# NORMAL CHEST CT PREVALENCE IN CORONAVIRUS DISEASE 2019 (COVID-19) PATIENTS: A REPORT OF 791 CASES

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***ABSTRACT***

***Introduction:*** *In this study, we aimed to better understand the role of chest CT as an initial workup tool among all COVID-19 patients admitted to a tertiary hospital.*

***Materials and Methods:*** *We retrospectively evaluated the data of patients that were suspected for COVID-19. All patients who had both noncontrast chest CT scan with RT-PCR test results included in the study. Symptomatic patients were divided into four groups according to time between the onset of symptoms and chest CT; ≤ 4 days, 5-8 days, 9- 13 days, and ≥14 days. Chest CT findings according to symptom status, duration, and RT-PCR positivity were evaluated.*

***Results:*** *Data for a total of 791 patients were evaluated. The mean patient age was 51.7 ± 19.7 years. 459 (58%) patients were male, and 332 (42%) were female. 55.1% of patients had positive and 44.9% negative RT-PCR tests. Typical, indeterminate, atypical and negative chest CT findings were seen in 241 (30.5%), 131 (16.6%), 154 (19.5%), and 265 (33.5%) patients, respectively. Among 355 patients with negative RT-PCR results, 152 (42.8%) had typical or indeterminate chest CT findings. Asymptomatic patients had a 91.9% of RT-PCR positivity. Only 123 (61.5%) patients had typical or indeterminate CT findings among symptomatic and RT-PCR positive cohort.*

***Conclusion:*** *The greatest value of our study is in demonstrating the value of chest CT in both patients that had symptoms but had negative RT-PCR test results and insignificance of chest CT in asymptomatic but had suspected contact with COVID-19 patients.*

***Keywords:*** *COVID-19, chest CT, normal, coronavirus, pandemic.*

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## Introduction

In December 2019, the first case of unexplained pneumonia was reported in Wuhan City, China[(1)]. The disease was caused by a new coronavirus (SARS-CoV-2). In the following months, the virus spread worldwide and became a pandemic. Unfortunately, there is neither specific treatment nor a vaccine for this novel 2019 coronavirus disease (COVID-19). This fact, in combination with the immediate isolation of infected patients, brings paramount importance for the early diagnosis of the infected ones. Recently the diagnosis of COVID-19 has to be made by the reverse transcription-polymerase chain reaction (RT-PCR) or gene sequencing[(2)]. However, there are some limitations, such as sample collection and transportation, kit performance, and low sensitivity[(3)]. These drawbacks lead to insufficient treatments in time, and of course, constitute a high risk for infecting a larger population[(4)].

Chest Computed Tomography (CT) is routinely used for pneumonia diagnosis, as it is a fast, reliable, and efficient tool[(5)]. Given its mentioned advantages, many clinicians adopted chest CT as an ancillary diagnostic tool for the diagnosis of COVID-19[(6)]. In most of the published series, typical radiological features in COVID-19 patients were described[(7)]. Moreover, in patients with clinical symptoms, chest CT

can reveal lung involvement of COVID-19 even in patients whose PCR tests are negative[4]. However, the role of chest CT has not been clearly defined in large-scale studies among RT-PCR negative/positive and symptomatic/asymptomatic patients.

The role of chest CT is particularly more important when the laboratory testing capacities using RT-PCR are inaccurate or insufficient during an epidemic/pandemic. In this study, we aimed to better understand the role of chest CT as an initial workup tool among all COVID-19 patients who admitted to a tertiary hospital.

## Materials and methods

After approval of our institutional review board, we retrospectively evaluated the clinical and radiological data of patients that were suspected for novel coronavirus infection and were hospitalized in our university hospital between March 18, 2020, and May 12, 2020. During this period of time, all patients who had contact with an infected patient or had symptoms suggestive for COVID-19 (i.e., fever, cough, dyspnea, and headache) underwent chest CT and RT-PCR testing. Nasal and throat swab samples were used for RT-PCR testing.

If the initial performed RT-PCR test was negative, repeated tests were performed at 1-2 days intervals-all patients who had both noncontrast chest CT scans and RT-PCR testing included in the study. The flowchart of the study was shown in figure 1. Initially, symptoms were divided into two groups as symptomatic and asymptomatic. Later on, symptomatic patients divided into four groups according to time between the onset of symptoms and chest CT; ≤4 days, 5-8 days, 9- 13 days, and ≥14 days.

