The Role of Teleradiology in the COVID-19 Pandemic

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Abstract

Objective: This study aimed to investigate the role of teleradiology during the COVID-19 pandemic in Turkey.

Methods: We evaluated chest computed tomography images of 1649 patients whose diagnoses of COVID-19 had been confirmed with the reverse transcription-polymerase chain reaction, using the COVID-19 imaging categories proposed by the Radiological Society of North America. Two staff radiologists independently evaluated the images, and the 2 results were compared. Disagreements were adjudicated by a third staff radiologist. This final consensus was used to evaluate the agreement between the computed tomography images and the teleradiology reports.

Results: There was an excellent and statistically significant agreement between the observers ($\kappa = 0.847$, $P < .001$). Similarly, there was a very high agreement between observer 1 and observer 2, and the final consensus ($\kappa = 0.934$, $P < .001$; $\kappa = 0.891$, $P < .001$, respectively). There was an excellent and statistically significant agreement between the consensus decisions and the teleradiology reports ($\kappa = 0.832$, $P < .001$).

Conclusion: There was an excellent interobserver agreement between the teleradiology assessments made during the COVID-19 pandemic and the assessments made by staff radiologists, as per the classification system proposed by the Radiological Society of North America. Our results support the suggestion that teleradiology can safely be used during pandemics.

Keywords: Computed tomography, COVID-19, interobserver agreement, teleradiology, the Radiological Society of North America COVID-19 pneumonia imaging classification

COVID-19 Pandemisinde Teleradyolojinin Rolü

Öz

Amaç: Bu çalışma Türkiye'deki COVID-19 pandemisinde teleradyolojinin rolünü araştırmayı amaçlamaktadır.

Yöntemler: Kuzey Amerika Radyoloji Derneği tarafından önerilen COVID-19 görüntüleme kategorilerini kullanarak ters transkripsiyon-polimeraz zincir reaksiyonu ile COVID-19 olduğu doğrulanan 1649 hastanın göğüs bilgisayarlı tomografi görüntülerini değerlendirdik. İki radyolog, görüntüleri bağımsız olarak değerlendirdi ve iki sonuç karşılaştırıldı. Anlaşmazlıklar üçüncü bir radyolog tarafından değerlendirilerek nihai karara varıldı. Varılan nihai karar bilgisayarlı tomografi görüntüleri ve teleradyoloji raporları arasındaki uyumu değerlendirmek için kullanıldı.

Bulgular: Gözlemciler arasında mükemmel ve istatistiksel olarak anlamlı bir uyum vardı ($\kappa = 0{,}847$, $P < ,001$). Benzer şekilde, gözlemci 1 ve gözlemci 2 ile nihai fikir birliği arasında çok yüksek bir uyum vardı (sırasıyla $\kappa = 0{,}934$, $P < ,001$; $\kappa = 0{,}891$, $P < ,001$). Uzlaşı kararları ile teleradyoloji raporları arasında mükemmel ve istatistiksel olarak anlamlı bir uyum vardı ($\kappa = 0{,}832$, $P < ,001$).

Sonuç: COVID-19 salgını sırasında yapılan teleradyoloji değerlendirmeleri ile Kuzey Amerika Radyoloji Derneği tarafından önerilen sınıflandırma sistemine göre hastane kadrosundaki radyologlar tarafından yapılan değerlendirmeler arasında mükemmel bir uyum vardı. Sonuçlarımız, teleradyolojinin pandemi sırasında güvenle kullanılabileceği önerisini desteklemektedir.

Anahtar Kelimeler: Bilgisayarlı tomografi, COVID-19, gözlemciler arası uyum, teleradyoloji, Kuzey Amerika Radyoloji Derneği COVID-19 pnömoni görüntüleme sınıflandırması.

Coronavirus disease 2019 (COVID-19), first appeared in Wuhan, China, in December 2019 and quickly spread around the world. In March 2020, the World Health Organization officially accepted COVID-19 as a pandemic.[1] COVID-19 is highly infectious and particularly causes pneumonia, acute respiratory distress syndrome, and respiratory failure.[2]

In the fight against COVID-19, the major approach has been to isolate patients via rapid diagnosis and to provide disease management. Testing with the reverse transcription-polymerase chain reaction (RT-PCR) using nasopharyngeal and oropharyngeal swabs is currently the gold standard for COVID-19 diagnosis.[3] Due to

