *Eur J Radiol Open*. 2020;7:100283. doi: 10.1016/j.ejro.2020.100283

47. Li J, Wang X, Huang X, et al. Application of Care Dose 4D combined with Karl 3D technology in the low dose computed tomography for the follow-up of COVID-19. *BMC Med Imaging*. 2020;20(1):56. doi: 10.1186/s12880-020-00456-5

48. Dangis A, Gieraerts C, De Bruecker Y, et al. Accuracy and reproducibility of low-dose submillisievert chest CT for the diagnosis of COVID-19. *Radiol Cardiothorac Imaging*. 2020;2(2):e200196. doi: 10.1148/ryct.2020200196

49. Radpour A, Bahrami-Motlagh H, Taaghi MT, et al. COVID-19 evaluation by low-dose high resolution CT scans protocol. *Acad Radiol*. 2020;27(6):901. doi: 10.1016/j.acra.2020.04.016

50. Tofighi S, Najafi S, Johnston SK, Gholamrezanezhad A. Low-dose CT in COVID-19 outbreak: Radiation safety, image wisely, and image gently pledge. *Emerg Radiol*. 2020;27(6):601–605. doi: 10.1007/s10140-020-01784-3

51. Tabatabaei SM, Talari H, Gholamrezanezhad A, et al. A low-dose chest CT protocol for the diagnosis of COVID-19 pneumonia: A prospective study. *Emerg Radiol*. 2020;27(6):607–615. doi: 10.1007/s10140-020-01838-6

52. Schulze-Hagen M, Hübel C, Meier-Schroers M, et al. Low-dose chest CT for the diagnosis of COVID-19: A systematic, prospective comparison with PCR. *Dtsch Arztebl Int*. 2020;117(22-23):389–395. doi: 10.3238/arztebl.2020.0389

53. Zhao Y, Wang Y, Duan W, et al. Low-dose chest CT presentation and dynamic changes in patients with novel coronavirus disease 2019. *Radiol Infect Dis*. 2020;7(4):186–194. doi: 10.1016/j.jrid.2020.08.001

54. Castelli M, Maurin A, Bartoli A, et al. Prevalence and risk factors for lung involvement on low-dose chest CT (LDCT) in a paucisymptomatic population of 247 patients affected by COVID-19. *Insights Imaging*. 2020;11(1):117. doi: 10.1186/s13244-020-00939-7

55. Morozov SP, Kuzmina ES, Vetsheva NN, et al. Moscow screening: screening of lung cancer using low-dose computed tomography. *Problems Social Hygiene Healthcare History Med*. 2019;27(S):630–636. (In Russ). doi: 10.32687/0869-866X-2019-27-si1-630-636

56. Patent RUS No. 2701922 C1. Gombolevsky VA, Morozov SP, Chernina VYu, et al. A method for screening lung cancer using ultra-low-dose computed tomography in patients with a body weight of up to 69 kg. mode: Available from: https://patents.google.com/patent/RU2701922C1/ru. Accessed: 15.01.2023.

57. Gombolevskiy V, Morozov S, Chernina V, et al. A phantom study to optimise the automatic tube current modulation for chest CT in COVID-19. *Eur Radiol Exp*. 2021;5(1):21. doi: 10.1186/s41747-021-00218-0

58. Kim YK, Lee BE, Lee SJ, et al. Ultra-low-dose CT of the thorax using iterative reconstruction: Evaluation of image quality and radiation dose reduction. *Am J Roentgenol*. 2015;204(6):1197–1202. doi: 10.2214/AJR.14.13629

59. Blokhin IA, Gonchar AP, Kotenko MR, et al. The influence of body mass index on the reliability of the 0–4 CT scale: Comparison of computed tomography protocols. *Digital Diagnostics*. 2022;3(2):108–118. (In Russ). doi: 10.17816/DD104358

60. Gierada DS, Bierhals AJ, Choong CK, et al. Effects of CT section thickness and reconstruction kernel on emphysema quantification. *Academic Radiology*. 2010;17(2):146–156. doi: 10.1016/j.acra.2009.08.007

61. Gao Y, Hua M, Lv J, et al. Reproducibility of radiomic features of pulmonary nodules between low-dose CT and conventional-dose CT. *Quant Imaging Med Surg*. 2022;12(4):2368–2377. doi: 10.21037/qims-21-609

