# Correlation of computerized tomography findings of novel corona virus disease with the duration of clinical presentation

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## Abstract

**Background and objective**: Physicians were more interested in using CT imaging techniques because of the limitations of RT-PCR during the COVID-19 pandemic and CT proved high specificity but moderate sensitivity in the diagnosis of the disease. The aim of the study was to find the correlation of the CT scan findings of the novel coronavirus disease with the duration of clinical presentation.

**Methods**: A cross-sectional study conducted in governmental and non-governmental tertiary hospitals in Erbil city that receive COVID-19 patients. The study started from May 2021 till June 2022. A convenience sampling method was used and 100 COVID -19 patients were included in the study. The Dutch Radiological Society CO-RADS assessment scheme was used to find the degree of suspicion for pulmonary involvement of COVID-19. The semi quantitative CT severity score was used to assess the degree of parenchymal involvement per lobe. A score less than 8 is considered mild, between 8-15 means moderate, and more than 15 is considered severe lung involvement.

**Results**: Significant differences were found between age groups and stages of disease ($P$ = 0.028). The highest rate of severe cases was in two age groups (40-59 and 60-79 years); 50% and 40% respectively. The bilateral ground-glass appearance was the predominant feature in all three degrees of the disease, 76%, 60%, and 52% respectively. The Spearman's Correlation Coefficient (r) was calculated, and a positive correlation was found between the age and CT- scores (r =0.188, $P$ = 0.061). A positive correlation was noticed between the time of first symptoms appeared and CT scores with a significant $P$-value (r = 0.382, $P$ <0.001).

**Conclusion**: A positive correlation was detected between CT scoring and the duration of the clinical presentation. The CT scoring methods used in the current study were beneficial and applicable in predicting COVID-19 pneumonia.

**Keywords**: Computerized tomography; COVID-19; Correlation; RT-PCR; CO-RADS.

## Introduction

In the city of Wuhan in central China in late December 2019, an outbreak of a new acute viral respiratory disease (COVID-19) caused by a novel coronavirus was reported.[1] On 30 January 2020, the world health organization considered the outbreak a public health emergency. Then it was recognized as a pandemic on 11 March 2020.[2] Public health systems facing global challenges since the emergence of coronavirus-associated diseases (SARS and MERS).[3] The case fatality rate of COVID- 19 is between 0.5–2.8% with a wide clinical spectrum; mild to moderate (80%) and severe (15%).[4]

The viral nucleic acid finding with real-time polymerase chain reaction (RT-PCR) remains the gold standard method in detecting cases. However, the false-negative results of RT-PCR in many studies directed the researchers to find more accurate diagnostic methods. The chest computed tomography showed

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higher sensitivity (98%) than RT-PCR (71%) in diagnosing, screening, and monitoring patients.[5] CT has been supported as an instrument for early diagnosis. The treatment is mainly supportive, so the management will be by early diagnosis and isolation of infected persons. The CT imaging is recommended in all settings for high-risk groups even if they presented with mild respiratory symptoms and the laboratory results were negative.[6]

The high-risk groups include; age over sixty-five years, diabetes, hypertension, chronic vascular diseases, and cancer. Risky persons with moderate to severe COVID-19 in low resources settings should be investigated with CT as studies revealed.[7,8] Chinese radiologists were able to differentiate cases of viral pneumonia from COVID pneumonia by CT with high specificity (94%) but moderate sensitivity (74%).[9] Physicians were more interested in using CT imaging techniques because of the limitations of RT-PCR during the pandemic. The clinical findings were; fever, sore throat, fatigue, and threatening conditions; therefore, early diagnosis is crucial for better outcomes.[10] The investigator found it necessary to conduct this study to diagnose cases of COVID 19 pneumonia by CT findings.

This study aimed to find the correlation of the CT scan findings of novel corona virus disease with the duration of clinical presentation, to assess the CT severity index and degree of suspicion (CO-RADS) score in patient with COVID-19 pneumonia.

## Methods

### Study design:
The study employed a cross-sectional design, utilizing a convenience sampling method to choose 100 patients.

