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Original Article

# Image Findings and Radiation Dose in Lung CT Scan of Patients With COVID-19 in Hamadan

**Salman Jafari**[1], **Faeze Heidari**[2], **Mahdi Asgari**[3], **Karim Ghazikhanlou Sani**[1], **Hossein Khosravi**[1*], **Reza Afzalipour**[4]

[1]Department of Radiology Technology, School of Paramedicine, Hamadan University of Medical Sciences, Hamadan, Iran
[2]Student Research Committee, Hamadan University of Medical Sciences, Hamadan, Iran
[3]Beast Hospital, Hamadan University of Medical Sciences, Hamadan, Iran
[4]Department of Radiology Technology, School of Paramedicine, Hormozgan University of Medical Sciences, Bandar Abbas, Iran

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***Corresponding author:**
Hossein Khosravi,
Email: hkhosravi55@gmail.com

**Abstract**

**Background:** Computed tomography (CT) scan plays an important role in the diagnosis of the COVID-19. Lung involvement appears in different forms on CT images. Absorbed dose to the patients may exceed diagnostic reference levels. This study aimed to investigate clinical symptoms, findings of lung CT scan, and absorbed dose to the patients.

**Methods:** This cross-sectional descriptive study was conducted in two CT scan centers in Hamadan: Besat and Sina. CT images of 163 patients with positive real-time polymerase chain reaction (PCR) tests were interpreted by six experienced radiologists. Volume CT dose index (CTDIvol), dose length product (DLP), and effective dose were calculated in both centers and compared using the Mann-Whitney statistical test.

**Results:** The most common findings in the CT images were ground-glass opacification (GGO), consolidation, and the combination of GGO and consolidation. CTDIvol, DLP, and effective dose to the patients were respectively $1.64 \pm 5.24$ mGy, $177.12 \pm 59.03$ mGy.cm, and $3.01 \pm 1.00$ mSv in Sina hospital and $4.58 \pm 1.91$ mGy, and $2.60 \pm 1.02$ mSv in Besat hospital. The difference between quantities in the two centers was statistically significant ($P > 0.05$).

**Conclusion:** The most common findings in lung CT images of patients with positive polymerase chain reaction (PCR) tests were GGO and consolidation. Furthermore, there were differences in radiation dose to patients between hospitals, indicating the need for optimization.

**Keywords**: COVID-19, Computed tomography, Radiation dosages

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## Introduction

Computed tomography (CT) scan is frequently performed for the diagnosis of lung involvement by COVID-19 (1-3). The spread of this disease was so extensive that the World Health Organization (WHO) declared it global on January 30, 2020 (4). According to the studies, there is no definitive cure for this disease, and physicians try to improve the condition of patients with auxiliary treatments such as drug therapy, antibiotics, and antiviral drugs (5). Common symptoms of this disease include high fever, shortness of breath, and cough, and the best way is to avoid contact with suspicious or infected people (6). Early diagnosis of the diseases can help better remedies for the patients and make healthy people aware of keeping their distance from them. Currently, the gold standard method for the diagnosis of the COVID-19 disease is real-time polymerase chain reaction (RT-PCR) (7,8). However, this method has problems such as time-consuming, the need for a large sample size, and high cost (9). In addition, this method may not be sufficiently implemented in areas with a high prevalence of COVID-19. CT scan provides sectional images along axial and coronal planes, and its sensitivity in detecting lung infection with COVID-19 has been reported up to 98% (10). Some studies reported that the presentation of lung involvement in CT scan images can be different according to the progress of the disease (11-13). One important issue in CT scan is radiation dose which should not be ignored under the diagnostic value of this method. Wide ranges of radiation doses to patients have been reported in lung CT of patients with COVID-19 (14). The lack of monitoring and diagnostic reference levels caused extra doses to patients in lung CT scans. The purpose of this study was thus to investigate the findings of imaging and absorbed dose in lung CT scans of patients with positive RT-PCR.

