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Research Article

CT scan Findings and Progressions of COVID-19 Patients in Jahrom, South of Iran

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Abstract:

Background: High Resolution Computed Tomography (HRCT) scan of chest is being used in diagnosis of the suspicious cases of COVID-19 and during the disease course. As we are facing a new pandemic with various unknown aspects of diagnosis and management, diagnostic imaging evidence should be intently described for further application in treatment.

Objective: To determine the trend of changes in lung HRCT scans from the initial diagnosis to disease progression in patients with COVID-19.

Methods: In this Cross-sectional study, Picture Archiving and Communication System (PACS) reports of lung HRCTs conducted in Peymaniyeh Hospital for patients with COVID-19 infection were queried. Reports matching the medical records with demographic and clinical data were included in the study. Chest CT Severity Score (CT-SS) and COVID-19 Reporting and Data System (CO-RADS) scoring were collected and analyzed.

Results: We studied 530 reports, including 275 male and 255 females. There were significant sex differences in CT-SS scores in various lung segments ($P<0.05$). Age was positively correlated with total and different lung segments' CT-SS scores ($P<0.05$). In cases with multiple imaging records, deterioration of CT-SS in the first two weeks from the symptom onset, followed by improvement in the next weeks was observed; while in some patients, no changes happened till fourth week.

Conclusion: When radiologists observe common chest imaging findings from this new strain of coronavirus, they can detect COVID-19 cases in a timely manner based on appropriate epidemiological and demographic characteristics. By doing so, immediate preventive measures can be taken to prevent transmission of the virus.

Keywords: COVID-19, High Resolution CT Scan, CT Severity Score, CO-RADS

Introduction

Chest High Resolution Computed Tomography (HRCT) scan is an essential component of the diagnostic algorithm for patients suspected of being COVID-19 infected (1). In fact, due to the limited number of real-time reverse transcription polymerase chain reaction (rRT-PCR) kits in some centers and the possibility of false negative rRT-PCR results, various medical authorities, as well as the National Health Commission of the People's Republic of China, has encouraged diagnosis based on clinical and CT Imaging findings (2).

Local radiographic imaging of COVID-19 pneumonia has shown obvious destruction of the pulmonary parenchyma, including interstitial inflammation and extensive integration, similar to later coronavirus infections (3-5). Therefore, CT may help to identify distinct patterns and features in COVID-19 patients. But, imaging findings of viral pneumonia are diverse and might overlap with other infectious and inflammatory lung diseases (6). So, from the beginning of the pandemic, many studies have tried to introduce imaging findings related to COVID-19 (3-5). COVID-19 pneumonia presents rapidly evolving CT imaging abnormalities of the chest, even in asymptomatic patients.

Combining imaging features with clinical and laboratory findings can facilitate early detection of COVID-19 pneumonia (7). The major manifestations seen on CT are defined by the naming of the International Standard and by the Fleischner Association Glossary and the literature review on viral pneumonia, using terms such as Ground Glass opacity, paving pattern, masonry and integration (8, 9). A semi-quantitative scoring system is used to quantify the pulmonary involvement of all these abnormalities based on the area involved (10).

Our perception of COVID-19 is changing on a daily basis and knowledge of using CT scan images is also evolving. So, the aim of this study was to determine the change in chest CT findings associated with COVID-19 pneumonia from initial diagnosis to medical course of the disease.

Methods

In this cross-sectional study reports of lung HRCTs conducted in Peymaniyeh Hospital for patients with COVID-19 infection were evaluated. Two main datasets were available including medical records and Picture Archiving and Communication System (PACS). All records of HRCT of lung in PACS were collected. Records were given special ID and matched with IDs Assigned in medical records. All 530 records of patients with Covid-19 who were admitted to Peymaniyeh Hospital in Jahrom from January to December 2020 were collected.

