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RESEARCH

Evaluation of the RSNA consensus: is it sufficient for the diagnosis of COVID-19 with CT?
RSNA konsensüsünün değerlendirilmesi: BT ile COVID-19'un tanısı için yeterli mi?

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Abstract

Purpose: Radiological Society of North America (RSNA) Consensus for coronavirus disease 19 (COVID-19) is developed to evaluate the lung involvement on chest computed tomography (CT) and create a common reporting lexicon. Aim of this study is to determine the frequency of CT features in sex and age groups in patients with COVID-19, compare the findings according to the RSNA consensus classifications, and evaluate the compatibility of the classifications and findings.

Materials and Methods: Chest CT images of 281 patients with COVID-19 were evaluated. Patients were noted in the appropriate RSNA consensus class. The patients' data were analyzed by group according to age and sex.

Results: The main findings included ground-glass opacity, consolidation, and air bronchogram. The common involvement patterns were as follows: bilateral, peripheral, and multifocal. The rates for the typical, atypical, and indeterminate classifications, according to the RSNA consensus, were 63.6%, 9.6%, and 27.0%, respectively. Subpleural fibrous streaking was more frequent in males. Air bronchogram, lymphadenopathy, pleural effusion, subpleural fibrous streaking, bilateral involvement, and a typical classification on CT features were more frequent in the ≥ 65-year age group.

Conclusion: While the typical appearance classification has results consistent with the findings, we think that the classifications specified as indeterminate and atypical appearance do not show sufficient agreement with the findings and revision is needed for correct diagnostic guidance.

Keywords:. COVID-19, CT features, age, sex, RSNA consensus

Öz

Amaç: Koronavirüs hastalığı 19 (COVID-19) Kuzey Amerika Radyoloji Derneği (RSNA) Konsensüsü, toraks bilgisayarlı tomografide (BT) akciğer tutulumunu değerlendirmek ve ortak bir raporlama dili oluşturmak için geliştirilmiştir. Bu çalışmanın amacı, COVID-19'lu hastalarda cinsiyet ve yaş gruplarında BT bulgularının sıklığını belirlemek, bulguları RSNA Konsensüs sınıflamalarına göre karşılaştırmak ve sınıflamalar ile bulguların uyumluluğunu değerlendirmektir.

Gereç ve Yöntem: COVID-19'lu 281 hastanın toraks BT görüntüleri değerlendirildi. Hastalar uygun RSNA konsensüs sınıfında not edildi. Hastaların verileri yaş ve cinsiyet gruplarına göre analiz edildi.

Bulgular: Sık bulgular arasında buzlu cam opasiteleri, konsolidasyon ve hava bronkogramı vardı. Yaygın tutulum paternleri şu şekildeydi: bilateral, periferal ve multifokal. RSNA konsensüsüne göre tipik, atipik ve belirsiz sınıflandırma oranları sırasıyla %63,6, %9,6 ve %27,0 idi. Subplevral fibrotik çizgilenmeler erkeklerde daha sıktı. Hava bronkogramı, lenfadenopati, plevral efüzyon, subplevral fibrotik çizgilenmeler, bilateral tutulum ve tipik sınıflandırma 65 yaş üstü grupta daha sıktı.

Sonuç: Tipik görünüm sınıflandırması bulgularla tutarlı sonuçlara sahipken, belirsiz ve atipik görünüm olarak belirtilen sınıflandırmaların bulgularla yeterli bir uyum göstermediği ve doğru tanısal yönlendirmeler için revizyona ihtiyaç olduğunu düşünmekteyiz.