62. Blokhin IA, Solovev AV, Vladzymyrskiy AV, et al. Automated analysis of lung lesions in COVID-19: Comparison of standard and low-dose CT. *SJCEM*. 2023;37(4):114–123. (In Russ). doi: 10.29001/2073-8552-2022-37-4-114-123

63. Bak SH, Kim JH, Jin H, et al. Emphysema quantification using low-dose computed tomography with deep learning-based kernel conversion comparison. *Eur Radiol*. 2020;30(12):6779–6787. doi: 10.1007/s00330-020-07020-3

СПИСОК ЛИТЕРАТУРЫ

1. Yang Y., Yang M., Shen C., et al. Evaluating the accuracy of different respiratory specimens in the laboratory diagnosis and monitoring the viral shedding of 2019-nCoV infections // medRxiv. 2020. doi: 10.1101/2020.02.11.20021493

2. Rubin G.D., Ryerson C.J., Haramati L.B., et al. The role of chest imaging in patient management during the COVID-19 Pandemic: A multinational consensus statement from the fleischner society // Radiology. 2020. Vol. 296, N 1. P. 172–180. doi: 10.1148/radiol.2020201365

3. Временные методические рекомендации. Профилактика, диагностика и лечение новой коронавирусной инфекции (COVID-19). Версия 12 (21.09.2021). Москва, 2021. 232 с.

4. Ng M., Lee E.Y., Yang J., et al. Imaging profile of the COVID-19 infection: Radiologic findings and literature review // Radiology: Cardiothoracic Imaging. 2020. Vol. 2, N 1. P. e200034. doi: 10.1148/ryct.2020200034

5. Ai T., Yang Z., Hou H., et al. Correlation of chest CT and RT-PCR testing for coronavirus disease 2019 (COVID-19) in China: A report of 1014 cases // Radiology. 2020. Vol. 296, N 2. P. E32–E40. doi: 10.1148/radiol.2020200642

6. Kang Z., Li X., Zhou S. Recommendation of low-dose CT in the detection and management of COVID-2019 // European Radiolohy. 2020. Vol. 30, N 8. P. 4356–4357. doi: 10.1007/s00330-020-06809-6

7. Морозов С.П., Кузьмина Е.С., Ледихова Н.В., и др. Мобилизация научно-практического потенциала службы лучевой диагностики г. Москвы в пандемию COVID-19 // Digital Diagnostics. 2020. Т. 1, № 1. С. 5–12. doi: 10.17816/DD51043

8. Pan F., Ye T., Sun P., et al. Time course of lung changes on chest CT during recovery from 2019 novel coronavirus (COVID-19) pneumonia // Radiology. 2020. Vol. 295, N 3. P. 715–721. doi: 10.1148/radiol.2020200370

9. Lei D.P., Fan B., Mao J., et al. The progression of computed tomographic (CT) images in patients with coronavirus disease (COVID-19) pneumonia. Running title: The CT progression of COVID-19 pneumonia // J Infect. 2020. Vol. 80, N 6. P. e30–e31. doi: 10.1016/j.jinf.2020.03.020

10. Power S.P., Moloney F., Twomey M., et al. Computed tomography and patient risk: Facts, perceptions and uncertainties // World J Radiol. 2016. Vol. 8, N 12. P. 902–915. doi: 10.4329/wjr.v8.i12.902

11. Yeung A.W. The "As low as reasonably achievable" (ALARA) principle: A brief historical overview and a bibliometric analysis of the most cited publications // Radioprotection. 2019. Vol. 54, N 2. P. 103–109. doi: 10.1051/radiopro/2019016

12. Kalra M.K., Homayounieh F., Arru C., et al. Chest CT practice and protocols for COVID-19 from radiation dose management perspective // Eur Radiol. 2020. Vol. 30, N 12. P. 6554–6560. doi: 10.1007/s00330-020-07034-x

13. Краснов А.С., Кабанов Д.О., Терещенко Г.В. Основы дозиметрии и оптимизации дозовой нагрузки при проведении мультиспиральной компьютерной томографии // Вопросы гематологии, онкологии и иммунопатологии в педиатрии. 2018. Т. 17, № 3. С. 127–132.

