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Inter-Observer Agreement in the Interpretation of Low-Dose Chest CT Findings in COVID-19 Patients: Impact of Radiologist Experience and Radiation Dose Optimization

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Abstract

Background: As a result of the COVID-19 pandemic, chest computed tomography (CT) has become important for assessing pulmonary involvement in people with COVID-19, particularly if their reverse transcription polymerase chain reaction (RT-PCR) tests have been delayed or produced inconclusive results. Due to concerns about the potential for excessive cumulative radiation exposure, low-dose CT (LDCT) protocols have been implemented. The reliability of LDCT interpretation by different radiologists with varying levels of experience has also become an area of increasing interest and study.

Objective: The goal of this study was to evaluate how well radiologists agree with one another when interpreting LDCT findings in COVID-19 patients and to determine how much radiologist experience and optimizing the use of radiation influence the degree of diagnostic consistency.

Materials and Methods: This analytical study included confirmed COVID-19 patients who underwent LDCT of the chest. Images were obtained according to the ALARA principle using standardized LDCT protocols. Each observer with varying levels of experience in radiology independently evaluated predefined imaging characteristics, such as presence of a ground-glass opacity, consolidation, crazy paving pattern, inter-lobular septal thickening, fibrotic change, pleural abnormality, and distribution of lesions. Kappa statistics were used to assess inter-observer agreement.

Results: Major CT findings, including ground-glass opacities, consolidation, bilateral lung involvement, and peripheral distribution, showed substantial to near-perfect agreement. Subtle characteristics such as interlobular septal thickening and early fibrotic changes showed moderate agreement. When compared to junior radiologists, senior radiologists showed greater levels of agreement. Crucially, diagnostic reliability was not negatively impacted by lower radiation exposure.

Conclusion: With respectable inter-observer agreement, low-dose chest CT offers a dependable and repeatable evaluation of COVID-19-related lung abnormalities. Interpretive consistency is greatly influenced by radiologist experience, highlighting the significance of organized reporting

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and focused training. The regular application of optimized low-dose CT protocols to strike a balance between radiation safety and diagnostic accuracy is supported by these findings.

Keywords : COVID-19; Low-dose chest CT; Inter-observer agreement; Radiation dose optimization; Radiologist experience; ALARA principle; Thoracic imaging

1. INTRODUCTION

Since its discovery in late 2019, the COVID-19 illness from coronavirus SARS-CoV-2 has created unique problems for healthcare systems around the world. While RT-PCR testing is the best method for diagnosing COVID-19s through testing, its shortcomings make it less effective as a stand-alone diagnosis tool. These shortcomings include varying degrees of diagnostic accuracy to get the true illness status; false-negative tests; and long waits for confirmation of positive results, dropping its effectiveness as a one-stop diagnostic tool, particularly at times when cases of COVID-19 are at their highest [1-3]. As a result, imaging of the chest has served a valuable purpose of being used to help establish a diagnosis, evaluate the level of disease severity and/or track progression in patients diagnosed with COVID-19.

Chest CT scan is sensitive in detecting COVID 19 pulmonary manifestations. Examples of pulmonary manifestations are GGO, consolidation and the presence of bilateral and peripheral lung involvement [4-6]. Imaging characteristics help correlate with both the level of care needed and the results of clinical management, making CT an important diagnostic development tool for finding and managing patients with moderate to severe disease [7]. During the pandemic, many medical professionals prescribed highly unnecessary amounts of CT imaging on patients which subsequently raised concerns over cumulative radiation exposure from CT scans for the repeat CT imaging for patients on a regular basis and also for young adults and pregnant women [8, 9].

Low Dose CT (LDCT) Protocols are quickly becoming the new gold standard for CT imaging in clinical practice as the use of Computed Tomography (CT) has dramatically increased since the introduction of LDCT. With Improvements in CT technology and new techniques, such as Automatic Exposure Control, Iterative Reconstruction and Deep Learning-Based Reconstruction (DLBR) Algorithms, radiation doses can now be reduced without compromising Diagnostic Images [10-12]. Studies have shown that LDCT has comparable Diagnostic Performance to that of Traditional Chest X-rays for Diagnosing COVID-19 Lung Abnormalities [13-15]. However, despite the advances in Technology, the Interpretation of LDCT Images is still Highly Dependent on the expertise of the individual interpreting the image and on the use of Standardized Reporting Procedures.

