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ORIGINAL ARTICLE – OPEN ACCESS

Evaluation of Performance Between Thoracic Computed Tomography and Reverse Transcription-Polymerase Chain Reaction Test in Coronavirus Disease-19 Management

Rezan Karaali, Zeynep Karakaya, Ejder Saylav Bora, Pınar Yeşim Akyol, Serkan Bilgin

ABSTRACT

Objective: In the present study, we compare Computed Tomography (CT) findings reported according to the Radiology Society of North America (RSNA) criteria and reverse transcription-polymerase chain reaction (RT-PCR) test results to evaluate their clinical compatibility with the diagnosis and for making the decision on hospitalization or discharge in patients presenting to the emergency department with the suspected Coronavirus disease (COVID)-19.

Materials and Methods: This is retrospective single-center study. Over the age of 18 years, patients were included, pregnant and trauma patients were excluded from the study. The patients' demographic characteristics, and their RT-PCR test, thoracic CT images results, and outcomes were recorded.

Results: Our study was conducted with 1377 patients, of which 60.2% (n=829) were male with a mean age of 42.79±16.07 (13–95) years. The sensitivity and specificity of the thoracic CT and RT-PCR test in diagnosis were, based on the first and second test results, the sensitivity was 63.34% (95% confidence interval [CI], 0.586–0.679) and the specificity was 81.08% (95% CI, 0.784–0835) for CT, and the sensitivity was 71.93% (95% CI, 0.674–0.761) for RT-PCR. Thoracic CT incompatible with COVID-19 and discharged 63.7% of patients did not apply to other healthcare facilities with COVID-19 symptoms.

Conclusion: The most effective approach to early diagnosis and the initiation of treatment is still the patient's clinical picture and thoracic CT findings, as seen in the present study. The assessment of thoracic CT in accordance with the RSNA criteria can be considered a convenient approach for clinicians in the emergency department when deciding on hospitalization or discharge.

Keywords: Coronavirus disease-19, diagnosis, emergency, polymerase chain reaction-test, tomography

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Department of Emergency Medicine, İzmir Kâtip Çelebi University Atatürk Training and Research Hospital, İzmir, Turkey

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Correspondence
Rezan Karaali,
İzmir Kâtip Çelebi University Atatürk Training and Research Hospital, Department of Emergency Medicine, İzmir, Turkey
Phone: +90 232 243 43 43
e-mail: rezantahtaci@hotmail.com

INTRODUCTION

The severe acute respiratory syndrome coronavirus (SARS-CoV-2) outbreak of December 2019 continues to affect the entire world (1). Early diagnosis and isolation play a key role in the management of the disease due to its rapid transmission. The definitive test for the diagnosis of SARS-CoV-2 is the nucleic acid amplification test, which is based on the reverse transcription-polymerase chain reaction (RT-PCR) (2–4). The specificity of the test is high, while the reported sensitivity ranges from 60–70% to 95–97%. The appropriate collection of the sample from the patient and storage conditions affect the sensitivity of the test, and results may take up to 8–24 h to be delivered (2, 3, 5).

On the identification of specific tomography findings for CoV disease (COVID)-19 pneumonia, and in line with data from China, thoracic computed tomography (CT) has gained popularity as a diagnostic tool. Ground glass opacities, multifocal irregular consolidation, and/or peripherally distributed interstitial changes on thoracic CT have been defined as findings specific to COVID-19 pneumonia (6–9). Due to difficulties in interpreting images obtained on CT, a classification was developed by the Radiology Society of North America (RSNA) (10).

The purpose of this study, to compare CT findings reported according to the RSNA criteria and RT-PCR test results to evaluate their clinical compatibility with the diagnosis and for making the decision on hospitalization or discharge in patients presenting to the emergency department with the suspected COVID-19.

MATERIALS and METHODS

Study Design

This retrospective single-center study was conducted to evaluate patients with suspected COVID-19 who presented to the emergency department of a tertiary hospital. The study included patients who presented to the pandemic unit within the emergency department between March 10, 2020, – the date of the first official case in Turkey – and June 1, 2020, the date of the decision for normalization, who were over the age of 18 years, and who had undergone both thoracic CT and an RT-PCR test. Pregnant patients and those with a history of trauma were excluded from the study.

