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ORIGINAL ARTICLE

Medicine Science International Medical Journal

Medicine Science 2021;10(3):758-63

CT evaluations by emergency medicine specialists in Covid-19 patients

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Received 04 February 2021; Accepted 29 April 2021
Available online 11.06.2021 with doi: 10.5455/medscience.2021.02.029

Abstract

During the Covid-19 epidemic period, there were too many patient applications to emergency services all over the world. Due to the insufficient number of radiologists, patients had to wait a long time for chest computed tomography (CCT) radiology reports. This situation caused intensity, chaos and poor quality healthcare provision. During the pandemic period, it was aimed to reduce the unnecessary intensity of emergency services and to provide more effective services. This study aimed to evaluate the consistency of the computed tomography (CT) findings associated with Coronavirus disease 2019 (Covid-19), published by the Radiological Society of North America (RSNA), with the radiology reports issued by emergency medicine specialists (EMS). The study universe consisted of 372 patients who had chest computed tomography (CCT) scan and real-time reverse transcription-polymerase chain reaction (RT-PCR) test for due to severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). CCT was categorized into four (4) groups (being typical, indeterminate, atypical and negative). The relationship between CCT consensus classification and RT-PCR was examined. It was observed that radiology reports were consistent with EMS evaluations in four categories (κ value 0.96, 95% CI 0.95-0.97). When we evaluated the groups separately in terms of consistency by four categories, results for all the categories were very good, being typical (κ 0.98, 95% CI 97–0.99), indeterminate (κ 0.94, 95% CI 0.91–0.97), atypical (κ 0.89, 95% CI 0.93–0.85) and negative (κ 0.98, 95% CI 0.99–0.97). According to the results of PCR tests, cases in the categories were positive as follows: typical 94%, indeterminate 54%, atypical 47%, and negative 45% ($p<0.001$). In chest CT reporting made using the classification of findings, the correlation between emergency medicine specialists and radiologists has been found similar in patients with suspected Covid-19.

Keywords: Covid-19, Chest CT, RSNA

Introduction

The Coronavirus disease 2019 (Covid-19), which is estimated to have begun in December 2019, broke out in Wuhan, a state in China, and reached pandemic level as of early March 2020. The pathogen, called severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), is detected in the lower respiratory tract of patients, and the disease has been defined as Covid-19. SARS-CoV-2 started in China and spread all over the world and the pandemic disease occurred [1, 2].

The World Health Organization reported the COVID-19 disease as a pandemic outbreak in mid-March 2020. Health institutions were faced with very intense patient admissions. Unfortunately, at the beginning of the epidemic, the accuracy rate of RT-PCR tests was not at reliable levels in diagnosis of COVID-19 patients. Therefore, CCT is used together with RT-PCR tests in diagnosis of COVID-19. The intensity of radiologists and the refusal of the relevant branches to hospitalize patients without the reports of radiologists caused emergency services to be inadequate. This situation; caused intensity, chaos and poor-quality health service delivery in covid areas of emergency service. At the end of the short and standardized training of emergency medicine specialists, it is to increase the level of CCT interpretation knowledge and to conclude these patients in a short time, to reduce the unnecessary intensity of the emergency services during the pandemic period and to provide more effective services. Covid-19 pneumonia RSNA chest computed tomography findings, agreed upon by international radiology associations and societies, have been published.

The disease manifested different clinical pictures in many cases. While most of the cases recovered with mild symptoms, a small number of patients developed respiratory difficulties requiring hospitalization. It is very important to correctly identify the large number of patients who admit to emergency services with suspected Covid-19 with such different clinical symptoms to distinguish them from non-infected patients and to restrict the spread of the pandemic [3].

