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ORIGINAL ARTICLE

Diagnostic Efficacy and Radiation Safety of Low Dose CT Protocol in COVID-19 Pandemic: An Alternative for Deficient RT-PCR

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ABSTRACT

Background: In this study, we aim to assess the diagnostic capability of low-dose CT chest for detection and follow-up of COVID-19 pneumonia to enhance radiation protection and ensure patient safety when RT-PCR is not available.

Methods: This prospective study was approved by the local ethics committee and informed consent was obtained. 86 patients were enrolled in this study with suspected COVID 19 infection. Non-contrast CT scan of the chest was done using a 320 multidetector CT machine. Low dose and standard dose techniques were done. Two experienced radiologists analyzed the imaging findings and give CORADS classification for each case blindly to each other.

Results: The study involved 86 patients. 52 were scanned with low dose technique there were 34 men (65.4 %) and 18 women (34.6 %). 34 were scanned with standard technique there were 14 men (41.2 %) and 20 women (58.8 %). There was a statistically significant difference between low and standard-dose groups regarding CTDI volume, DLP, and radiation exposure (p =<0.001) with good diagnostic accuracy of low dose CT. As regards CT findings for low dose technique, GGO was detected by both observers more than consolidation in the two techniques while mixed GGO and consolidation was the least finding.

Conclusions: As chest CT together with clinical and laboratory findings can help the diagnosis of COVID-19 as an alternative for deficient RT-PCR, we recommend the utilization of LDCT as it offers a significant reduction of radiation exposure with comparable efficacy to standard dose CT.

Keywords: Low dose CT chest, COVID 19, GGO, CORADS

INTRODUCTION

In 1965, the first human coronavirus was isolated from an infected patient, presented by mild respiratory diseases, and was neglectable for healthy people **[1].**

In the 21st century, six types of coronaviruses have been identified causing human disease: four cause mild respiratory symptoms, whereas the other two, Middle East respiratory syndrome (MERS) coronavirus and severe acute respiratory syndrome (SARS) coronavirus, had caused severe respiratory symptoms, respectively **[2].**

In December 2019, New type of coronavirus, COVID-19, was isolated from lower respiratory tract of many patients in Wuhan, China. Those patients were presented with symptoms of severe pneumonia, fever, dry cough, fatigue, and variable degrees of respiratory distress. The virus had shown transmission from human to human and caused a worldwide pandemic **[3].**

The rapid rise in morbidity and mortality rates, pushed World Health Organization (**WHO**) to announce the outbreak as a global health emergency **[4].**

Definitive diagnosis is made by the detection of viral RNA in specimens collected from patients' respiratory secretions using reverse transcriptase-polymerase chain reactions (RT-PCR). **[5].**

Shortage of RT-PCR kits has been encountered by some Governments with problems in their storage, distribution, and administration with the increasing emergent need **[6].** And so, increasing the need for depending on chest CT findings as an alternative diagnostic and screening tool in suspected patients. **[7].**

With this emergent situation of the COVID-19 pandemic, the demand for performing CT scans is significantly increased due to the high rate of infected individuals **[8].**

Using CT chest for the diagnostic workup for symptomatic patients with suspected COVID-19 has been recommended by **WHO** when RT-PCR: (1) is not available; (2) Delayed results of testing; and (3) Negative testing with high clinical suspicion of COVID-19 **[9].**

In the study performed at Enze Hospital, 2020, **[10]** the rate of detection of COVID-19 infection based on the initial chest CT and RT-PCR was compared and they found that the sensitivity of CT for COVID-19 infection was 98% compared to RT-PCR sensitivity of 71%**.**

In another study, it was reported that 88% of suspected patients had findings suggestive of COVID-19 in chest CT while the positive rate of RT-PCR kits was only 59%, It was also shown that CT findings were detected in infected individuals before the RT-PCR kits did in symptomatic individuals **[5].**

As for severely symptomatic or clinically deteriorating patients, they may often undergo various imaging studies during their illness, in turn, this can significantly increase the collective radiation dose they receive during hospitalization and recovery **[8].**

There is an increasing awareness of the possible side effects of diagnostic radiation exposure because the medical radiation exposure has increased significantly due to more utilization of medical imaging than before, of which CT examinations had the major share of radiation exposure **[11].** Regarding the possible adverse effects, the principle of as low as reasonably achievable (ALARA) should be kept and observed in medical imaging using ionizing radiation. So low dose CT techniques are advisable keeping image quality not to affect physicians' decisions **[12].**

AIM OF WORK

In this study, we aim to assess reliability, diagnostic capability, and accuracy of low dose CT scan of the chest for detection and follow up of COVID-19 pneumonia to enhance radiation protection and ensure patient safety.