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low viral loads, RT-PCR testing has low sensitivity in cases of early illness.[4,5] In such situations, chest computed tomography (CT) is an important component of the diagnostic algorithm for COVID-19. Chest CT has high sensitivity in the diagnosis of COVID-19 pneumonia, where typical findings include bilateral peripheral ground-glass opacities (GGOs) and consolidation.[6] In addition, COVID-19 pneumonia can present with atypical findings, such as unilateral, perihilar, limited, or multifocal involvement. Studies have also reported isolated lobar involvement, tree-in-bud appearance, and a reticular pattern.[7]

The Radiological Society of North America (RSNA) proposed a standardized reporting language for chest CT images based on COVID-19 pneumonia imaging characteristics for the management of patients during the pandemic, which was subsequently approved by the American College of Radiology and the Society of Thoracic Radiology (Table 1).[8] Accordingly, COVID-19 patients are divided into 4 categories according to CT imaging characteristics: typical appearance, indeterminate appearance, atypical appearance, and negative for pneumonia. This classification system aims to create a common language to improve communication between clinicians and radiologists and to reduce inconsistencies between reports.[8]

Teleradiology is the electronic transmission of diagnostic imaging studies via the internet, from medical centers with few or no radiologists, to other centers. Teleradiology gives the radiologist the opportunity to remotely connect and interpret radiology images from the same or a different health institution. Although outsourced teleradiology application differs between countries, it is widely used. According to a study conducted in 2016, in 70.8% of the European Society of Radiology member countries, outsourced teleradiology is used.[9] The quality and insufficiency of outsourced teleradiology reports due to insufficient communication with the clinician are controversial.[10,11] Despite the prominent role of diagnosis and treatment in the management of the COVID-19 pandemic, isolation measures to prevent transmission are the most effective prevention methods.[12] As is the case in many professions, remote work is an effective approach to isolation for radiologists.[13,14] Outsourced teleradiology is also commonly used in Turkey. The Republic of Turkey's Ministry of Health Teleradiology System enables the images of the radiological examinations with a 24-hour reach of the web environment, facilitates the reporting of these images, and allows the radiologist to provide teleconsultation in a system that allows the transmission of medical images that can be evaluated in terms of the quality of the reports.[15] The aim of this study was to compare the agreement of outsourced teleradiology results obtained from the remote assessment of CT images and the reports of staff radiologists in the diagnosis of COVID-19, and to reveal the role of tele-radiology in the COVID-19 pandemic in Turkey.

Table 1. The chest CT reporting language proposed by the Radiological Society of North America

Reporting Language for COVID-19 pneumonia suggested by the Radiological Society of North America[11]		
Chest CT Imaging Classification	**CT Findings**	**Reporting Language**
Typical appearance	1. Bilateral, peripheral, GGO with or without consolidation or visible intralobular lines ("crazy-paving") 2. Multifocal GGO of rounded morphology with or without consolidation or visible intralobular lines ("crazy-paving") 3. "Reverse halo sign or other findings of organizing pneumonia (seen later in the disease)"	Commonly reported imaging features of (COVID-19) pneumonia are present Other processes such as influenza, pneumonia, and organizing pneumonia, as can be seen with drug toxicity and connective tissue disease, can cause a similar imaging pattern
Indeterminate appearance	1. Non-peripheral or non-rounded diffuse, unilateral, multifocal or perihilar GGOs with or without consolidation, lacking a specific distribution 2. Few very small GGOs with a Non-peripheral and non-rounded distribution	Imaging features can be seen with (COVID-19) pneumonia, though they are nonspecific and can occur with a variety of infectious and noninfectious processes
Atypical appearance	1. Isolated segmental or lobar consolidation without GGOs 2. Discrete small nodules ("tree-in-bud," centrilobular) 3. Lung cavitation 4. vPleural effusion and smooth interlobular septal thickening	Imaging features are atypical or uncommonly reported for (COVID-19) pneumonia. Alternative diagnoses should be considered
Negative for pneumonia	No features of pneumonia	No CT findings present to indicate pneumonia

Methods

Patient selection

This was a single-center, observational retrospective study. All chest CT images reported by teleradiology in our hospital between October 2020 and January 2021 were retrospectively evaluated. Clinical data were obtained using the hospital's information manage-ment system. The ethics committee approval was obtained from the Ministry of Health of the Turkish Republic and the authors' Institutional Clinical Research Ethics Committee (Date: February 16, 2021, Number: 2021/02-41). Due to the retrospective design of the study, informed consent was not obtained. A total of 2993 patients were evaluated according to the exclusion and inclusion criteria, and the criteria were as follows:The inclusion criteria:

1. Chest CT images suitable for assessment;
2. COVID-19 diagnosis with PCR and clinical findings;
3. Exclusion of pneumonia of other causes; and
4. Teleradiology reports prepared using RSNA guidelines.