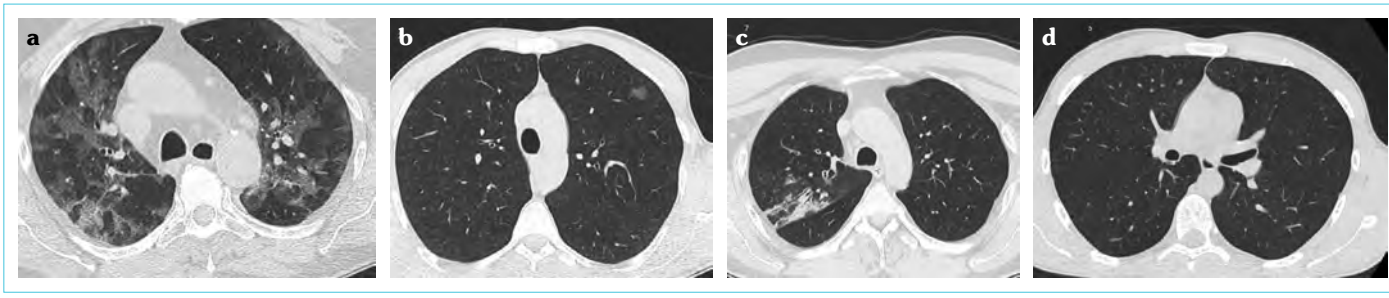

Figure 1. (a) Type 1 findings in thoracic computed tomography according to RSNA classification. (b) Type 2 findings in thoracic computed tomography according to RSNA classification. (c) Type 3 findings in thoracic computed tomography according to RSNA classification. (d) Type 4 findings in thoracic computed tomography according to RSNA classification

Data Collection

The patients' demographic characteristics, such as age and gender, were recorded. Thoracic CT images were acquired using the Siemens® SOMATOM Definition 128-slice CT scanner in the emergency department and were evaluated as blinded by an independent radiologist in accordance with the RSNA classification. The RSNA classification defines thoracic CT findings as Type-1 – typical appearance for COVID-19 pneumonia; Type-2 – indeterminate appearance for COVID-19 pneumonia; Type-3 – atypical appearance for COVID-19 Pneumonia; and Type-4 – negative for pneumonia (10). Accordingly, patients with thoracic CT findings reported as type 1 and 2 were classified as compatible with COVID-19 (Group 1), and those with thoracic CT findings reported as type 3 and type 4 as non-compatible with COVID-19 (Group 2) (Fig. 1).

The patient's RT-PCR (Bio-speedy® COVID-19 RT-qPCR test) test results were recorded. Repeated test results were recorded for patients whose first test was negative, but whose symptoms persisted or whose CT scan was found to be COVID-19 compatible. Data on discharge status, intensive care unit admission, or hospitalization were recorded for each patient, and 15-day mortality was followed. The data obtained were compared between the Group 1 and Group 2.

For the patients who were not hospitalized, any admission to a health-care facility during the 15-day isolation-treatment period and the results of such an admission (discharge-intensive care unit admission-hospitalization) were retrieved from the personal health system application (e-nabız) of the Turkish Ministry of Health. Outcomes of these patients were compared according to BT and RT-PCR test results.

Statistics

Study data were analyzed using IBM SPSS Statistics for Windows (Version 20.0. Armonk, NY: IBM Corp.) license number 10240642. The use of parametric or non-parametric tests was determined using the Kolmogorov–Smirnov test. Minimum - maximum (min–max) values and arithmetic mean±standard deviation (SD) were calculated for descriptive statistics, number (n) and percentage (%) were calculated for qualitative data. Pearson Chi-square test was used to compare categorical data. Sensitivity and specificity were calculated using the data obtained. Kappa Correlation Test was used to evaluate the correlation between tests. McNemar Test was used for the relationship between dependent variables.

Statistical significance level was set at $p<0.05$.