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Standard covid-19 diagnosis; is provided by the positivity of real-time reverse transcription-polymerase chain reaction (RT-PCR). However, the sensitivity of this test remains uncertain as it is reported between 42% and 71% due to the lack of sampling technique, limitations in test performance or few viruses in the nasopharyngeal region [4, 5, 6]. It has been shown that the sensitivity of chest computed tomography (CCT) is 97% correlated compared to PCR and that CT-related abnormalities are higher compared to PCR positivity [4,7]. Various radiology societies have recommended standard CT reporting according to the imaging of lung involvement to communicate with physicians. [6, 8, 9, 10].

In response to the Covid-19 outbreak, the Radiological Society of North America (RSNA) shared their consensus in March 2020 that they have standardized the CCT findings for Covid-19. Clinicians should be standardized with the necessary tools in the best way possible and become able to interpret imaging findings accurately and quickly, so that they can make informed decisions about the management of Covid-19. Four groups were formed for standardized CT reporting among experts by the RSNA association with the participation of the Thoracic Radiology Association and the American College of Radiology [6]. This type of classification can directly contribute to the clinical decision-making process.

Emergency services were faced with very intense patient admissions. The process of diagnosis with CCT has been experienced all over the world. The numerical insufficiency of radiology specialists, the refusal of the pulmonologists, who had to follow these patients, to admit patients without radiology reports, caused the emergency services to fall short. In order to reduce the congestion and chaos in the emergency services, without waiting for the CCT report; It should be evaluated to a similar standard with radiology specialists.

The aim of this study is to evaluate the correlation between radiologists and emergency medicine specialists (EMS) having knowledge of Covid-19-related imaging standard according to the criteria stated in the consensus statement published by the RSNA.

Materials and Methods

Patient selection

This single-centre retrospective study was conducted in a tertiary training research hospital upon the approval of the relevant ethics committee (Approval number: 200302 Date: 24/12/2020). Data of 1816 patients admitted to our hospital's adult emergency Covid-19 department between November 20 and November 30, 2020 due to suspected Covid-19 were analysed. 384 of these patients had only CCT scan, and 372 of them who had both CCT scan and RT-PCR of SARS-CoV-2 patient samples were involved in the study (Figure 1). CCT was performed in critically ill patients or to help early triage in Covid-19-related pneumonia clinically. The data of these patients on CCT, RT-PCR and electronic recording media were analysed retrospectively.

Based on radiologists' reports, 161 of them were identified as "typical", 70 as "indeterminate", 40 as "atypical" and 101 as "negative" according to the RSNA classification system. Electronic medical records and files were manually scanned to diagnose the Covid-19 of 372 patients tested with nasal swab polymerase chain reaction. RT-PCR positivity was taken as basis for the diagnosis of Covid-19.

Clinical and laboratory data collection

The data of the patients were obtained from the electronic hospital medical database.

Patients' symptoms, oxygen requirement, the time from the beginning of the patient's complaints to the CT scan and additional diseases were recorded. The results of PCRtests, performed either using nasopharyngeal swabs contents and Diaonovital HS® SARS-CoV-2 RT-PCR kit, were obtained from the system.

Chest CT protocols

Chest CT scans were performed using a four-detector CT (Astenion Super 4 model and Toshiba branded) without injecting any contrast agent. The patients are placed on his back with inspiration. Parameters are 135 KV, automatic exposure control for tube current (10 mA to 300 mA step of 10 mA), collmimation 40 mm scan, exposure time 0.75-3 s per rotaion depending on the CT unit. Images werw generated with 1 mm slice thickness and 0.8 mm inter-slice space using a high frequency reconstruction algorithm.

Imaging analysis

All CT scans were performed by four senior emergency medicine specialists and four radiologists. EMSs were divided into one of four categories as in the RSNA classification of each CCT during the examination phase. The four categories defined in Table 1.

These categories were blindly evaluated by EMS participants based on the CCT-RSNA classification system. EMS participants were asked to classify the findings of each of their CCTs into one of four RSNA Covid-19 imaging categories.

