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Association between age and pneumonia profiles in COVID-19 patients

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Abstract

Introduction: This study aimed to determine the frequency of CT scan involvement due to COVID-19 pneumonia in different age groups of patients.

Methods: Patients with COVID-19 were referred to Amir al-Momenin Hospital in Arak City from May 2020 to June 2021. Age, sex, history of underlying disease, and CT scan results were recorded. CT scan Scores on the 5th to 8th day for patients were determined. The prepared CT scan was evaluated, and the pattern of pulmonary involvement and the prevalence of involvement in the lobes were assessed separately (upper, lower, peripheral, and bronchovascular fairytale).

Results: Overall, 349 patients were included. The mean age was 50.89 years. The most common involvement of the right lower lobe was 92% and the left lower lobe was 89.1%. Most patients had peripheral lung involvement. The average number of lobes involved was 4.14. GGO and GGO and Consolidation were correlated with younger patients. Higher Consolidations were observed in the age groups of 30 to 50 and 50 to 70. Crazy Paving is more common in the elderly and Halo was more common in young patients. The severity of lung involvement and the number of lobes involved were associated with high age.

Conclusion: Different age groups have specific features in CT scans to assess COVID-19 patients. Crazy Paving Appearance, Subplural bands, GGO, and Consolidation were seen in the elderly and severe/critical patients. Also, the amount of involvement and the number of lobes involved in the lungs of patients increases in patients of high age.

Keywords: COVID-19, pneumonia, age.

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Introduction

COVID-19 is the most important global health crisis of century [1-3]. Typical clinical symptoms of patients are fever, dry cough, breathing difficulties (dyspnea), headache, and pneumonia [2-5]. Disease onset may result in progressive respiratory failure owing to alveolar damage (as observed by transverse chest computerized tomography images) and even death. Imaging plays a crucial role in the diagnosis and evaluation of the disease[6]. Although, diagnosis relies on Real-Time Reverse-Transcriptase Polymerase Chain Reaction (RT-PCR) positivity for the presence of coronavirus[7].

Pneumonia is the most serious clinical presentation of COVID-19, although the majority of infected patients experience a mild disease without pneumonia or only mild pneumonia Ageing is associated with certain changes in pulmonary physiology, pathology and function, during the period of lung infection [8-10]. Several risk factors for severe COVID-19 pneumonia have been well-defined in the literature. However, the factors predicting COVID-19 pneumonia on hospital admission are not yet clear [11]. Advanced radiological methods (CT and USG) are used in addition to chest X-rays. The use of these methods increases labor and cost and causes additional radiation exposure. Therefore, it is important to evaluate all patients for pneumonia-predicting factors on hospital admission and then decide which tests to perform[12].

Therefore, age-related differences in responsiveness and tolerance become obvious and lead to worse clinical outcomes in elderly individuals[13]. Previous studies have

mentioned that older COVID-19 patients are at an increased risk of death [14-17]. However, the age-related clinical characteristics, disease courses and outcomes other than death in COVID-19 patients remain unclear [15].

COVID-19 pneumonia is one of the critical health system challenges in the world [16]. One of the essential issues related to COVID-19 is the diagnosis of patients in the community. Early methods for diagnosing COVID-19 pneumonia include the RT-PCR and CT scan of the chest. Imaging plays a crucial role in diagnosing the COVID-19 disease [7-12].

COVID-19 is more dangerous and deadly for elderly patients compared to general populations and those with underlying physical diseases [12-14]. This study aimed to determine the frequency of CT scan involvement due to COVID-19 pneumonia regarding different age groups.

