Возможности снижения лучевой нагрузки при проведении компьютерной томографии для оценки изменений в лёгких, характерных для COVID–19: использование адаптивной статистической итеративной реконструкции

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АННОТАЦИЯ

Обоснование. Большинство пациентов с COVID-19 во время госпитализации проходит многократные визуализационные обследования, кумулятивный эффект которых может значительно увеличивать общую дозу полученного облучения. Эффективная доза облучения может быть снижена за счёт уменьшения тока и напряжения рентгеновской трубки, что, однако, снижает качество изображения. Возможным решением этой проблемы может стать внедрение технологии адаптивной статистической итерационной реконструкции «сырых данных» компьютерной томографии (КТ) — Adaptive Statistical Iterative Reconstruction (ASIR). В последнее время в литературе появились сведения об эффективности низкодозной КТ (НДКТ) в диагностике COVID-19.

Цель — анализ качества и диагностической ценности НДКТ-изображений лёгких после применения итеративного алгоритма обработки; оценка возможности снижения лучевой нагрузки на пациента при диагностике COVID-19.

Материал и методы. В проспективном исследовании приняли участие пациенты, проходившие стационарное лечение в инфекционном отделении МНОЦ МГУ им. М.В. Ломоносова. Исследования КТ выполнялись при поступлении и выписке; в период госпитализации их повторяли по мере клинической необходимости. При первом исследовании использовался стандартный протокол КТ с напряжением тока на трубке 120 кВ и автоматическим модулированием силы тока в диапазоне 200–400 мА, при повторных КТ применяли протокол НДКТ с уменьшенными параметрами напряжения тока на трубке (100 или 110 кВ) и автоматической модуляцией тока в диапазоне 40–120 мА. Для оценки диагностической ценности НДКТ по сравнению со стандартной КТ было проведено анкетирование среди врачей отделения лучевой диагностики МНОЦ МГУ. Анкета включала в себя сравнительную характеристику двух методик при выявлении таких патологических процессов, как уплотнение лёгочной ткани по типу матового стекла, уплотнение по типу матового стекла с ретикулярными изменениями, участки консолидации лёгочной ткани, лимфаденопатия.

Результаты. В исследовании принял участие 151 пациент; средний возраст 58±14,2 года; 53,6% мужчин. При НДКТ в сравнении со стандартной КТ лучевая нагрузка снижалась в среднем в 2,96 раза, компьютерно-томографический индекс дозы (CTDI) — в 2,6 раза, средняя поглощённая доза (DLP) — в 3,1 раза, сила тока на трубке — в 1,83 раза, напряжение на трубке — в 1,2 раза. Полученные анкетные данные свидетельствуют о том, что при проведении НДКТ эффективность выявления основных признаков вирусной пневмонии и оценки динамики состояния пациента существенно не меняется по сравнению с КТ, проведённой по стандартному протоколу.

Заключение. Результаты сравнения стандартной и НДКТ демонстрируют отсутствие значимых потерь диагностической информации и качества при снижении лучевой нагрузки. Таким образом, НДКТ грудной клетки может использоваться в рутинной практике для успешной диагностики COVID-19.

Ключевые слова: COVID-19; НДКТ; лёгкие; лучевая нагрузка; SARS-CoV-2.

Opportunities to reduce the radiation exposure during computed tomography to assess the changes in the lungs in patients with COVID-19: use of adaptive statistical iterative reconstruction

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ABSTRACT

BACKGROUND: Several COVID-19 patients are subjected to multiple imaging examinations during hospitalization, the cumulative effect of which can significantly increase the total dose of radiation received. The effective radiation dose can be reduced by lowering the current and voltage of the X-ray tube, but this reduces image quality. One possible solution is to use adaptive statistical iterative reconstruction technology on the «raw» CT data. Recently, data on the efficacy of low-dose CT (LDCT) in the diagnosis of COVID-19 have appeared in the literature.

AIM: To analyze the quality and diagnostic value of LDCT images of the lungs after applying an iterative processing algorithm and to assess the possibility of reducing the radiation load on the patient when diagnosing COVID-19.