Anahtar kelimeler: COVID-19, BT özellikleri, yaş, cinsiyet, RSNA konsensüsü

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INTRODUCTION

Coronavirus disease 2019 (COVID-19) was first detected in a group of patients with pneumonia in Wuhan, China in December 2019. It was caused by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2)[1,2]. The virus spreads rapidly and can cause severe clinical problems, such as pneumonia[1]; however, some patients are asymptomatic[3]. Early diagnosis of COVID-19 is crucial, and computed tomography (CT) can be helpful in the diagnosis, even before the onset of symptoms[4]. Furthermore, the gold standard method for the diagnosis of COVID-19 is the polymerase chain reaction (PCR) test[1]; however, the PCR test may show negative results in the early period and has a sensitivity lower than a CT[5]. On the other hand, CT findings may be similar to other infectious conditions. Therefore, several classifications for evaluating COVID-19 lung involvement have been developed, one of which is the Radiological Society of North America (RSNA) consensus[3]. This consensus consists of four classifications: a typical appearance, an indeterminate appearance, an atypical appearance, and a negative appearance for pneumonia. Other studies have recently been published evaluating the diagnostic performance of the RSNA consensus[6]. We planned to study considering that this consensus does not have adequate diagnostic definitions, and demonstrated the frequency of CT features of COVID-19, compared them between age groups and sexes, and evaluated the consistency of the classifications with the frequency of the findings.

MATERIALS AND METHODS

This retrospective study was conducted using non-contrast CT images of patients with COVID-19 performed between April 2020 and June 2021 at two institutions. Ethics committee approval, dated 06.05.2020 and numbered 854, was obtained from the clinical research ethics committee of Adana City Training and Research Hospital. Since the study was conducted retrospectively with CT images, informed consent was not obtained. The study was carried out in accordance with the provisions of the Declaration of Helsinki and the Good Clinical Practice guidelines.

Participants

Pediatric patients (0-18 years of age) were excluded from the study. Among 520 patients who underwent CT scan with a preliminary diagnosis of COVID 19, those with positive PCR tests were included in the study. Of those patients included in the study, 281 had a positive PCR test. The number of samples was determined by considering the large series of studies in the literature and by excluding examinations with low diagnostic value, eg with artifacts. The first CT examinations of patients who were admitted to the hospital for the first time were evaluated. Exclusion criteria were a CT examination after the initiation of treatment, no clear treatment history, and a history of chronic lung disease.

CT technique and evaluation

CT images were performed in Adana City Training and Research Hospital using a 128-detector multi-detector (MD) CT unit (Philips Ingenuity 128, Eindhoven, The Netherlands) with technical parameters as follows: 120 kVp, 75–400 mAs, a rotation time of 0.4 sec, a pitch of 1.49, and a slice thickness of 1 mm, and in Cukurova University Balcali Hospital using a 160-detector MDCT unit (Toshiba Alexion, Japan) with technical parameters as follows: 120 kVp, 100–400 mAs, a rotation time of 0.5 sec, a pitch of 1.2, and a slice thickness of 1 mm. These institutions, where CT scans were performed, are institutions that provide well-established medical education, and the evaluations were made by 4 radiology specialists, two of whom had 12 years of experience and the others 9 and 5 years of radiology experience.

CT findings were evaluated in terms of ground-glass opacity (GGO), consolidation, air bronchograms, halo and reverse halo signs (RHS), interlobular septal thickening (IST), reticular pattern, tree-in-bud sign, subpleural fibrous streaking (SFS), bronchial structural distortion (BSD), lymphadenopathy, and pleural effusion. Also, multifocal, unilateral or bilateral, peripheral/central or lobar involvement patterns, and which lobe(s) was involved were noted. A lymphadenopathy was considered when the short-axis diameter was > 10 mm. The patients were divided into three age groups as follows: 18–40, 41–64, and ≥ 65 years old. In addition, patients were divided into groups according to sex. All findings were compared between groups. The frequencies of typical, atypical, and indeterminate findings according to the RSNA consensus were determined for both age and sex groups, and compared. The radiologic evaluations were simultaneously performed by two

radiologists with 8 and 10 years of experience, respectively.

Statistical analysis

The mean, standard deviation (SD), median, minimum, maximum, frequency, and ratios were used in the descriptive statistics of the data. The suitability of variables to a normal distribution was examined using the Kolmogorov-Smirnov and Shapiro-Wilk tests. Chi-square and Fisher's exact tests were used in comparing categorical variables. The Statistical Package for the Social Sciences (SPSS; ver. 23.0) program was used for the analyses. *P* values < 0.05 were considered statistically significant.