Methods

In this analytical cross-sectional study, patients with COVID-19 that referred to Amir al-Momenin Hospital in Arak city from May 2020 to June 2021. To evaluate for COVID-19, patients underwent a visit to an infectious disease specialist, and a PCR test was performed to confirm the diagnosis. Information including age, sex, and history of underlying disease as well as the results of the tests was recorded. For all CT scan was performed without contrast. CT scan Scores on the 5th to 8th day for patients were determined. The prepared CT scan was evaluated and the pattern of pulmonary involvement and the prevalence of involvement in the lobes were determined and recorded separately (upper, lower, peripheral, and bronchovascular fairytale) in each patient. The age groups in this study included 4 groups under 30 years, 30 to 50 years, 50 to 70 years, and over 70 years old.

A CT scans were performed using 16 slices, without contrast, whereas the patient was in the supine position and at the end of their tail. The cut thickness of all CT scan images was 0.5-5 mm. The scans were examined for the 1. Ground Glass Opacities, 2. Consolidation, 3. Mixed Ground Glass with Consolidation Opacities, 4. Crazy Paving Appearance, 5. Halo sign, 6. Reverse Halo sign, 7. Pulmonary Nodules with a halo, 8. Tree in the bud, 9. Centrilobular Nodules, 10. Bronchial wall thickening, 11. Traction bronchiectasis, 12. Normal. Pulmonary involvement score (CT score) after evaluating all five lobes, separately, was as follows: Score zero: no involvement, score 1: mild involvement of one lobe, score 2: mild involvement of one lobe, score 3: moderate involvement of one Lobe, Score 4: Severe involvement of a lobe. The sum of the scores of pulmonary involvement in each patient is determined by summing the scores of 5 lobes. The CT scan conflict score reaches its peak on the 5th to the 8th day of infection. So, the CT score was determined for the patients on the sixth to the tenth day.

The results of the initial CT scan after confirmation of the disease, patients in both groups were evaluated by the principal facilitator (radiologist) based on the mentioned patterns. Then, in addition to the type of involvement pattern, a pulmonary involvement score was recorded for each patient. Ct-score grading was assessed according 0=none, 1=<20%, 2=25-50% mild, 3=50-75% sever and 4=75-100 complete in this study.

Statistical analysis

Data were analyzed via SPSS-20 software. After entering the information in Stata software, central indicators, dispersion, and graphs were used to examine descriptive statistics. Kolmogorov Smirnov test was used for assessing normality test. Chi-square and Independent Sample T-test were used at a significance level of less than 0.05 to compare the two groups.

Results

Overall, 349 patients were included. 87 (53.6%) patients were female and 162 patients (46.4%) were male. The mean age of patients was 50.89 ± 21.25 years. Patients were divided into four groups according to age, which were 26.9% under 30 years old, 24.1% between 30 and 50 years old, 26.4% between 50 and 70 years old, and 22.6% over 70 years old.

Right Upper Lobe (RUL)

In the groups of 30 to 50 years and 50 to 70 years, the Consolidation was significantly higher than the group under 30 years and the group over 70 years. Crazy Paving has been significantly higher in the age group of 50 to 70 years and over 70 years than in other age groups. Halo was significantly higher in the under-30 age group than in other age groups. Subpleural bands are significantly less common in the under-30 age group than in other age groups (Table 1).

Right Middle Lobe (RML)

There was no difference in GGO between different age groups, but the Consolidation and GGO+ Consolidation were significantly higher in the age group over 30 years than in the age group under 30 years. Crazy Paving was significantly higher in the 50-70 years and over 70 years than in other age groups. Halo was significantly higher in the under-30 age group than in older patients. Subpleural bands were also significantly lower in the under-30 than in other age groups (Table 1).

Right Lower Lobe (RLL)

GGO was significantly higher in the under-30s and 30s-50s than in the older age groups. GGO and Consolidation were significantly higher in the age groups of 50 to 70

years and over 70 years than in other age groups. Crazy Paving was higher in the age group over 50 than in those under 50 years. Halo and reverse Halo were significantly higher in the under-30 age group than in the older age group. Subpleural bands were significantly lower in the under-30 age group than in other age groups (Table 1).