### Study setting:
This study was conducted in governmental and non-governmental tertiary hospitals in Erbil city that treat COVID-19 patients. The trial lasted one year, from May 2021 to June 2022. Patients exhibiting radiological characteristics indicative of COVID-19 was included in the study, regardless of symptomatology or the results of RT-PCR testing, whether positive or negative. Where as exclusion criteria included patients with known history of TB, cancer or any specific lung disease like emphysema or interstitial lung disease. Children patients due to radiation hazard as well as pregnant ladies due to radiation hazard to the fetus were also excluded.

### Data collection:
The data was collected by a questionnaire that was designed by the investigator and included three parts. The first part was about sociodemographic characteristics of the studied population, the second part included signs and symptoms of the disease and the third part included CT scan features of COVID pneumonia. The unenhanced CT images were taken by the multidetector-row scanner (SOMATOM Definition Edge Siemens medical system, Germany and Philips Brilliance Slice CT). The supine position was selected with hands up, from the upper neck to mid-abdomen depending on the scanner, in a single breath-hold cluster, with 5-mm collimation, reconstruction at 1mm interval, and energy level of 120 Kv and 200-250 mA. The investigator with the help of two experienced radiologists evaluated the CT images as defined by the Radiological Society of North America Expert guidelines.[11] The images were examined to find the CO-RADS and severity index scores for each patient. The Dutch Radiological Society CO-RADS assessment scheme was used to find the degree of suspicion for pulmonary involvement of COVID-19.[12] In CO-RADS -1 the suspicion is very unlikely, in CO-RADS-2 is very low, the CO-VID 19 is unsure in CO-RADS 3, high suspicion in CO-RADS 4, and very high in CO-RADS-5. The CO-RADS-6 was introduced to indicate proven cases of COVID pneumonia with positive RT-PCR. Diagnosis of a suspected COVID 19 pneumonia was established considering the following chest CT patterns; GGO,

crazy-paving, and consolidation. These radiological terms were defined based on the standard glossary for thoracic imaging reported by the Fleischner Society.[14]

The semi quantitative CT severity score was used to assess the degree of parenchymal involvement per lobe. Each of the five lung lobes had been visually scored and given a score from 1 to 5. Score 1 means less than 5% lobar involvement, 2 means 5-25%, 3 indicated 26-50%, 4 means 51-75% lobar involvement, and more than 75% scored 5.Then, the final score was calculated by the summation of individual lobar scores out of 25 (total score); the total lung involvement was then obtained by multiplying the total score times 4.[15] A score less than 8 is considered mild, between 8-15 means moderate, and more than 15 is considered severe lung involvement.

**Statistical analysis:**
The collected data were analyzed using IBM-SPSS (Statistical Package of Social Science) version-26. Measures of central tendency and dispersion were found. The associations between categorical variables were calculated by Fisher's Exact and Chi-square test. The relations between numerical variables were found by independent t-test and one-way ANOVA test. The correlation between the time of first symptoms appeared and the CT severity score was found by the spearman Correlation Coefficient (r). The *P*-value of ≤0.05 was considered significant and <0.001 was highly significant.

**Ethical considerations:**
The ethical approval of the study was obtained from the ethical committee in the college of medicine/Hawler Medical University. An official letter was introduced to the study settings in Erbil city. An informed consent verbal or written was obtained from each patient. In critical cases, patients' relatives approached. Confidentiality was assured, and all pieces of information about each patient were kept private.

## Results

In this study among the 100 collected cases 57 were males and 43 were females and the mean ± Sd age was 56.8 ± 14.6 with a range from (21-92).The largest proportion from collected data were the elderly age group account 47%and the least age group was the young 13% as shown in Table 1.

**Table 1** Distribution of the studied sample by gender and age groups.

| Variables | Total No=100 No. (%) |
|---|---|
| **Gender** | |
| Male | 57 (57) |
| Female | 43 (43) |
| **Age groups** | |
| 20-39 | 13 (13) |
| 40-59 | 40 (40) |
| 60-79 | 43 (43) |
| 80 and more | 4 (4) |

Among the common CT findings of the disease, the bilateral ground-glass appearances were the predominant feature which present in 100% of the cases out of which 62% were bilateral, 18% was bilateral sub-pleural, diffuse confluent in 14% and peripheral and central in 6%.