14. Singh S., Kalra M.K., Thrall J.H., Mahesh M. CT radiation dose reduction by modifying primary factors // J Am Coll Radiol. 2011. Vol. 8, N 5. P. 369–372. doi: 10.1016/j.jacr.2011.02.001

15. Zarb F., Rainford L., McEntee M.F. Developing optimized CT scan protocols: Phantom measurements of image quality // Radiography. 2011. Vol. 17, N 2. P. 109–114. doi: 10.1016/j.radi.2010.10.004

16. Hilts M., Duzenli C. Image noise in X-ray CT polymer gel dosimetry // J Physics: Conference Series. 2004. Vol. 3, N 1. P. 252. doi: 10.1088/1742-6596/3/1/040

17. Lira D., Padole A., Kalra M.K., Singh S. Tube potential and CT radiation dose optimization // Am J Roentgenol. 2015. Vol. 204, N 1. P. W4–W10. doi: 10.2214/AJR.14.13281

18. Reid J., Gamberoni J., Dong F., Davros W. Optimization of kVp and mAs for pediatric low-dose simulated abdominal CT: Is it best to base parameter selection on object circumference? // AJR Am J Roentgenol. 2010. Vol. 195, N 4. P. 1015–1020. doi: 10.2214/AJR.09.3862

19. Khoramian D., Sistani S., Firouzjah R.A. Assessment and comparison of radiation dose and image quality in multi-detector CT scanners in non-contrast head and neck examinations // Paul J Radiol. 2019. Vol. 84. P. 61–67. doi: 10.5114/pjr.2019.82743

20. Mahesh M., Scatarige J.C., Cooper J., Fishman E.K. Dose and pitch relationship for a particular multislice CT scanner // AJR Am J Roentgenol. 2001. Vol. 177, N 6. P. 1273–1275. doi: 10.2214/ajr.177.6.1771273

21. Tack D., Gevenois P.A., Abada H. Radiation dose from adult and pediatric multidetector computed tomography // Springer. 2007. doi: 10.1007/978-3-540-68575-3

22. Greffier J., Pereira F., Hamard A., et al. Effect of tin filter-based spectral shaping CT on image quality and radiation dose for routine use on ultralow-dose CT protocols: A phantom study // Diagnostic and Interventional Imaging. 2020. Vol. 101, N 6. P. 373–381. doi: 10.1016/j.diii.2020.01.002

23. Paul J., Krauss B., Banckwitz R., et al. Relationships of clinical protocols and reconstruction kernels with image quality and radiation dose in a 128-slice CT scanner: Study with an anthropomorphic and water phantom // Eur J Radiology. 2012. Vol. 81, N 5. P. e699–e703. doi: 10.1016/j.ejrad.2011.01.078

24. Hashemi S., Mehrez H., Cobbold R.S., Paul N.S. Optimal image reconstruction for detection and characterization of small pulmonary nodules during low-dose CT // Eur Radiol. 2014. Vol. 24, N 6. P. 1239–1250. doi: 10.1007/s00330-014-3142-9

25. Beister M., Kolditz D., Kalender W.A. Iterative reconstruction methods in X-ray CT // Physica Medica. 2012. Vol. 28, N 2. P. 94–108. doi: 10.1016/j.ejmp.2012.01.003

26. Shiri I., Akhavanallaf A., Sanaat A., et al. Ultra-low-dose chest CT imaging of COVID-19 patients using a deep residual neural network // Eur Radiology. 2021. Vol. 31, N 3. P. 1420–1431. doi: 10.1007/s00330-020-07225-6

27. Shan H., Padole A., Homayounieh F., et al. Competitive performance of a modularized deep neural network compared to commercial algorithms for low-dose CT image reconstruction // Nat Machine Intelligence. 2019. Vol. 1, N 6. P. 269–276. doi: 10.1038/s42256-019-0057-9

28. Blokhin I., Gombolevskiy V., Chernina V., et al. Inter-observer agreement between low-dose and standard-dose CT with soft and sharp convolution kernels in COVID-19 Pneumonia // J Clin Med. 2022. Vol. 11, N 669. doi: 10.3390/jcm11030669

29. Филатова Д.А., Синицын В.Е., Мершина Е.А. Возможности снижения лучевой нагрузки при проведении компьютерной томографии для оценки изменений в легких, характерных для COVID-19: использование адаптивной статистической итеративной реконструкции // Digital Diagnostics. 2021. Т. 2, № 2. С. 94–104. doi: 10.17816/DD62477