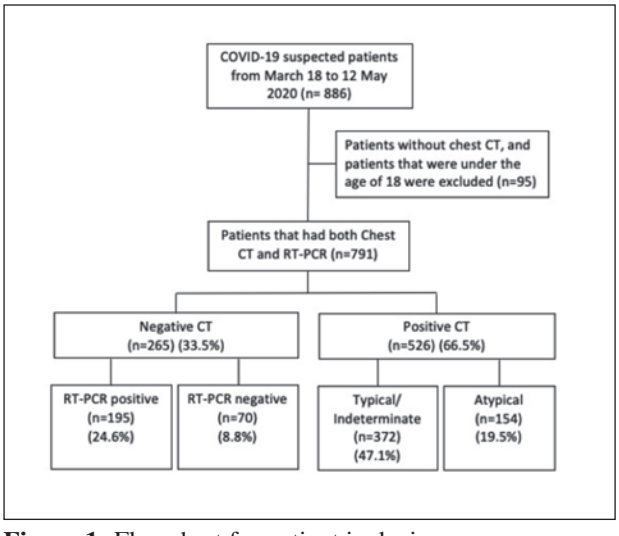


**Figure 1:** Flowchart for patient inclusion.

### *Chest CT protocols*

Chest CT images were obtained with 64-MDCT Aquilion ONE (Toshiba Medical System, Tokyo, Japan) CT device. Lung (width, 1600 HU; level, –550 HU) and mediastinal (width, 400 HU; level, 40 HU) windows were used for all CT images evaluation. Patients were asked to breath-holding at the end-inspiratory phase in the supine position. For image acquisition, tube voltage was 100 kV or 120 kV with automatic tube current modulation (100-400 mA). The slice thickness was 1.0 mm, and the reconstruction matrix size was 512 × 512.

### *Image viewing*

Chest CT images were evaluated by two experienced (more than eight years in radiology practice) radiologists' blinded RT-PCR test results. Chest CT images were evaluated according to "Radiological Society of North America (RSNA) Expert Consensus Statement on Reporting Chest CT Findings Related to COVID-19" published by Simpson et al., and grouped as typical, indeterminate, atypical and negative[8].

Statistical analyses were performed using SPSS for Mac 20.0 package program (SPSS Inc, Chicago, IL). Data were summarized as the mean±standard deviation (minimum-maximum) for the continuous variables, and categorical variables were expressed as number (%).

## Results

A total of 791 patients who have both chest CT images and RT-PCR test results were included in the study. The mean patient age was 51.7±19.7 years (ranged between 18 and 98). Of 791 patients, 459 (58%) were male, and 332 (42%) were female. Of all 791 patients, 436 (55.1%) had positive, and 355 (44.9%) had negative RT-PCR test results. Typical, indeterminate, atypical and negative chest CT findings were seen in 241 (30.5%), 131 (16.6%), 154 (19.5%), and 265 (33.5%) patients, respectively. All demographic data, including chest CT scans and RT-PCR test results among the entire cohort, were summarized in Table 1.

Among 436 RT-PCR positive patients typical, indeterminate, atypical and negative CT findings were seen in 150 (34.4%), 70 (16.1%), 21 (4.8%), 195 (44.7%) patients, respectively. On the other hand, of 355 patients with negative RT-PCR results, 91 (25.6%) had typical, and 61 (17.2%) had indeterminate chest CT findings (Table 2).

| | Results n (%) |
|---|---|
| Age, yr | |
| <40 | 234 (29.6%) |
| 40-59 | 261 (33%) |
| 60-79 | 216 (27.3%) |
| ³80 | 80 (10.1%) |
| Male | 459 (58%) |
| Female | 332 (42%) |
| RT-PCR | |
| Positive | 436 (55.1%) |
| Negative | 355 (44.9%) |
| CT findings | |
| Typical | 241 (30.5%) |
| Indeterminate | 131 (16.6%) |
| Atypical | 154 (19.5%) |
| Negative | 265 (33.5%) |
| Symptoms | |
| Symptomatic | 513 (64.9%) |
| Asymptomatic | 236 (29.8%) |
| Unknown | 42 (5.3%) |

**Table 1:** Characteristics of all included 791 patients.
*CT: Computed Tomography, RT-PCR: reverse transcription polymerase chain reaction.*

| CT findings | RT-PCR, positive (n=436) n, (%) | RT-PCR, negative (n=355) n, (%) |
|---|---|---|
| Typical | 150 (34.4%) | 91 (25.6%) |
| Indeterminate | 70 (16.1%) | 61 (17.2%) |
| Atypical | 21 (4.8%) | 133 (37.5%) |
| Negative | 195 (44.7%) | 70 (19.7%) |