RESULTS

Overall, 281 patients were included in the study (112 women, 39.9%; 169 men, 60.1%; age range: 19–88 years; mean age: 47.14 ± 15.92 years). Regarding age, 39.9% of the patients were 18–40 years old, 43.8% were 41–64 years old, and 16.4% were ≥ 65 years old.

The frequency of common parenchymal infiltration patterns were 90.0% for GGO and 37.0% for air bronchograms. Other findings are detailed in Table I. The frequencies of common involvement patterns were 63.0% for bilateral lung, 55.2% for peripheral, 77.9% for multifocal, 74.7% for left lung lower lobe, and 71.9% for right lung lower lobe. Other involvement patterns are detailed in Table I.

Comparing the findings according to sex, SFS was significantly more frequent in males (p = 0.038). However, there were no other significant difference between the sexes. Detailed data on comparisons by sex are shown in Table I.

The patients were divided into three groups according to age and the findings were compared. Air bronchogram (p = 0.001), lymphadenopathy (p = 0.007), pleural effusion (p = 0.027), SFS (p = 0.001), BSD (p = 0.001), and bilateral involvement (p = 0.008) were significantly higher in the ≥ 65-year-old group. Single lung involvement and left lung lower lobe involvement were significantly higher in the 18–40-year age group. In terms of other findings, no significant differences were found. Detailed information on the comparison of findings between age groups is given in Table I.

CT findings were evaluated as typical, atypical, and indeterminate according to the RSNA consensus and the findings were compared between age groups and sex groups. In terms of these classifications, no significant difference was found between the sexes (Table I). Patients in the atypical category were found at similar rates in all three age groups. However, the indeterminate appearance was more frequent in the 18–40-year age group, and the typical appearance was more frequent in the ≥ 65-year age group (p = 0.024). The evaluation between age groups according to the RSNA consensus is detailed in Table I. Examples of CT images for classifications are shown in Figures 1–2.

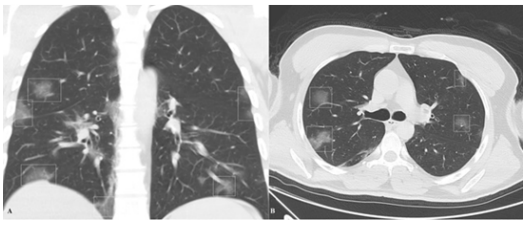

Fig. 1. Coronal (A) and axial (B) CT images of a 39-year-old male patient shows bilateral peripheral multifocal GGOs (frames) which are compatible with the "typical appearance".

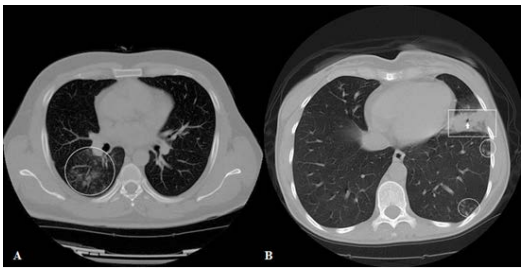

Fig. 2A: Axial CT image of a 32-year-old male patient shows diffuse localized GGO in the right lower lobe (oblique circle) which is compatible with the "indeterminate appearance".

Fig. 2B: Axial CT image of a 37-year-old female patient shows consolidation areas (frame) and small air bronchogram (arrow) in left upper lobe and minimal subpleural reticulonodular densities in the left lower lobe (oblique circles) which is compatible with the "atypical appearance".