30. Afshar P., Rafiee M.J., Naderkhani F., et al. Human-level COVID-19 diagnosis from low-dose CT scans using a two-stage time-distributed capsule network // Sci Rep. 2022. Vol. 12, N 1. P. 4827. doi: 10.1038/s41598-022-08796-8

31. Fukumoto W., Nakamura Y., Yoshimura K., et al. Triaging of COVID-19 patients using low dose chest CT: Incidence and factor analysis of lung involvement on CT images // J Infect Chemother. 2022. Vol. 28, N 6. P. 797–801. doi: 10.1016/j.jiac.2022.02.025

32. Bieba C.M., Desmet J.N., Dubbeldam A., et al. Radiological findings in low-dose CT for COVID-19 pneumonia in 182 patients: Correlation of signs and severity with patient outcome // Medicine (Baltimore). 2022. Vol. 101, N 9. P. e28950. doi: 10.1097/MD.0000000000028950

33. Piqueras B.M., Casajús E.A., Iriarte U.C., et al. Low-dose chest CT for preoperative screening for SARS-CoV-2 infection // Radiologia (Engl.). 2022. Vol. 64, N 4. P. 317–323. doi: 10.1016/j.rxeng.2021.11.004

34. Thieß H.M., Bressem K.K., Adams L., et al. Do submillisievert-chest CT protocols impact diagnostic quality in suspected COVID-19 patients? // Acta Radiol Open. 2022. Vol. 11, N 1. P. 20584601211073864. doi: 10.1177/20584601211073864

35. Greffier J., Hoballah A., Sadate A., et al. Ultra-low-dose chest CT performance for the detection of viral pneumonia patterns during the COVID-19 outbreak period: A monocentric experience // Quant Imaging Med Surg. 2021. Vol. 11, N 7. P. 3190–3199. doi: 10.21037/qims-20-1176

36. Karakaş H.M., Yıldırım G., Çiçek E.D. The reliability of low-dose chest CT for the initial imaging of COVID-19: Comparison of structured findings, categorical diagnoses and dose levels // Diagn Interv Radiol. 2021. Vol. 27, N 5. P. 607–614. doi: 10.5152/dir.2021.20802

37. Finance J., Zieleskewicz L., Habert P., et al. Low dose chest CT and lung ultrasound for the diagnosis and management of COVID-19 // J Clinic Med. 2021. Vol. 10, N 10. P. 2196. doi: 10.3390/jcm10102196

38. Desmet J., Biebaû C., De Wever W., et al. Performance of low-dose chest CT as a triage tool for suspected COVID-19 patients // J Belgian Society Radiology. 2021. Vol. 105, N 1. P. 9. doi: 10.5334/jbsr.2319

39. Aslan S., Bekçi T., Çakır İ.M., et al. Diagnostic performance of low-dose chest CT to detect COVID-19: A Turkish population study // Diagn Interv Radiol. 2021. Vol. 27, N 2. P. 181–187. doi: 10.5152/dir.2020.20350

40. Stoleriu M.G., Gerckens M., Obereisenbuchner F., et al. Automated quantitative thin slice volumetric low dose CT analysis predicts disease severity in COVID-19 patients // Clin Imaging. 2021. Vol. 79. P. 96–101. doi: 10.1016/j.clinimag.2021.04.008

41. Bai L., Zhou J., Shen C., et al. Assessment of radiation doses and image quality of multiple low-dose CT exams in COVID-19 clinical management // Chin J Acad Radiol. 2021. Vol. 4, N 4. P. 257–261. doi: 10.1007/s42058-021-00083-1

42. Agostini A., Borgheresi A., Carotti M., et al. Third-generation iterative reconstruction on a dual-source, high-pitch, low-dose chest CT protocol with tin filter for spectral shaping at 100 kV: A study on a small series of COVID-19 patients // Radiol Med. 2021. Vol. 126, N 3. P. 388–398. doi: 10.1007/s11547-020-01298-5

43. Zali A., Sohrabi M.R., Mahdavi A., et al. Correlation between low-dose chest computed tomography and RT-PCR results for the diagnosis of COVID-19: A report of 27,824 cases in Tehran, Iran // Acad Radiol. 2021. Vol. 28, N 12. P. 1654–1661. doi: 10.1016/j.acra.2020.09.003