MATERIALS AND METHODS: Patients from the Infectious Diseases Department of the Moscow State University Hospital participated in the prospective study. CT examinations were performed at the time of patient admission and discharge and were repeated as needed during hospitalization. In the first study, a standard CT protocol with a tube voltage of 120 kV and automatic current modulation in the range of 200–400 mA was used; in repeated CT scans, the LDCT protocol was used with reduced tube voltage parameters (100 or 110 kV) and automatic current modulation in the range of 40–120 mA. To assess the diagnostic value of LDCT in comparison with standard CT, a survey was conducted among doctors from the Department of Radiation Diagnostics at Moscow State University Hospital. The questionnaire included a comparison of the two methods for identifying the following pathological processes: «ground-glass» opacities, compaction of the lung tissue with reticular changes, areas of lung tissue consolidation, and lymphadenopathy.

RESULTS: The study included 151 patients. The average age was 58±14.2 years, with men accounting for 53.6% of the population. During LDCT the radiation load was reduced by 2.96 times on average, CTDI by 2.6 times, DLP by 3.1 times, the current on the tube by 1.83 times, and the voltage on the tube by 1.2 times. The results indicate that the effectiveness of detecting the main signs of viral pneumonia and assessing the dynamics of the patient's condition does not differ significantly from CT performed according to the standard protocol.

CONCLUSIONS: The results of a comparison of standard and low-dose CT show that there is no significant loss of diagnostic information and image quality as the radiation load is reduced. Thus, chest LDCT can be used to successfully diagnose COVID-19 in routine practice.

Keywords: COVID-19; X-ray computed tomography; lung; radiation protection; SARS-CoV-2.

在计算机断层扫描期间减少辐射负荷以评估COVID-19肺特性变化的可能性：使用自适应统计迭代重建

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简评

论证大多数COVID-19患者在住院期间接受多次成像检查，其累积效应可以显着增加接受的辐射总剂量。有效辐射剂量可以通过降低x射线管的电流和电压来降低，然而，这会降低图像质量。这个问题的一个可能的解决方案是引入自适应统计迭代重建 （Adaptive Statistical Iterative Reconstruction （ASIR））技术，用于计算机断层扫描（CT）的»原始数据»的自适应统计迭代重建。最近，有关低剂量CT（LDCT）有效性的信息已经出现在COVID-19诊断中的文献中。

目的是在应用迭代处理算法后分析肺部LDCT图像的质量和诊断价值，以评估在COVID-19诊断期间减少患者辐射负荷的可能性。

材料与方法。这项前瞻性研究涉及在罗蒙诺索夫莫斯科国立大学医学中心传染病部门接受住院治疗的患者。CT研究在入院和出院时进行； 在住院期间，根据临床需要重复进行。在第一项研究中，使用120kV管电压和200-400mA范围内的自动电流调制的标准CT协议，通过重复CT扫描的时候，LDKT协议使用管电压（100或110kV）和40-120mA范围内的自动电流调。为了评估LDCT与标准CT相比的诊断价值，在莫斯科国立大学医学中心辐射诊断系的医生中进行了问卷调查。调查问卷包括两种方法的比较描述，用于检测这种病理过程，如通过磨砂玻璃类型压实肺组织，通过磨砂玻璃类型压实具有网状变化，肺组织固结区域，淋巴结病。

结果该研究涉及151名患者；平均年龄为58±14.2岁；男性为53.6%。使用LDCT，与标准CT相比，辐射负荷平均下降2.96倍，计算机断层扫描剂量指数（CTDI）−2.6倍，平均吸收剂量（DLP）−3.1倍，管上的电流−1.83倍，管上的电压-1.2倍。获得的问卷数据表明，在LDCT期间，与根据标准协议进行的CT相比，检测病毒性肺炎的主要体征和评估患者病情动态的有效性没有显着变化。

结论比较标准的CT和LDCT的结果表明，在辐射负荷降低的情况下，诊断信息和质量没有显着损失。因此，胸部的LDCT扫描可以在常规实践中用于成功诊断COVID-19。

关键词：COVID-19；LDCT；肺；辐射负荷；SARS-CoV-2。

BACKGROUND

During the coronavirus disease 2019 (COVID-19) pandemic, computed tomography (CT) studies are used to diagnose coronavirus pneumonia in both outpatient and inpatient settings and are recommended to be performed in patients suspected or verified with COVID-19 on the day of hospitalization for an initial examination, then repeatedly after 2–3 days if the required therapeutic effect is not achieved and then after 5–7 days in the absence or improvement of symptoms dynamics [1–5].