METHODS

This prospective study was conducted at our radiology department during the period from November 2020 to January 2021 after being approved by the local ethics committee.

patients' selection criteria

Patients referred to our radiology department and met the inclusion criteria of enrollment were asked to participate in this study and informed consents were obtained from the participants before the examination. The work has been carried out following The Code of Ethics of the World Medical Association (Declaration of Helsinki) for studies involving humans.

inclusion criteria

No age predilection.

Risk factors include COVID-19 patients with positive RT-PCR. Patients with negative RT-PCR but still highly suspicious; either with laboratory data abnormalities (lymphopenia and monocytosis), clinically symptomatic persons in direct contact with COVID-19 patients, symptomatic persons with fever and respiratory manifestations of unknown origin, and suspected patients with equivocal clinical symptoms.

exclusion criteria

There are no absolute contraindications to chest CT other than general contraindications for CT e.g., pregnancy. The relative benefits and risks of the procedure should be evaluated before the examination, as with all procedures. Proper precautions should be taken to decrease patient risks, including radiation exposure as much as we can.

Clinical history and weight measurements were taken from all cases. Cases were randomly divided into 52 cases examined with low-dose CT (subject group) and 34 cases with standard-dose CT (control group). No intravenous contrast media was used.

Scanning

All CT examinations were performed using 320 multidetector CT scanner (Toshiba, Aquilion one).

Typical screening CT of the thorax is better to be performed in a single breath-hold using a multi-detector CT machine.

Scans should be obtained while the patient is in a state of full inspiration whenever possible.

Scans must cover the entire lungs, from apices to bases, and the field of view must be optimized for each patient to include the entire transverse and anteroposterior diameter of the lungs.

Non-contrast CT study includes axial scans viewed at ≤ 2.5-mm slice thickness with reconstruction intervals equal to or slightly less than the slice thickness.

Maximum intensity projection (MIP) using proper slice thickness, 2-3 mm, could be useful to increase the sensitivity for detection in some cases.

Multiplanar reconstruction (MPR) may be useful to further characterize lesions, particularly one located along the pleural surfaces.

Radiation exposure factors (including mA, kVp, gantry rotation time) should be adjusted to yield computed tomography dose index (CTDIvol) of < 3-5 mGy for a standard-sized patient.

Dose length product (DLP) = (CTDIvol) * (length of scan, cm) and automatically calculated by the machine software

interpretation and analysis:

The images were anonymized by removing all the patient-specific data. The scan parameters were deleted from DICOM files for blind interpretation using Vitrea workstation.

Two experienced radiologists will be asked blindly to interpret the images for each case.

Proper window width and level values were adjusted to view all the anatomy within the scanned field of view, including the lung parenchyma, mediastinum, chest wall, lower neck, and upper abdomen.

Lung lesions should be reported with respect to Anatomic location (lung lobe, segment).

Lesions should be described with respect to pattern and distribution of opacity (mainly ground-glass opacities and consolidation), using coronavirus reporting and data system (CO-RADS) with a scoring level of suspicious from very low (CO-RADS 1) to very high (CO-RADS 5) with two additional categories (CO-RADS 0) technically insufficient examination, and (CO-RADS 6) for RT-PCR proven before the examination.

Screening results would be reported using a structured reporting system for lesion characterization, imaging-clinical correlation, quality improvement, and medical outcomes assessment.

CTDI and dose length product (DLP) was recorded on axial scanning for each case.

STATISTICAL ANALYSIS

An Excel spreadsheet was established for the entry of data. We used validation checks on numerical variables and the option-based data entry method for categorical variables to reduce potential errors. The analyses were carried with SPSS software (Statistical Package for the Social Sciences, version 24, SSPS Inc, Chicago, IL, USA). The normality of the data was assessed using Shapiro-Wilk Test. Numerical data were described as mean ±SD if normally distributed, or median and interquartile range [IQR] if not normally distributed. Frequency tables with percentages were used for categorical variables. Independent Student t-test and paired t-test were used to compare parametric quantitative variables, while Mann-Whitney tests and Wilcoxon matched pairs test were used to compare non-parametric quantitative variables. Chi-square test or Mc Nemar-Bowker tests were used to analyze categorical variables. A p-value < 0.05 is considered statistically significant.