The distribution of the disease was more common in the lower lobes 74% and dorsal in distribution in 73% of the cases as shown in Table 2.

**Table 2** common CT findings of COVID-19 disease and distribution of the disease.

| CT findings | Total 100 No (%) |
|---|---|
| **Ground glass appearance** | 100 (100) |
| Bilateral | 62 (62) |
| Bilateral subpleural | 18 (18) |
| Diffuse confluent | 14 (14) |
| Peripheral and central | 6 (6) |
| **Consolidation** | |
| Peripheral | 14 (14) |
| Central | 2 (2) |
| Both | 22 (22) |
| Absent | 62 (62) |
| **Marginal consolidation** | |
| Sharp | 33 (33) |
| Hazy | 6 (6) |
| Absent | 61 (61) |
| **Multiple rounded consolidations** | |
| Present | 14 (14) |
| Absent | 86 (86) |
| **Distribution** | |
| Upper lobes | 1 (1) |
| Lower lobes | 74 (74) |
| None | 25 (25) |
| **AP distribution** | |
| Dorsal | 73 (73) |
| None | 27 (27) |

The other CT features of COVID- 19. Septal thickening (64%), crazy paving (63%), vascular thickening (51%), thickening of pleura (36%), air bronchogram (30%), and bronchiectasis (17%) as shown in Table 3.

Figure 1 illustrated the degree of suspicion among cases of COVID -19. CO-RADS -6 constituted 66%, 32% were graded as CO-RADS-5 and only 2% were CO-RADS-4.

**Table 3:** Other CT findings of COVID 19

| CT findings | Total (%) |
| --- | --- |
| Vascular thickening | 51 (51) |
| Septal thickening | 64 (64) |
| Air bronchogram | 30 (30) |
| Crazy paving | 63 (63) |
| Thickening of pleura | 36 (36) |
| Nodules | 4 (4) |
| Cystic changes | 12 (12) |
| Bronchiectasis | 17 (17) |
| Pleural effusion | 6 (6) |
| Lymphadenopathy | 22 (22) |
| Tree in bud | 8 (8) |
| Masses | 1 (1) |
| Cavitation | 1 (1) |
| Calcification | 1 (1) |
| Reserved halo | 7 (7) |
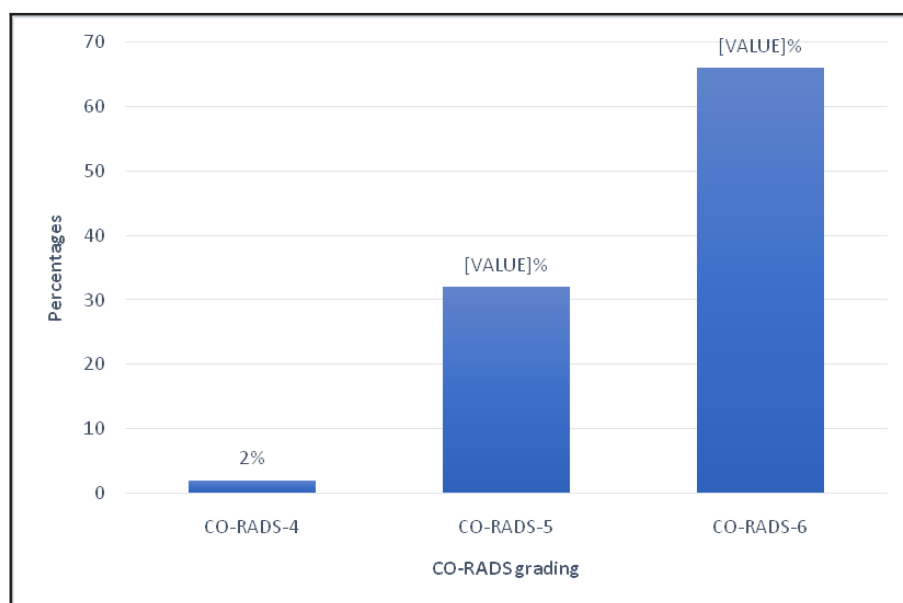


**Figure 1** The distribution of the studied sample by the degree of suspicion (CO-RADS grading)

The mean scores increased with duration in weeks, the lowest mean reported in the first week was 7.48 ± 3.34 and the highest mean (14.57 ± 5.71) was reported after more than two weeks with a highly significant $P$ <0.001. The total CT mean score was (11.93± 5.43) as shown in Table 4.