Table 1. Comparison of CT findings according to gender and age groups

	Male n (%)	Female n (%)	Total n (%)	P value	18-40 n (%)	41-64 n (%)	>65 n (%)	P value
GGO only	69 (40.8)	44 (39.3)	113 (40.2)	0.796	52 (46.4)	45 (36.6)	16 (34.8)	0.219
GGO and consolidation	83 (49.1)	57 (50.9)	140 (49.8)	0.770	48 (42.9)	66 (53.7)	26 (56.5)	0.155
Only consolidation	18 (10.7)	11 (9.8)	29 (10.3)	0.823	13 (11.6)	12 (9.8)	4 (8.7)	0.829
Air bronchogram	61 (36.1)	43 (38.4)	104 (37.0)	0.696	27 (24.1)	55 (44.7)	22 (47.8)	0.001
Reverse halo sign	3 (1.8)	0 (0.0)	3 (1.1)	0.156	2 (1.8)	1 (0.8)	0 (0.0)	0.572
Halo sign	7 (4.1)	3 (2.7)	10 (3.6)	0.517	5 (4.5)	3 (2.4)	2 (4.3)	0.670
Interlobular septal thickening	32 (18.9)	21 (18.8)	53 (18.9)	0.969	17 (15.2)	23 (18.7)	13 (28.3)	0.161
Mediastinal lymphadenopathy	9 (5.3)	7 (6.3)	16 (5.7)	0.743	1 (0.9)	9 (7.3)	6 (13.0)	0.007
Pleural effusion	8 (4.7)	4 (3.6)	12 (4.3)	0.637	1 (0.9)	7 (5.7)	4 (8.7)	0.027
Reticular pattern	11 (6.5)	7 (6.3)	18 (6.4)	0.931	5 (4.5)	9 (7.3)	4 (8.7)	0.528
Tree-in-bud sign	4 (2.4)	3 (2.7)	7 (2.5)	0.870	2 (1.8)	4 (3.3)	1 (2.2)	0.763
Subpleural fibrous streaking	32 (18.9)	11 (9.8)	43 (15.3)	0.038	4 (3.6)	22 (17.9)	17 (37.0)	0.001
Bronchial structural distortion	27 (16.0)	14 (12.5)	41 (14.6)	0.419	1 (0.9)	16 (13.0)	24 (52.2)	0.001
Bilateral involvement	103 (60.9)	74 (66.1)	177 (63.0)	0.384	59 (52.7)	83 (87.5)	35 (76.1)	0.008
Right lung involvement	34 (20.1)	16 (14.3)	50 (17.8)	0.452	28 (25.0)	18 (14.6)	4 (8.7)	0.030
Left lung involvement	32 (18.9)	22 (19.6)	54 (19.2)		25 (22.3)	22 (17.9)	7 (15.2)	
Peripheral involvement	93 (55.0)	62 (55.4)	155 (55.2)	0.957	64 (57.1)	64 (52.0)	27 (58.7)	0.639
Both peripheral and central involvement	65 (38.5)	43 (38.4)	108 (38.4)	0.898	40 (35.7)	51 (41.5)	17 (37.0)	0.728
Central involvement	11 (6.5)	7 (6.3)	18 (6.4)	0.900	8 (7.1)	8 (6.5)	2 (4.3)	0.787
Multifocal involvement	130 (76.9)	89 (79.5)	219 (77.9)	0.615	84 (75.0)	97 (78.9)	38 (82.6)	0.547
Right lung upper lobe involvement	96 (56.8)	75 (67.0)	171 (60.9)	0.088	64 (57.1)	74 (60.2)	33 (71.7)	0.228
Right lung middle lobe involvement	74 (43.8)	51 (45.5)	125 (44.5)	0.773	44 (39.3)	55 (44.7)	26 (56.5)	0.140
Right lung lower lobe involvement	121 (71.6)	81 (72.3)	202 (71.9)	0.895	74 (66.1)	91 (74.0)	37 (80.4)	0.149
Left lung upper lobe involvement	100 (59.2)	69 (61.6)	169 (60.1)	0.683	60 (53.6)	77 (62.6)	32 (69.6)	0.133
Left lung lower lobe involvement	122 (72.2)	87 (77.7)	209 (74.4)	0.302	76 (67.9)	92 (74.8)	41 (89.1)	0.021
RSNA consensus atypical appearance	17 (10.1)	10 (8.9)	27 (9.6)	0.753	11 (9.8)	12 (9.8)	4 (8.7)	0.974
RSNA consensus indeterminate	49 (29.0)	27 (24.1)	76 (27.0)	0.367	42 (37.5)	26 (21.1)	8 (17.4)	0.005
RSNA consensus typical	103 (60.9)	75 (67.0)	178 (63.3)	0.305	59 (52.7)	85 (69.1)	34 (73.9)	0.009

