



## Diagnostic Performance and Reproducibility of the Radiological Society of North America Expert Consensus Statement on COVID-19 Pneumonia COVID-19 Pnömonisine İlişkin Kuzey Amerika Radyoloji Derneği Uzman Konsensusunun Tanısal Performansı

Sevim Özdemir<sup>1</sup>, Rüştü Türkay<sup>1</sup>, Bahar Atasoy<sup>2</sup>

<sup>1</sup> Health Sciences University, Istanbul Haseki Training and Research Hospital, Department of Radiology, Istanbul, Turkey  
<sup>2</sup> Bezmialem Vakıf University, Department of Radiology, Istanbul, Turkey

### ABSTRACT

**Aim:** To investigate the interobserver and intraobserver agreement and performance of the Radiological Society of North America Expert agreement declaration in assessing chest computed tomography (CT) findings related to new COVID-19 pneumonia.

**Materials and Methods:** In this retrospective study, conducted from March 15 to April 1, 2020, 113 patients with suspected COVID-19 infection were enrolled. All patients underwent investigation using real-time reverse transcription polymerase chain reaction (RT-PCR) and chest CT scans. Chest CT features were categorized by three radiologists following the North American Consensus Statement. Characteristic and indeterminate features were considered as Group A, while atypical and negative features were considered as Group B. The interobserver and intraobserver agreement of the imaging features were evaluated, along with the sensitivity and specificity of the consensus statement.

**Results:** The study population comprised 113 consecutive patients. Out of the 113 patients, 61 tested positive for RT-PCR. Group A (categories 3 and 4) consisted of 89 patients, while Group B (categories 1 and 2) included 24 patients. The ICC score for intraobserver and interobserver agreement was 0.996 (95% CI) and 0.971 (95% CI), respectively. Using RT-PCR as a reference standard, the sensitivity, specificity, negative predictive value, and positive predictive value of CT findings (group A, B) for COVID-19 pneumonia were 82%, 25%, 56.1%, and 54.1%, respectively.

**Conclusion:** The expert agreement declaration on reporting new COVID-19 pneumonia tomography findings is a well-designed, reliable, and reproducible standardized CT reporting language. It demonstrates excellent intra- and interobserver agreement.

**Keywords:** Computed tomography, coronavirus disease-2019, diagnosis, pneumonia, real-time reverse transcription polymerase chain reaction

### ÖZET

**Amaç:** COVID-19 pnömonisinde gözlenen toraks bilgisayarlı tomografi (BT) bulgularının değerlendirilmesinde Kuzey Amerika Radyoloji Derneği Uzman Anlaşması beyanının gözlemciler arası ve gözlemci içi uyumunu ve performansını araştırmayı amaçladık.

**Gereç ve Yöntemler:** 15 Mart - 1 Nisan 2020 tarihleri arasında yürütülen bu retrospektif çalışmaya COVID-19 enfeksiyonu şüphesi olan 113 hasta dahil edildi. Tüm hastalara real time reverse transkriptaz polimeraz zincir reaksiyonu (RT-PCR) ve toraks BT incelemesi yapıldı. Toraks BT özellikleri Kuzey Amerika Uzlaşma Beyannamesine göre üç radyolog tarafından kategorize edildi. Karakteristik ve intermediate özellikler A grubu olarak kabul edildi. Atipik ve negatif özellikler B grubu olarak kabul edildi. Görüntüleme özelliklerinin gözlemciler arası ve gözlemci içi uyumu konsensus ifadesinin duyarlılığı ve özgüllüğü ile birlikte değerlendirildi.

**Bulgular:** Çalışma popülasyonu 113 ardışık hastadan oluşmaktadır. 113 hastanın 61'i RT-PCR pozitif. Grup A (kategori 3 +4) 89 hastadan ve grup B (kategori 1+2) 24 hastadan oluşuyordu. Gözlemci içi ve gözlemciler arası uyum için skoru sırasıyla 0.996 (%95 CI) ve 0.971 (%95 CI) idi. Referans standart olarak RT-PCR kullanıldığında, BT bulgularının (grup A, B) COVID-19 pnömonisi için duyarlılık, özgüllük, negatif ve pozitif prediktif değerleri sırasıyla %82, %25, %56.1 ve %54.1 idi.

**Sonuç:** Yeni COVID-19 pnömonisi tomografi bulgularının raporlanmasına ilişkin uzman anlaşması beyanı, iyi tasarlanmış, güvenilir ve tekrarlanabilir standart raporlama dilidir ve gözlemciler arası ve gözlemci içi mükemmel bir uyum gösterir.