**Table 2:** Chest CT features according to RT-PCR test results.
*CT: Computed Tomography, RT-PCR: reverse transcription polymerase chain reaction.*

Chest CT findings, according to symptom status and RT-PCR test results, were summarized in Table 3.

| CT findings | Symptom status | | | | | |
|---|---|---|---|---|---|---|
| | Symptomatic (n=513)(%) | | Asymptomatic (n=236)(%) | | Unknown (n=42)(%) | |
| | RT-PCR (+) (n=200) | RT-PCR (-) (n=313) | RT-PCR (+) (n=217) | RT-PCR (-) (n=19) | RT-PCR (+) (n=19) | RT-PCR (-) (n=23) |
| Typical | 93 (46.5%) | 83 (26.5%) | 45 (20.7%) | 6 (31.6%) | 12 (63.2%) | 2 (8.7%) |
| Indeterminate | 30 (15%) | 52 (16.6%) | 38 (17.5%) | 4 (21.1%) | 2 (10.5%) | 5 (21.7%) |
| Atypical | 12 (6%) | 123 (39.3%) | 6 (2.8%) | 3 (15.8%) | 3 (15.8%) | 7 (30.4%) |
| Negative | 65 (32.5%) | 55 (17.6%) | 128 (59%) | 6 (31.6%) | 2 (10.5%) | 9 (39.1%) |

**Table 3:** Chest CT findings according to symptom status, and RT-PCR test results.
*CT: Computed Tomography, RT-PCR: reverse transcription polymerase chain reaction.*

Among symptomatic and RT-PCR positive patients, only 123 (61.5%) patients had typical or indeterminate CT findings. RT-PCR positivity was 91.9% (217 of 236 patients) among all asymptomatic patients. Surprisingly, within this group, typical or indeterminate CT findings were seen in 38.2% (83 patients) of patients, suggesting chest CT as an unnecessary diagnostic tool among this patient cohort.

When we evaluated the chest CT scans according to the duration of symptoms, we saw that RT-PCR test negativity was 60.3% (283 of 469 patients) among patients that had symptoms less than eight days. Within this patient group (RT-PCR negative patients that had symptoms less than eight days), typical or indeterminate chest CT findings were seen in 119 (42%) patients. These findings showed us those chest CT findings were positive in nearly half of symptomatic but RT-PCR negative patients, suggesting the necessity of chest CT. Paramount importance of treating and isolation of this COVID-19 patient subgroup can help us to understand the importance of chest CT in disease management. On the other hand, positive RT-PCR tests were determined in 186 of 469 (39.6%) patients that had less than eight days of symptoms, suggesting the unnecessity of chest CT in RT-PCR positive symptomatic patients (Table 4).

| CT findings | Symptom onset-CT, day | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | ≤4 days (n=364) | | 5-8 days (n=105) | | 9-13 days (n=32) | | ≥14 days (n=12) | |
| | RT-PCR (+) (n=140) | RT-PCR (-) (n=224) | RT-PCR (+) (n=46) | RT-PCR (-) (n=59) | RT-PCR (+) (n=13) | RT-PCR (-) (n=19) | RT-PCR (+) (n=1) | RT-PCR (-) (n=11) |
| Typical | 59 (42.1%) | 47 (21%) | 26 (56.5%) | 26 (44.1%) | 7 (53.8%) | 6 (31.6%) | 1 (100%) | 4 (36.4%) |
| Indeterminate | 22 (15.7%) | 42 (18.8%) | 8 (17.4%) | 4 (6.8%) | 0 | 3 (15.8%) | 0 | 3 (27.3%) |
| Atypical | 9 (6.4%) | 95 (42.4%) | 2 (4.3%) | 21 (35.6%) | 1 (7.7%) | 6 (31.6%) | 0 | 1 (9.1%) |
| Negative | 50 (35.7%) | 40 (17.9%) | 10 (21.7%) | 8 (13.6%) | 5 (38.5%) | 4 (21.1%) | 0 | 3 (27.3%) |

**Table 3:** Chest CT findings according to duration of symptoms, and RT-PCR test results.
*CT: Computed Tomography, RT-PCR: reverse transcription polymerase chain reaction.*