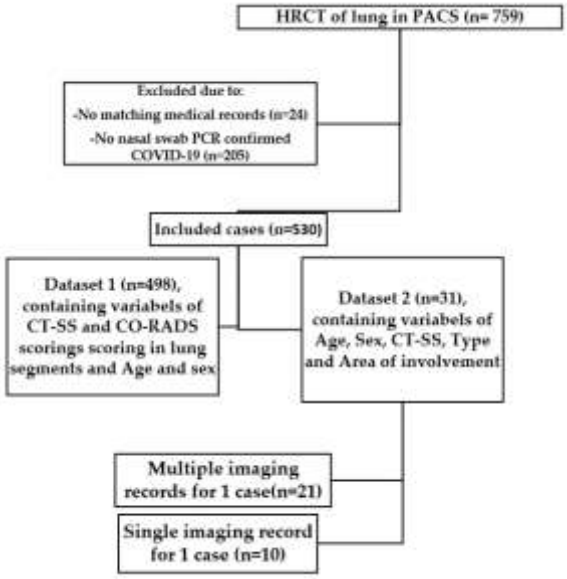

Figure 1. Flowchart of case recruitment

As CT scan reports were provided by various radiologists at different times of the year, heterogeneity in variables of CT scan reports was observed. As the aim of this study was to determine diagnostic characteristics of HRCT among COVID-19 patients in Jahrom, no CT scan reports belonging to COVID-19 patients with positive nasal swap PCR were excluded. Therefore all 530 cases with confirmed COVID-19 were included as shown in figure 1. Some patients could not be evaluated for the course of the disease due to an incomplete clinical history. Therefore, we only had 31 cases with complete information for the disease course.

Chest CT Severity Score (CT-SS)

The pulmonary involvement is evaluated and scored by chest CT severity score (CT-SS) in Jahrom city hospitals. CT-SS semi-quantitatively estimates pulmonary involvement based on the area affected and severity of involvement, with score values of

zero to 25, showing no involvement to most severe involvement (11).

CO-RADS scoring

To measure the level of suspicion of COVID-19 disease, the COVID-19 Reporting and Data System (CO-RADS) was used, which has a scoring from 0 (very improbable) to 5 (typical for COVID-19) (12).

Ethical considerations

This study was confirmed by the ethical committee of Jahrom University of Medical Sciences and Ethics Council of Peymaniyeh hospital under the code IR.JUMS.REC.1399.104 No personal information was gathered in this study.

Statistical analysis:

We analyzed data applying Chi-square, T-test, and ANOVA at a significant level of P<0.05 in SPSS version 21. GraphPad Prism version 8 was used to visualize the data. The correlation matrix was visualized using Multivariate Correlation Matrix (v1.0.11) in Free Statistics Software (v1.2.1) (13).

Results

Total number of 530 HRCT records of patients admitted to COVID-19 ward were collected from Picture Archiving and Communication System (PACS). Among the records, 498 reports were containing detailed CT-SS in left upper lobe (LUL), left lower lobe (LLL), right upper lobe (RUL), right middle lobe (RML), and right lower lobe (RLL) and CO-RADS scoring provided by responsible radiologist; while no clinical outcome or characteristics were available (dataset 1). A total number of 31 reports were available with complete information on symptoms, history of CT scan from the symptom onset, type of the abnormalities, and CT-SS (dataset 2).

Table 1. Total characteristics of evaluated records

Characteristics		N/Mean	%/SD
Sex	Male	275	51.9
	Female	255	48.1
Age (Mean years)		56.33	16.41
CORADS (only in group 1)	II	4	0.8
	III	19	3.82
	IV	91	18.27
	V	364	73.09
	Missing	20	4.02
Total CT-SS		9.85	5.1

As shown in table 1, 275 male subjects and 255 females were studied. Mean age of all subjects in studied records was 56.33±16.41. Mean CT-SS of all subjects was 9.85±5.1.

As figure 2.a indicates, patients with CORADS-V had total CT-SS higher than other CORADS categories (P<0.05). However, other categories had no significant difference from each other (P>0.05). Mean CT-SS was 1.95±1.09 for LUL, 2.39±1.17 for LLL, 1.88±1.27 for RUL, 1.82±1.1 for RML, and 2.42±1.15 for RLL. There were significant differences between various CORADS categories in terms of CT-SS (figure 2.b). There were significant sex differences in CT-SS for LUL, LLL, and RUL, showing higher values in male compared with females (P<0.05); while there were no differences in RML and RLL categories.

In dataset 1, there wasn't any significant correlation between Age and CORADS (r=0.0011, P=0.9813); while there was a significant correlation between Age and LUL score (r=0.0737, P=0.1081), LLL score (r=0.142, P=0.0019), RUL score (r=0.084, P=0.067), RML score (r=0.057, P=0.2141), RLL score (r=0.1379, P=0.0026), and total score (r=0.0982, P=0.0321). The most powerful correlations were seen between age and LLL score, as shown in the Figure 3.