A number of patients with COVID-19 undergo multiple imaging studies during hospitalization, whose cumulative effect can significantly increase the total dose of radiation received. The principle "as low as reasonably achievable" (ALARA) states that whenever radiation is required, the impact should be ALARA. Bearing in mind this important principle, it is extremely important to remember that any CT scan must be accompanied by a justification of examination and optimization of radiation dose [6]. CT scans are significant aid in diagnosing COVID-19; however, the potential to increase radiation exposure of large numbers of patients across the country cannot be ignored. Maintaining the balance between the need for efficient imaging for rapid diagnostics and efforts to minimize radiation exposure is important.

Effective dose of radiation during CT studies can be decreased by reducing the current and voltage of X-ray tube; however, this leads to image quality distortion due to an increase in the amount of noise and artifacts. A possible solution to this problem is the introduction of technology adaptive to statistical iterative reconstruction of CT "raw data," for example, using the Adaptive Statistical Iterative Reconstruction (ASIR) technology and numerous similar methods [7–9].

Recently, data on the efficiency of low-dose CT (LDCT) in diagnostics of COVID-19 compared with standard one were presented in literature. It should be noted that CT with a radiation dose of 0.2 mSv or less is considered low dose. In a retrospective study, LDCT with iterative reconstruction in the diagnostics of COVID-19 demonstrated sensitivity, specificity, and predictive value of approximately 90%. Values of these parameters increased to 96% if patients had symptoms for >48 hours. Disease probability increased from 43.2% (before the test) to 91.1% or 91.4% (after the test) in patients with a positive CT scan, whereas the probability of disease decreased from 43.2% (before the test) to 9.6% or 3.7% (after the test) in patients with negative CT result. Additionally, LDCT revealed an additive diagnostic advantage in patients with concomitant bacterial pneumonia or an alternative diagnosis other than COVID-19 [10]. Research in this promising field is actively performed.

This study aimed to analyze the quality and diagnostic value of LDCT images of the lungs after applying the ASIR processing algorithm and to assess the possibility of reducing radiation exposure of patients diagnosed with COVID-19.

METHODS

Study design

Patients undergoing inpatient treatment at the infectious diseases department of the M.V. Lomonosov Moscow State University Medical Research and Education Center took part in a prospective, single-center, uncontrolled study. CT examinations were performed upon patient admission and discharge, then were repeated as clinically required during the period of hospitalization, but at least once every 5 days. Study 1 was conducted in all patients in the standard CT mode, subsequent ones were conducted in LDCT mode.

The primary endpoint of the study was the absence of a significant loss of diagnostic information during LDCT compared to standard CT.

Inclusion criteria

Inclusion criteria included infection with COVID-19 verified by molecular genetic studies (polymerase chain reaction method, PCR), and undergoing inpatient treatment.

Conducting conditions

The study was conducted in the infectious diseases department of the Moscow State University Medical Research and Education Center with the involvement of patients who were hospitalized with COVID-19.

Study duration

The study was conducted from April 21 to May 11, 2020.

Medical intervention description

CT of the lungs and chest organs was performed on a 32-row Somatom Scope CT manufactured by Siemens (Germany). Studies were conducted with a slice thickness of 1 mm. The first study used a standard CT protocol with a tube voltage of 120 kV, with an automatic modulation current of 200–400 mA; with repeated CT, the LDCT protocol was used with reduced parameters of tube voltage (100 or 110 kV) and automatic modulation of tube current of 40–120 mA; the ASIR algorithm was used to reduce radiation exposure. All images obtained in DICOM format were stored in the Radiological Information Network of the Moscow State Scientific and Educational Center of Moscow State University. Syngo.via workstations (Siemens, Germany) were used for CT processing and analysis.