Left Upper Lobe (LUL)

The Consolidation rate in the age groups of 30 to 50 years and 50 to 70 years was significantly higher than in the age groups under 30 years and over 70 years. GGO+ Consolidation was significantly lower in the under-30 age group than in the older age groups. Crazy Paving was more common in the older age groups and the Halo sign was more common in the younger age group. Subpleural bands were also significantly lower in the under-30 age group than in other age groups (Table 1).

Left Lower Lobe (LLL)

GGO was more common in the age group of 30 years and 30 to 50 years than in the older age groups. The incidence of Consolidation in the age groups of 30 to 50 years and 50 to 70 years was more common than in the age group under 30 years and over 70 years. GGO+ Consolidation has been more common in older age groups than in young people. Crazy Paving was higher in the older age group and Halo in the younger age group. Subpleural bands were also significantly lower in the under-30 group than in other age groups (Table 1).

Table 1. CT characteristics

Items	N (%)	<30	30-50	50-70	>70	P-value
Right Upper Lobe (RUL)						
GGO	149 (2.7%)	38 (40.4%)	43 (51.2%)	38 (41.3%)	30 (38%)	0.325
Consolidation	27 (7.7%)	3 (3.2%)	10 (11.9%)	12 (13.0%)	2 (2.5%)	0.010
GGO+ Consolidation	64 (18.3%)	10 (10.6%)	15 (17.9%)	22 (23.9%)	17 (21.5%)	0.103
CRAZY	24 (6.9%)	0 (0.0%)	0 (0.0%)	10 (10.9%)	14 (17.7%)	<0.001
Halo sign	12 (3.4%)	8 (8.5%)	2 (2.4%)	2 (2.2%)	0 (0.0%)	0.013
Reverse Halo sign	10 (2.9%)	2 (2.1%)	2 (2.4%)	3 (3.3%)	1 (1.3%)	0.399
Pulmonary nodules with Halo	1(0.3%)	1 (1.1%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0.437
Tree in Bud	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	---
Centrilobular lung nodules	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	---
Subplural bands	39 (11.2%)	1 (1.1%)	14 (16.7%)	14 (15.2%)	10 (12.7%)	0.003
Nodular pattern	20 (5.7%)	9 (9.6%)	4 (4.8%)	6 (6.5%)	1 (1.3%)	0.125
Right Middle Lobe (RML)						
GGO	155 (44.4%)	43 (45.7%)	46 (54.8%)	38 (41.3%)	28 (35.4%)	0.084
Consolidation	32 (9.2%)	3 (3.2%)	12 (14.3%)	13 (14.1%)	4 (5.4)	0.012
GGO+ Consolidation	69 (19.8%)	8 (8.5%)	14 (16.7%)	23 (25.0%)	24 (30.4%)	0.002
CRAZY	22 (6.3%)	0 (0.0%)	0 (0.0%)	10 (10.9%)	12 (15.2%)	<0.001
Halo sign	10 (2.9%)	7 (7.4%)	1 (1.2%)	2 (2.7%)	0 (0.0%)	0.015
Reverse Halo sign	12 (3.4%)	6 (6.4%)	2 (2.4%)	4 (4.3%)	0 (0.0%)	0.123
Pulmonary nodules with Halo	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	---
Tree in Bud	1 (0.3%)	1 (1.1%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0.437
Centrilobular lung nodules	1 (0.3%)	0 (0.0%)	1 (1.1%)	0 (0.0%)	0 (0.0%)	0.367
Subplural bands	42 (12.0%)	2 (2.1%)	14 (16.7%)	14 (15.2%)	11 (13.9%)	0.020
Nodular pattern	20 (5.7%)	10 (10.6%)	3 (3.6%)	6 (6.5%)	1 (1.3%)	0.047