**Anahtar Kelimeler:** Bilgisayarlı tomografi, koronavirus hastalığı-2019, pnömoni, polimeraz zincir reaksiyonu, tanı

**Corresponding Author :** Sevim Özdemir, Istanbul Haseki Training and Research Hospital, Department of Radiology, Istanbul, Turkey, **Email:** sevimozdemir76@yahoo.com

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## INTRODUCTION

Many studies have been carried out on COVID-19 infection, such as the symptoms, diagnosis and clinical approach of the disease, during the pandemic period declared in early 2020, and today, studies on the sequelae of this infection continue. During this pandemic stage, chest computed tomography (CT) has shown great importance for the rapid and accurate diagnosis and plays a pivotal role in assisting the clinical management of patients with uncertain clinical scenarios. Performing imaging, especially thorax CT, is a forced situation because serologic testing results have some drawbacks such as the long turnaround time and false-negative results (1). Suggestions for performing CT have increased through expert opinions (1). The value of structured reporting of COVID-19-related CT exams is paramount because of the need for rapid clinical acts such as patient care, treatment management, isolation of the patient, and filiation.

Several recent studies characterized CT imaging features of COVID-19 and reported the performance of radiologists in discriminating COVID-19 pneumonias from other viral etiologies (2-4). The described typical imaging patterns were bilateral, multifocal, and predominantly peripheral ground-glass opacities (GGO) associated with sub-segmental and mostly subpleural patchy consolidations, predominantly involving the lower lung lobes and posterior segments (2-4).

The purpose of this retrospective study was to measure the performance and interobserver and intraobserver variability of this recently published expert agreement statement in tomography findings of COVID-19 pneumonia.

## MATERIALS and METHODS

### *Patients*

This retrospective study was approved by our Institutional Ethics Committee (Decision number: 39-2020). Our retrospective study comprised 113 caucasian patients (67 males and 46 females) who were enrolled from March 15th through April 1st, 2020. Inclusion criteria were patients with suspected COVID-19 pneumonia, thorax CT examination and RT-PCR testing. Exclusion criteria were accepted as non-diagnostic thorax CT examination and no RT-PCR test. Patients who were found suspicious of having COVID-19 pneumonia, were sent to the radiology department to perform thorax CT. All patients were investigated using real-time reverse transcription polymerase chain reaction (RT-PCR) testing. After PCR testing, CT imaging was employed in all patients. COVID-19 pneumonia was confirmed through positive

PCR test results. A total of 61 patients were verified as having COVID-19 on the basis of positive results for respiratory samples tested using RT-PCR. The diagnosis of 'not COVID-19' for 52 patients was called after 2 negative RT-PCR tests. Time interval between 2 tests was 2 days. There were no follow up CT scans in our study.

### *CT Scanning Protocol*

CT data were acquired using a 128 detector CT scanner (PHILIPS Ingenuity, Netherlands). The parameters of the CT scan were as follows: the patient was in the supine position and end inspiratory acquisition; tube current-exposure time product, 200–300 mAS; tube voltage, 120 kV and section thickness after reconstruction, 1.25 mm. CT scans were obtained without contrast material administration.

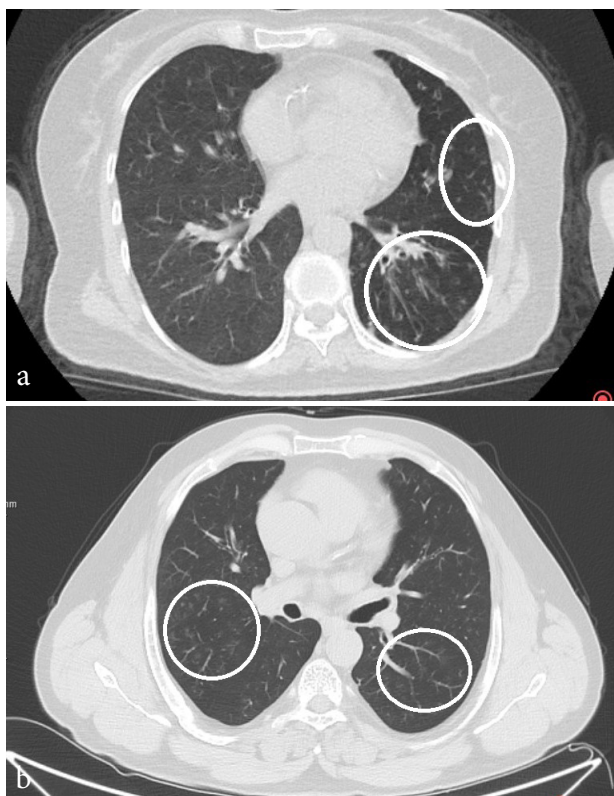
### *Imaging Analysis*

CT images were retrospectively evaluated by three radiologists with 6-, 15- and 18- years' experience in general radiology. All CT features were categorized as typical, indeterminate, atypical and negative features in accordance with Radiological Society of North America (RSNA) Expert Consensus Statement on reporting chest CT findings related to COVID-19 published on March 25th (5). The typical features are based upon available literature and more specific and commonly observed and reported imaging properties of this pandemic virus pneumonia.