## Materials and Methods

### *Patients' Demographics*

This cross-sectional descriptive study was conducted in two CT scan centers in Hamadan: Besat and Sina. A total of 163 patients (63 in Besat and 100 in Sina hospitals) with positive RT-PCR tests were randomly selected through a simple sampling method from individuals referred for lung CT scans. Each patient had an equal opportunity to participate in the study. The sample size was chosen based on the previous studies. Exclusion criteria encompassed incomplete CT procedures and THE lack of informed consent to participate in the study. Patients' demographic information, including gender, age, clinical symptoms, as well as imaging parameters were recorded during imaging.

### *Computed Tomography Protocol*

Patients underwent lung CT scans using two 16-slice scanners (SOMATOM Emotion), and they were instructed to remove all metal and other objects from the thorax region and lie on the table in a supine position with arms above the head. A topogram with a bottom tube position was obtained first from the patients (Figure 1).

All scans were performed in spiral mode. The entire range of the lung from the apex to the costophrenic angles was included in the scan box. Images were reconstructed using two kernels of sharp smooth (Figure 2A) for lung parenchyma evaluation and medium smooth (Figure 2B) for mediastinum. CT images were then interpreted by six experienced radiologists. The desired diagnostic information in the CT images includes types of lesion, unilateral or bilateral involvement, expansion in the transverse or superior-inferior direction, the size and shape of the lesion, effusions, or other cases.


**Figure 1.** Topogram Image Obtained With Bottom Tube Position from the Patients

### *Radiation Dose Evaluation*

For each patient, the CT dose index (CTDIvol) and dose length product (DLP) were recorded from scanner software. The effective dose to the patients was calculated as follows (13):

$$DE = DLP \times K\ (mSv)\ (1)$$

In this equation, $K$ is the conversion factor of 0.017 according to the literature (15). The normality test of Kolmogorov-Simonov was then used to examine whether variables are normally distributed. The nonparametric test of Mann-Whitney was also used to compare the means of dose indices ($P < 0.05$).

## Results

### *Patients' Demographic Characteristics*

A total of 163 patients participated in this study. In terms of gender, the frequency of patients was 57 men and 43 women in Sina Hospital and 39 men and 24 women in Besat hospital. Additionally, the average age of the patients in Sina and Besat centers was 46 ± 18 years and 50 ± 19 years, respectively.

### *Computed Tomography Protocol*

For all patients, the CT sequence comprised a topogram and the main scan. The topogram was obtained in the posterior-anterior view, while a lung scan was performed from the lungs' apex to the costophrenic angle. Details regarding scan parameters such as kVp, mA, collimation, rotation time, slice thickness, and pitch factor for each scanner are delineated in Table 1.

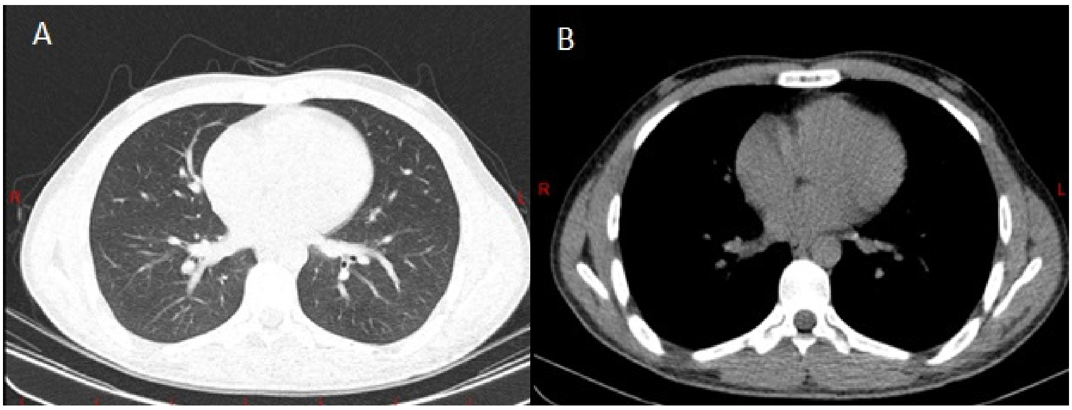


**Figure 2**. Images Reconstructed Using Two Kernels: B80S (A) for Lung Parenchyma and B31S (B) for Mediastinum Evaluation

**Table 1.** Scan Parameters for Lung CT in the Study

| Center | Data Acquisition Step | kVp | Average Tube Current (mA) | Rotation Time (s) | Pitch Factor | Slice Thickness (mm) | Collimation (mm) |
|---|---|---|---|---|---|---|---|
| Besat | Topogram | 110 | 35 | - | - | - | - |
| | Scanning | 110 | 54.07 ± 18.23 | 0.6 | 1.5 | 5 | 16 × 1.2 |
| Sina | Topogram | 110 | 30 | - | - | - | - |
| | Scanning | 110 | 75.05 ± 23.28 | 0.6 | 1.2 | 4 | 16 × 1.2 |

*Note.* CT: Computed tomography.