Among those 31 patients (25.64%) in dataset 2, there were 10 patients who only had one CT scan record in PACS. Improvement of CT-SS happened in 9

(23.08%) records and deterioration in eight (20.51%) cases. One case had deterioration at first, followed by improvement. No changes happened in three (7.69%) cases. The days that CT scan was performed were compared between these patients. There was a significant difference between improvement and deterioration time (P=0.001), as shown in figure 4. These results show that patient may have deterioration of CT-SS in first two weeks from the symptom onset, followed by improvement in next weeks; while in some patients no changes happen till fourth week.

In comparison of the sex, age, mean CT-SS, amount of CT-SS change, type of involvement, and area of lung involvement, there were no significant differences among the groups having improvement, deterioration, or no change (P>0.05), as shown in table 2.

Discussion:

Due to the false negative results of common imaging methods such as Chest X-Ray and because of the unavailability of rapid PCR COVID-19 tests to sensitively diagnose COVID-19, there is a need for faster diagnosis for prompt medical care. Therefore, most clinician's diagnostic preference was given to CT scan, due to the ease of access to CT scans and also as it could be used for monitoring the prognosis of patients. In this study, we tried to determine the trend of changes in lung CT scan from the time of initial diagnosis to patient recovery among COVID-19 patients referred to Jahrom hospitals.

In our study, mean CT-SS of all subjects was 9.85±5.1. In the study of Egyptian subjects, the average CT-SS was 11.2 in COVID-19 patients (14). Based on WHO reports in June, total mortality of COVID-19 in Egypt was about 5.72% (15); while it is about 2.71% in Iran (16). In Italy, a study showed mean CT-SS of 12.3 ± 11.1 (17) with a country mortality rate of about 2.99% during the whole pandemic (18). However, correlational perspectives of the severity of Lung involvement and COVID-19 mortality in a worldwide view would be biased by numerous number of factors.

Table 2. Study variables based on the CT-SS prognosis

Variables		Improvement (n=10)	Deterioration (n=8)	No change (n=3)	P
Sex (N)	male	4	3	2	0.663
	female	6	5	1	
Age (mean, year)		51.07±13.27	56.25±7.11	47.83±15.23	0.374
CT-SS (mean, unit)		4±2.22	9.13±5.54	3.42±1.93	0.001
Δ CT-SS (mean, unit*)		3.47±2.1	1.25±7.38	0±0	0.064
Type of Involvement	Clear	0	1	1	0.184
	Crazy-paving pattern	2	1	1	
	Ground-glass pattern	3	7	2	
	Consolidation	2	3	1	
	Fibrotic	0	2	6	
Area	Diffuse	1	0	1	0.131
	Peripheral	5	4	0	
	Random	3	0	2	
* CT-SS deterioration was scored negative values.					