Table 1. Demographic characteristics of patients, results of RT-PCR test and computed tomography and outcomes of patients

Parameter	n	%
Age, Mean±SD	42.79±16.07 (18–95)	
Gender		
Female	548	39.8
Male	829	60.2
RT-PCR test		
Negative	1067	77.5
Positive	310	22.5
CT findings		
RSNA Type 1	354	25.7
RSNA Type 2	98	7.1
RSNA Type 3	82	6.0
RSNA Type 4	843	61.2
Mortality		
Ex	24	1.7
Live	1353	98.3
Outcome		
Discharge from emergency department	996	72.3
Inpatient in ward	353	25.6
Inpatient in ICU	28	2.0

SD: Standard deviation; RT-PCR: Reverse transcription polymerase chain reaction test; CT: Computed tomography; RSNA: Radiology Society of North America; ICU: Intensive care unit

Ethical Statement

The study was initiated after permission was granted by the Turkish Ministry of Health, dated May 9, 2020, and numbered 2020-05-06T13-20-23, and after approval was given by the Ethics Committee, dated May 12, 2020, and numbered 707.

RESULTS

Our study was conducted with 1377 patients, of which 60.2% (n=829) were male with a mean age of 42.79±16.07 (18–95) years, while the mean age of female patients was 43.71±16.10 years. The patients' demographic characteristics and disease data are presented in Table 1.

Table 2. RT-PCR test results according to thoracic CT findings

	CT findings				p
	Group 1		Group 2		
	n	%	n	%	
RT-PCR test negative	179	39.6	767	82.9	
First test positive	182	40.3	128	13.8	<0.001
Second test positive	91	20.1	30	3.2	

*: Pearson X^2 test; RT-PCR: Reverse transcription polymerase chain reaction test; CT: Computed tomography; Group 1: CT findings are according to Radiology Society of North America type 1 and type 2; Group 2: CT findings are according to Radiology Society of North America type 3 and type 4

According to the thoracic CT findings, the first RT-PCR test result was positive in 40.3% of the 452 patients in Group 1. Among the patients with a negative RT-PCR test at admission, the second test was positive in 20.1%, and negative in 39.6%. In Group 2, comprising 925 patients, the first RT-PCR test result was positive in 13.8%, while both first and second tests were negative in 82.9%. The second test was positive in 3.2% in this patient group. The RT-PCR positivity ratio was thus statistically significantly higher in patients who were evaluated as compatible with COVID-19 on thoracic CT than in those deemed incompatible with COVID-19 ($p<0.05$) (Table 2).

When the sensitivity and specificity of the thoracic CT and RT-PCR test in diagnosis were examined, based on the first and second test results, the sensitivity was 63.34% (95% confidence interval [CI], 0.586–0.679) and the specificity was 81.08% (95% CI, 0.784–0835) for CT, and the sensitivity was 71.93% (95% CI, 0.674–0.761) for RT-PCR (Table 3).

The RT-PCR test and thoracic CT results of the cases were compared with their outcomes in terms of hospitalization/discharge. Based on their thoracic CT results, 89% of the patients in Group 2 were discharged from the emergency department; while based on their RT-PCR test results, 43.9% of the cases with a positive COVID-19 PCR test were discharged from the emergency department. The comparison of the two groups revealed that the ratio of hospitalized cases based on thoracic CT findings was statistically significantly higher than those hospitalized based on their RT-PCR test results ($p<0.001$). In addition, with kappa correlation analysis, the correlations of CT and RT-PCR test in determining the outcome were examined. It was found that there was a statistically significant but moderate compatible between CT and RT-PCR test ($\kappa=0.51$; $p=0.018$) (Table 4).

The mortality rate of the patients included in our study was 1.74%. The relationship between the admitted patients' thoracic CT results, RT-PCR test results, and mortality was examined. In the kappa correlation analysis of CT and RT-PCR Test in terms of determining mortality, it was seen that there was a statistically significant but low significance compatible between CT and RT-PCR test ($\kappa=0.31$; $p=0.027$) (Table 5).

The patients who were discharged from the emergency room after undergoing examination and tests were evaluated based on their RT-PCR test results and thoracic CT findings. The admission of the patients to a health-care facility again, if any, and the patients' hospitalization or discharge status after such admission, are presented in Table 6.