44. Argentieri G., Bellesi L., Pagnamenta A., et al. Diagnostic yield, safety, and advantages of ultra-low dose chest CT compared to chest radiography in early stage suspected SARS-CoV-2 pneumonia: A retrospective observational study // Medicine (Baltimore). 2021. Vol. 100, N 21. P. e26034. doi: 10.1097/MD.0000000000026034

45. Leger T., Jacquier A., Barral P.A., et al. Low-dose chest CT for diagnosing and assessing the extent of lung involvement of SARS-CoV-2 pneumonia using a semi quantitative score // PLoS One. 2020. Vol. 15, N 11. P. e0241407. doi: 10.1371/journal.pone.0241407

46. Hamper C.M., Fleckenstein F.N., Büttner L., et al. Submillisievert chest CT in patients with COVID-19: Experiences of a German Level-I center // Eur J Radiol Open. 2020. Vol. 7. P. 100283. doi: 10.1016/j.ejro.2020.100283

47. Li J., Wang X., Huang X., et al. Application of Care Dose 4D combined with Karl 3D technology in the low dose computed tomography for the follow-up of COVID-19 // BMC Med Imaging. 2020. Vol. 20, N 1. P. 56. doi: 10.1186/s12880-020-00456-5

48. Dangis A., Gieraerts C., De Bruecker Y., et al. Accuracy and reproducibility of low-dose submillisievert chest CT for the diagnosis of COVID-19 // Radiol Cardiothorac Imaging. 2020. Vol. 2, N 2. P. e200196. doi: 10.1148/ryct.2020200196

49. Radpour A., Bahrami-Motlagh H., Taaghi M.T., et al. COVID-19 evaluation by low-dose high resolution CT scans protocol // Acad Radiol. 2020. Vol. 27, N 6. P. 901. doi: 10.1016/j.acra.2020.04.016

50. Tofighi S., Najafi S., Johnston S.K., Gholamrezanezhad A. Low-dose CT in COVID-19 outbreak: Radiation safety, image wisely, and image gently pledge // Emerg Radiol. 2020. Vol. 27, N 6. P. 601–605. doi: 10.1007/s10140-020-01784-3

51. Tabatabaei S.M., Talari H., Gholamrezanezhad A., et al. A low-dose chest CT protocol for the diagnosis of COVID-19 pneumonia: A prospective study // Emerg Radiol. 2020. Vol. 27, N 6. P. 607–615. doi: 10.1007/s10140-020-01838-6

52. Schulze-Hagen M., Hübel C., Meier-Schroers M., et al. Low-dose chest CT for the diagnosis of COVID-19: A systematic, prospective comparison with PCR // Dtsch Arztebl Int. 2020. Vol. 117, N 22-23. P. 389–395. doi: 10.3238/arztebl.2020.0389

53. Zhao Y., Wang Y., Duan W., et al. Low-dose chest CT presentation and dynamic changes in patients with novel coronavirus disease 2019 // Radiol Infect Dis. 2020. Vol. 7, N 4. P. 186–194. doi: 10.1016/j.jrid.2020.08.001

54. Castelli M., Maurin A., Bartoli A., et al. Prevalence and risk factors for lung involvement on low-dose chest CT (LDCT) in a paucisymptomatic population of 247 patients affected by COVID-19 // Insights Imaging. 2020. Vol. 11, N 1. P. 117. doi: 10.1186/s13244-020-00939-7

55. Морозов С.П., Кузьмина Е.С., Ветшева Н.Н., и др. Московский скрининг: скрининг рака легкого с помощью низкодозовой компьютерной томографии // Проблемы социальной гигиены, здравоохранения и истории медицины. 2019. Т. 27, № S. С. 630–636. doi: 10.32687/0869-866X-2019-27-si1-630-636

56. Патент РФ № 2701922 C1. Гомболевский В.А., Морозов С.П., Чернина В.Ю., и др. Способ скрининга рака легкого с помощью ультранизкодозной компьютерной томографии у пациентов с массой тела до 69 кг. Режим доступа: https://patents.google.com/patent/RU2701922C1/ru. Дата обращения: 15.01.2023.