A questionnaire survey was conducted among the doctors of the Department of Radiation Diagnostics of the Medical Research and Education Center of the M.V. Lomonosov Moscow State University to assess the diagnostic value of LDCT in comparison with standard CT. The questionnaire included a comparative description of two methods in identifying pathological processes, namely ground glass opacity induration of the lung tissue, ground glass opacity induration with reticular changes (thickened interlobular septa; "patchwork" presentation, crazy paving), areas of consolidation

of lung tissues, and lymphadenopathy. Medical specialists evaluated each of the two methods on a five-point scale, where the worst detectability of a particular pathological process corresponded to 1 point, the best detectability corresponded to 5 points, and then the arithmetic mean was calculated for each item. In conclusion, it was proposed to assess the efficiency of LDCT diagnostics of COVID-19. Each study was assessed by two medical specialists, and decision was independently made in each case.

Primary study outcome

The primary outcome of the study was comparable diagnostic value of CT performed according to the standard protocol and LDCT.

Ethical considerations

The subject of this article was approved at a meeting of the Local Ethics Committee of the Medical Research and Education Center of the M.V. Lomonosov Moscow State University, dated May 25, 2020 (within the research project on diagnostics and treatment of COVID-19 at the Medical Research and Education Center of the M.V. Lomonosov Moscow State University).

Statistical analysis

Statistical analysis was performed using MS Office Excel software.

RESULTS

Study participants

A total of 151 patients who underwent inpatient treatment at the infectious diseases department of the Medical Research and Education Center of the M.V. Lomonosov Moscow State University participated in the study. The average age of patients was 58 ± 14.2 years; wherein 70 were women (46.4%) and 81 were men (53.6%). COVID-19 diagnosis was confirmed by PCR results.

Main research results

Characteristics of study 1 (standard CT) included average radiation exposure of 3.76 ± 1.28 mSv; average computed tomography dose index (CTDI) of 6.69 ± 2.18 mGy; average dose length product (DLP) of 222.28 ± 76.33 mGy/cm; average tube current of 2165.97 ± 682.83 mA/s; and average tube voltage of 129.43 ± 3.21 mV. Characteristics of subsequent studies (LDCT) included radiation exposure of 1.27 ± 0.47 mSv; CTDI of 1.57 ± 1.40 mGy; DLP of 73.01 ± 19.94 mGy/cm; tube current of 1182.55 ± 366.55 mA/s; and tube voltage of 111.79 ± 5.73 mV. If a patient underwent several LDCT studies, the arithmetic mean between them was considered when calculating statistical indicators.

The following results were obtained from standard and low-dose CT comparison. During LDCT, radiation exposure decreased on average by 2.96 times, CTDI reduced by 2.6 times, DLP reduced by 3.1 times, tube current reduced by 1.83 times, and tube voltage reduced by 1.2 times. These values are presented in Table 1.

Table 2 presents the results of the survey questionnaire of doctors of the Department of Radiation Diagnostics of the Medical Research and Education Center of the M.V. Lomonosov Moscow State University for assessing the diagnostic accuracy of LDCT in comparison with standard CT.

Table 2 demonstrates that with LDCT, the efficiency of detecting the main signs of viral pneumonia, and assessment of the patient's condition dynamics does not significantly change compared to that of standard CT. It should also be noted that, according to survey results, 7 doctors (100% of those surveyed) believe that LDCT is effective for COVID-19 diagnostics.

Here are illustrative examples of clinical cases (Figs. 1–6), demonstrating the similarity of diagnostic value of two aforementioned research methods. Columns on the left (*a*) show images of a standard CT scan performed upon admission of the patient to the hospital, and columns on the right (*b*) present LDCT over time. The top line of images indicates the pulmonary window mode, whereas the bottom line indicates the mediastinal window mode. For comparison, values of radiation exposure in each case are presented. Time intervals between standard CT and LDCT were 2–7 days; thus, the primary endpoint was reached in all patients enrolled in the study.

Adverse events

During the study, no adverse events were recorded because of CT according to the standard protocol and LDCT.