New agreement declaration of imaging features was described as follows:

- I. Typical features (Category 4);
- II. Indeterminate features (Category 3, Figs. 1a and 1b);
- III. Atypical features (Category 2);
- IV. Negative features (Category 1);

The only pre-test preparation for all three radiologists is to read RSNA Expert Consensus Statement on reporting chest CT findings related to COVID-19 (4). They implemented RSNA Expert Consensus imaging features as mentioned above and newly categorized. Typical features were categorized as 4, indeterminate features as 3, atypical features as 2, and negative for pneumonia was 1. Three radiologists evaluated CT imaging features without any knowledge about the RT-PCR test results. They evaluated CT scans individually. For intraobserver agreement evaluation, one of three radiologists evaluated the scans again after 3 weeks to avoid case memory. Categories 4+3 (typical and indeterminate features) were allocated to group A, and categories 2+1 (atypical and negative features) were assigned as group B. Group A stands for likely COVID-19 findings. Group B is for unlikely



**Figure 1.** 45 year-old woman with suspected COVID-19 infection and PCR (-) test result. Axial CT scans (a,b) indicated a focal ground-glass opacities and tree-in-bud sign in lingual segment of the left lung (a) and left lower lobe (b) (white circles). The CT imaging score was evaluated as score 2 (atypical features for COVID-19).

COVID-19 findings. These groups were created in order to maintain more definitive radiologic results so that evaluation of suspected COVID-19 patients can be less complicated in clinical practice.

#### **Statistical Analysis**

Statistical analyses were performed using the Number Cruncher Statistical System (NCSS) 2007 (Kaysville, UT) software. The interobserver and intraobserver agreement of the imaging features were examined using the interclass coefficient (ICC) with confidence intervals of 95%. Agreement values are interpreted as follows: values less than 0.5 are indicative of poor reliability, values between 0.5 and 0.75 indicate moderate reliability, values between 0.75 and 0.9 indicate good reliability, and values higher than 0.90 indicate excellent reliability. Sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) were calculated in order to test the performance of the agreement statement for patients with COVID-19.

#### **RESULTS**

The study population comprised 113 consecutive patients (67 males and 46 females). The mean age of the patients was  $51 \pm 14$  (range, 20-88) years.

Of the 113 patients, 61 were RT-PCR-positive and 52 were RT-PCR negative (Table 1). Group A (categories 3 +4) was constituted by 89 patients and group B (categories 1+2) included 24 patients (Table 1). The ICC score for intraobserver agreement was 0.996 (95% CI), and the ICC score for interobserver agreement was 0.971 (95% CI). Using RT-PCR as a reference standard, the sensitivity, specificity and positive and negative predictive values of CT findings (group A, B) for COVID-19 pneumonia were 81.97%, 25%, 56.18%, and 54.17%, respectively.

#### **DISCUSSION**

Several research papers have been recently published for the description of characteristic CT imaging features and the temporal evaluation of imaging findings in patients with COVID-19 (2-4). In these studies, chest CT was strongly suggested in suspected COVID-19 patients for both the initial evaluation and follow-up (6).

Li et al. mentioned that CT imaging had high accuracy in suggesting COVID-19 and might be beneficial as a standard method for the diagnosis of COVID-19 pneumonia (7). Similarly, Ai et al. reported about the complementary role of chest CT in cases with false-negative RT-PCR test results, stating that the sensitivity of chest CT imaging was 97% in RT-PCR-confirmed cases (8). In a meta-analysis, the pooled positive rate of chest CT imaging was reported as 89.76% among subjects suspected of having COVID-19 (9). These findings emphasize the importance of CT imaging, especially in clinically suspected patients with negative test results. Owing to the strong infectivity of COVID-19, accurate and rapid identification tools are promptly required to recognize and to clinically manage these patients appropriately as soon as possible. This approach can reduce mortality ratios and spread of the pandemic virus.

The existence of the many different studies and the identification of the many characteristic imaging findings related to COVID-19 pneumonia as a result of these studies have created the necessity of reaching a consensus in reporting.