RESULTS

The study involved 86 patients. 52 patients were scanned with low dose technique there were 34 men (65.4 %) and 18 women (34.6 %). Their mean age was 34.69 with ±14.68 SD.34 patients were scanned with standard technique there were 14 men (41.2 %) and 20 women (58.8 %). Their mean age was 41.08 with ±14.58 SD **(Table 1).**

Table (2) shows the distribution of CT parameters among both studied groups. Mean CTDI for low dose technique was 4.78 with ± 3.06 SD, while mean CTDI for the standard technique was 12.14 with ±4.5 SD. Mean DLP for low dose technique was 189.67 with ±124.293 SD, while mean DLP for the standard technique was 469.89 with ± 167.62 SD. As regard radiation exposure the mean KV was 100.38 with ±8.392 SD and mean MA 92.08 with ± 60.49 SD for low dose technique, while the mean KV was 107.65 with ±9.86 SD and mean MA 219.59 with ±108.14 SD for standard dose technique. There was a statistically significant difference between low and standard dose techniques groups regarding CTDI volume, DLP, and radiation exposure (p =<0.001) with good diagnostic efficacy of low dose CT.

Table (3) shows the distribution of patients according to CT findings for the low dose technique. For observer 1 GGO was seen in 15 patients (28.8%) while for observer 2 was seen in 14 patients (26.9%) with Cronbach's Alpha 0.86. For observer 1 consolidation was seen in 8 patients (15.4%) and the same for observer 2 with Cronbach's Alpha equals 0.92 and mixed GGO with consolidation in 5 patients (9.6%) while for observer 2 was seen in 6 patients

(11.5%) with Cronbach's Alpha equals 0.94. Negative findings were found in 24 patients (46.15%) by both observers with Cronbach's Alpha equals 1.

Table (4) shows the distribution of patients according to CT findings for standard dose technique. For observer 1 GGO was seen in 14 patients (41.2%) while for observer 2 was seen in 12 patients (35.3 %) with Cronbach's Alpha 0.93. For observer 1 consolidation was seen in 6 patients (17.6 %) and the same for observer 2 with Cronbach's Alpha equals 1 and mixed GGO with consolidation in 6 patients (17.6%) and the same for observer 2 with Cronbach's Alpha equals 1. Negative findings were found in 8 patients (23.5%) by observer 1 and 10 patients (29.4%) by observer 2 with Cronbach's Alpha equals 0.93.

CORADS classification of the cases was demonstrated in **table (5).** as regard low dose technique CORAD 1 was recorded in a large number of patients by both observers. 34 patients (65.4 %) by observer 1 while observer 2 recorded 37 patients (71.2%) with Cronbach's Alpha (0.83). also, in the standard dose technique, CORADS 1 was recorded many patients by both observers. observer 1 recorded 20 patients (58.8 %) while observer 2 recorded 22 (64.7%).

Few patients show other associated findings such as basal atelectatic bands, small calcified pulmonary nodules, and bronchiectasis. One patient was having a central venous port.

Table 1: The distribution of baseline demographic characteristics of the included patients

Variables	**Low dose (N =52)**	**Standard (N =34)**	**P-value**
Age in years Mean ±SD Median (Range)	34.69±14.68 29.5 (24.25-45)	41.088±14.58 41 (25.75-55.25)	0.04* mann whitney
Gender			
Female	18 (34.6%)	20 (58.8%)	0.02*
Male	34(65.4%)	14(41.2%)	Chi square
Weight in Kg Mean ±SD	7.761±1.07	8.00±1.37	0.65

Data are presented as mean ±SD, median (IQR), or number (%).

Table 2: The comparison of CT parameters of the included patients.

Variables	**Low dose (N =52)**	**Standard (N =34)**	**P-value**
CTDI volume Mean ±SD Median (Range)	4.78± 3.061 4.3 (1.80-6.67)	12.14 ±4.5 8.8 (11.0-15.42)	<0.001
DLP Mean ±SD Median (Range)	189.67±124.29 73.165 (165.5-262.72)	469.89±167.62 317.97 (439.90-588.10)	<0.001
MA Mean ±SD Median (Range)	92.08±60.49 72 (25-275)	219.59±108.14 184 (100-483)	<0.001
KV Mean ±SD Median (Range)	100.38±8.392 100 (80-120)	107.65±9.86 100 (80-120)	<0.001

Data are presented as mean ±SD, median (IQR), or number (%).

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Table 3: Distribution of patients according to CT findings low dose

CT findings	Observer 1	Observer 2	Cronbach's Alpha
	15 (28.8%)	14 (26.9%)	0.86
GGO	8 (15.4%)	8 (15.4%)	0.92
Consolidations	5 (9.6%)	6 (11.5%)	0.94
GGO and consolidations	24 (46.15%)	24 (46.15%)	1
Negative findings			

Data are presented as No. (%).