In 66% of mild cases, the lung involvement was between 5-25%, and in 53% of severe cases, the lung involvement was between 51-75% and $P$ ≤0.001 (Table 5).

**Table 4** Distribution of the studied sample by mean severity scores and duration from the first symptom started

| Weeks | N | Mean ± Sd | 95% confidence interval (CI) | Mean Rank |
|---|---|---|---|---|
| First week | 21 | 7.48 ± 3.34 | 5.96-9.00 | 25.79 |
| Second week | 56 | 12.52 ± 5.02 | 11.17-13.86 | 53.99 |
| More than two weeks | 23 | 14.57 ± 5.71 | 12.10-17.4 | 64.57 |
| Total mean severity score | | 11.93± 5.43 | 10.85-13.01 | |

Kruskal-Wallis H statistic = 21.55,df= 2, $P$ <0.001

**Table 5** Distribution of the studied sample by the percentage of lung involvement and severity scores

| Lung involvement in % | Mild (< 8) | Moderate (8-15) | Severe (>15) | Total | χ2 P-value |
|---|---|---|---|---|---|
| 5–25% | 16 (66.66) | 1 (2.27) | 0 (0) | 17 (17) | <0.001 |
| 26–50% | 8 (33.33) | 30 (68.18) | 0 (0) | 38 (38) | |
| 51-75 | 0 (0) | 13 (29.54) | 17 (53.12) | 30 (30) | |
| > 75% | 0 (0) | 0 (0) | 15 (46.87) | 15 (15) | |
| Total | 24 (100.0) | 44 (100.0) | 32 (100.00 | 17 (100.0) | |

Largest proportion of the ICU patients in the studied sample had severe disease 87% compared with only 4% of the outpatient cases were presented with severe disease (Table 6).

The Spearman's Correlation Coefficient was calculated at r =0.188 and the *P* was non-significant (*P* = 0.061). A positive correlation was found between the age and CT- scores (Figure 2).