Table 3. Sensitivity and specificity rates of CT and RT-PCR test

	Sens% (95% CI)	Spec% (95% CI)	+LR (95% CI)	-LR (95% CI)	PPV% (95% CI)	NPV% (95% CI)
CT	63.34 (0.586–0.679)	81.08 (0.784–0.835)	3.35 (2.88–3.89)	0.45 (0.4–0.51)	60.4 (0.567–0.639)	82.92 (0.810–0.846)
RT-PCR	71.93 (0.674–0.761)	100 (0.996–0.100)		0.28 (0.24–0.33)	100	88.66 (0.870–0.900)

RT-PCR: Reverse transcription polymerase chain reaction test; CT: Computed tomography; Sens: Sensitivity; Spec: Specificity; LR: Likelihood ratio; PPV: Positive predictive value; NPV: Negative predictive value; CI: Confidence interval

Table 4. Outcomes of the patients, according to RT-PCR test, and thoracic computed tomography results

Parameters	Group 2 discharge from ED n=823 (59.78%)	Group 2 inpatien in ward n=37 (2.69%)	Group 2 inpatient ICU n=0 (0%)	Group 1 discharge from ED n=173 (12.56%)	Group 1 inpatient in ward n=316 (22.95%)	Group 1 inpatient ICU n=28 (2.03%)	p*	p**
TEST (–) discharge from ED n=860 (62.47%)	732	0	0	128	0	0	**<0.001**	
TEST (–) inpatient in ward n=193 (14.02%)	0	0	0	0	193	0		**<0.018**
TEST (–) inpatient ICU n=14 (1%)	0	0	0	0	0	14		
TEST (+) discharge from ED n=136 (9.88%)	91	0	0	45	0	0		
TEST (+) inpatient in ward n=160 (11.62%)	0	37	0	0	123	0		
TEST (+) inpatient ICU n=14 (1.01%)	0	0	0	0	0	14		

*: McNemar-bowker test; **: Kappa correlation test. Reverse transcription polymerase chain reaction test; Group 1: CT findings are according to radiology society of North America type 1 and type 2; Group 2: CT findings are according to Radiology Society of North America type 3 and type 4

Table 5. The relationship between the RT-PCR test results and CT findings of the patients with mortality

	CT group 1 Ex		CT group 1 live		CT group 2 Ex		CT group 2 live		Total		p*
	n	%	n	%	n	%	n	%	n	%	
RT -PCR test positive Ex	12	75	0	0.0	4	25	0	0.0	16	100.0	**0.027**
RT-PCR test positive live	0	0.0	170	57.0	0	0.0	128	43.0	298	100.0	
RT-PCR test negative Ex	8	100	0	0.0	0	0.0	0	0.0	8	100.0	
RT-PCR test negative live	0	0.0	262	24.8	0	0.0	793	75.2	1055	100.0	
Total	20	100.0	432	100.0	4	100.0	921	100.0	1377	100.0	

*Kappa test. RT-PCR: Reverse transcription polymerase chain reaction test, CT: Computed tomography, Group 1: CT findings are according to Radiology Society of North America type 1 and type 2, Group 2: CT findings are according to Radiology Society of North America type 3 and type 4

Table 6. Admission status of patients discharged from the emergency department to another health institution

Admission status	CT		RT-PCR test	
	Group 1 n=173 (%)	Group 2 n=823 (%)	Positive n=136 (%)	Negative n=860 (%)
No admission	107 (61.8)	524 (63.7)	70 (51.6)	584 (67.9)
Admitted another health institution, discharged from ED	56 (32.3)	284 (34.5)	62 (45.5)	262 (30.5)
Admitted another health institution, hospitalized to ward	9 (5.2)	15 (1.8)	4 (2.9)	14 (1.6)
Admitted another health institution, hospitalized ICU	1 (0.7)	0 (0)	0 (0)	0 (0)

CT: Computed tomography; ICU: Intensive care unit; ED: Emergency department; Group 1: CT findings are according to Radiology Society of North America type 1 and type 2; Group 2: CT findings are according to Radiology Society of North America type 3 and type 4