Statistical Analysis

Data were analysed using Windows SPSS version 26.0 (SPSS Inc.). Categorical variables were defined with numbers and percentages for each category. Continuous data were summarized using mean and SD or median and minimum-maximum.

Categorical data were summarized using frequencies (ratios), and frequencies were compared using the Pearson's chi-square test, as appropriate. The value "$p<.05$" was considered statistically significant.

The agreement between the radiology reports and the evaluations made by EMSs was measured by the Kappa coefficient and the confidence interval measuring the extent of the agreement. The consensus between observers was considered to be very weak for <0.20, weak for 0.21-0.40, medium for 0.41-0.60, good for 0.61-0.80, and very good for 0.81-1.00.

Results

Demographic Findings

A total of 372 patients with CT scans meeting the inclusion

criteria were included in this study (Figure 1). The patients' demographic characteristics, symptoms at the time of admission and comorbidities are given in Table 2. The patients' average age was 61 [20-96] years, and 172 of them (46.2%) were women. The patients' symptoms, in majority, were as follows: fever 175 patients (46%), cough 182 patients (48%), shortness of breath 107 patients (28.8%), and weakness 198 patients (53.2). The most common comorbidity among patients (83) was hypertension (22%). Of the patients included, 238 (63.9%) were positive for Covid-19 with RTP-CR and 134 (36.1%) were negative for Covid-19 infection. CT scans were performed on average 2 [1-4] days after the onset of the reported symptoms (Table 2).

Table 1. RSNA Chest CT Classification System for Reporting COVID-19 Pneumonia

COVID-19 Pneumonia Imaging Classification	Rationale	CT Findings
Typical appearance	Commonly reported imaging features of greater specificity for COVID-19 pneumonia	Peripheral, bilateral, GGO with or without consolidation or visible intralobular lines (“crazy-paving”)
		Multifocal GGO of rounded morphology with or without consolidation or visible intralobular lines (“crazy-paving”)
		Reverse halo sign or other findings of organizing pneumonia (seen later in the disease)
Indeterminate appearance	Nonspecific imaging features of COVID-19 pneumonia	Absence of typical features AND presence of:
		Multifocal, diffuse, perihilar, or unilateral GGO with or without consolidation lacking a specific distribution and are nonrounded or nonperipheral
		Few, very small GGOs with a nonrounded and nonperipheral distribution
Atypical appearance	Uncommonly or not reported features of COVID-19 pneumonia	Absence of typical or indeterminate features AND presence of:
		Isolated lobar or segmental consolidation without GGOs
		Discrete small nodules (centrilobular, “treein-bud”)
		Lung cavitation
		Smooth interlobular septal thickening with pleural effusion
Negative for pneumonia	No features of pneumonia	No CT features to suggest pneumonia

Abbreviations: GGO = Ground-glass opacity.