Table 4: Distribution of patients according to CT findings standard dose

CT findings	Observer 1	Observer 2	Cronbach's Alpha
GGO	14 (41.2%)	12 (35.3%)	0.93
Consolidations	6 (17.6%)	6 (17.6%)	1
GGO and consolidations	6 (17.6%)	6 (17.6%)	1
Negative findings	8 (23.5)	10 (29.4)	0.93

Data are presented as No. (%).

Table 5: Distribution of patients according to CT Findings

variables	**Low dose**			**Standard dose**		
CT findings	**Observer 1 No (%)**	**Observer 2 No (%)**	**Cronbach's Alpha**	**Observer 1 No (%)**	**Observer 2 No (%)**	**Cronbach's Alpha**
CORADS 0	**1 (1.9)**	**0**	**0.83**	**0**	**0**	0.97
CORADS 1	**34 (65.4)**	**37 (71.2)**		**20 (58.8)**	**22 (64.7)**	
CORADS 2	**2 (3.8)**	**4 (7.7)**		**0**	**0**	
CORADS 3	**9 (17.3)**	**5 (9.6)**		**4 (11.8)**	**2 (5.9)**	
CORADS 4	**3 (5.8)**	**4 (7.7)**		**4 (11.8)**	**4 (11.8)**	
CORADS 5	**2 (3.8)**	**1 (1.9)**		**6 (17.6)**	**6 (17.6)**	
CORADS 6	**1 (1.9)**	**1 (1.9)**		**0**	**0**	

Data are presented as No. (%).

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Figure 1: low dose CT for middle-aged male patient presented by fever, dry cough with lymphopenia, and monocytosis showing clearly identified peripheral and central GGO with an interobserver agreement (CORADS V).

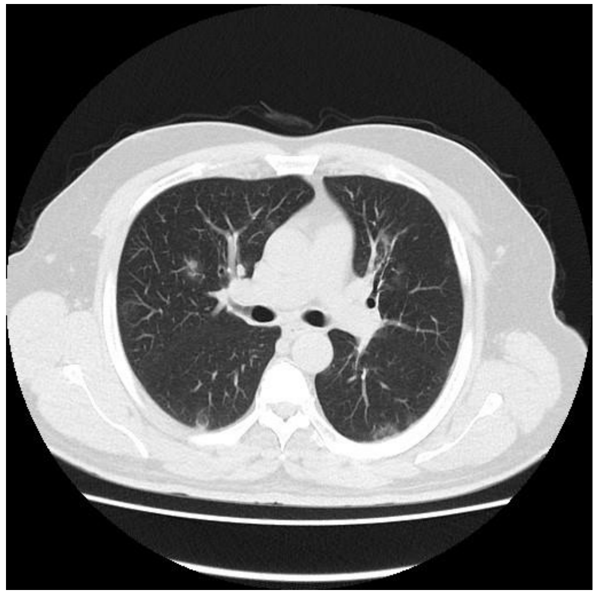

Figure 2: low dose CT for middle-aged male patient presented by fever, dry cough with lymphopenia, monocytosis, and positive RT-PCR showing clearly identified peripheral and central GGO with an interobserver agreement (CORADS VI).

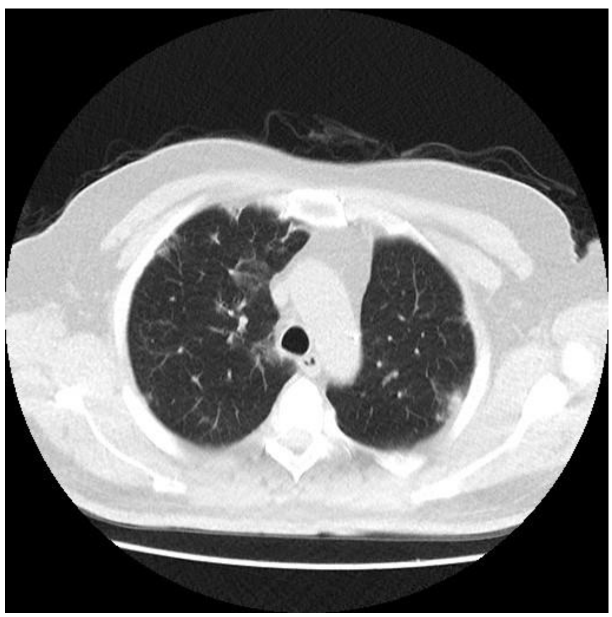

Figure 3: Standard dose CT for middle-aged female patient presented by fever, dry cough with lymphopenia, and monocytosis showing peripheral GGO with septal thickening and interobserver agreement (CORADS V).