The exclusion criteria:

1. Chest CT images of patients with traumatic injury;
2. Patients not diagnosed with COVID-19 by PCR and clinical findings;
3. Chest CT images obtained after treatment;
4. Previously known lung diseases and/or non-COVID-19 pneumonia;
5. Teleradiology reports not prepared according to RSNA guidelines; and
6. Inadequate clinical data.

A total of 1649 patients who met all criteria after the evaluation were included in this study (Figure 1). All chest CT images were independently evaluated by 2 staff radiologists with 7 years (MÇ) and 4 years (CO) of experience in radiology, and reinterpreted using the format recommended by the RSNA, divided into 4 groups (Figure 2). The results obtained by the 2 radiologists were compared, and in cases of disagreement, the images were evaluated by a third staff radiologist (HTB) with 17 years of experience in radiology to adjudicate the results. The consensus from the assessments of the 3 staff radiologists and the teleradiology results were compared.

CT procedure

All chest CT scans were obtained with a 16-slice multidetector CT scanner (MX16, Philips Medical System, Koninklijke, the Netherlands). The CT scans were obtained during deep inspiration in the supine position. The scanning and reconstruction parameters were as follows: beam collimation 16 × 0.75 mm, rotation time 0.75 seconds, slice thickness 1 mm, 1-mm slice reconstruction, tube voltage 90-120 kV, and effective tube current-time product 50-110 mAs. CT images were acquired from lung apex to lung base. The field of view was 250-300 mm.

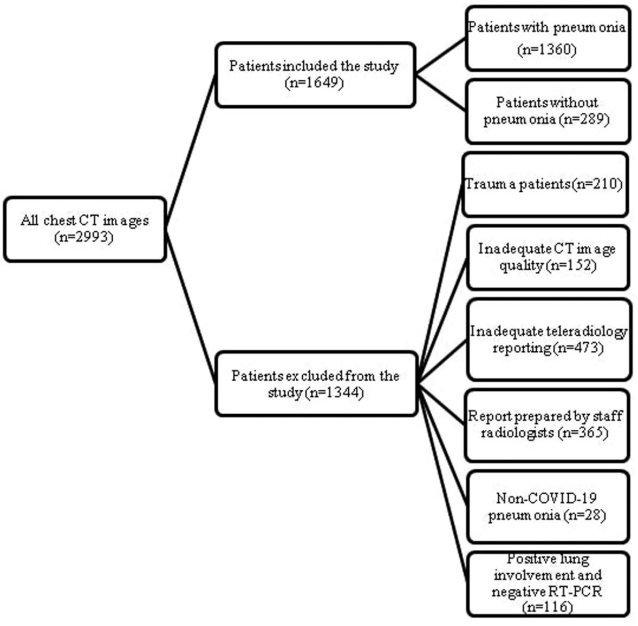

Figure 1. Flowchart for patient selection.

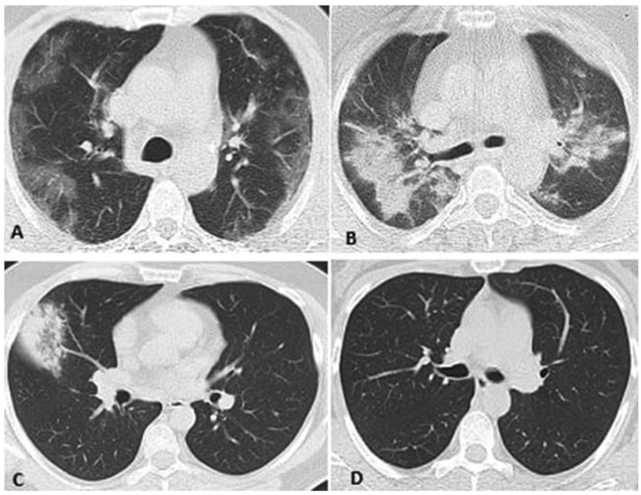

Figure 2. A-D. Axial lung-window chest CT scan shows (A) Typical appearance (bilateral, peripheral, GGO without consolidation), (B) Indeterminate appearance (perihilar consolidation with GGO), (C) Atypical appearance (isolated segmental consolidation without GGO), and (D) Negative for pneumonia (no features to suggest pneumonia).