57. Gombolevskiy V., Morozov S., Chernina V., et al. A phantom study to optimise the automatic tube current modulation for chest CT in COVID-19 // Eur Radiol Exp. 2021. Vol. 5, N 1. P. 21. doi: 10.1186/s41747-021-00218-0

58. Kim Y.K., Lee B.E., Lee S.J., et al. Ultra-low-dose CT of the thorax using iterative reconstruction: Evaluation of image quality and radiation dose reduction // Am J Roentgenol. 2015. Vol. 204, N 6. P. 1197–1202. doi: 10.2214/AJR.14.13629

59. Блохин И.А., Гончар А.П., Коденко М.Р., и др. Влияние индекса массы тела на надёжность шкалы КТ0–4: сравнение протоколов компьютерной томографии // Digital Diagnostics. 2022. Т. 3, № 2. С. 108–118. doi: 10.17816/DD104358

60. Gierada D.S., Bierhals A.J., Choong C.K., et al. Effects of CT section thickness and reconstruction kernel on emphysema quantification // Academic Radiology. 2010. Vol. 17, N 2. P. 146–156. doi: 10.1016/j.acra.2009.08.007

61. Gao Y., Hua M., Lv J., et al. Reproducibility of radiomic features of pulmonary nodules between low-dose CT and conventional-dose CT // Quant Imaging Med Surg. 2022. Vol. 12, N 4. P. 2368–2377. doi: 10.21037/qims-21-609

62. Blokhin I.A., Solovev A.V., Vladzymyrskiy AV., et al. Automated analysis of lung lesions in COVID-19: Comparison of standard and low-dose CT // SJCEM. 2023. Vol. 37, N 4. P. 114–123. doi: 10.29001/2073-8552-2022-37-4-114-123

63. Bak S.H., Kim J.H., Jin H., et al. Emphysema quantification using low-dose computed tomography with deep learning-based kernel conversion comparison // Eur Radiol. 2020. Vol. 30, N 12. P. 6779–6787. doi: 10.1007/s00330-020-07020-3

AUTHORS' INFO

*** Ivan A. Blokhin;**
address: 24/1 Petrovka street, 127051 Moscow, Russia;
ORCID: https://orcid.org/0000-0002-2681-9378;
eLibrary SPIN: 3306-1387; e-mail: BlokhinIA@zdrav.mos.ru

Denis A. Rumyantsev;
ORCID: https://orcid.org/0000-0001-7670-7385;
eLibrary SPIN: 8734-2085; e-mail: x.radiology@mail.ru

Maria M. Suchilova;
ORCID: https://orcid.org/0000-0003-1117-0294;
eLibrary SPIN: 4922-1894; e-mail: SuchilovaMM@zdrav.mos.ru

Anna P. Gonchar;
ORCID: https://orcid.org/0000-0001-5161-6540;
eLibrary SPIN: 3513-9531; e-mail: GoncharAP@zdrav.mos.ru

Olga V. Omelyanskaya;
ORCID: https://orcid.org/0000-0002-0245-4431;
eLibrary SPIN: 8948-6152;
e-mail: OmelyanskayaOV@zdrav.mos.ru

ОБ АВТОРАХ

*** Блохин Иван Андреевич;**
адрес: Россия, 127051, Москва, ул. Петровка, д. 24, стр. 1;
ORCID: https://orcid.org/0000-0002-2681-9378;
eLibrary SPIN: 3306-1387; e-mail: BlokhinIA@zdrav.mos.ru

Румянцев Денис Андреевич;
ORCID: https://orcid.org/0000-0001-7670-7385;
eLibrary SPIN: 8734-2085; e-mail: x.radiology@mail.ru

Сучилова Мария Максимовна;
ORCID: https://orcid.org/0000-0003-1117-0294;
eLibrary SPIN: 4922-1894; e-mail: SuchilovaMM@zdrav.mos.ru

Гончар Анна Павловна;
ORCID: https://orcid.org/0000-0001-5161-6540;
eLibrary SPIN: 3513-9531; e-mail: GoncharAP@zdrav.mos.ru

Омелянская Ольга Васильевна;
ORCID: https://orcid.org/0000-0002-0245-4431;
eLibrary SPIN: 8948-6152;
e-mail: OmelyanskayaOV@zdrav.mos.ru

---

* Corresponding author / Автор, ответственный за переписку