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Original Research Article

The Evaluation of Correlation between Clinical Characteristics and Chest CT Findings in Recovered and Dead COVID-19 Patients

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Abstract: ***Objectives*:** The purpose of this study was to retrospectively investigate the correlation between clinical characteristics and chest CT findings in recovered and dead covid-19 patients. ***Patients*:** In this retrospective study, 63 hospitalized patients infected with COVID-19 were reviewed, from 1 May 2020 to 30 Dec 2020. The lobe involvement and infection pattern were evaluated in both groups. A semi-quantitative CT score was calculated based on the extent of lobar involvement (0 indicate no involvement; 1, less than 5% involvement; 2, 5-25% involvement; 3, 26%–50% involvement; 4, 51%–75% involvement; and 5, 76%–100% involvement. ***Results*:** In the recovered group, 16 (30.76%) had opacities in two lobes, 10 (19.23%) in three lobes, 20 (38.46%) in four lobes, and 16 (30.76%) in all five lobes. While, in the dead group just four (7, 63.63%) and five (4, 36.36%) affected lobes were shown. The most hallmarks of COVID-19 infection on chest CT images of recovered patients were ground-glass opacities, GGO, (26.92%), consolidation (17.30%), GGO & Consolidation predominance, MIX, (42.30%), and crazy paving (CP) patterns (13.46%). Intubation was performed for 16 patients to be recovered. While in the dead patients the lung infection was completely the MIX pattern (100%) and all of them were intubated. CT score was calculated significantly higher in dead patients than recovered patients ($p < 0.01$). ***Conclusions*:** Our data suggest the potential role of chest CT for predicting the outcome of SARS-CoV-2 patients. According to CT results, patients with more lung involvement, the MIX pattern, and higher CT score in lung infection had less chance for recovery.

Keywords: Computed Tomography, Chest CT, COVID-19, Coronavirus Infection, Comorbidity.

INTRODUCTION

In late 2019, new respiratory contagious disease cases with no identifiable cause were reported in Wuhan, China which has promptly spread worldwide. It soon became clear that a novel coronavirus was responsible [1]. Since its detection, the SARS-CoV-2 infection outbreak has evolved into an enormous global healthcare emergency, recently fulfilling the epidemiological criteria required by the WHO to be declared a pandemic [1, 2]. Studies declared rapid human-to-human transmission with a median incubation period of 3 days [3]. The relatively prolonged turnaround time for viral testing together with the low sensitivity of a single RT-PCR assay of pharyngeal and nasal swab specimens also suggests that a large number of SARS-CoV-2 patients would not be rapidly recognized and may not be appropriately managed [1-5]. Although a high percentage of infected patients only develop mild symptoms, some individuals can progress to pneumonia, multi-organ failure, or even death [6].

In the midst of a pandemic, it can be difficult to rule in or out COVID-19, particularly considering the large number of people who visit the emergency unit every day [7]. As a standard, a non-invasive diagnostic tool for pneumonia, a chest CT scan is relatively simple to perform and can provide a quick diagnosis. In the early stages of COVID-19 diagnosis, chest CT plays an

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important role in the prompt detection of lung infection abnormalities [8, 9]. As a result, with a sensitivity of 97 percent and faster performance, chest CT is recommended as the primary screening modality [3]. The Fleischner Society indicated that when symptoms develop in a resource-constrained environment, a chest CT scan is critical in patients with COVID-19 [10]. Moreover, the chest CT scanning may find out the severity of the disease based on the findings on the imaging. The CT involvement score is an imaging tool used to assess COVID-19 pneumonia. Recent research has recommended the usage of CT scoring criteria that take lobe involvement into account for assessing the diseases severity and lung involvement pattern of COVID-19 pneumonia [1-10].

The present study aimed to find out a series of clinical and imaging features such as lung involvement stage, infection pattern, and CT score in patients with confirmed COVID-19 who had no comorbidities in both dead and recovered patient groups.

MATERIAL AND METHODS

Study Design

This retrospective study was approved, and written informed consent was waived by the medical ethics committee of our hospital. We retrospectively reviewed patients diagnosed with COVID-19 from 1 May 2020 to 30 Dec 2020. Among patients who were hospitalized, 132 participants were included in this study. The inclusion criteria were: individuals with confirmed COVID-19 infection by RT-PCR and chest CT scan, Hospitalization, no comorbidity, complete nursing records (demographic data, hospitalization time period, any kind of symptoms, and intubation), and the patient's final condition (died or recovered).