## Discussion

Current published data suggest RT-PCR testing as a gold standard diagnostic tool for patient hospitalization, isolation, and treatment follow-up. But unfortunately, it has low sensitivity, stability, and relatively long processing time, all leading major drawbacks during a disease epidemic/pandemic. In our study, 55.1% of patients had positive RT-PCR samples taken from nasal and throat swab. This rate was consistent with previously published series (30 - 60%). It is well known that the positivity rate of RT-PCR testing can be influenced by sampling er-

rors, sampling time, and sampling location. Moreover, kit performance may also affect these results[3]. The shortage of rapid and highly sensitive RT-PCR tests for the diagnosis of COVID-19 has led many in the health care community to consider a screening or diagnostic role for radiological imaging. Chest CT is an easily performed, non-invasive, reliable testing tool for lung evaluation among pneumonia patients, making it comparable with RT-PCR testing in COVID-19 diagnosis, especially in endemic areas. During this pandemic, published studies demonstrated that nearly all patients had some characteristic chest CT features during the disease process. These include ground-glass opacities, crazy-paving pattern, multifocal consolidation, and architectural distortion in a peripheral distribution[9-11].

Publications from China during the outbreak there suggest a central role for computed tomography. While published studies from Wuhan showed very high rates of pulmonary infiltration and chest CT findings[12, 13], relatively lower rates are also published. In their series, Guan et al. reported 20.1% (among 1099 patients), and Chuang et al. reported 14.3% normal chest CT findings among symptomatic patients that had positive RT-PCR test results[7, 14]. Fang and colleagues reported CT findings of pneumonia in 50 of 51 patients with RT-PCR–proven COVID-19[15]. Ai and colleagues then reported CT findings of pneumonia in 580 of 601 patients with RT-PCR-proven COVID-19[4].

In our study, 53% of patients (419 out of 791patients) had negative or atypical chest CT findings on admission among all COVID-19 suspected patients (contact with an infected patient, or had symptoms). Within this group, 51.5% had RT-PCR positivity, suggesting that a negative or atypical chest CT scan cannot exclude the COVID-19 disease.

According to current practice, RT-PCR analysis remains the gold standard and reference test for COVID-19 diagnosis, although its' low sensitivity. Supporting these diagnostic suggestions, chest CT was removed from diagnostic workup in the recent sixth version of the "Diagnosis and Treatment Program of 2019 New Coronavirus Pneumonia" that was offered by The National Health Commission of China[2]. Consistently with these current recommendations, our study revealed 50.5% of typical or indeterminate CT findings among positive RT-PCR patients, which was lower than the literature (4). The difference may be due to diagnostic confusion between COVID-19 and other viral pneumonia. In most of published series CT findings are grouped as positive or negative, however, in our study we classified the CT findings as typical, indeterminate, atypical, and negative according to RSNA COVID-19 Expert Consensus recommendations (8). On the other hand, our series also revealed 42.8% of typical or indeterminate CT findings among RT-PCR negative patients. These low positivity rates among RT-PCR negative patients are also important in the diagnostic workup and increases the importance of positive RT-PCR or gene sequencing confirmation of COVID-19 diagnosis. Nevertheless, suspicious cases have paramount importance in the disease spreading, and every case suspected by chest CT still plays an important role during this COVID-19 pandemic. When we consider 42.8% typical or indeterminate chest CT findings among RT-PCR negative patients, chest CT can be considered as an ancillary diagnostic tool when RT-PCR is unavailable.

The results of this study also demonstrated that in the symptomatic patient group with RT-PCR test negative, typical or indeterminate CT findings were 43.1%, and only 17.6% had totally normal chest CT findings. In our current practice, we classified these patients as probable cases with COVID-19 and isolated and initiated medical treatment. It can be speculated that RT-PCR testing within this group could be due to test drawbacks.

In our opinion, chest CT has paramount importance in this group of patients, and exposure history, symptom status, chest CT imaging all should be interpreted during COVID-19 diagnosis in patients with negative RT-PCR tests.

Our study has some limitations; one of them is the retrospective nature of our analysis. A second limitation is that the severity of symptoms was not evaluated. Thus, this might have the effect of chest CT findings among symptomatic patients. Laboratory data were not also included, which can also be considered as a limitation. Nevertheless, our results are from a single-center, tertiary university hospital and will make a major contribution to the English literature regarding the clinical role of chest CT.

## Conclusion

The greatest value of our study is in demonstrating the value of chest CT in patients that had symptoms but had negative RT-PCR test results.

Another important finding that shed light on the current literature was in showing the insignificance of chest CT in asymptomatic but had suspected contact with COVID-19 patients.

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*Author's contributions:*
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