### *Clinical Symptoms*

The clinical symptoms of patients during imaging are separately presented for each center in Table 2. As can be observed, shortness of breath is the most frequent symptom in both hospitals.

### *Imaging Parameters*

Imaging parameters were 110 kVp for all patients in Sina hospital, while they were 110 kV for 43 cases and 130 kV for 20 patients in Besat hospital. In both centers, a rotation time of 0.6 seconds was used for all patients. In the Sina and Besat centers, the pitch factors of 1.2 and 1.5 were used for all cases, respectively. Moreover, a slice thickness of 4 mm was used in Sina and 5 mm in Besat. Tube current (mA) was different based on the body thickness, and combined application was used for all patients to reduce exposure (CARE dose 4D). The distribution of tube current is shown in Figure 3.

### *Radiation Dose Evaluation*

Table 3 presents CTDIvol, DLP, and effective dose in terms of hospital. As observed, all dose quantities in Sina Hospital were higher than those in Besat Center ($P < 0.05$).

### *Image Findings*

Findings of CT scan images of all patients are presented in Figure 4. Ground-glass opacification (GGO) was the most common lesion (21.47%) found in CT images of patients with positive RT-PCR for COVID-19. Notably, nothing was detected in CT images of 39.26% of cases.

## Discussion

The findings of this research showed that despite the same model of CT scanners in two centers, different protocols

**Table 2.** Clinical Symptoms of Patients During Imaging

| Hospital | Clinical Symptoms | Frequency | Percent |
|---|---|---|---|
| Besat | Shortness of breath | 28 | 28 |
| | Fever + narcosis | 6 | 6 |
| | Cough + fever + shortness of breath | 9 | 9 |
| | Fever + cough | 6 | 6 |
| | Narcosis + cold sweat | 2 | 2 |
| | Cough + shortness of breath | 18 | 18 |
| | Nausea and lethargy | 3 | 3 |
| | Cold sweat + nausea | 2 | 2 |
| | Fever + body pain | 3 | 3 |
| | Fever + shortness of breath | 4 | 4 |
| | Fever + body pain + cold sweat | 1 | 1 |
| | Fever + body pain + cough | 5 | 5 |
| | Fever + body pain + lethargy | 4 | 4 |
| | Cough + lethargy | 1 | 1 |
| | Shortness of breath + lethargy | 2 | 2 |
| | Cold sweat + fever + lethargy | 1 | 1 |
| | Cough + fever + lethargy | 2 | 2 |
| | Cough + fever + cold sweat | 1 | 1 |
| | Body pain + nausea | 1 | 1 |
| | Body pain + nausea + fever | 1 | 1 |
| | Total | 100 | 100 |
| Sina | Shortness of breath | 32 | 50.8 |
| | Cough | 22 | 34.9 |
| | Cough + fever + shortness of breath | 3 | 4.8 |
| | Cough + shortness of breath | 5 | 7.9 |
| | Shortness of breath and gastrointestinal symptoms | 1 | 1.6 |
| Total | | 63 | 100 |

