Original Article

Characteristics and Severity of CT Scan Involvement in COVID Pneumonia and its Value in Predicting the Outcome

Masood Alam[1], Urfa Mudassar[4], Khalid Bin Khursheed[2], Safdar Ali Sabri[2], Sheraz Hassan Bhutta[3] and Muhammad Aneel Razzaq[1]

ABSTRACT

Objective: To evaluate the association of CT scan severity in-terms of severity score and characteristic of different lesions on admission in predicting the outcome of COVID pneumonia.

Study Design: Retrospective cross-sectional observational study

Place and Duration of Study: This study was conducted at the Department of Pulmonology, Recep Tayyip Erdogan Hospital, Muzaffargarh from May 2020 to December 2021.

Materials and Methods: Data of 209 patients was obtained from hospital record after clearance from hospital ethical board. Main variables of study were CT severity score, smoking status, total leukocyte count, lymphocyte count, ICU admission, LDH, CRP, ferritin, clinical stage of disease, mechanical ventilation and final outcome (discharge or death). SPSS version 24 was used for data analysis.

Results: ICU admission was needed in 11.8% mild disease stage, 16.9% in moderate stage and 20.0% in severe stage (P<0.001). Mechanical ventilation was given in 5.8% in mild, 10.8% in moderate and 8.0% in severe stage (P<0.001). In mild stage 58.8% patients discharged at room air, in moderate stage 78.5% and in severe stage 28.0% patients were discharged at room air (P<0.001). Death rate was high 40.0% in stage in which CT scan shows severe disease, in mild and moderate diseased stage death incidence was 17.7% and 4.6% respectively.

Conclusion: Computed tomography (CT) has an important role in diagnosis and assistance of clinicians during treatment of COVID-19 and it is a strong predictor of disease severity and final outcomes. Severity score predicted on CT scan is positively correlated with hospital stay, laboratory investigations and demand of oxygen.

Key Words: COVID-19 pneumonia, Clinical outcomes, Death, Severity of CT scan, Laboratory investigations.

INTRODUCTION

The outbreak of the coronavirus disease 2019 (COVID-19) has spread rapidly throughout Wuhan (Hubei province) to other provinces in China and other more than 75 countries around the world[1,2], representing a significant and urgent threat to the global health. The clinical spectrum ofCOVID-19 pneumonia ranges from mild to critical cases, among which the diagnoses of ordinary, severe, and critical cases were all correlated with chest computed tomography (CT) findings[3,4].

[1.] Department of Pulmonology / Radiology[2] / Medicine[3], Recep Tayyip Erdogan Hospital, Muzaffargarh.

[4.] Department of Pulmonology, Mukhtar A Sheikh Hospital, Multan.

Correspondence: Dr. Masood Alam, Consultant Pulmonologist of Pulmonology, Recep Tayyip Erdogan Hospital, Muzaffargarh.
Contact No: 0333 6253500
Email: dr.masood174@gmail.com

Previously published studies have described the general typical and atypical CT image manifestations[5], the time-course evolution of CT findings,[4] the correlation between CT features and clinical features[6], and evaluated the CT severity of patients with COVID pneumonia [7]. To reduce or eliminate the subjectivity in the qualitative and semi-quantitative visual evaluation of CT severity scores, quantitative approaches for assessing lung opacification percentage of the whole lung have been developed, such as deep-learning method, computer tool, or the calculation method of combing mean attenuation values and opacity volumes [8,9]. However, these quantitative analysis methods did not fully specify information characterising and quantifying different clinical stages with CT features.

High resolution CT scan chest is a common investigation to evaluate the extent of involvement and see the pattern of lesions in case of negative report of RT-PCR[10]. All the treatment strategies depend on clinical severity of COVID pneumonia[11]. So the study is designed to investigate the importance and value of CT scan severity and the characteristic of lesions in predicting the outcome of COVID pneumonia.

MATERIALS AND METHODS

After receiving clearance from our institutional review board, a retrospective cross-sectional observational research was conducted in hospitalized patients diagnosed with COVID-19 pneumonia in Recep Tayyip Erdogan Hospital Muzaffargarh from May 2020 to December 2021. Because there is no active intervention in this trial, informed permission was be required. Patients' privacy and confidentiality was protected in accordance with norms. The research was covering all COVID-19 pneumonia patients at our hospital who are 18 years or older (as defined by our operational criteria). Patients with COVID 19 pneumonia (as defined in operational definition) with non-sever and sever clinical status on day 1, received other medical standard care according to institutional guidelines, whose CT scan was done within three days of admission, both genders and 18 years to 80 years of age were included in the study.