CT Scanning Protocol

A low dose chest CT scan was performed in all patients with the same protocol using the SOMATOM Emotion 16 scanner (Siemens Healthineers, Forchheim, Germany), KVp=100-120, effective mAs= 60-90, slice thickness=5 mm, pitch=1, FOV=350×400 mm, collimation=16×0.6, and section thickness after reconstruction, 5.0 mm, with a sharp reconstruction kernel (Sharp 70s) or a Mediastinum 41s kernel. All CT images were achieved without the administration of an intravenous contrast medium.

CT Image Analysis

The CT findings were described by using internationally standard nomenclature defined by the Fleischner Society Glossary [11] and peer-reviewed literature on viral pneumonia [12, 13]. The main CT patterns were described using terms including consolidation, GGO, MIX, CP, and fibrosis. GGO was determined as hazy enhanced lung density, with indistinct margins of pulmonary vessels and bronchus. For consolidation, the increased pulmonary parenchymal attenuation was shown with the obscured margins of the bronchus and the pulmonary vessels. The combination of GGO and consolidation was defined as a MIX pattern. CP pattern was shown as a combination of GGO and reticulation or/and interlobular septal thickening. An air bronchogram is a clear air-filled bronchus with low density on a background of consolidation or GGO opacity. Thoracic lymphadenopathy was pointed as the short-axis dimension ≥ 10 mm.

A semi-quantitative scoring system was employed to quantitatively estimate the pulmonary involvement of all these abnormalities based on the area involved. The degree of involvement for every five lobes was classified from none involvement to severe involvement (0 to 5). 0 indicate no involvement; 1, less than 5% involvement; 2, 5-25% involvement; 3, 26%–50% involvement; 4, 51%–75% involvement; and 5, 76%–100% involvement.

Data Analysis

Data were analyzed using the Statistical Package for Social Science (SPSS, v. 22.0, IBM Corporation, Armonk, NY). The quantitative variables were presented in terms of mean ± standard deviation (range). Categorical variables were expressed in terms of frequency and percentage of the total, and the differences between recovered and dead groups were compared by chi-square or Fisher exact test between groups. A two-sided $p < 0.05$ was considered statistically significant.

RESULTS

Clinical Findings

The study population comprised 132 COVID-19 infected patients. 69 patients were excluded from the study due to comorbidities (31), lack of chest CT exam or RT-PCR tests for diagnosis of COVID-19 (28), motion artifact in chest CT images (5), and incomplete data files (5).

Of the remained 63 patients with positive chest CT and RT-PCR tests, 52 (82.54%) patients (31 males and 21 females, mean age, 45.83 years ±17.04) were recovered. The most frequent symptoms on the admission of these patients were fever in 46 (88.46%), dyspnea in 32 (61.53%), weakness in 43 (82.69%), and cough in 34 (65.38%) patients.

Accordingly, 11 (17.46%) COVID-19 infected patients (3 males and 8 females, mean age, 51.91 years ±12.78) died that showed a significantly higher mortality rate among females ($p<0.05$). The most frequent symptoms in this group were fever (11, 100%), cough (7, 63.63%), weakness (9, 81.81%), dyspnea (8, 72.72%), and anosmia (10, 90.90%). Demographics and clinical characteristics of the study population are summarized in Table 1.

Chest CT Findings

In terms of the distribution of chest CT findings, 41 (78.84%) of the recovered patients were more likely

to show the bilateral distribution and 11 (21.15%), unilateral involvement. While, the bilateral distribution was shown in all dead patients (11, 100%).

As shown in Table 2, in recovered patients, 26 (50%) had opacities in three lobes, 10 (19.23%) in four lobes, and 16 (30.76%) in all five lobes. While, in dead patients, just four (7, 63.63%) and five (4, 36.37%) affected lobes were shown. As shown in figure 1, in recovered patients the RUL was involved in 18 (34.61%), the RML in 21 (40.38%), the RLL in 36 (69.23%), the LUL in 26 (50%), and the LLL in 32 (61.53%) patients. In dead patients, the RUL was involved in 6 (54.54%), the RML in 7 (63.63%), the RLL in 10 (90.90%), the LUL in 6 (54.54%), and the LLL in 9 (81.81%) patients.

According to CT patterns of COVID-19 patients of 52 recovered COVID-19 patients, the most frequent involvement patterns of the lung parenchymal findings were MIX (22, 42.30%), GGO (14, 26.92%), consolidation (9, 17.39%), and CP (7, 13.46%). Intubation was performed for 16 (30.77%) patients to be recovered. While the involvement patterns were MIX (100%) in all dead patients and all of them (100%) were intubated (Fig. 2). Results are summarized in Table 3. The degree of a lung severity score for every lobe was significantly higher for dead than recovered COVID-19 patients (3.9 ± 0.9 vs. 2.7 ± 0.7, *p=0.01*). Thoracic lymphadenopathy, pulmonary nodules, and lung cavitation were notably absent in both groups.