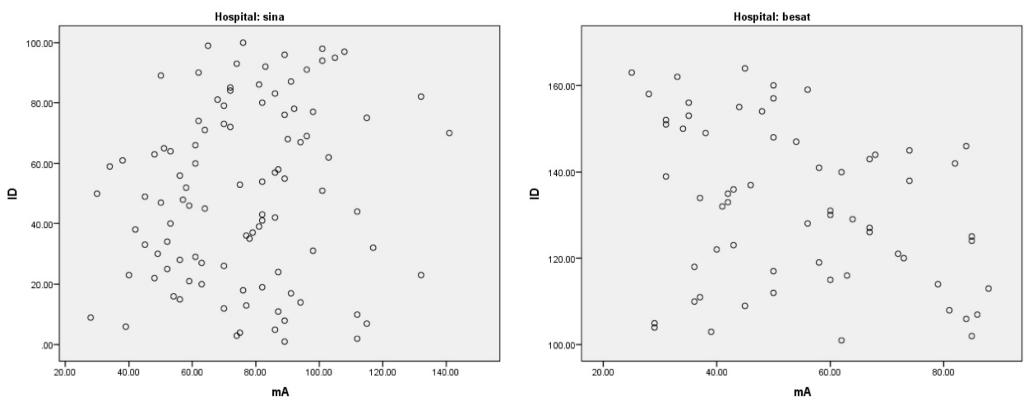


**Figure 3.** Tube Current Used for Lung CT in Sina and Besat Hospitals. *Note.* CT: Computed tomography

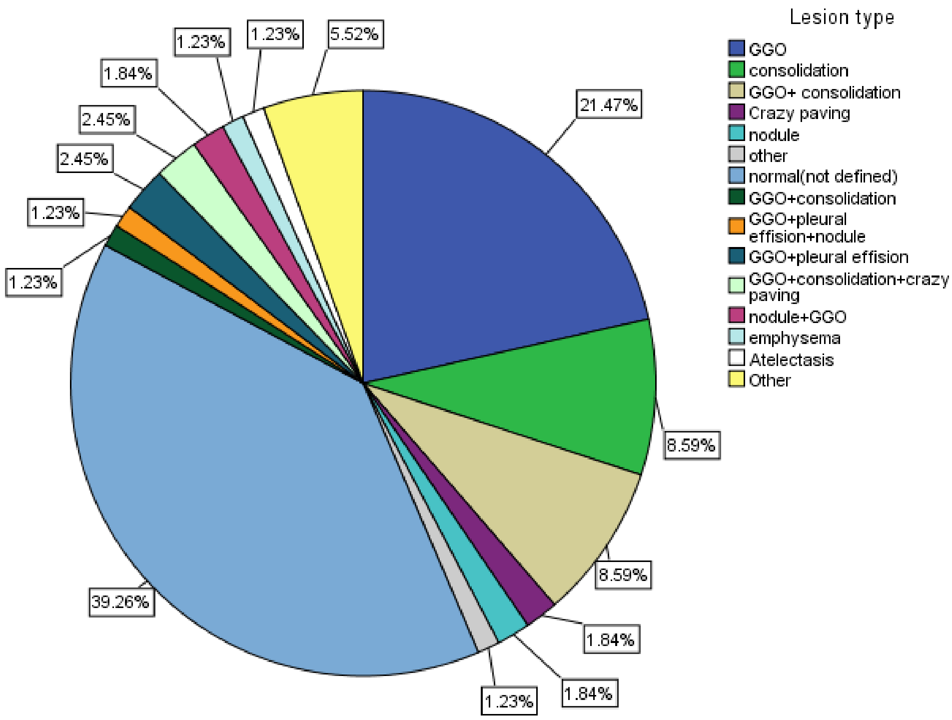


**Figure 4.** The Percent of Lesion Type Founded in the CT Images of Patients with Positive RT-PCR test for COVID-19 in this Study. *Note.* CT: Computed tomography; RT-PCR: Real-time polymerase chain reaction; GGO: Ground-glass opacification

**Table 3.** CTDIvol, DLP, and Effective Dose in Terms of Hospital

| Dose Index | Hospital | Mean | SD | *P* Value |
|---|---|---|---|---|
| CTDIvol (mGy) | Sina | 5.24 | 1.64 | 0.009 |
| | Besat | 4.58 | 1.91 | |
| DLP (mGy.cm) | Sina | 177.12 | 59.03 | 0.004 |
| | Besat | 153.12 | 60.50 | |
| Effective dose (mSv) | Sina | 3.01 | 1.003 | 0.004 |
| | Besat | 2.60 | 1.02 | |

*Note.* CTDIvol, Computed tomography dose index; DLP: Dose length product.