There is a wide range of CT manifestations of viral pneumonia and most cases have similar presentations on imaging. However, some CT imaging features that are not characteristic for COVID-19 pneumonia, like centrilobular and tree-in-bud nodules, bronchial mucus plug and bronchial wall thickening could be noted during reporting. On March 25th, 2020, the RSNA published a consensus on reporting chest CT findings based upon available literature and more specifically observed CT imaging findings in COVID-19 pneumonia (5). The goal of the expert consensus was to serve as a guide to radiologists while evaluating chest tomographic imaging features probably related to COVID-19 pneumonia. Some atypical imaging features could be confusing for radiolo-

**Table 1.** Details of the total numbers of Group A (categories 3+4) and group B (categories 1+2) patients with positive and negative RT-PCR test results.

CT Imaging Score		RT-PCR Test Results		
		Positive	Negative	Total
Group A	Positive	50	39	89
Group B	Negative	11	13	24
	Total	61	52	113

*RT-PCR: Real-Time Reverse Transcriptase-polymerase chain reaction*

gists and can complicate interpretations while addressing the probability of COVID-19 infections. Furthermore, the frequency of incidental lung lesions detected, which could be attributed to COVID-19, may increase. Structured reporting has the advantage of reducing miscommunication problems with referring physicians, thereby assisting in the medical management of patients during this epidemic stage. Additionally, this will reduce uncertainty in CT reporting findings and enhance physicians' comprehension of documentation, thereby enabling improved and more efficient clinical management.

Our study demonstrates excellent inter- and intra-observer agreement in utilizing the RSNA Consensus Statement for reporting chest CT findings, with high ICC scores. This high agreement score implies a high level of reliability and reproducibility of this reporting language. We have demonstrated that this standardized reporting language can be widely utilized, providing guidance and boosting confidence for radiologists by reducing reporting variability. Furthermore, this consensus enhances the diagnostic performance of radiologists in evaluating COVID-19 pneumonia imaging. Facilitating the universal collection of data for future COVID-19 studies could be another potential benefit of structured reporting (categories like 1 to 4).

The diagnostic performance of chest CT remains widely unknown. In the literature, the reported sensitivities and specificities of chest tomography for detecting new pandemic virus pneumonia vary widely (ranging from 60% to 98% and 25% to 53%, respectively) (8,10-13). The RSNA associated these differences with the retrospective structure of the published papers and the lack of rigorous diagnostic criteria for CT imaging (5). In our study, the sensitivity and specificity of the new expert agreement declaration for pandemic pneumonia were 82% and 25%, respectively, which is consistent with the current literature. Also, Bryne et al. conducted a similar study and reported that North America Expert Consensus Statement showed significant to almost perfect agreement among expert thoracic radiologists in patients with suspected COVID-19 pneumonia, which is consistent with our study (13). They reported high ICC scores for negative (0.962), typical (0.815), and atypical (0.806)

COVID-19 CT findings, and a significant score (0.636) for indeterminate COVID-19 CT findings. In our study, we also demonstrated high interobserver and intraobserver agreement among radiologists who were not experts in thoracic radiology. Our results showed that the RSNA Expert Consensus Statement can be widely utilized by general radiologists with excellent consistency. In addition, the relatively high sensitivity value suggests that the RSNA Consensus Statement is a reliable CT reporting language for identifying patients with COVID-19. However, its low specificity reduces its effectiveness in diagnosing non-COVID-19 cases.

In the literature, the positive and negative predictive values of chest CT in indicating COVID-19 were reported as 65% to 92% and 42% to 83%, respectively (8,10). In our study, the PPV and NPV of the RSNA Expert Consensus Statement were 56.18% and 54.17%, respectively. Our NPV result is consistent with the literature. By contrast, the PPV is not compatible (56.82% vs. nearly 90% in the literature). Several reasons might explain the incompatible result. Our local RT-PCR testing results may not demonstrate the same level of sensitivity and specificity as RT-PCR tests conducted in other studies. There may be sampling errors. One other possible explanation could be the potential high prevalence of other non-COVID-related viral pneumonias.

### Limitations

There are some limitations in the current study. First, the number of cases is relatively small because the number of tests available at that time was low. Second, patients who were CT-positive but RT-PCR-negative were not tested for other etiological agents such as influenza, which may have affected our relatively low positive predictive value (PPV).

### Conclusion

The North America Agreement Declaration on reporting CT features of new pandemic virus pneumonia is a well-designed, reliable, and reproducible standardized CT reporting language that demonstrates excellent intra- and inter-observer agreement. This reporting language can reduce variability in reporting, eliminate uncertainty among radiologists, and improve clinical management during similar pandemic stages.



**Ethics Committee Approval:** The study was approved by the ethics committee board of Istanbul Haseki Training and Research Hospital (Decision number: 39-2020).

**Conflict of Interest:** The authors declare no conflict of interest in this study.

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