Items	N (%)	<30	30-50	50-70	>70	P-value
Right Lower Lobe (RLL)						
GGO	177 (50.7%)	60 (63.8%)	48 (57.1%)	37 (40.2%)	32 (40.5%)	0.002
Consolidation	37 (10.6%)	8 (8.5%)	11 (13.1%)	14 (15.2%)	4 (5.2%)	0.132
GGO+ Consolidation	80 (22.9%)	9	16	26	28	0.001
CRAZY	22 (22.6%)	0	0	12	10	<0.001
Halo sign	12 (3.4%)	10	0	2	0	<0.001
Reverse Halo sign	13 (3.7%)	8	2	3	0	0.023
Pulmonary nodules with Halo	1 (0.3%)	1	0	0	0	0.432
Tree in Bud	0 (0.0%)	0	0	0	0	---
Centrilobular lung nodules	0 (0.0%)	0	0	0	0	---
Subplural bands	59 (16.9%)	4	23	18	14	<0.001
Nodular pattern	20 (5.7%)	9	2	8	1	0.032
Left Upper Lobe (LUL)						
GGO	150 (43.0%)	37	44	38	31	0.252
Consolidation	26 (7.4%)	3	10	11	2	0.016
GGO+ Consolidation	66 (18.9%)	9	16	18	22	0.047
CRAZY	21 (6.0%)	0	0	7	14	<0.001
Halo sign	12 (3.4%)	10	1	1	0	<0.001
Reverse Halo sign	8 (2.3%)	4	1	3	0	0.230
Pulmonary nodules with Halo	1 (0.3%)	0	0	1	0	0.423
Tree in Bud	0 (0.0%)	0	0	0	0	---
Centrilobular lung nodules	0 (0.0%)	0	0	0	0	---
Subplural bands	40 (11.5%)	1	14	13	12	0.003
Nodular pattern	18 (5.2%)	6	4	6	1	0.381
Left Lower Lobe (LLL)						
GGO	172 (49.3%)	54	48	36	33	0.50
Consolidation	33 (9.5%)	5	9	17	2	0.002
GGO+ Consolidation	72 (20.6%)	9	17	21	25	0.004
CRAZY	21 (6.0%)	0	0	9	12	<0.001
Halo sign	11 (3.2%)	10	0	1	0	<0.001
Reverse Halo sign	10 (2.9%)	5	2	3	0	0.213
Pulmonary nodules with Halo	1 (0.3%)	0	0	1	0	0.423
Tree in Bud	0 (0.0%)	0	0	0	0	---
Centrilobular lung nodules	0 (0.0%)	0	0	0	0	---
Subplural bands	59 (16.9%)	2	23	17	28	<0.001
Nodular pattern	23 (6.6%)	12	3	17	1	0.013

The most common involvement of the right lower lobe was 92% and the left lower lobe was 9.1%. Most patients had peripheral lung involvement. The average number of lobes involved was 4.14. GGO, GGO, and Consolidation were correlated with younger patients. Higher Consolidations were observed in the age groups of 30 to 50 and 50 to 70. Crazy Paving is more common in the elderly and Halo is more common in young patients. The severity of lung involvement and the number of lobes involved were associated with high age. The central distribution of lesions in the age group of 30 to 50 years was more common than in other age groups.

Peripheral distribution of simultaneous central and peripheral distribution did not differ significantly between age groups.

The mean total scores of lung involvement in the age groups under 30 years, 30 to 50 years, 50 to 70 years, and over 70 years were 4.90 ± 3.59, 7.48 ± 4.15, 8.55 ± 3.84, and 8.70±3.59, respectively (P<0.001). The intensity scores of each lobe were compared separately according to the four age groups. In all lobes, the severity of the conflict was significantly different according to the age group (Table 2).