**Table 6** Relation of admission status with severity of the disease

| Admission status | mild | moderate | severe | Total | χ2 *P*-value |
|---|---|---|---|---|---|
| ER | 0 (0) | 3 (6.81) | 0 (0) | 3 (3) | < 0.001 |
| ICU | 0 (0) | 2 (4.54) | 28 (87.5) | 30 (30) | |
| Outpatients | 24 (100) | 39 (88.63) | 4 (12.5) | 67 (67) | |
| Total | 24 (100.0) | 44 (100.0) | 32 (100.0) | 100 (100.0) | |
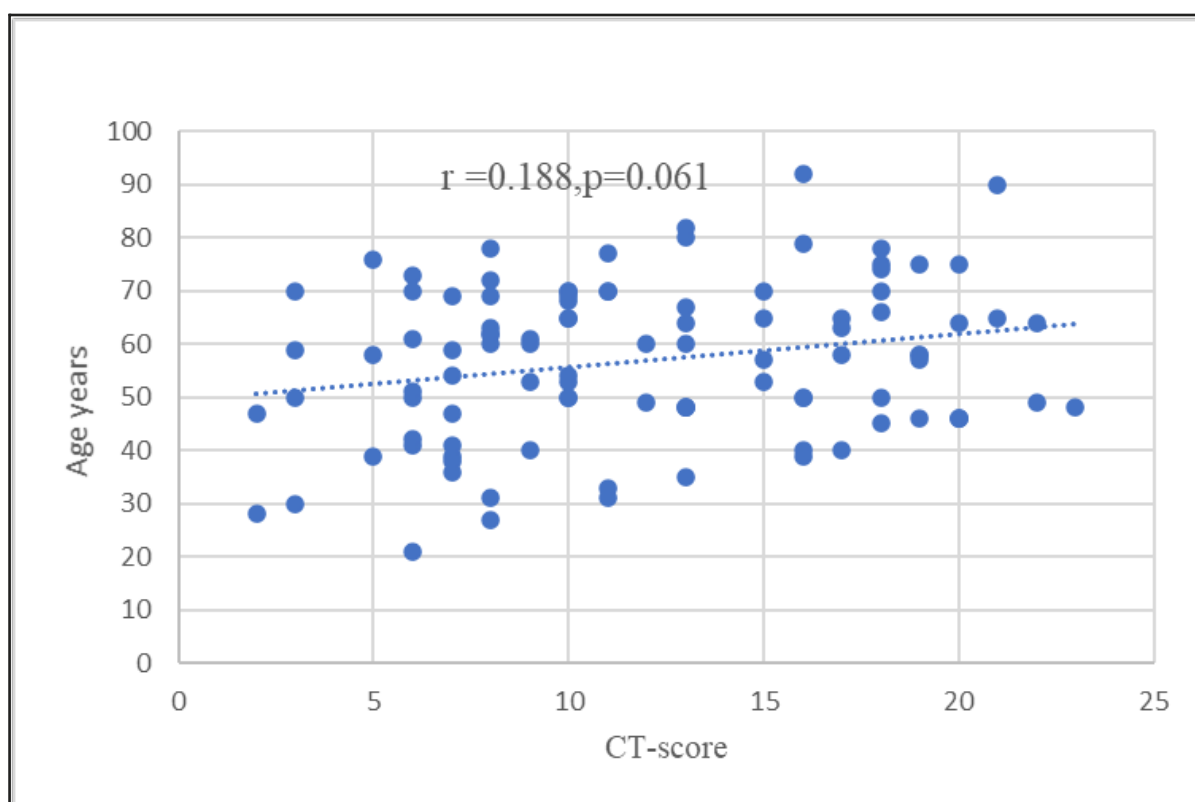


**Figure 2** Correlations between the CT scores and age.
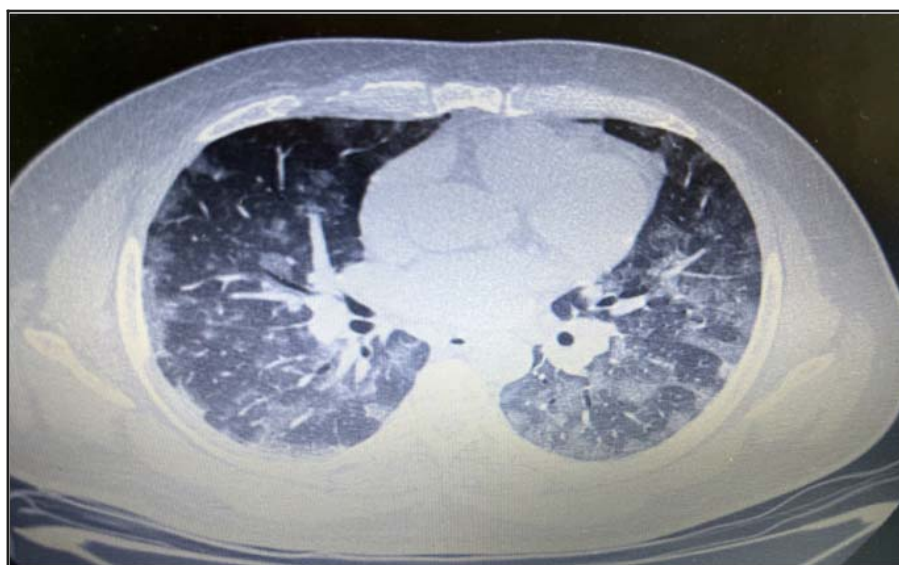
A positive Spearman's correlation was detected between the time of first symptoms appearing and CT scores with a significant *P*-value (r = 0.382, *P* <0.001), Figure 3.