GGO: ground-glass opacity

DISCUSSION

COVID-19, which was first detected in China in December 2019, was characterized as a pandemic as of March 2020[2]. COVID-19 mainly causes respiratory tract infections, like the other coronaviruses[7]. Due to the primary involvement of the respiratory system, chest CT imaging is recommended for the diagnosis, especially in cases where PCR tests can provide false negatives in the early periods[5]. CT scans are also recommended during the follow-up of hospitalized patients, in cases of severe or critical disease[1], and even when mild cases are suspected[4]. Chest CT imaging findings are often peripheral, subpleural, and multiple GGOs in the early period[7]. However, in more serious cases, findings such as SFS and BSD are also detected[1,4,7]. Due to the diversity and variability of findings, some consensus was designed to provide standardization on the reporting of CT findings with COVID-19, such as RSNA and COVID-19 reporting and data system (CO-RADS)[3,4].

According to the RSNA consensus, bilateral and peripheral involvement and GGO, which belong to the typical appearance classification, were the most common findings in our study, as in the literature. The features specified in the typical appearance classification were found in the 76%–88% of the studies with a large patient population and in review articles[5,10,11]. Considering these results, the typical appearance classification seems to be consistent and usable.

Perihilar or non-peripheral and unilateral involvement were used to define the indeterminate appearance classification and were relatively less common in our study. The rates of patients with only perihilar/non-peripheral and unilateral involvement were 38.4% and 37.0%, respectively. In the literature, these findings vary between 5–26%, rates that are slightly lower than our findings[5,10-12]. However, the unilateral involvement, which is associated with an indeterminate appearance, may be seen in early CT examinations. Wang et al. state that unilateral involvement can only be seen in very early stages or very late stages with a regression of the disease[13]. In addition, previous reports suggest that CT findings may change depending on the clinical conditions of the patients. In a previous study, unilateral involvement was found in 6.9% of mild cases, while it was not detected in patients with severe disease[12]. It is understood that the classification of indeterminate appearance may vary according to the early/late period or to ordinary/severe patients. To make the consensus more usable, we think that this classification can be improved by dividing it into two sub-classifications. For example, it can be divided into two groups as indeterminate A (higher risk for Covid-19) and indeterminate B (lower risk for Covid-19), and [multifocal, diffuse, perihilar or unilateral GGOs without consolidation] and [few very small GGOs with consolidation and a non-peripheral distribution] features can be included in the indeterminate A and B classification, respectively.

Isolated consolidation, tree-in-bud sign, IST, and pleural effusion findings were used to define the atypical appearance. Considering our results and the results of other studies, the frequency of detection of the features included in the atypical appearance classification vary. Isolated consolidation has been detected in the range of 5–15%, pleural effusion from 1–6%, and tree-in-bud sign in 1–9%[5,10,14-17]. It is interesting that IST, which is in this classification, was found at a rate of 18.9% in our study. Similar to our result, Caruse D et al. reported a rate of 13%[18]. Additionally, in a meta-analysis[11], a high rate of 48.46% was specified, and this finding was defined as a common feature. Considering these findings, we think it is necessary to review some of the features included in the atypical appearance classification.

Few studies have compared the findings between the sexes. In one study[19], consolidation and fibrosis were significantly higher in males. In our study, however, only SFS was found to be significantly higher in males.

In the literature review, we encountered very few studies comparing CT findings between age groups. When the results of various studies were compared, the findings were not fully consistent[20-23]. According to our findings in terms of the RSNA consensus, the typical appearance was higher in the ≥ 65-year age group, but COVID-19 can present with the indeterminate or atypical CT appearance in the < 65-year age group.

Our study has some limitations, such as a failure to evaluate patients according to the disease stage. We also only performed a two-center evaluation and there were no interobserver evaluations. Since findings such as pre-existing pathologies that may be found in the lungs of the patients are not known, the

findings in the evaluated examinations may cause an exaggerated assessment of the findings of the current disease.

As a conclusion, the RSNA consensus has made a significant contribution to the assessment of imaging findings with COVID-19. However, considering both our own findings and those in the literature, we want to emphasize that the typical appearance classification has consistent results, but the indeterminate and atypical appearance classifications need revisions. These should be developed according to the results of large meta-analysis studies.

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