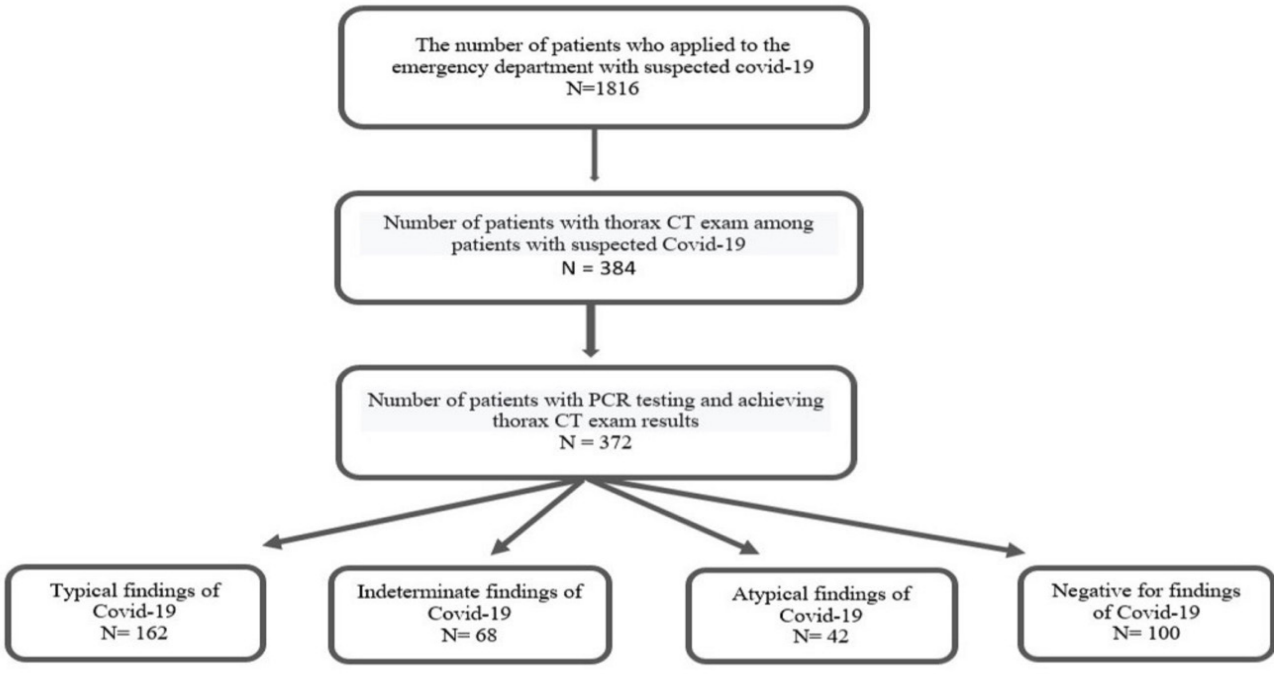

Figure 1. Flow diagram of patient exam selection

Figure 1. Flow diagram of patient exam selection

Table 2. Demographic and clinical characteristics of 372 included patients with clinical suspicion of COVID-19

Characteristics	N (%) veya median [min–max]
Age (year)	61 [20-96]
Female (%)	172 (46.2)
Comorbidities	
COPD	35 (9.4)
Heart failure	37 (9.7)
Other	93 (25)
Signs at presentation	
Respiratory (any)	237 (63.7)
Cough	182 (48.9)
Expectoration	10 (2.7)
Dyspnea	107 (28.8)
Chest Pain	31 (8.3)
Need for oxygen supply (SpO2>90)	37 (9.9)
Digestive (abdominal pain, diarrhea, nausea)	38 (10.2)
Neurologic (headache, dizziness, loss of taste or smell)	22 (5.9)
Asthenia	198 (53.2)
Fever, chills, sweats	175 (47)
Onset-to-CT-delay (days)	2 [1-4]

Data are numbers with percentages in brackets or medians with lower and upper quartiles in square brackets

Chest CT categorization

Radiology reports and evaluations made by EMSs were found to be consistent in four categories. (κ value 0.96, 95% CI 0.95-0.97). When we evaluated the groups separately in terms of consistency by four categories, results for all the categories were very good, being typical (κ 0.98, 95% CI 97–0.99), indeterminate (κ 0.94, 95% CI 0.91–0.97), atypical (κ 0.89, 95% CI 0.93–0.85) and negative (κ 0.98, 95% CI 0.99–0.97) (Table 3).

Table 3. Chest CT categorization of the groups and interobserver agreement for each category

Group	Typical	Indeterminate	Atypical	Negative
Radiologists N (%)	161 (43.3)	70 (18.8)	40 (10.8)	101 (27.2)
Emergency medicine specialists N (%)	162 (43.5)	68 (18.3)	42 (11.3)	100 (26.9)
Kappa value	0.984	0.947	0.890	0.980

Correlation of PCR and chest CT categories

PCR positivity rate was quite different between the four categories (p<0.0001): While 162, 68, 42 and 100 patients, respectively, were categorized as typical, indeterminate, atypical and negative in EMS evaluations according to the RSNA, PCR was positive in 132 (84%), 37 (54.4%), 20 (47.7%) and 45 (45%) patients. PCR was positive in 65 (45%) of 142 patients (in the categories "atypical" and "negative") who were not considered to have pneumonia according to the RSNA (table 4).