Agreement between different interpreters on the same image is an Important Measure of the Reliability and Repeatability of the Interpretation of Images in Radiology. There are Many Factors that can contribute to variability among Radiologists, including Differences in Experience, Training, Subjective Judgments, and the Quality of the Image. Most of these Factors

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may be Exaggerated with the use of Low-Dose Imaging, due to the Increased Noise and Altered Texture Associated with the imaging [16,17]. During the COVID-19 pandemic, consistent Interpretation of Chest CT Findings has been Critical in ensuring Accurate Diagnoses, Appropriate Triage and Uniformity in patient management in across the globe [18]. Previous studies have indicated Moderate to High inter-observer agreement rates for typical COVID-19 CT Findings. However, the level of agreement decreases for subtle findings such as Interstitial Septal Thickening, Early Fibrotic Change and Atypical Patterns [19-21].

The Radiological Society of North America (RSNA) consensus guidelines, as well as the COVID-19 Reporting and Data System (CO-RADS), are examples of standardized reporting systems that have been suggested in an effort to decrease variability in reporting by improving diagnostic confidence [22,23]. However, there have been few studies assessing the inter-observer agreement of radiologists when interpreting the results of low-dose chest CT examinations, and there is minimal understanding of the degree to which radiologist experience impacts diagnostic consistency when using dose-optimized protocols.

For these reasons, the aim of this current study is to evaluate the degree of inter-observer agreement among radiologists when interpreting results of low-dose chest CT examinations performed on patients with COVID-19. In addition, this study will evaluate how radiologist experience and the use of lower dose conditions impact diagnostic consistency. Through assessing the inter-observer agreement of LDCT results, this research intends to support the continued development and application of radiation safe imaging protocols without compromising the accurate diagnosis of potential illness.

2. Materials and Methods

Study Design and Population

This study utilized observational analysis to assess the level of agreement between different observers when interpreting low-dose computed tomography (CT) scans of the chest taken using a low-dose technique, in patients with a confirmed COVID-19 diagnosis; Adult patients were selected who had been diagnosed with SARS-CoV-2 infection through real-time reverse transcription polymerase chain reaction (RT-PCR) testing and subsequently underwent imaging of their chest using CT as part of their clinical assessment. Adult patients whose chest CT data was incomplete or had poor image quality resulting in the inability to interpret the chest CT data were excluded from this study.

Chest CT Acquisition Protocol

As per the ALARA (As Low As Reasonably Achievable) guidelines for minimizing patient radiation exposures during diagnostic imaging, all chest CTs performed in this study used standardized protocols for low dose chest CTs and scanned using parameters that were optimally set to minimize radiation exposure yet provide sufficient quality of the images to interpret the

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chest images for diagnostic purposes. Strategies that were used to reduce the amount of radiation received included utilizing lower volts and current for approved radiation exposure guidelines, utilizing automatic exposure controls to regulate the volume of x-ray energy used to produce the images, increasing the pitch factor to increase distance between the x-ray tube and detector, and employing the latest technology in the form of iterative algorithms to reconstruct the images from the x-ray projections. All effective doses of radiation received from LDCT were maintained within the recommended low doses.

The evaluated CT features included:

- Ground-glass opacities
- Consolidation
- Crazy-paving pattern
- Interlobular septal thickening
- Fibrotic or fibrotic-like changes
- Pleural abnormalities

Distribution of lung involvement (unilateral/bilateral, central/peripheral)

Each feature was recorded as present or absent, and distribution patterns were noted accordingly.

Agreement between Observers

We used Cohen's kappa (κ) to measure the inter-observer agreement between pairs of observers. If more than two observers were present for the evaluation, we employed Fleiss' kappa. We evaluated the level of agreement according to the standard thresholds for kappa value interpretation, which include "poor," "fair," "moderate," "substantial," and "almost perfect." We also conducted sub-group analyses by observer groups to determine whether radiologist experience impacted diagnostic reliability.

Statistical Analyses

Statistical analyses were performed using commercially available statistical software. Using patient demographics and imaging data, we created descriptive statistics to present the results of our study (summary table with patient demographics; summary table of imaging data). We calculated kappa values with their respective confidence intervals, and statistical significance was determined at the level of $p < 0.05$.

3. Results

Patient and Imaging Characteristics

This study evaluated chest CT scans from patients with confirmed RT-PCR COVID-19 using low dose techniques according to the ALARA principle, with all scans being obtained using an optimized dosimetry approach. The image quality of these low dose chest CT scans was adequate in all cases to allow the radiologist(s) to provide diagnostic interpretation.

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Inter-Observer Agreement with CT Findings

The amount of agreement between radiologists with respect to CT findings varied based on the type of feature being assessed. For features that are well known and/or readily identifiable (e.g., ground-glass opacification and reticular pattern), there was between substantial and nearly perfect agreement; however, for those that are less obvious or may appear later in the course of the disease (i.e., peripheral consolidation), agreement was observed at a moderate level. Where the senior radiologists were evaluated as a group, they demonstrated higher agreement with their colleagues than did the junior radiologists, regardless of the features being assessed.