Figure 4 shows one of the admitted cases in the RCU unit with severe COVID-19.
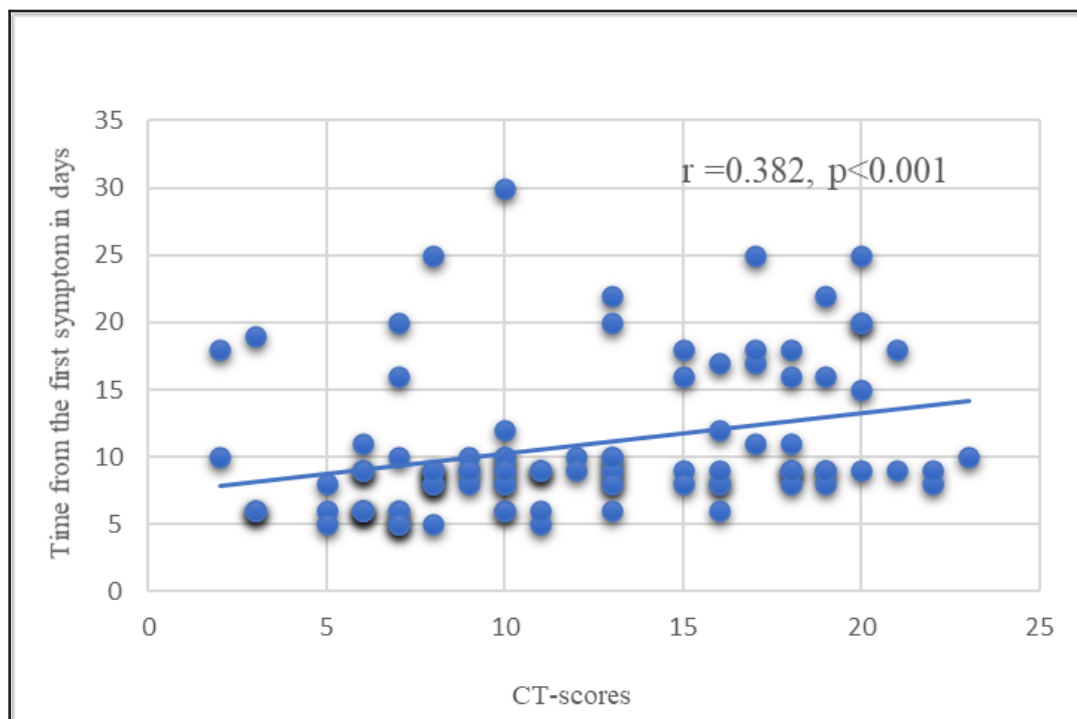


**Figure 3** The correlation between the time from the first symptom and CT scores



**Figure 4** 52 years old male presented with fever, cough and shortness of breath for 9 days duration, CT scan show severe COVID pneumonia with CO-RAD 6 (PCR +ve) and severity index: 18/25 = 72% lung involvement

## Discussion

This multicentric cross-sectional study was conducted in Erbil city and 100 symptomatic COVID- 19 patients were enrolled, 57% were males and 43% were females. The mean±Sd age was 56.8 ± 14.6 with a range from (21-92) and no difference in gender distribution was reported.

The current study revealed 53% prevalence of COVID 19 in the age group 20-59, this could be explained by the fact that this group was more exposed to the virus because they serve in the population. The older age groups (60-79, 80 years and more) were the most vulnerable due to compromised immunity and chronic health problems. This finding was in line with other studies done earlier.[15,16] In this study, the CT scores were positively correlated with age (r = 0.229, $P$ = 0.022). The mean CT score was higher (47%, 12.47 ± 4.9) in those aged 60 years and older than (53%, 11.45 ± 5.8) in younger age groups.