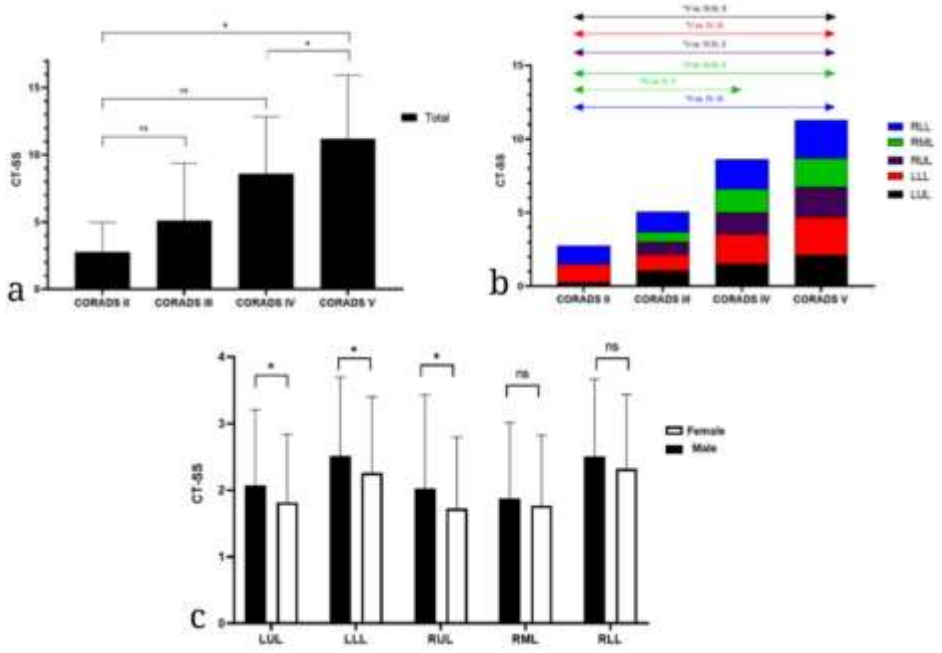

Figure 2. a, Total CT-SS based on the CORADS categories; b, CT-SS in each lung area based on the CORADS categories; c, total CT-SS based on the sex. *: Significant difference; ns: Not significant.

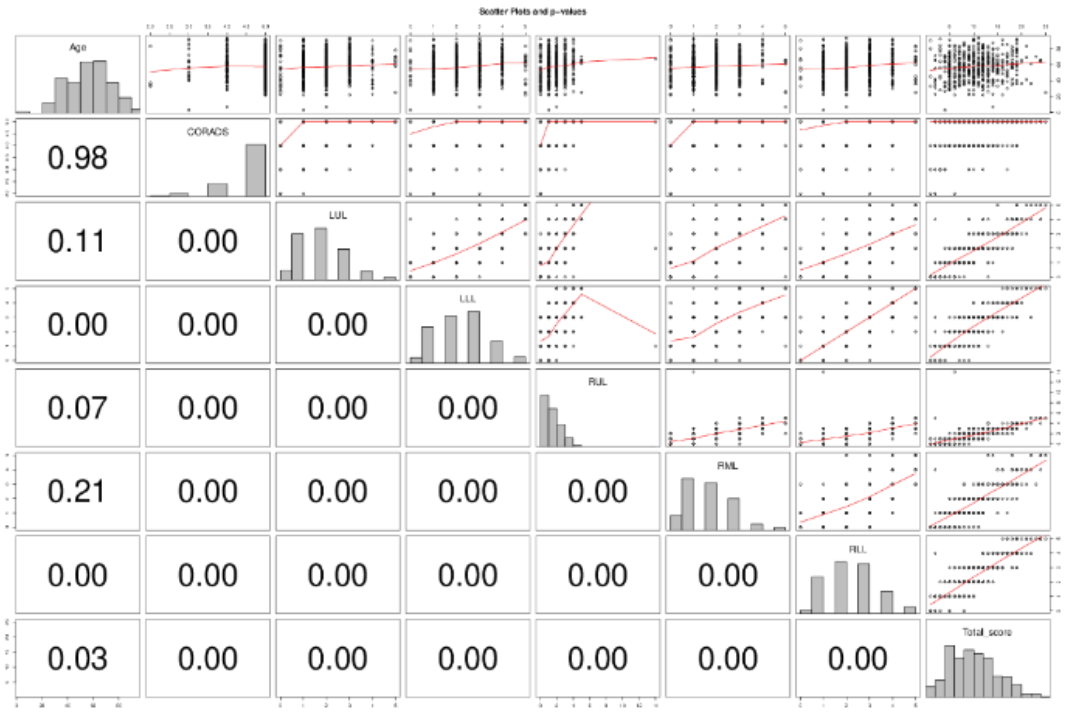

Figure 3. Correlation matrix of study variables. P-values are shown on left and scatter plots are on the right side.

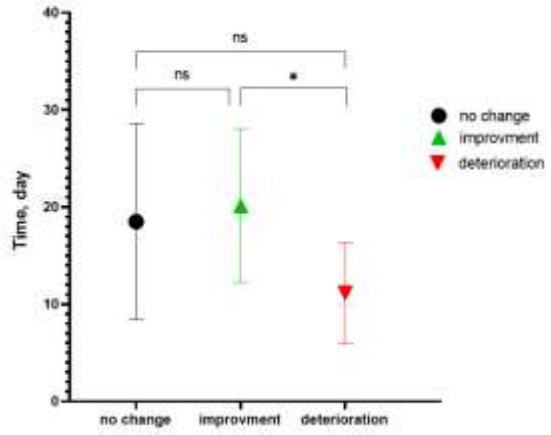

Figure 4. Time of CT scan changes based on the CT-SS prognosis.