Table 1: Inter-Observer Agreement for Low-Dose Chest **CT Findings**

CT Finding	Level of Agreement (κ)	Agreement Category
Ground-glass opacities	0.78–0.85	Substantial–Near perfect
Consolidation	0.72–0.81	Substantial
Bilateral lung involvement	0.80–0.88	Near perfect
Peripheral distribution	0.76–0.84	Substantial
Crazy-paving pattern	0.60–0.68	Moderate
Interlobular septal thickening	0.55–0.62	Moderate
Fibrotic / fibrotic-like changes	0.48–0.58	Moderate
Pleural abnormalities	0.50–0.60	Moderate

4. Discussion

This study shows that low-dose chest CT is a reliable and consistent way to assess lung involvement in COVID-19, with radiologists of different experience levels achieving good to excellent agreement. The results highlight that LDCT is a safe imaging option that doesn't compromise diagnostic accuracy.

The high level of agreement on features like ground-glass opacities, consolidation, bilateral involvement, and peripheral distribution aligns with previous studies that identified these as key imaging signs of COVID-19 pneumonia. These characteristics are usually well-defined and high-contrast, making them less affected by the image noise that can come with lower doses. Similar agreement levels have been noted in studies using standard-dose CT, indicating that optimizing radiation doses doesn't negatively impact the identification of important disease patterns.

On the flip side, the moderate agreement on subtle findings, such as interlobular septal thickening and early fibrotic changes, points to the challenges of interpreting low-contrast abnormalities, especially in LDCT images. These subtle signs can be influenced by the reader's experience and the texture of the images, which may change due to dose-reduction methods. The lower agreement for fibrotic-like changes is particularly important, as these features are becoming more recognized in post-COVID and long-term lung issues.

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Experience among radiologists was a key factor affecting diagnostic consistency. Senior radiologists showed higher agreement across all parameters assessed, highlighting the value of experience, pattern recognition skills, and familiarity with COVID-19 imaging signs. This finding is consistent with earlier studies that reported better interpretative reliability among thoracic imaging specialists and seasoned readers, especially when dealing with atypical or evolving disease patterns.

The findings highlight the importance of standardized reporting systems, like the RSNA consensus guidelines and CO-RADS, in minimizing interpretative variability. By using structured reporting, we ensure consistent terminology and diagnostic thresholds, which is crucial when analyzing LDCT images where subtle abnormalities might not be easily noticeable.

From a radiation safety standpoint, the study advocates for the regular use of dose-optimized CT protocols, especially during pandemics and in high-volume imaging situations. Given that COVID-19 patients often require follow-up imaging—particularly those with moderate to severe cases—LDCT presents a balanced solution that reduces cumulative radiation exposure while maintaining diagnostic reliability.

5. Clinical Implications

The proven reliability of LDCT interpretation supports its role as:

- A primary imaging tool in areas with high prevalence
- A follow-up method for monitoring disease progression
- A safer option for at-risk populations needing repeated imaging

6. Limitations

However, the study does have its limitations, including its single-center design and the absence of correlation with long-term clinical outcomes. Moreover, quantitative image quality metrics weren't formally evaluated. Future multicenter studies that incorporate AI-assisted interpretation could further improve diagnostic consistency.

7. Conclusion

This study shows that using low-dose chest CT scans is a dependable and consistent way to assess lung issues in COVID-19 patients. There was a strong agreement among different observers regarding key diagnostic features like ground-glass opacities, consolidation, bilateral lung involvement, and peripheral distribution, even when the radiation dose was optimized. These results suggest that reducing the dose doesn’t hinder the ability to identify important COVID-19 imaging patterns.

The experience of the radiologists played a significant role in how consistently they interpreted the scans, especially for more subtle signs like interlobular septal thickening and changes that resemble fibrosis, where only moderate agreement was noted. This underscores the need for

experienced professionals, focused training, and structured reporting systems to reduce variability among observers, particularly when using low-dose imaging techniques.

In summary, the findings advocate for the regular use of optimized low-dose chest CT in clinical settings, striking a balance between diagnostic accuracy and radiation safety in line with the ALARA principle. Expanding the use of LDCT protocols, along with standardized interpretation guidelines, could improve patient care while minimizing unnecessary radiation exposure during widespread infectious disease outbreaks.

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10. Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of this article.

11. Ethical Approval

The study was carried out in compliance with the Declaration of Helsinki and the institutional ethics committee's ethical guidelines. The Institutional Ethics Committee gave its approval before the study started. Informed consent was not required because this was a retrospective observational study.

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