DISCUSSION

The optimum approach to the diagnosis of COVID-19 is the RT-PCR test (2, 11), although the large number of samples being collected daily leads to delays in results, as a significant disadvantage of the approach. Furthermore, challenging for clinicians is the prevalence of false negative results as a result of the inappropriate collection and storage of samples (3, 5, 12). In countries such as ours with large populations, the use of thoracic CT to distinguish between those who should be hospitalized and those who should be discharged, as well as the appropriate treatment method, has increased to overcome the delays associated with the RT-PCR test. Thoracic CT has taken its place in the diagnostic algorithm for COVID-19 pneumonia due to its easy accessibility, its rapid results and its suitability for pneumonia diagnosis (6, 7, 11). Thoracic CT was recommended for patients with fever+cough first in the diagnostic algorithm suggested by the National Health Commission of the People's Republic of China, and later in the diagnostic algorithm published by the Turkish Ministry of Health in our country (13, 14). Certain criteria have been published for the assessment of thoracic CT for COVID-19. Among these, the RSNA criteria classify the thoracic CT findings into four categories (10). Our study is the first to evaluate thoracic CT results reported in accordance with the criteria adopted by the RSNA in comparison with RT-PCR test results with the diagnosis and for making the decision on hospitalization and discharge among COVID-19 patients.

The mean age of the study patients was 42.79±16.07 years, which is consistent with the mean age reported by similar studies (4, 15, 16). Of the patients who presented to the emergency pandemic unit, 24.98% of those who were hospitalized were Group 1 patients. Given that the test results were obtained later, it can be argued that both the clinical assessment and the CT findings were taken into account when deciding on the hospitalization of the patients. In this regard, we believe that it would be appropriate to assess the patient's clinical picture, presence and degree of pneumonia (thoracic CT findings), and comorbidities together when making decisions for hospitalization or discharge. PCR test results obtained later appear influential the when deciding whether the patient is to be admitted to the COVID-19 service or to the clean service, as well as in the planning of treatment.

It was found in the present study that CT findings reported in accordance with the RSNA criteria were more effective when deciding on hospitalization/discharge, and the sensitivity and specificity of CT in diagnosis were 63.34% and 81.08%, respectively. In the present study, we established a lower sensitivity than that reported by previous studies comparing thoracic CT and RT-PCR for the diagnosis of COVID-19. Among the studies comparing the sensitivity of thoracic CT and RT-PCR for the diagnosis of COVID-19, Fang et al. (4) examined 51 patients with findings compatible with COVID-19 on thoracic CT, and found 36 patients to be negative for the first RT-PCR test, among which 12 were found to be positive in the second test, and three in the third test. Fang et al. (4) reported the sensitivity of thorax CT in diagnosing COVID-19 to be 98%. Likewise, Long et al. (17) reported the first RT-PCR test to be positive in 30 of 36 patients who had findings compatible with COVID-19 pneumonia on thoracic CT, while the repeat tests of all the other six patients were positive. The authors reported the sensi-

tivity of thoracic CT and RT-PCR in diagnosing COVID-19 as 97% and 84.6%, respectively. The study by Ai et al. (18), which had the highest number of patients among the studies comparing thoracic CT and RT-PCR, made a retrospective review of 1014 patients, and identified positive RT-PCR results in 59% of the patients. Of this RT-PCR positive patients, 95% were detected to have at least one of the lesions defined as compatible with COVID-19 pneumonia on CT. Accordingly, the authors reported a sensitivity of 97% for thoracic CT for the diagnosis of COVID-19. The leading aspect of our study differentiating it from these three studies is the number of cases, which is higher in the present study than in all of them. Second, the previous studies evaluated the presence of any of the findings compatible with COVID-19 as a thoracic CT finding. In the present study, thoracic CT findings were based on the RSNA classification, and so patients with thoracic CT findings reported as type 2 were also considered compatible with COVID-19. These may contribute to the low sensitivity we established. The third difference is that the previous studies evaluated only the thoracic CT findings of patients with a positive RT-PCR test result. Our study, in contrast, evaluated patients presenting to the emergency pandemic unit based on available algorithms, and included those for whom both thoracic CT and RT-PCR were requested, based on their indications. The intention in the present study was assess the success of thoracic CT and RT-PCR in detecting the disease, and so patients with a negative RT-PCR test were also included in the study. Of the patients with a negative RT-PCR test, 39.6% were detected to have compatible findings for COVID-19 on CT (group 1). Although it is believed that the findings on CT may also be attributed to other viral diseases, the recommended procedure for these patients during the pandemic involves a repeat test for patients who are compatible with COVID-19 clinically and on CT findings. The time of sample collection, collection using the proper technique and viral load are all factors that affect the result of the test (5). The previous studies in which the PCR-test was used have also reported low sensitivity in diagnosis. Fang et al. (4) reported the sensitivity of RT-PCR in diagnosis to be 72%, while Kucirka et al. (19) reported sensitivities ranging between 6% and 73% for the diagnosis pf COVID-19. The study by Wen et al. (20) reported the sensitivity of RT-PCR in diagnosing COVID-19 varied between 42% and 71%, and that it may take up to 4 days for an initially negative RT-PCR test to become positive. In the present study, we found the sensitivity of the RT-PCR test in diagnosing COVID-19 to be 71.93%. Our findings are consistent with those reported by previous studies.