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DISCUSSION

Many recent studies have declared that chest CT examination has high sensitivity in COVID-19 pneumonia lung parenchymal changes detection **[5,10,13].** In many countries, CT chests together with serological and clinical data are commonly used to suggest COVID-19 infection, and so we need CT imaging protocol to enhance radiation protection and achieve the ALARA radiation rule. Radiation exposure dose to the patient better to be kept as low as possible while maintaining the diagnostic image quality necessary for patient care. Low-dose CT technique can be applied by many methods, including automatic exposure systems and imaging filters **[14-17].**

The radiation dose is directly proportional to the tube current-time product at a fixed peak tube voltage and slice thickness. Therefore, reducing tube current is a simple and applicable means to decrease radiation exposure **[18].**

This study aimed to assess the reliability and diagnostic efficacy of a low dose CT scan of the chest for detection of COVID-19 pulmonary changes to enhance radiation protection by lowering patient exposure. In our study, there was a statistically significant difference between low and standard dose techniques groups regarding CTDI volume, DLP, and radiation exposure (p =<0.001) with good diagnostic efficacy of low dose CT. This was concordant to multiple prior studies that have confirmed that low-dose chest CT protocols have a diagnostic accuracy similar to standard-dose despite degraded image quality detection **[19-22].** A comprehensive study performed by Kubo et al. showed that low and standard doses have the statistically near-equal ability for detection of chest abnormalities. Their study showed that low-dose chest CT (50 mAs) is as accurate as standard-dose (150 mAs) in the detection of lung lesions as, ground-glass opacities, micronodules, emphysema, honeycombing, and reticular densities, and mediastinal/pleural findings **[23].** More specifically Salar Tofighi et al. **[36]** showed that LDCT and ULDCT have demonstrated comparable efficacy in the detection of GGO and consolidation in patients with pneumonia and can be potentially recommended for the evaluation of these patients with suspected COVID-19, particularly in pregnant and pediatric populations to reduce radiation exposure. Lung cancer screening programs with low-dose chest CT protocols have been associated with reduced mortality **[24]**. Also, in the era of COVID 19, Tabatabaei et.al. **[25]** have proposed the use of low-dose CT chest protocol as a reliable test in detecting COVID-19 pneumonia.

The low-dose CT scan is also suitable for special cases such as pediatric patients, pregnant women, and repeated follow-up because of the lower risk of long-term adverse effects. The reduction of the radiation dose also lowers the risk of CT tubes and detectors damage, which in turn reduces the running cost and increases the lifetime of the cathode-ray tubes and detectors **[18, 26].**

In our study regarding CT findings, GGO without consolidation was detected in many cases more than consolidation alone or mixed GGO with consolidation. This was consistent evidence to other studies where GGO is a typical common CT finding in COVID-19 patients **[27-32]**. Also showed that low-dose chest CT (50 mAs) **<Fig 1, 2>** is as accurate as standard-dose (150 mAs) **<Fig 3>** in detecting lung abnormalities such as ground-glass opacities and consolidations. GGO is a hazy gray (slightly increased density) area without bronchovascular dimming, caused by partial air displacement resulting from either alveolus partial filling of interstitial thickening **[33]**. In up to 2 weeks after disease onset, lesion density gradually increases to consolidation as stated in a study by Pan et al. **[34]**, which coordinates with a study by Shi et al. **[35]** which showed that GGO can progress to or co-existed with consolidations within 1–3 weeks. While Consolidation reflects alveolar spaces occupied by fluids or cells with density higher than GGO, high enough for bronchovascular obscuration **[33]**.

Limitations

Artifacts and lower image quality in overweight patients.

Sample size as we have only one floor as an isolation ward.

CONCLUSION

Deficient RT-PCR kits raised the need for alternative diagnostic tools for COVI-19 infection, since CT of the chest together with clinical and serological data were able to help in the diagnosis of COVID-19, the use of low dose protocol can be recommended to be used as standard protocol for diagnosis and follow up, as it provides diagnostic performance and lesion characterization efficacy comparable to that of standard-dose CT technique with up to 94% of interobserver agreement and significant reduction of radiation exposure keeping radiation safety help protecting patients from excess radiation hazards.

Conflicts of interests: *None*

Financial disclosure: *None*

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