Table 2. Score of lob involvement

Items	<30	30-50	50-70	>70	P-value
RUL	0.77±0.84	1.32±0.94	1.42±0.89	1.41±1.01	<0.001
RML	0.79±0.77	1.41±0.90	1.63±0.92	1.58±1.00	<0.001
RLL	1.29±0.84	1.75±0.89	2.07±0.92	2.13±0.76	<0.001
LUL	0.80±0.82	1.32±0.90	1.40±0.90	1.51±0.87	<0.001
LLL	1.22±0.85	1.67±0.90	2.02±0.92	2.07±0.87	<0.001

Discussion

In the current study, the most common findings on CT scans in all five lobes were GGO, GGO + CON, and subpleural bands. The most common lobes involved were 92% right lower lobe, 89.1% left lower lobe, and 79.9% right middle lobe, respectively. Involvement in both patients was peripheral and then peripheral and central. A single central conflict has been rare. The average number of lobes involved in the whole study was 4.14 and 70.5% of patients had five lobes involved.Male gender and older age were identified as risk factors for COVID-19 disease and a severe clinical course [13-19].

A study by Bao et al. showed that 89.76% of COVID-19 patients had symptoms on CT scan. The most common symptoms on CT scan of the lungs were 83.31% GGO, GGO and density of 58.42%, thickness of the interlobular septum was 48.46% and air bronchogram was 46.46%. Crazy Paving was seen in 14.81% of patients. The most common distribution of lesions in bilateral CT scan was 78.2% and peripheral CT was 76.95%. The most common lobes involved were 87.21% of the right lower lobe and 81.41% of the left lower lobe. A significant proportion of patients had involvement in three or more lung lobes, 70.81%, as it is known, the findings of Bao's review of the general findings of CT scans in COVID-19 patients are fully compatible with our study findings [20].

Older age and comorbid diseases are associated with a severe clinical course in COVID-19 cases [12-14]. In a recent meta-analysis, 35.6% of COVID-19 cases had at least one comorbid disease. Comorbidities which are most frequently detected in COVID-19 cases and are proven to be associated with poor prognosis are hypertension, cardiovascular diseases, diabetes, and COPD, and active smoking, respectively [15].

In the present study, the incidence of GGO in patients in different lobes was not different between different age groups or was higher in the age group under 50 years. In the case of Consolidation and GGO, conversely, it was either no different or more common in the older group. Consolidation is most affected in the middle age groups of 30 to 50 years and 50 to 70 years. It is found in other symptoms, but the same pattern is seen in all lobes. Halo is more common in all lobes in the under-30 age group, and Crazy Paving belongs to the over-50 age group. The subpleural band was significantly higher in the over-30 age group than in the under-30 age group.

Central distribution was rare but was more common in the 30s and 50s, and other forms of distribution did not differ between age groups. The total score of lung involvement increased with age, from 4.90 in the under-30 age group to 8.70 in the over-70 age group. This increase in points can be seen in all lobes separately. The number of lobes involved also increases from 3.4 to 4.39 in groups under 30 years old to over 70 years old. For example, 14.9% of people under 30 years old have only one involved lobe, but this rate is only 3.8% for those over 70 years old. In the case of 5-lobe involvement, only 50% of patients under the age of 30 have five-lobe

involvement, while this rate was 72.2% in patients over the age of 70. Thus, with age, both the severity of the involvement and the number of lobes involved increase, and the pattern of lung involvement on the various features found on CT scans can vary, reflecting the deteriorating clinical condition of the disease, as in studies Some findings on CT scans are associated with worse clinical conditions.

A study by Farghaly et al reported that the severity of lung involvement had a significant correlation with age, a finding consistent with our study. The study by Wang et al. Also reported that more lobes were involved in the elderly and more subpleural lesions were seen in this group of patients. Crazy Paving Bronchodilation and pleural effusion are more common in the elderly. Similar findings were reported in the number of lobes involved, subpleural lesions, and crazy paving in our study. Steinberger et al. Examined COVID-19 disease in the pediatric age group and reported that even in this age group, the severity of the findings increased and the pattern of CT scan findings changed [21].

Zheng et al.'s study reported findings of consolidation, pleural effusion, lymphadenopathy, pattern, Crazy Paving, intercellular septal thickness, reticulation, traction bronchiectasis, involvement of more than two lobes, and central distribution indicate more severe disease. According to the findings of our study, it seems that these findings may be associated with higher severity of the disease at a higher age [22].