Table 1. Comparative characteristics of standard and low-dose computed tomography

Indicator	Standard CT	Low-dose CT	Difference, times
Average radiation exposure, mSv	3.76±1.28	1.27±0.47	2.96
CTDI, mGy	6.69±2.18	1.57±1.40	2.6
DLP, mGy/cm	222.28±76.33	73.01±19.94	3.1
Average tube current, mA/s	2165.97±682.83	1182.55±366.55	1.83
Tube voltage, mV	129.43±3.21	111.79±5.73	1.2

Note. CT, computed tomography; CTDI (Computed Tomography Dose Index), average computed tomography dose index; DLP, dose length product.

Table 2. Results of the survey questionnaire of doctors of the Department of Radiation Diagnostics of the Medical Research and Education Center of the M.V. Lomonosov Moscow State University

Characteristics	Standard CT	LDCT
Identification of the lung tissue induration by the type of ground glass opacity	5	5
Identification of induration areas by the type of ground glass opacity with reticular changes (thickened interlobular septa)—presentation of patchwork, crazy paving	5	4,43
Identification of lung tissue consolidation areas	5	5
Detection of lymphadenopathy	5	4

Note. The average values of points given for each item are indicated: the minimum point is 1, the maximum is 5. CT, computed tomography; LDCT, low-dose computed tomography.

DISCUSSION

Main research result summary

Study results confirm the absence of significant loss of diagnostic information in chest LDCT in patients with COVID-19; thus, chest LDCT can be routinely used for successful diagnostics of this disease.

Main research result discussion

In the absence of etiotropic treatment of COVID-19, it is especially important to diagnose the disease at an early stage and immediately isolate the infected person. According to clinical guidelines, COVID-19 diagnosis is established based on clinical examination, epidemiological anamnesis data, and laboratory testing results [11]. The task of etiological laboratory diagnostics comprises searching for severe acute respiratory syndrome coronavirus 2 ribonucleic acid using nucleic acid amplification methods (reverse transcription PCR, RT-PCR). Pathogen detection in a nasopharyngeal smear is possible as early as a week before the onset of clinical manifestations of the infection [12]. Nevertheless, evidence that RT-PCR can give false negative results was reported. Therefore, Ch. Long et al. [13] reported that 35 patients had CT signs of characteristic pneumonia among 36 patients diagnosed with COVID-19, whereas a positive RT-PCR result was obtained for the first time in only 30 patients. In the remaining six cases, repeated testing was performed, and the test result was positive in three of them at the second test (after 2 days) and in three more cases at the third test (after 6 days). Thus, CT sensitivity was 97.2%, and RT-PCR in study 1 was 84.6% [13]. In a study by Y. Fang et al. [14], similar results were obtained, when CT sensitivity was 98% and that of RT-PCR was 71% (in study 1, the positive result was obtained in 36 of 51 patients with symptoms of pneumonia on CT and a suitable epidemiological history;
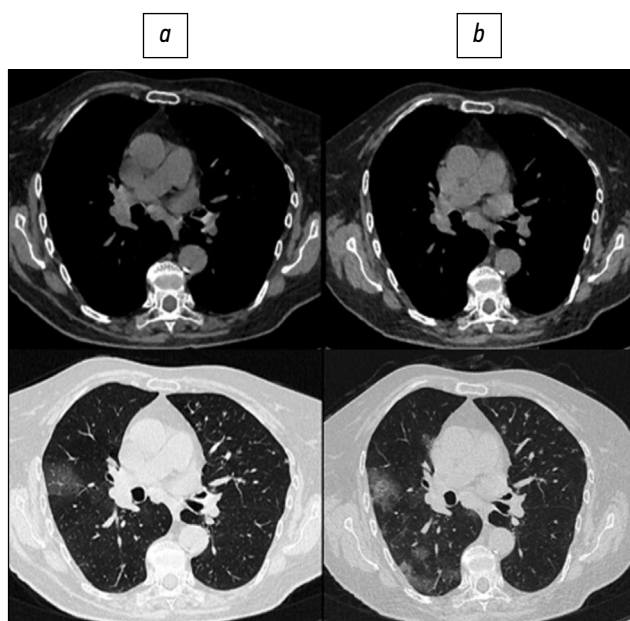