Figure 1: The most frequent lung lobs involvement. (A), Axial CT image shows bilateral consolidation in both upper lobes. (B), Axial CT image shows bilateral ground-glass opacity (GGO) and consolidation in both lower lobes. (C), sagittal CT image shows ground-glass opacity (GGO) and consolidation in both upper and lower lobes.

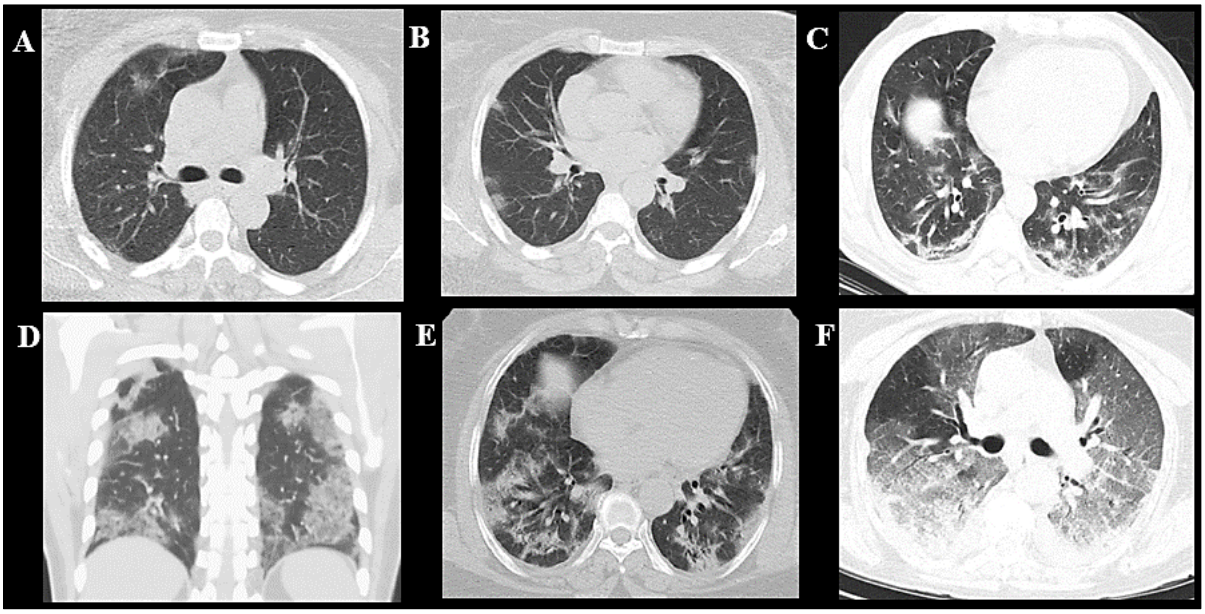

Figure 2: The most frequent involvement patterns of the lung parenchymal findings in chest CT images. (A), Axial image shows unilateral ground-glass opacity (GGO) in the right lobe, (B), Axial image shows bilateral ground-glass opacities (GGO) in both lobes, (C), Axial image shows fibrotic streaks and strip-like opacities mostly in peripheral parts. (D), Coronal image shows bilateral ground-glass opacities (GGO) with consolidation. (E), the axial image shows diffuse bilateral ground-glass opacities and consolidation. (F), Axial CT image shows bilateral ground-glass opacity associated with interlobular septal thickening (crazy paving appearance) patchy consolidations.

Table 1: Characteristics and Symptoms on admission of patients

Parameter	Recovered patients n = 52 (100%)	Dead patients n = 11 (100%)
Male	31 (59.61%)	3 (27.27%)
Female	21 (40.38%)	8 (72.72%)
Age (y)*	45.83±17.04	51.91±12.78
Symptoms on admission		
Fever	46 (88.46%)	11 (100%)
Cough	34 (65.38%)	7 (63.63%)
Weakness	43 (82.69%)	9 (81.81%)
Dyspnea	32 (61.53%)	8 (72.72%)
Anosmia	37(71.15%)	10 (90.90%)
Chills	11 (21.15%)	4 (36.36%)
Diarrhea	10 (19.23%)	1 (9.09%)
Body pain	17 (32.69%)	4 (36.36%)
Headache	7 (13.46%)	4 (36.36%)
Trembling	18 (34.61%)	4 (36.36%)

Note: Data is the number of patients. Percentage within Parentheses is in comparison with all patients in every group.
*Data are means ± standard deviation, with the range within parentheses.