are applied in CT scans of the lung which in turn results in different radiation doses to the patients. All dose indices were higher in Sina Hospital. In this center, the pitch factor was lower than that in Beast hospital. The pitch factor is inversely proportional to the dose (16). Considering the image motion artifact due to respiration and heartbeat, it is logical to increase the imaging speed by optimizing the rotation time, collimation, and pitch factor. Technicians can reduce the scan time by rotation time reduction and increasing collimation and pitch factor, but they should pay attention to the image quality. On the one hand, the tube currents in Sina hospital (with an average of 76 mA) are higher than those in Besat (with an average of 54 mA). Tube current is directly proportional to the radiation dose to the patient (16). The tube current distribution is wide in both centers. This is due to CARE Dose 4D which changes the current of the tube based on the thickness of the patient's body when scanning. Due to the same device model and similar collimation (1.2 × 16 mm), a different pitch factor has been chosen, which is also related to the technician's experience. Considering the difference in scan parameters that affect the absorbed dose to the patient between the two centers, a significant difference is expected between dose indices. Different scan parameters were used in various centers which resulted in different doses to the patients. In a study by Alramlawy and Maamoun with 100 kV and 160 mAs, the values of CTDIvol, DLP, and effective dose were reported to be 7.8 ± 0.09 mGy, 322.4 ± 24.5 mGy, and 4.83 ± 0.36 mSv, respectively, which are higher compared with the results of this study (17). Čiva et al reported that the median CTDIvol in lung CT scans of men and women under 40 years old is 3.1 mGy and 2.4 mGy, respectively (18).

There are different clinical symptoms in patients with positive RT-PCR for COVID-19. Shortness of breath was the most frequent symptom in our study. In a review study by da Rosa Mesquita et al, six symptoms were reported as the most common, including fever, cough, shortness of breath, weakness, fatigue, and sputum (19). Vetter et al reported fever, cough, and shortness of breath as common symptoms along with non-respiratory symptoms such as ischemic or hemorrhagic stroke, dizziness, headache, musculoskeletal disorder, altered mental status, Guillain-Barré syndrome, and encephalopathy as other symptoms of COVID-19 (20).

The obtained results indicated that the presentation of lung involvement by COVID-19 is different in the CT scan image. The most frequent manifestations include GGO, consolidation, combination of GGOs and consolidation, linear opacities, crazy paving sign, bronchial wall thickening, air bronchogram, pulmonary enlarged lymph nodes, pleural effusion, emphysema, and atelectasis (21-23). In the current study, the most common lesion found in lung CT scans of patients with positive RT-PCR for COVID-19 was GGO followed by consolidation. This is consistent with the results of other studies. In a study by Xu et al, GGO was common in the peripheral areas of the lung near the pleural membrane along with partial integration (24). Shi et al declared that the common findings in lung CT scans of patients with positive RT-PCR for COVID-19 are bilateral involvement (79%), the involvement of peripheral lung regions (54%), vague and unclear shape (81%), and GGO (65%) which involve the lower segment of the right lung (25). The lack of lung lesions in CT scan images of patients with a positive PCR result can indicate the presence of disease without lung involvement or a false positive result of the PCR test.

## Conclusion

The most common findings in lung CT scan images of patients with COVID-19 were GGO and consolidation. Despite the positive PCR test, nothing was detected in lung CT images for a noticeable percentage of patients. Moreover, there was a significant difference between radiation doses to patients in lung CT scans which indicates the lack of dose monitoring and the need for protocol optimization.

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### Authors' Contribution

**Conceptualization:** Salman Jafari.
**Data curation:** Faeze Heidari, Mahdi Asgari.
**Formal analysis:** Karim Ghazikhanlou Sani, Hossein Khosravi.
**Funding acquisition:** Salman Jafari.
**Investigation:** Faeze Heidari, Mahdi Asgari.
**Methodology:** Salman Jafari.
**Project administration:** Salman Jafari.
**Resources:** Salman Jafari.
**Software:** Salman Jafari.
**Supervision:** Salman Jafari.
**Validation:** Reza Afzalipour.
**Visualization:** Reza Afzalipour.
**Writing–original draft:** Salman Jafari.
**Writing–review & editing:** Salman Jafari.

### Competing Interests

There is no conflict of interests.

### Ethical Approval

This study was approved by the Research Ethics Committee of Hamadan University of Medical Sciences (IR.UMSHA.REC.1399.089).

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