Patients with previously chronic lung disease like COPD, asthma and ILD evaluated on history and medical records, required ICU admission or mechanical ventilation on day1 and patients on long term oxygen therapy were excluded from the study. Using a predetermined case report form, the hospital's Electronic Medical Records was utilized to collect and record important clinical and laboratory data. Demographic variables like age, gender, BMI and previous clinical status with given codes are code 1 is diabetes mellitus, code 2 is hypertension, code 3 is ischemic heart disease, code 4 is chronic obstructive pulmonary disease and code 5 is for other disease was recorded on Performa.

Patients with symptoms with Covid-19 e.g. fever, sore throat, cough, malaise headache, muscle pain, vomiting, diarrhea, loss of taste and smell without chest involvement i.e. dyspnea and abnormal chest findings were labelled as mild pneumonia.

Patients who have dyspnea with/without clinical signs of lower respiratory tract infection (crepitations, bronchial breathing) or have radiographic evidence of pulmonary involvement (ground glass opacities, infiltrates, consolidations) was labelled as moderate pneumonia.

Patients with COVID pneumonia and having oxygen saturation < 94% at room air or respiratory rate of over 25 breaths/min which can be maintained by nasal cannulation or simple face mask and there is no need for non-invasive ventilation, High flow nasal cannula, or mechanical ventilation were labelled as severe COVID pneumonia.

Ct scan severity score was measured by using percentages of anatomical structures of five lobes of lungs: 1:<5% involvement, 2: 5% to 25% involvement, 3: 26% to 49% involvement, 4: 50% to 75% involvement, 5: >75% involvement. Total CT score is the sum individual lobar score that can range 0 to 25 means no involvement to maximum involvement.

On day of presentation clinical severity of each patient was noted. CT scan of these patients was evaluated by consultant radiologist. CT scan severity score calculated visually, no of segments involved and types of radiological pattern. Every patient was followed for the outcome and event of ICU admission, mechanical ventilation and death was recorded. Radiological lesions were assessed on CT scan of COVID pneumonia by radiologist and characteristic of radiological lesions like consolidation, ground glass, infiltrates, reverse halo, crazy paving, effusion or pneumothorax / pneumomediastinum were noted of each patient. Primary outcome of this study is to evaluate the role of CT scan and characteristic radiological pattern in predicting the ICU admission, mechanical ventilation and death.

Data was analysed by SPSS 24, quantitative variables like age BMI, CT scan severity score, length of hospital stay, no of total segments involved and absolute lung volume of affected lung were statistically analysed in mean and standard deviation. Qualitative variables like gender, presence of co morbidity, clinical severity on admission, types of radiological pattern, event of ICU admission , mechanical ventilation and mortality was analyse in percentage and frequency. CT scan severity in-terms of score and absolute volume were compared in non-sever and sever COVID pneumonia. CT scan severity was compared between patients with and without event of ICU admission, mechanical ventilation and mortality. Independents t-test was applied to check the significance. Type of radiological pattern and CT scan severity score and its association with length. Of hospital stay, ICU admission, mechanical ventilation and death was analysed by regression. ROC of CT scan severity score for these events were calculated.

RESULTS

A total of 209 patients were analyzed, CT scan evaluation shows mild severity of disease in 34 (14.2%), moderate in 130 (54.4%) and severe in 75 (31.4%) of patients. Mean age of patients in three groups was 62.76±13.72, 52.83±13.52, 56.05±15.57 in mild, moderate and severe groups respectively (P<0.001). No patients were having age below 30 years, maximum age was observed in age group of 40-50 years and severe diseased patients. Male gender was dominant in all groups as 28 (82.4%) in mild, 69 (53.1%) in moderate and 38 (50.7%) in severe stage (P=0.004). In mild severity group no patients was smoker but in moderate and severe stage 8 (6.2%) and 8 (10.7%) were smoker. Mean TLC count was 16.49±5.18 in mild, 12.45±6.94 in moderate and 9.18±6.23 in severe stage (P<0.001). Lymphocytes count was 2316.98±18.21 in mild, 1409.31±10.1 in moderate and 1129.58±17.61 in severe stage (P<0.001).

Mean LDH at time of admission was 662.14±12.54 in mild disease, 517.11±12.1 in moderate stage and 697.33±6.41 in severe stage (P<0.001). Mean CRP in mild stage was 19.29±26.73, 10.61±12.25 in moderate and 32.98±7.12 in severe diseased stage (P<0.001). Mean serum ferritin was 324.71±42.1 in mild, 872.75±14.19 in moderate and 2854.29±25.11 in severe stage (P<0.00) (Table-1).