The mortality rate of the patients included in our study was 1.74% and there were findings compatible with COVID-19 pneumonia (group 1) on thoracic CT in 83.3% of the 24 patients who died. This result indicates the significance of findings detected on CT when deciding on intensive care unit admission and mortality risk.

The present study also examined the admission of discharged patients to other health-care facilities. Of the patients who were discharged after no findings compatible with COVID-19 were identified on thoracic CT, 63.7% did not present to other health-care facilities with COVID-19 symptoms, while only 1.8% of those who did refer to other facilities were admitted to the COVID-19 service. An analysis of the 15-day outcomes of the patients in the present study who were discharged from the emergency room, as the isolation period, revealed no mortality. Considering that the RT-PCR test results cannot be obtained immediately, it can be argued that thoracic CT findings, when evaluated according to the RSNA criteria, can serve as a guide when making a decision on the hospitalization/discharge of patients.

CONCLUSION

There is as yet a lack of consensus on the discharge/hospitalization of patients with COVID-19, even in the present time, when new treatments are under testing and vaccination studies are gaining momentum. The most effective approach to early diagnosis and the initiation of treatment is still the patient's clinical picture and thoracic CT findings, as seen in the present study. Although its sensitivity was low in the present study, the assessment of thoracic CT in accordance with the RSNA criteria can be considered a convenient approach for clinicians in the emergency room when deciding on hospitalization or discharge. Future studies and innovations related to a rapid diagnostic method may provide more detailed information on the diagnosis and treatment of COVID-19.

Limitations

Our study had some limitations, including its retrospective and single-center design, its inclusion of patients presenting at the onset of the outbreak in our country, the limited sample size and the lack of differential diagnosis for patients with CT findings compatible with COVID-19, but a negative test.

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Ethics Committee Approval: The study was initiated after permission was granted by the Turkish Ministry of Health, dated May 9, 2020, and numbered 2020-05-06T13-20-23, and after approval was given by the Ethics Committee, dated May 12, 2020, and numbered 707.

Informed Consent: Written informed consent was obtained from patients who participated in this study.

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REFERENCES

1. World Health Organization. Coronavirus disease 2019 (COVID-19) situation report, No. 185. Geneva: World Health Organization; 2019. Available from: https://www.who.int/docs/default-source/coronaviruse/situation-reports. Accessed July 23, 2020.
2. Yates TA, Cooke GS, MacPherson P. Rational use of SARS-CoV-2 polymerase chain reaction tests within institutions caring for the vulnerable. F1000Res 2020; 9: 671. [CrossRef]