Statistical analysis

Interobserver agreement was statistically analyzed. Descriptive statistics for categorical variables were given as numbers (*n*) and percentages. Interobserver agreement for CT findings between the 3 radiologists and the teleradiologists was assessed using Cohen's kappa (κ). Statistical analyses were carried out using SPSS 23 (IBM Corp., Armonk, NY, USA). Values of $P < .05$ were considered statistically significant.

Results

The study included 1649 COVID-19 patients who met the inclusion criteria. The mean age was 56.3 years (range: 18-89), and 807 patients (48.9%) were male. The distribution of chest CT appearance according to the 2 observers and the teleradiology reports was as shown in Table 2. Disagreements were adjudicated by a third staff radiologist, and the consensus decisions of the 3 staff radiologists were as follows: typical appearance 860 (52.2%), indeterminate appearance 299 (18.1%), atypical appearance 201 (12.2%), and negative for pneumonia 289 (17.5%). There was an excellent and statistically significant agreement between the observers ($\kappa = 0.847$, $P < .001$) (Table 3). Similarly, the agreement between observer 1 and observer 2 and the consensus decisions were evaluated separately, and were very high for both pairs ($\kappa = 0.934$, $P < .001$; $\kappa = 0.891$, $P < .001$, respectively). There was an excellent and statistically significant agreement between the consensus decisions and the teleradiology reports ($\kappa = 0.832$, $P < .001$) (Table 3). Disagreement between the 2 observers was mostly seen in the indeterminate group. Disagreement between the consensus decisions and the teleradiology reports was mostly seen for images with atypical and indeterminate appearance (Figure 3).

Discussion

Our study is unique in that it reveals the role of teleradiology in the COVID-19 pandemic in Turkey. In addition, due to the differences in the methods and the teleradiology applications between countries, the study is of an original nature. Our study revealed excellent agreement between different staff

Table 2. Distribution of chest CT appearance according to the 2 observers, the consensus decision, and the teleradiology reports

	COVID-19 Pneumonia Imaging Classification (*n* = 1649)			
n **(%)**	**Typical Appearance**	**Indeterminate Appearance**	**Atypical Appearance**	**Negative for Pneumonia**
Observer 1 (MÇ)	841 (51%)	308 (18.7%)	219 (13.3%)	281 (17%)
Observer 2 (CO)	827 (50.2%)	320 (19.4%)	222 (13.4%)	280 (17%)
Consensus decision	860 (52.2%)	299 (18.1%)	201 (12.2%)	289 (17.5%)
Teleradiology	806 (48.9%)	334 (20.3%)	251 (15.2%)	258 (15.6%)

Table 3. Agreement results between the 2 observers, the consensus decision, and the teleradiology results

	Kappa Statistical Value (κ)	*P*
Observer 1 (MÇ) vs Observer 2 (CO)	0.847	<.001
Observer 2 (CO) vs Consensus decision	0.891	<.001
Observer 1 (MÇ) vs Consensus decision	0.934	<.001
Consensus decision vs Teleradiology	0.832	<.001

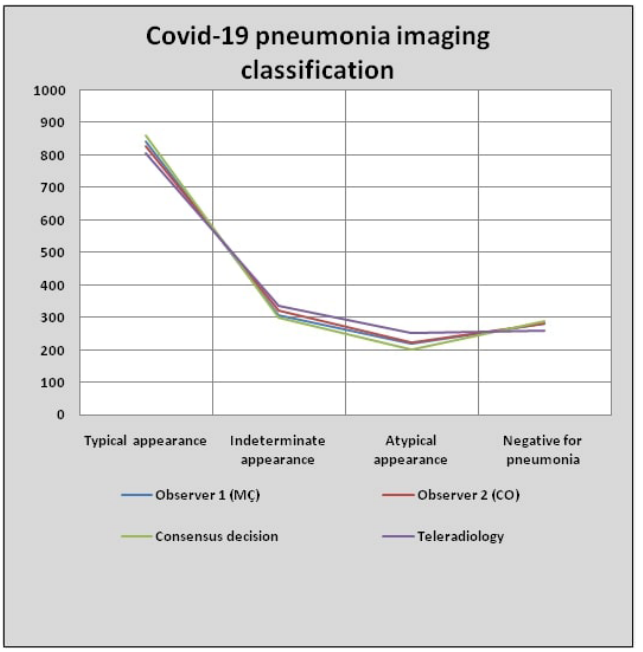

Figure 3. Graph demonstrating the agreement between the staff radiologists and the teleradiology reports.