Clinically moderate disease was observed in 0% patients in mild disease in CT scan stage 33 (25.4%) and 0% patients in severe disease in CT scan stage, similarly severe clinical disease was observed in 22 (64.7%) mild disease stage, 81 (62.3%) in moderate stage and 38 (50.7%) in severe stage (P<0.001). ICU admission was needed in 4 (11.8%) mild disease stage, 22 (16.9%) in moderate stage and 15 (20.0%) in severe stage (P<0.001). Mechanical ventilation was given in 2 (5.8%) in mild, 14 (10.8%) in moderate and 6 (8.0%) in severe stage (P<0.001). In mild stage 20 (58.8%) patients discharged at room air, in moderate stage 102 (78.5%) and in severe stage 21 (28.0%) patients were discharged at room air (P<0.001). Death rate was high 30 (40.0%) in stage in which CT scan shows severe disease, in mild and moderate diseased stage death incidence was 6 (17.7%) and 6 (4.6%) respectively (Table-2). Correlation of final outcomes with findings of HRCT was shown in Table-III with statistically significant values (P<0.001).

Table No.1: Demographics and Special Investigations

Characteristic	CT scan severity			p-value
	Mild 34 (14.2%)	Moderate 130 (54.4%)	Severe 75 (31.4%)	
Age (years)	62.76±13.72	52.83±13.52	56.05±15.57	<0.001
<30	0 (0.0)	0 (0.0)	0 (0.0)	<0.001
30-40	0 (0.0)	22 (16.9)	8 (10.7)	
40-50	8 (23.5)	36 (27.7)	23 (30.7)	
50-60	6 (17.6)	30 (23.1)	22 (29.3)	
60-70	6 (17.6)	28 (21.5)	16 (21.3)	
70-80	14 (41.2)	6 (4.6)	6 (8.0)	
>80	0 (0.0)	8 (6.2)	0 (0.0)	
Gender				
Male	28 (82.4)	69 (53.1)	38 (50.7)	0.004
Female	6 (17.6)	61 (46.9)	37 (49.3)	
Smoking status	0 (0.0)	8 (6.2)	8 (10.7)	<0.001
TLC on admission	16.49±5.18	12.45±6.94	9.18±6.23	<0.001
Absolute lymphocytes on admission	2316.98±18.21	1409.31±10.1	1129.58±17.61	<0.001
LDH on admission	662.14±12.54	517.11±12.1	697.33±6.41	<0.001
CRP on admission	19.29±26.73	10.61±12.25	32.98±7.12	<0.001
Ferritin on admission	324.71±42.1	872.75±14.19	2854.29±25.11	<0.001

Table No.2: Clinical stages of disease and final outcomes

Characteristic	CT scan severity			p-value
	Mild 34 (14.2%)	Moderate 130 (54.4%)	Severe 75 (31.4%)	
CT scan severity	8.11±1.41	13.79±2.47	19.41±2.44	<0.001
Clinical stage of disease				
Moderate	0 (0.0)	33 (25.4)	0 (0.0)	<0.001
Severe	22 (64.7)	81 (62.3)	38 (50.7)	
Very severe	12 (35.3)	16 (12.3)	37 (49.3)	
ICU admission	4 (11.8)	22 (16.9)	15 (20.0)	<0.001
NIV	3 (8.8)	28 (21.5)	6 (8.0)	<0.001
Mechanical ventilation	2 (5.8)	14 (10.8)	6 (8.0)	<0.001
Final outcome				
Discharge at home	6 (17.7)	16 (12.3)	16 (21.3)	<0.001
Discharge at room air	20 (58.8)	102 (78.5)	21 (28.0)	
LAMA	2 (5.8)	6 (4.6)	8 (10.7)	
Death	6 (17.7)	6 (4.6)	30 (40.0)	