Fig. 1. A 78-year-old patient: standard computed tomography at admission was performed with a radiation exposure of 2.5 mSv (*a*), and low-dose computed tomography was performed with exposure of 1.0 mSv (*b*).
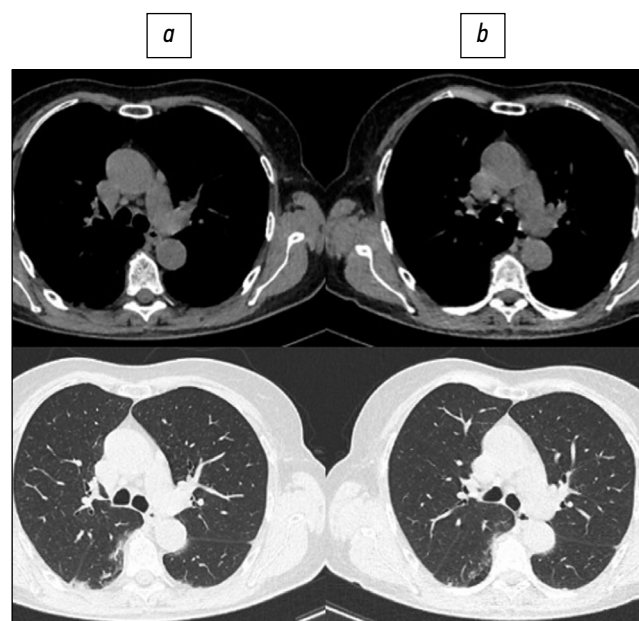

Fig. 2. A 72-year-old patient: standard computed tomography at admission was performed with radiation exposure of 2.1 mSv (*a*), and low-dose computed tomography was performed with exposure of 0.87 mSv (*b*).
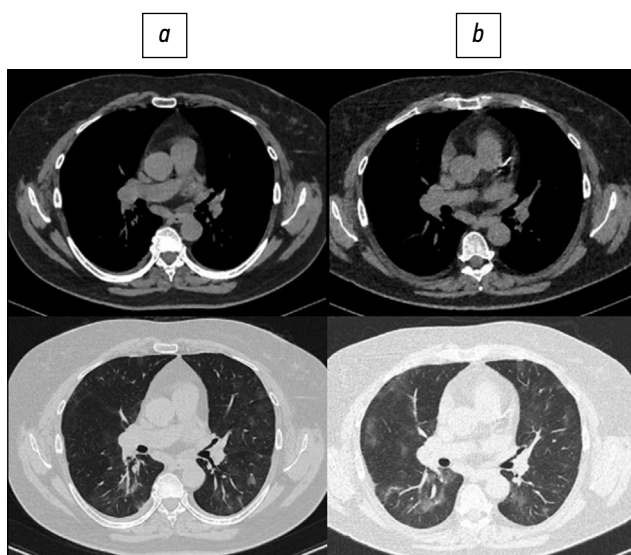
Fig. 3. A 60-year-old patient: standard computed tomography at admission was performed with a radiation exposure of 3.3 mSv (*a*), and low-dose computed tomography was performed with exposure of 1.1 mSv (*b*).

Fig. 4. A 46-year-old patient: standard computed tomography at admission was performed with a radiation exposure of 5.6 mSv (*a*), and low-dose computed tomography was performed with exposure of 1.7 mSv (*b*).
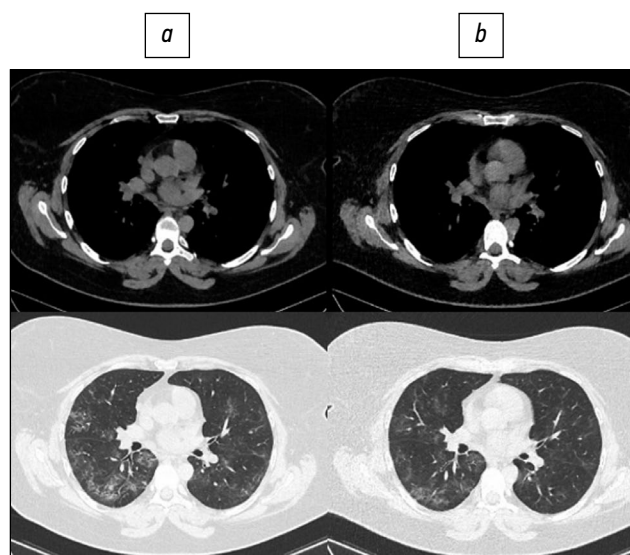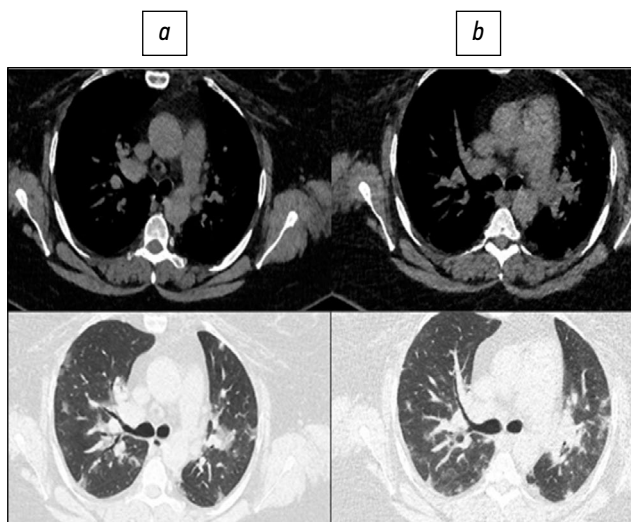