Chest CT is a key element of the diagnostic work-up for patients with suspected infection, and this investigation has shown some imaging findings commonly noticed in affected patients. Among the 100 patients studied the bilateral ground-glass opacities were reported in 62%, and peripheral and central consolidation were observed in 22% with significant differences between phases ($P$ <0.001). The AP distribution was dorsal (73%) and lower lobes involvement was predominant (74%). The sharp marginal consolidation was revealed in 33% (14% in the early phase and 17% in the late phase). Previous studies showed ground-glass opacity (GGO) at 68%, followed by GGO with consolidation (48%).[18]

In this investigation, the septal thickening, crazy paving, vascular thickening, and thickening of pleura were 64%, 63%, 51%, and 36% respectively. In the study of Italy, the thickening of small vessels was 70% and the thickening of the interlobular septum was 53%.[14] The findings in the late phase, which highpoint the increased frequency of features such as central and peripheral consolidation (10.3%), bilateral disease, greater total lung involvement (46.8%), a "crazy-paving" pattern (73.9%), the appearance of the "reverse halo" sign (8.6%), and dorsal lung distribution (60.8%) in patients imaged with CT a longer time after symptomatology started, represented the CT correlation to the basic pathophysiology of the disease process as it organizes.

Furthermore, the notable low rate of secondary chest CT findings in this study such as lymphadenopathy (22%), pleural effusions (6%), pulmonary nodules (4%), Tree in the bud (8%), cystic changes (12%), lung calcification (1%) and lung cavitation (1%) similarly are consistent with earlier case descriptions.[19]

The grading and scoring system used in this study helped in diagnosing COVID 19 pneumonia cases. The CORADS grading identified 66% as proven cases and all had positive PCR, 32% graded as very highly suspected, and 2% as highly suspect. A larger study among 859 cases with COVID showed that CORADS had a good diagnostic performance.[20]

The CT scoring system used in the current study categorized patients into three stages (24%) mild, (44%) moderate, and (32%) severe. The mean CT severity score was (11.93± 5.43) with a 95% confidence interval (CI,10.85-13.01).

A study was conducted in Egypt and used the same CT scoring, they reported a higher rate for mild cases (41.5%) and a lower rate for both (40.5%) moderate and (18%) severe cases.[21] A similar figure was reported in the Egypt study for the (11.2) mean CT severity score in cases with COVID-19 pneumonia[22] In the current study, the CT scoring was positively correlated with duration (r= 0.306, $P$ = 0.002). The CT mean score was lower in the first week (7.48 ± 3.34)and higher after more than two weeks(14.57 ± 5.71) with a highly significant difference ($P$ <0.001). The symptoms of COVID could

appear after a few days or longer than two weeks according to CDC (Center for Disease Control),[22] this explains the variation in duration.

In this study, the cases inside ICU (30%, 17.52 ± 3.5) scored higher than outpatient and ER cases (67%, 9.18 ± 3.8) and (3%)ER with a highly significant difference ($P$ <0.001). In a study in Greece, ($P$ = 0.004) statistically significant difference was reported between CT mean scores in ICU units in comparison to other units (12.60±4.25 Vs 7.38±4.23). CT scoring was positively correlated with markers of disease severity and predicted admission to ICU.[23]

The prevalence rate of COVID pneumonia in the current study was 100%, all the 100 cases were diagnosed as bilateral interstitial pneumonia. A study in Spain[24] reported a lower figure (60%). Wong and his colleagues[25] recognized a prevalence rate of 69% among COVID-19 infected persons. The explanation for this variation in the rate could be due to the different populations of the study, different staging of the disease, age differences, and the presence of other medical conditions.

One of the limitations of the current study is the small sample size, duration was defined as a subjective statement of patients (recall bias), and comorbidities were not included. However, conducting the study in multiple centers was one of its strengths. Another Strength of the current investigation was the assessment of the severity of symptoms. To our knowledge, it is the first study that correlated chest CT scoring with the duration of symptom appearance inside Erbil city, signifying that scanning may provide useful information about chest infectivity.

## Conclusion

A positive correlation was detected between CT scoring and the duration of the clinical presentation. The CT scoring methods used in the current study were beneficial and applicable in predicting COVID-19 pneumonia. Further studies are recommended with larger sample sizes, including comorbidities with detailed laboratory investigations.

## Competing interests

The authors declare that they have no competing interests.

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