Table 2: Findings on Chest CT Scans

Parameter	Recovered patients 52(100%)	Dead patients 11(100%)
Pattern		
No involvement	0.00 (0%)	0.00 (0%)
Unilateral	11 (21.15%)	0.00 (0%)
Bilateral	41 (78.84%)	11 (100%)
No. of lobes affected		
1	0.00 (0%)	0.00 (0%)
2	0.00 (0%)	0.00 (0%)
3	26 (50%)	0.00 (0%)
4	10 (19.23%)	7 (63.63%)
5	16 (30.77%)	4 (36.37%)
Lobes of involvement		
RUL	18 (34.61%)	6 (54.54%)
RML	21 (40.38%)	7 (63.63%)
RLL	36 (69.23%)	10 (90.90%)
LUL	26(50%)	6 (54.54%)
LLL	32 (61.53%)	9 (81.81%)

RUL, Right Upper Lobe of Lung; RML, Right Middle Lobe of Lung; RLL, Right Lower Lobe of Lung; LUL, Left Upper Lobe of Lung; LLL, Left Lower Lobe of Lung

Table 3: Imaging Characteristics on Chest CT Scans

Parameter	Recovered patients 52(100%)	Dead patients 11(100%)
Radiological finding		
GGO pattern	14 (26.92%)	0.00 (0%)
Consolidation pattern	9 (17.30%)	0.00 (0%)
MIX pattern	22 (42.30%)	11 (100%)
CP pattern	7 (13.46%)	0.00 (0%)
Vacuolar sign	6 (11.53%)	2 (18.18%)
Microvascular dilation	2 (3.84%)	1 (9.09%)
Air bronchogram	2 (3.84%)	1 (9.09%)
Subpleural transparent line	1 (1.92%)	0.00 (0.00%)
Thickening of pleura	7 (13.46%)	2 (18.18%)
Pleural retraction	2 (3.84%)	1 (9.09%)
Pleural effusion	4 (7.69%)	2 (18.18%)
Repairing sign	2 (3.3.84%)	1 (9.09%)
Subpleural line	3 (5.76%)	1 (9.09%)
Bronchus distortion	4 (7.69%)	1 (9.09%)
Fibrotic strips	4 (7.69%)	2 (18.18%)

CT, computed tomography; GGO, ground-glass opacities; MIX, GGO & consolidation predominance; CP, crazy paving.

DISCUSSION

Our study pointed to the analysis of basic clinical information, symptoms, chest CT findings, and clinical outcomes in 63 COVID-19 patients. This study comprehensively showed the major differences in clinical features and chest CT findings between recovered and dead patients of covid-19. These results tried to find out a relationship between chest CT scan features and clinical characteristics of COVID-19 disease since people with a diagnosis of novel coronavirus have a wide range of symptoms from mild to severe. In addition, this study expands the understanding of the relationship between lung involvement patterns and the recovery or mortality rate.

Of the 63 patients who were studied, 17.46% died and the rest (82.54%) were recovered. No significant change was shown on median age of recovered and dead patients (45.83±17.04 and 51.91±12.78, respectively). It should be mentioned that although the mortality rate varies widely in different studies [14-17], the obtained mortality rate in this study is in line with Noordzij *et al*., [18], and Gansevoort *et al*., [19], studies. The same is true for studies that included hospitalized patients, young patients, and patients without comorbidities versus those that included all patients with a COVID-19 diagnosis who were not admitted to a hospital.

According to previous studies [20-22], the vast majority of symptomatic COVID-19 patients commonly present with cough, fever, and shortness of breath and less commonly with anosmia, sore throat, anorexia, dysgeusia, malaise, myalgias, nausea, and diarrhea that is in accordance with the present study in both died and recovered patient who had a cough, dyspnea, fever, chills, headache, weakness, diarrhea, and intubation.

On the CT side, the present study showed that multi-lobular infiltrates were noticed in all the critically ill patients with COVID-19 pneumonia. In recovered patients three, four, and five lobes opacities (50%, 19.23%, and 30.77%, respectively) were shown. While, in dead patients, just four (63.63%) and five (36.37%) affected lobes were observed.