Fig. 5. A 40-year-old patient: standard computed tomography at admission was performed with radiation exposure of 6.8 mSv (*a*), and low-dose computed tomography was performed with exposure of 2.0 mSv (*b*).
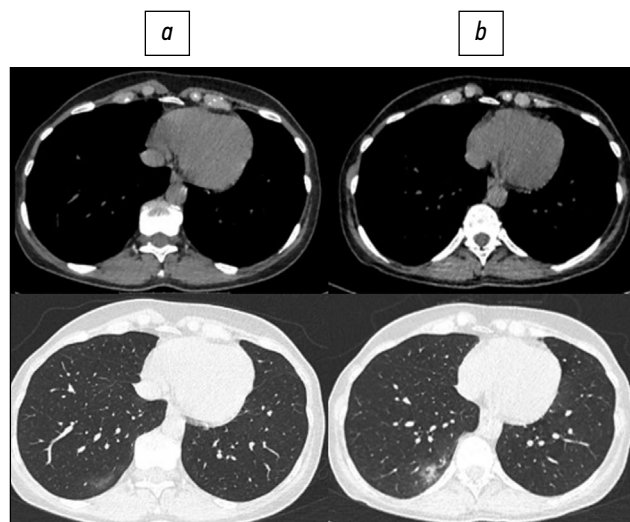

Fig. 6. A 56-year-old patient: standard computed tomography at admission was performed with a radiation exposure of 1.6 mSv (*a*), and low-dose computed tomography was performed with exposure of 0.87 mSv (*b*).

the diagnosis was further confirmed in 12 patients in study 2, 2 patients in study 3, and 1 patient in study 4). Assumed reasons that the RT-PCR sensitivity in COVID-19 diagnosis was lower than that of CT, including the imperfection of nucleic acid amplification technologies, the variability of the sensitivity threshold of tests from different manufacturers, low viral load, and wrong technique of sampling material for analysis. Additionally, the number of viral particles varies depending on the site where the material for analysis is taken, as evidence revealed that it is preferable to examine the sputum first, followed by a nasopharyngeal swab in sensitivity [15]. Thus, despite a negative RT-PCR result, CT is recommended to visualize changes in the lungs if the patient has characteristic symptoms and epidemiological history. In

case of CT signs of pneumonia, it is necessary to take measures for emergency isolation of the patient, after which a repeated laboratory analysis should be performed.

In the context of an increased number of CT examinations, an issue of a significant increase in radiation exposure and associated risk arise, for example, the evidence that approximately 2% of cancers in the USA are associated with radiation doses received as CT result [16]. Despite the absence of major epidemiological studies on this subject, a large amount of data on radiation-induced cancer in survivors of atomic bombs dropped on Japan in 1945 was reported. In the subgroup of people who received radiation doses in the range from 5 to 150 mSv, a significant increase was observed in the overall risk of developing

cancer, the average dose in this subgroup was 40 mSv [17], and the average effective radiation dose for standard chest CT is 5 mSv [18]. As for LDCT of the chest with radiation exposure of 0.4 mSv, no sufficient evidence of efficacy in the context of screening and diagnostics of COVID-19 is currently reported [3].