The study by Li et al. reported that, as in our study, younger ages had lower lobes, but with age, older patients had four or five lobes, and there was a significant difference between age groups. Our study of CT scan findings reported only a higher incidence of large and multiple GGOs in the older age group and found no difference between other CT scan findings between different age groups [23].

A study by Zhu et al reported that extensive involvement of the lung lobes was more common in the older group than in the younger group (71.4% vs. 36.4%). Subpleural line and pleural thickness are also more likely to occur in the elderly, which is similar to the findings of our study. The study by Chen et al. Reported that patients aged 45 to 59 years and over 60 years had more bilateral involvement of the lungs and pulmonary lobes and a higher number of lesions than patients under 18 years of age. GGO has also been more common in patients aged 45 to 59 years and 60 years and older than those under 18 years of age and 18 to 44 years of age with patients with an intercellular septum or Crazy Paving pattern, Consolidation, and air bronchogram symptoms. Similar findings have been obtained in our study [24].

In a study by Li et al., It was reported that Consolidation, GGO, Crazy Paving pattern, and bronchial wall thickness were significantly higher in severe/critical patients than in normal patients. Also, the CT scores of severe/critical patients were significantly higher than normal patients, and the sensitivity and specificity of CT to differentiate severe/critical cases from normal were 80 and 82.8%. Given that age in our study was associated with a number of these findings and was correlated with the severity of lung involvement, in interpreting the results of such studies, the age and age group of patients should be considered [24].

The current study has also encountered limitations that are briefly mentioned. The main limitation of our study was the lack of patient clinical data. In the presence of patients' clinical data, it was possible to score the clinical severity of the disease, and the study of the correlation of clinical status with CT scans could provide much better clinical vision and provide additional assistance to physicians in making decisions. Also, due to the existence of different variants of the disease in our country and the possibility of different lung involvement by different variants, the study of variants based on PCR could help to better interpret and classify the results.

This study has several limitations. Our data were collected retrospectively, and the number of cases was limited. Therefore, patients with COVID-19 pneumonia have not been evaluated according to disease severity. In addition, we could not assess the risk factors for poor outcomes, because the number of critically ill patients was low.

Conclusion

The results showed that different age groups have specific features in CT scan that attention is needed to assess COVID-19 patients. Crazy Paving Appearance, Subplural bands, GGO, and Consolidation were seen in the elderly and severe/critical patients. Also, the amount of involvement and the number of lobes involved in the lungs of patients increases in the patients of high age.

Highlights

What Is Already Known?

COVID-19 is a more dangerous disease for elderly patients with underlying physical diseases compared to general populations.

What Does This Study Add?

Different age groups have specific features in CT scans that attention is needed to evaluate COVID-19 patients.

Abbreviations

Ground Glass Opacities (**GGO**), Consolidation (**CON**)
Mixed Ground Glass with Consolidation Opacities (**GGO+CON**)
RUL: right upper lobe, **RML**: right middle lobe
RLL: right lower lobe, **LUL**: left upper lobe, **LLL**: left lower lobe,

Authors' Contributions

Concepts: Sima Salimi, Saeedeh Shahali, Mersad Mehrnahad.Data gathering: Sima Salimi, Saeedeh Shahali, Mersad Mehrnahad. Results: Sima Salimi, Saeedeh Shahali, Mersad Mehrnahad. Writing and editing the paper: Sima Salimi, Saeedeh Shahali, Mersad Mehrnahad.

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Consent for Publication

We declare consent for publication.

Conflict of Interest

The authors declared no potential conflict of interests with respect to the research, authorship, and /or publication of this article.

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Ethics approval

Department of Radiology and Radiotherapy, School of Medicine, Arak University of Medical Sciences, Arak, Iran confirmed the proposal of this study.

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