3. Li Y, Yao L, Li J, Chen L, Song Y, Cai Z, et al. Stability issues of RT-PCR testing of SARS-CoV-2 for hospitalized patients clinically diagnosed with COVID-19. J Med Virol 2020; 92(7): 903–8. [CrossRef]
4. Fang Y, Zhang H, Xie J, Lin M, Ying L, Pang P, et al. Sensitivity of Chest CT for COVID-19: Comparison to RT-PCR. Radiology 2020; 296(2): E115–7. [CrossRef]
5. Cengel F, Gurkan O, Calik M, Demirkol MA, Altunok ES, Kaya MF, et al. Diagnosis of the coronavirus disease 2019 with chest computed tomography: A retrospective inter-observer agreement study between radiologists and clinicians. Hong Kong J Emerg Med 2020; 28(1): 1–7.
6. Xu X, Yu C, Qu J, Zhang L, Jiang S, Huang D, et al. Imaging and clinical features of patients with 2019 novel coronavirus SARS-CoV-2. Eur J Nucl Med Mol Imaging 2020; 47(5): 1275–80. [CrossRef]
7. Li Y, Xia L. Coronavirus disease 2019 (COVID-19): Role of chest CT in diagnosis and management. AJR Am J Roentgenol 2020; 214(6): 1280–6. [CrossRef]
8. Chung M, Bernheim A, Mei X, Zhang N, Huang M, Zeng X, et al. CT imaging features of 2019 novel coronavirus (2019-nCoV). Radiology 2020; 295(1): 202–7. [CrossRef]
9. Li B, Li X, Wang Y, Han Y, Wang Y, Wang C, et al. Diagnostic value and key features of computed tomography in coronavirus disease 2019. Emerg Microbes Infect 2020; 9(1): 787–93. [CrossRef]
10. Simpson S, Kay FU, Abbara S, Bhalla S, Chung JH, Chung M, et al. Radiological society of North America expert consensus statement on reporting chest CT findings related to COVID-19. Endorsed by the society of thoracic radiology, the American College of Radiology, and RSNA. Radiology 2020; 2(2): 2020200152. [CrossRef]
11. Abbasi-Oshaghi E, Mirzaei F, Farahani F, Khodadadi I, Tayebinia H. Diagnosis and treatment of coronavirus disease 2019 (COVID-19): Laboratory, PCR, and chest CT imaging findings. Int J Surg 2020; 79: 143–53. [CrossRef]
12. He JL, Luo L, Luo ZD, Lyu JX, Ng MY, Shen XP, et al. Diagnostic performance between CT and initial real-time RT-PCR for clinically suspected 2019 coronavirus disease (COVID-19) patients outside Wuhan, China. Respir Med 2020; 168: 105980. [CrossRef]
13. National Health Commission of the People's Republic of China Website. Diagnosis and treatment of novel coronavirus infection (Trial Version 6). Available from: http://www.nhc.gov.cn/yzygj/s7653p/202002/8334a8326dd94d329df351d7da8aefc2.shtml.
14. Republic of Turkey, Ministry of Health. COVID-19 (SARS-CoV-2 Infection) Guide. Available from: https://www.covid19bilgi.saglik.gov.tr/depo/rehberler/COVID-19_Rehberi.pdf?type=file. Accessed April 14, 2020.
15. Bernheim A, Mei X, Huang M, Yang Y, Fayad ZA, Zhang N, et al. Chest CT findings in coronavirus disease-19 (COVID-19): Relationship to duration of infection. Radiology 2020; 295(3): 200463. [CrossRef]
16. Zhao X, Liu B, Yu Y, Wang X, Du Y, Gu J, et al. The characteristics and clinical value of chest CT images of novel coronavirus pneumonia. Clin Radiol 2020; 75(5): 335–40. [CrossRef]
17. Long C, Xu H, Shen Q, Zhang X, Fan B, Wang C, et al. Diagnosis of the Coronavirus disease (COVID-19): rRT-PCR or CT? Eur J Radiol 2020; 126: 108961. [CrossRef]
18. Ai T, Yang Z, Hou H, Zhan C, Chen C, Lv W, et al. Correlation of chest CT and RT-PCR testing for coronavirus disease 2019 (COVID-19) in China: A report of 1014 cases. Radiology 2020; 296(2): E32–40.
19. Kucirka LM, Lauer SA, Laeyendecker O, Boon D, Lessler J. Variation in false-negative rate of reverse transcriptase polymerase chain reaction-based SARS-CoV-2 tests by time since exposure. Ann Intern Med 2020; 173(4): 262–7. [CrossRef]
20. Wen Z, Chi Y, Zhang L, Liu H, Du K, Li Z, et al. Coronavirus disease 2019: Initial detection on chest CT in a retrospective multicenter study of 103 Chinese patients. Radiol Cardiothorac Imaging 2020; 2(2): e200092. [CrossRef]