Table 4. Positivity of RT-PCR for each categories

Radiologisits evaluation	Pozitive RT-PCR N (%)	Emergency medicine specialists evaluation	Pozitive RT-PCR N (%)
Typical	135 (83.9)	**Typical**	136 (84)
Indeterminate	39 (55.7)	**Indeterminate**	37 (54.4)
Atypical	18 (45)	**Atypical**	20 (47.6)
Negative	46 (45.5)	**Negative**	45 (45)
P-value	<0.001*	**P-value**	<0.001*

* p-value is <0.001 for 4 categories (typical, indeterminate, atypical, negative)

Discussion

This study explains the agreement between radiology reports covering CCT findings and EMSs in a series of consecutive retrospective patients with suspected COVID-19. Patients with suspected COVID-19 pneumonia by our hospital radiologists RSNA-CCT findings; It is reported as typical, indeterminate, atypical, and negative. Correlation between radiology reports and EMS' evaluations in all 4 categories according to RSNA-CCT criteria is parallel. It is found that the category of CCT "typical for COVID-19 pneumonia" has a very high rate, and the rate of "atypical" is the lowest.

SARS-CoV-2 RT-PCR is positive in the majority of cases in the study (63.9%). PCR positivity rate is quite different between the four categories (p<0.0001). The RT-PCR positivity rate in the indeterminate group, especially in the typical pneumonia group, suggested that CCT could help the disease probability.

The current study describes the observer agreement with chest CCT reports in a series of consecutive large patients suspected of COVID-19. We have determined that chest CT's "typical for COVID-19 pneumonia" reports and SARS-CoV-2 RT-PCR predict this disease (84%) and there is consensus among standard-trained EMSs for this category. The rate of RT-PCR positivity is quite different between categories, suggesting that CT could be helpful in stratification of disease probability. It should be emphasized that almost half of the patients with chest CT classified as "atypical and negative" are positive RT-PCR. However, it should be emphasized that no CCT classification model can rule out COVID-19 on the basis of the epidemic. As different studies [4, 11] have published, SARS-CoV-2 RT-PCR can also be positive in patients without lung abnormalities on CT. Although alignment with radiology reports for the " indeterminate " category is very good, we have observed that readers have difficulty interpreting CCT. This can be explained by the standardized probability of the method used to classify patients. In our service, standardizing and reading CCT according to routine practice can provide accurate diagnosis and rapid treatment.

Our study supports that CCT can be included in predicting the likelihood of COVID-19 pneumonia by showing significant variation in the rate of RT-PCR positivity among the four categories [12, 13]. However, there are studies that do not support the possibility of CCT pneumonia with the RT-PCR positivity rate [14]. The role of chest CT for patients with suspected COVID-19 has not been fully established. Despite limitations in sensitivity and delay in reporting, RT-PCR remains the diagnostic reference and chest CT is usually not recommended for screening by most radiology communities [15, 16].

The Radiology Association does not recommend using CCT scans for the diagnosis of Covid-19. However, physicians frequently request CT of the chest to guide the diagnosis and treatment of COVID-19 patients [15, 16, 17, 16, 18, 19]. Given the recent literature, the importance of CCT increases as the risk of thromboembolic complications increases in Covid-19 patients [20]. In the evaluation of COVID-19 cases, CT images should be reported by the radiologist with a reliable and accurate method. This classification system was generated to properly standardize imaging findings for radiologists and emergency medicine specialists dealing with the management of Covid-19. The results of this study show that there is a considerable agreement between radiology specialists and emergency medicine specialists, who have received CCT training, in evaluating CCT findings.