Table No.3: Correlation of final outcomes and findings of HRCT

Characteristic	HRCT chest pattern					p-value
	Consolidation 96 (40.2%)	Crazy paving 32 (13.4%)	Ground Glass 36 (15.1%)	Infiltrate 65 (27.2%)	Other 10 (4.2%)	
ICU admission	8 (8.3)	32 (100.0)	16 (44.4)	13 (20.0)	2 (20.0)	<0.001
NIV	18 (18.8)	6 (18.8)	8 (22.2)	8 (12.3)	2 (20.0)	<0.001
Mechanical ventilation	12 (12.5)	6 (18.8)	6 (16.7)	8 (12.3)	2 (20.0)	<0.001
Final outcome						
Discharge at home	8 (8.3)	0 (0.0)	8 (22.2)	16 (24.6)	8 (80.0)	
Discharge at room air	54 (56.3)	21 (65.6)	28 (77.8)	42 (64.6)	0 (0.0)	<0.001
LAMA	6 (6.3)	8 (25.0)	0 (0.0)	4 (6.2)	0 (0.0)	
Death	28 (29.2)	3 (9.4)	0 (0.0)	3 (4.6)	2 (20.0)	
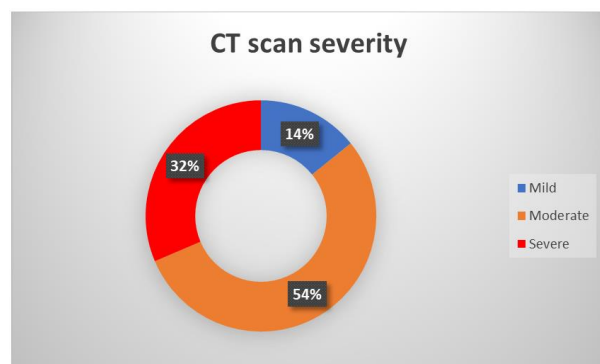
Figure No.1: CT scan Severity

DISCUSSION

World Health Organization recommended use of chest imaging as part diagnosis in COVID-19. Through quantitative assessment on CT chest severity of disease can be predicted[12]. In our study mean age of patients in three groups was 62.76±13.72, 52.83±13.52, 56.05±15.57 in mild, moderate and severe groups respectively (P<0.001), mortality rate was higher in severe stage of disease on CT chest. A study conducted by Francone et al[13] in 2020 was reported mean age of patients 63.2 ± 15.8, age range was 27 to 90 years, it was concluded that CT score above 18 is associated with increased rate of mortality.

In our study males were 82.4% in mild, 53.1% in moderate and 50.7% in severe stage. Dangis et al[14] conducted a study on impact of gender on severity of COVID-19 and reported that male gender is more vulnerable (93.4%) to disease which may be due to protective role of estrogen. Some other factors like stage of pandemic at the time of study, maturity of health facilities, co morbidities, also skill of health care facilitators and spread of disease in study area are also important[15].

In our study ICU admission was needed in 11.8% mild disease stage, 16.9% in moderate stage and 20.0% in severe stage. Death rate was high 40.0% in stage in which CT scan shows severe disease. Another similar study was conducted by Colombi et al[16] reported a positive association between severity of disease on CT chest and ICU admission, hospital stays and mortality. ICU mortality was 16% in Pan et al[17] also reported that CT findings along with clinically correlation are very helpful for physicians to treat early disease and rapid recovery.

In our study 10.7% smokers diagnosed as severe CT score and 6.2% as mild disease; mild disease was not diagnosed in any smoker. Guan et al[18] conducted a study and concluded that presence of co morbidities like smoking, hypertension yielded poor outcomes and prognosis. Increased number of comorbidities results in more poor outcomes. Serum ferritin was also found associated as in severe stage of CT score mean ferritin was 2854.29±25.11. Ferritin is an important marker and mediator of immune regulation its level have strong association with recovery of COVID-19[19].

Saeed et al[6] reported in a study that laboratory investigations significantly correlated with CT chest and demand of oxygen. Lymphopenia was observed 13.7%, 35.6% and 50.8% in mild, moderate and severe CT score stage respectively. These findings are identical with our results as we observed increased lymphocyte count in severe disease stage as compare to mild and moderate (<0.001). Similarly like our study Li et al[20] also reported increased CT score is associated with increased mortality.

CONCLUSION

Computed tomography (CT) have an important role in diagnosis and assistance of clinicians during treatment of COVID-19 and it is a strong predictor of disease severity and final outcomes. Severity score predicted on CT scan is positively correlated with hospital stay, laboratory investigations and demand of oxygen.

Author's Contribution:

Concept & Design of Study:	Masood Alam
Drafting:	Urfa Mudassar, Khalid bin Khursheed
Data Analysis:	Safdar Ali Sabri, Sheraz Hassan Bhutta,

	Muhammad Aneel Razzaq
Revisiting Critically:	Masood Alam, Urfa Mudassar
Final Approval of version:	Masood Alam

Conflict of Interest: The study has no conflict of interest to declare by any author.