All of the deceased patients manifested the bilateral distribution (11, 100%). While, 78.84% of the recovered patients were more likely to show the bilateral distribution and 21.15%, unilateral involvement. Among the recovered patients in this study, the mean degree of each lobe involvement was 2.7 ± 0.7. While, in deceased patients, 3.9 ± 0.9 mean score was shown, indicating a higher degree of lobe involvement that was similar to Zhang *et al*., [23], study with mean scores of 3.3 ± 0.5 and 2.0 ± 0.7 for deceased and recovered patients, respectively.

Of the 63 patients in this study, 11 (17.46%) patients died, which was similar to the 17% and 15% that were reported by Zhang *et al*., [23], and Cao *et al*., [24], respectively. However, different mortality rates from 1.4% to 49% were reported by several studies [25-28] that could be due to different items for inclusion and exclusion criteria. The low mortality rate recorded by this study could be due; COVID-19 patients with comorbidities were excluded, just hospitalized patients were admitted to this study, young patients were included, and this work was single-center study.

Since the outbreak of COVID-19 pneumonia, several studies are available focused on the description of chest imaging features [23-30]. Typical chest CT findings involve GGO and consolidation, observed in most of the patients. While, other findings such as MIX pattern, CP pattern, interlobular thickening, and Vacuolar sign could be seen in patients with severe symptoms. In this study, our investigation presented the imaging findings regarding the involvement and distribution patterns in recovered and deceased COVID-19 pneumonia patients.

The lung involvement patterns in recovered patients were characterized by MIX involvement (42.30%), GGO pattern (26.92%), consolidation pattern (17.30%), and CP (13.46%), while in dead patients completely was MIX pattern (100%). Several studies indicated the most common CT findings include GGO and consolidative opacities. Development of pleural effusions, as well as progression to a MIX pattern, has been reported in high disease stages [31-33], resulting in the death of some patients. Therefore, chest CT findings could be predictive of patients' outcomes.

Another finding was that no significant difference was found between the mean age of recovered and dead patients. While previous studies mentioned that older age might cause more lung involvement of the virus since old age is associated with irregularities in many aspects of immune function [34-36]. Besides, in this study, the infection rate was different by gender in which the mortality rate was higher among females, while men's mortality rate was higher in some other countries such as the USA, Italy, China, and South Korea. This disagreement with previous studies might be partially justified due to the dissimilarity in implemented methods, inhomogeneity in participated patients as well as biological and cultural-behavioral differences. On the other hand, it should be mentioned that since the present study data were collected in one center and in a short period of time, future multicenter studies with comprehensive data should clarify the effective factors.

Some limitations exist in this study. The sample size was relatively small due to the strict selection

criteria used for these patients. Thus, further investigations with the inclusion of more patients should be done to robust conclusions drawn by this study. Second, the data gathering was done at one clinical center, resulting in sample size reduction. An increase in chest CT findings from different clinical centers can give further information for clinical outcome prediction and management assessment.

CONCLUSION

There is an increasing concern that COVID-19 disease can result in large economic and social costs. So, early detection of disease progression is associated with accessing the proper medical care, decreasing the costs, and lower mortality rate as well. Present study findings have shown that fever and cough are two important clinical symptoms with high prevalence among individuals with infected COVID-19. Chest CT plays an important role in assessing the severity of COVID-19. Additionally, common chest CT patterns knowledge could potentially measure the lung involvement in patients with pneumonia of COVID-19. Therefore, chest CT imaging could be known as an accurate, efficient, and fast method for disease severity grading and recovery prediction. According to CT imaging results, patients with more lung involvement and the MIX pattern had less chance for recovery. Therefore, chest CT findings could be introduced as a predictive modality of patients' outcomes.

ABBREVIATIONS

COVID-19, coronavirus disease 2019; RT-PCR, reverse transcription polymerase chain reaction; WHO, world health organization; SARS-CoV-2, severe acute respiratory syndrome coronavirus 2; CT, computed tomography; GGO, ground-glass opacities; MIX, GGO & consolidation predominance; CP, crazy paving; ARDS, acute respiratory distress syndrome; PACS, picture archiving and communication system; RUL, Right Upper Lobe of Lung; RML, Right Middle Lobe of Lung; RLL, Right Lower Lobe of Lung; LUL, Left Upper Lobe of Lung; LLL, Left Lower Lobe of Lung

Highlights

- The most infection patterns in recovered patients of COVID-19 were ground-glass opacities (GGO), consolidation, GGO & consolidation predominance, (MIX), and crazy paving (CP).
- The lung infection was completely the MIX pattern (100%) in dead patients of COVID-19 and all of them were intubated.
- CT score was significantly higher in dead patients than recovered patients of COVID-19.

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