Findings regarding the results between EMS and radiology reports in the present study are consistent with the recently published article of de Jaegere et al. [21]. Our study standardized the RSNA classification and evaluated 372 patients, four EMS and four radiologists. Compared to the current study designed by Jaegere et al. with 70 patients and 2 radiology groups of 5 people with different training periods from two to five years, it has the feature of comparing it with a larger patient group and crowded emergency services during the pandemic period.

An important difference between the categories "typical" and "indeterminate" is that the category "typical" is considered as rounded and circumferentially distributed GGOs, while the category "indeterminate" is considered as non-rounded and/or randomly distributed GGOs. For different categories, the participants were in tendency to disagree in cases where the mixture of features was combined. Similarly, the tendency for disagreement among tomography translators has been highlighted in other studies [13, 14]. It can be challenging for the participants to accurately recognize which of the two features are available and the presence of both features in CT. The potential solution to this dilemma would be, as the RSNA chest CT classification does, to emphasize to radiologists that the presence of any feature in the category "typical" takes precedence over any other features. In the absence of the "typical" features, the "indeterminate" features take priority over other categories and can be interpreted as such.

Other than one-month radiology training during residency and two-hour Covid-19 pneumonia training, emergency medicine specialists have not been given any structured training related to the RSNA classification system despite the second wave and peak period of the Covid-19 pandemic. Since the unfamiliarity of emergency medicine specialists with the RSNA classification system could lead to inaccurate or incomplete interpretation of the imaging findings specific to Covid-19, its correlations with radiology reports were nearly complete, although we expected it to be a potential shortcoming of this study. Standardized training and subsequent tomography interpretation provide harmony between specialities.

Our study is a single-centre, retrospective study. The experience among the four radiologists in the study varied from 5 to 15 years, and four of them had received Covid-19 CCT training. The four EMS participants had 3 to 8 years of experience and a parallel correlation with the experienced radiology group in all categories as a result of the structured and standardized CCT training. The diversity in years of experience did not lead to any differences in diagnosis.

There are different articles discussing the striking changes in CCT findings in Covid-19 cases [22-25]. However, this situation could not be investigated sufficiently, since the study included emergency department admission cases, representing a certain period of the disease. Given this limitation, unfortunately, the patients may have admitted earlier without any imaging findings of Covid-19 during the course of their disease, or some may have admitted later with very severe symptoms. The change in time from onset of symptoms to CCT scan would probably distort the results.

A new classification system was developed by Prokop et al., And they named it CO-RADS. This classification system was not included in our study since it was not introduced to the emergency department specialists of our hospital [26].

Unfortunately, the pandemic period continues in the world and the third global wave is expected. It is of vital importance to make a correct and rapid diagnosis and finalize the patients.

After receiving this training, the emergency medicine specialists in our hospital started to conclude patients more effectively. The congestion and chaos in our emergency room has decreased. However, patients who need to be hospitalized are still not hospitalized without radiology reports by the relevant branches, and this adverse situation prevents effective patient care. In solving this problem, it may be considered to give standardized RSNA CCT training to all branches of COVID-19.

Limitations of the Study

The time to interpret optimal CT scans could not be measured as the study was retrospective. Other limitations of our study include: More groups and in-group intepreters had to be created.

Conclusion

Our study, based on the RSNA classification system, found out that the correlation between radiologists and emergency medicine specialists was very good in all the categories in terms of Covid-19 CCT findings. The RSNA classification system can be reliably used by EMSs after a short training and standardization.

Conflict of interests
The authors declare that they have no competing interests.

Financial Disclosure
All authors declare no financial support.

Ethical approval

Mugla training research hospital upon the approval of the relevant ethics committee (Approval number: 200302 Date: 24/12/2020).

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