However, studies have evaluated the correlational associations of imaging factors with disease severity in retrospective analysis. In Francone et al. study (17), a CT-SS of less than 18 was linked to an elevated mortality risk; while we did not evaluate mortality rate in our cases. Saeed et al. showed that the COVID-19 severity and the CT-SS are highly correlated (19).

In our study the most powerful correlations were found between age and CT-SS; as age was increasing, total CT-SS also increased. This correlation was most powerful in LLL. In the study of Hafez et al. (15) the CT-SS was considerably greater in subjects over the age of 75 which is consistent with our study.

Another CT scan severity score evaluate in our study was CO-RADS. Zayed et al. (20) compared CO-RADS versus CT-SS and find that both of them are very sensitive. Our study showed that Patients with CORADS-V had total CT-SS higher than other CORADS categories; while other categories had no significant difference from each other in case of CT-SS ($P>0.05$). The finding of our study could be justified in comparison to other studies if we include PCR negative cases and determine the Sensitivity and specificity of these two scoring methods. While previous studies in Jahrom city have addressed CO-RADS scoring as a criterion for the severity of the COVID-19 (21, 22); this study shows that CT-SS in categorizes of 1 to 4 does not significantly differ.

In summary, literature shows that lung CT scan is very sensitive to detecting cases of Covid-19 disease (23). While this study excluded PCR negative cases; some researchers have discussed that due to relatively low specificity of CT scans in diagnosis of COVID-19, relying solely on CT scans of the lungs for definitive diagnosis of Covid-19 disease in medical centers can lead to a considerable number of false positives. A high ratio of false positive to positive results, in addition to an overestimation of the actual incidence of the disease, can be due to the fact that patients without the disease can be treated in specific sections of the COVID-19 patients. In order to improve the diagnostic evaluation and to continue the process of treatment and isolation of patients, molecular RT-PCR test should be performed for all hospitalized patients suspected of having COVID-19 disease. However, application of CT scan in determining the disease progression is valuable as literature has shown evidence of the correlation of CT findings with COVID-19 outcomes.

Pan's study that assessed lung abnormalities over the course of the disease indicated that chest CT showed the most extensive symptoms approximately ten days after the onset of the initial symptoms (24). Our findings suggest that CT-SS usually gets deteriorates in the first two weeks after symptom initiation, then improve in the following weeks; nevertheless, in some individuals, no changes occur until the fourth week.

In the study of Chung et.al. chest CT was examined in 21 infected patients and showed a high degree of Ground-glass opacity (GGO), sometimes in the form of a round morphology and peripheral distribution in the lung (3). Also in our study, most type of involvement was GGO, followed by Consolidation

and Crazy-paving pattern. Another early prospective analysis in Wuhan showed bilateral GGO in 40 of 41 (98%) CT cases in infected patients and described the lobular regions as the most involved (5).

Study limitations

Most important limitation of this study was its descriptive study design. We did not have the opportunity to include final outcomes of ICU admission, mechanical ventilation rate, and mortality rates. Also, paraclinical findings' correlation with lung involvement could also be assessed. In addition, some patients had received medical interventions (antimicrobial, fluid, or steroid therapy) as soon as the COVID-19 infection was suspected or confirmed, that may affect chest CT findings. To reduce such effect we tried to not include those cases in this study. In addition, there may be a selection bias about the criteria for conducting CT scans. For example, if most patients who are clinically ill are likely to be imaged sooner or not at all, this may affect the outcome.

When radiologists observe common chest imaging findings from this new strain of coronavirus, they can detect COVID-19 cases in a timely manner based on appropriate epidemiological and demographic characteristics. By doing so, immediate preventive measures can be taken to prevent transmission of the virus.

Conclusion:

The results of this study indicate that the level of knowledge and attitude of nurses working in the emergency departments of the centers covered by Jahrom University of Medical Sciences regarding triage is moderate. In this regard, holding triage training courses for staff in order to provide high quality services is recommended.

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Authors' contributions:

MJA and MH designed the study. MJA read and interpreted the CT scans. CT scans were requested by ARA. ER, YS, MJA, and MH performed analyses. all authors contributed to writing and editing the manuscript.

Acknowledgments

None.

Ethical considerations

This study was confirmed by the ethical committee of Jahrom University of Medical Sciences and Ethics Council of Peymaniyeh hospital under the code IR.JUMS.REC.1399.104 No personal information was gathered in this study.

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