Radiation dose received by a patient during CT scan depends on tube current strength, voltage, scan time, slice thickness, scan volume, and interval. Scanning time is reduced with the use of modern models of spiral tomographs; however, radiation exposure sometimes even increases due to increased current strength and scan volume. Under these conditions, it is reasonable to resort to radiation dose reduction techniques. The dose is directly proportional to the tube current. Recently, several studies showed that chest LDCT at 10–140 mAs does not significantly reduce the image quality, and nodular structures are still observed [19–21]. In their study, X. Zhu et al. [22] demonstrated a linear correlation between the tube current and the DLP at a constant voltage and scan time, and also assessed the feasibility of optimization of radiation dose by reducing the tube current. By comparing images obtained at different CTDI values, the threshold value of this parameter was determined, which enables to obtain images without a significant loss of information content (25 mAs), and with an increase in the thickness of sections, the loss of image quality occurred more slowly. Statistical analysis revealed no significant difference between images obtained at 115, 40, and 25 mAs. Thus, 25 mAs or more is an acceptable exposure parameter to provide satisfactory image quality for chest CT, whereas CTDI at 25 mAs was reduced by 70% compared to CTDI at 115 mAs. Despite the accuracy of this parameter, clinicians should be aware that its value may vary with different CT systems; additionally, it must be adjusted considering the biological characteristics of patients (for example, the radiation dose should be increased for obese patients and when examining the upper lobe of the lung due to the false shadow caused by the scapula). Threshold values of CDTI parameter obtained in this study are consistent with the results of the study by T. Kubo et al. [23], where standard and low-dose CTs were compared to determine the main characteristics of lung lesions, which enabled us to confirm or rule out malignant nature. Parameters of 20–50 mAs were sufficient to determine the nature of the lesion without additional standard CT. Edge characteristics, calcification, and lobulation, as well as pleural response, standard and low-dose CTs showed the same efficiency to determine parameters of lesions as structure.

For many years, the question of LDCT safety in screening for oncological diseases, for example, lung cancer, has remained controversial [24]. In their study, C. Rampinelli et al. [25] analyzed the possible risks of radiation lung cancer and leukemia in healthy people who had been regularly screened using LDCT for 10 years. It turned out that the total cumulative dose of radiation was approximately 9 mSv for men and 13 mSv for women, which is equivalent to one standard CT scan. Additionally, given that the average dose from background sources in the USA is approximately 30 mSv over 10 years, it can be concluded that LDCT screening accounts for only 1/3 of the exposure to natural background radiation over the same period. Study results revealed that after 10 years of screening with LDCT, in 5203 patients aged over 50 years old who are asymptomatic with smoking experience of more than 20 pack-years, approximately 1.5 cases of lung cancer, and 2.4 cases of other types of cancer were caused by radiation exposure. Compared to the number of cases of lung cancer detected, it can be calculated that approximately 100 cases of cancer are detected by screening per case of radiation-induced cancer. Additionally, results of a study of LDCT screening in the population of smokers aged 55–74 years showed a reduction in mortality from lung cancer by 20% [26]. All these data indicate that the LDCT method is safe and effective for multiple repetitions within screening or monitoring the dynamics of the patient's condition in the hospital despite the possible risks associated with radiation exposure. There is no doubt about the importance of using LDCT to reduce radiation exposure and ensure greater safety of the study for the patient.

CONCLUSION

Comparative analysis of the efficacy and diagnostic value of LDCT and CT performed according to a standard protocol revealed that LDCT is not only a full-fledged alternative, but also a preferable option, since its implementation can significantly reduce the radiation exposure of the patient. Given that during inpatient COVID-19 treatment, patient undergoes several imaging studies, the issue of radiation safety becomes urgent. According to practicing doctors, the amount of information provided by LDCT is not inferior to the standard CT technique in quality and accuracy; therefore, for dynamic studies, it is advisable to prefer LDCT, which is a method that enables the radiation exposure reduction.

ADDITIONAL INFORMATION

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