radiologists and also between the consensus decisions and teleradiology results. A multicenter study from France reported that the COVID-19 diagnostic accuracy and interobserver agreement were high among radiologists with varying degrees of experience in teleradiology.[16] Our agreement results are consistent with those reported in that study. However, different from our study, that study used the COVID-19 Reporting and Data System (CO-RADS) classification. The CO-RADS classification was first developed in the Netherlands.[17] The CO-RADS and the RSNA chest CT classification systems, both developed for reporting COVID-19 pneumonia, are very similar. The CO-RADS categories 5, 4-3, 2, and 1 are equivalent to the categories of typical, indeterminate, atypical, and negative in the RSNA classification system, respectively. Jaegere et al.[18] established that the use of either system does not produce significantly different results. Due to its retrospective nature, our study only included the RSNA method of chest CT classification, which was the method used in the teleradiology reports. We were unable to use the CO-RADS classification, as the language used in the teleradiology reports did not meet the relevant criteria.

Hadied et al.[19] evaluated chest CT images from 70 patients using the RSNA classification system and assessed interobserver and intraobserver variability. Their study showed that the RSNA classification system is reliable for evaluating imaging findings in the context of COVID-19. Compared to our results, they reported a more moderate interobserver and intraobserver agreement. This may be due to the fact that the study by Hadied et al.[19] was conducted in the early periods of the pandemic. Likewise, the high interobserver agreement in our study may be ascribed to our research being conducted 9 months into the pandemic. The increased experience in COVID-19 imaging and increased recognition and sensitivity regarding the pandemic may have contributed to our results.

There was excellent agreement between the staff radiologist consensus and the teleradiology reports. That said, there was comparatively more disagreement concerning the indeterminate and atypical appearance groups. This may be due to the fact that the

characterization of the GGO distribution in the indeterminate group is similar to that of typical appearance. The disagreement concerning the atypical appearance group may be ascribed to the similarity of those imaging findings to non-COVID-19 pneumonia.

Among our 1649 subjects, 289 (17.5%) tested positive by RT-PCR but had no lung involvement. The negative lung involvement may be attributed to imaging in early illness and a mild prognosis; therefore, these patients were included in the negative for pneumonia group. Meanwhile, 82.5% of RT-PCR-positive patients had lung involvement. This finding is consistent with other studies in the literature.[7] In cases where RT-PCR testing cannot be performed or is delayed, chest CT imaging plays an important role to prevent delays in diagnosis, isolation, and treatment.

When we started this study, we hypothesized that having numerous radiologists evaluate radiography images via teleradiology may negatively affect diagnostic accuracy. Later in the study, however, we observed that the teleradiology reports were so consistent that they appeared to have been prepared by the same person. We established a high level of agreement between the teleradiology reports and the assessments by staff radiologists, and demonstrated the utility of teleradiology during the pandemic. Telehealth, an application similar to teleradiology but used in other medical fields, concerns physicians of all branches and facilitates healthcare during the pandemic.[20] This method is prominent in that it has eased the increased workload related to the pandemic, allowed health workers to work remotely, and facilitated isolation in all parts of the world.[13,15] The increased availability of telehealth will help to bring remote healthcare to regions in need and facilitate healthcare access even after the pandemic.

Our study had some limitations. First, it was conducted retrospectively in a single center. Second, we used RT-PCR test results to confirm the COVID-19 diagnosis; however, the literature reports that the sensitivity of this test varies between 42% and 71%.[3-5]

The increased workload during the pandemic has resulted in a shortage of radiologists in numerous healthcare institutions. Hence, diagnostic support with teleradiology plays a prominent role in the fight against COVID-19 in Turkey as well as around the world. In addition, since remote imaging allows isolation, teleradiology will potentially remain a favorable alternative, particularly in the setting of possible future pandemics.

Ethics Committee Approval: The ethics committee approval was obtained from the Ministry of Health of the Turkish Republic and the authors' Institutional Clinical Research Ethics Committee (Date: February 16, 2021, Number: 2021/02-41).

Informed Consent: Due to the retrospective design of the study, informed consent was not obtained.

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