REFERENCES

1. Deng SQ, Peng HJ. Characteristics of and public health responses to the coronavirus disease 2019 outbreak in China. J Clin Med 2020;9(2):575.
2. Lyu P, Liu X, Zhang R, Shi L, Gao J. The performance of chest CT in evaluating the clinical severity of COVID-19 pneumonia: identifying critical cases based on CT characteristics. Investigative Radiol 2020;55(7):412-21.
3. Ojha V, Mani A, Pandey NN, Sharma S, Kumar S. CT in coronavirus disease 2019 (COVID-19): a systematic review of chest CT findings in 4410 adult patients. Eur Radiol 2020;30(11):6129-38.
4. Pan F, Ye T, Sun P, Gui S, Liang B, Li L, et al. Time course of lung changes on chest CT during recovery from 2019 novel coronavirus (COVID-19) pneumonia. Radiol 2020 Feb 13.
5. Zhao W, Zhong Z, Xie X, Yu Q, Liu J. Relation between chest CT findings and clinical conditions of coronavirus disease (COVID-19) pneumonia: a multicenter study. AJR Am J Roentgenol 2020; 214(5):1072-7.
6. Saeed GA, Gaba W, Shah A, Al Helali AA, Raidullah E, Al Ali AB, et al. Correlation between chest CT severity scores and the clinical parameters of adult patients with COVID-19 pneumonia. Radiol Res Practice 2021;1.
7. Nair AV, Kumar D, Yadav SK, Nepal P, Jacob B, Al-Heidous M. Utility of visual coronary arterycalcification on non-cardiac gated thoracic CT in predicting clinical severity and outcome in COVID-19. Clinical Imaging 2021;74:123-30.
8. Kohli A, Jha T, Pazhayattil AB. The value of AI based CT severity scoring system in triage of patients with Covid-19 pneumonia as regards oxygen requirement and place of admission. Ind J Radiol Imaging 2021;31(S 01):S61-9.
9. Yang R, Li X, Liu H, Zhen Y, Zhang X, Xiong Q et al. Chest CT severity score: an imaging tool for assessing severe COVID-19. Radiology: Cardiothoracic Imaging 2020;2(2):23-34..
10. Palwa AR, Slehria AU, Nayyar B, Aquil H, Riaz S, Nisar U, et al. Chest CT Severity Score as an Auxiliary Grading Tool to COVID-19 Pneumonia Imaging Classification: A Tertiary Care Experience in Pakistan. Age 2021;11(86):0-01.
11. Halmaciu I, Arbănași EM, Kaller R, Mureșan AV, Arbănași EM, Bacalbasa N et al. Chest CT Severity Score and Systemic Inflammatory Biomarkers as Predictors of the Need for Invasive Mechanical Ventilation and of COVID-19 Patients' Mortality. Diagnostics 2022;12(9):2089.
12. Lyu P, Liu X, Zhang R, Shi L, Gao J. The performance of chest CT in evaluating the clinical severity of COVID-19 pneumonia: identifying critical cases based on CT characteristics. Investigative Radiol 2020;55(7):412-21.
13. Francone M, Iafrate F, Masci GM, Coco S, Cilia F, Manganaro L et al. Chest CT score in COVID-19 patients: correlation with disease severity and short-term prognosis. Eur Radiol 2020; 30(12):6808-6817.
14. Dangis A, De Brucker N, Heremans A, Gillis M, Frans J, Demeyere A, et al. Impact of gender on extent of lung injury in COVID-19. Clin Radiol 2020;75(7):554-556.
15. Mallapaty S. The coronavirus is most deadly if you are older and male - new data reveal the risks. Nature 2020;585(7823):16-17.
16. Colombi D, Bodini FC, Petrini M, Maffi G, Morelli N, Milanese G, et al. Well-aerated Lung on Admitting Chest CT to Predict Adverse Outcome in COVID-19 Pneumonia. Radiol 2020;296(2): E86-E96.
17. Pan F, Ye T, Sun P. Time course of lung changes on chest CT during recovery from 2019 novel coronavirus (COVID-19) pneumonia. Radiol 2020; 295(3):12-25.
18. Guan WJ, Liang WH, Zhao Y, Liang HR, Chen ZS, Li YM, et al. China Medical Treatment Expert Group for COVID-19. Comorbidity and its impact on 1590 patients with COVID-19 in China: a nationwide analysis. Eur Respir J 2020;55(5): 2000547.
19. Kaushal K, Kaur H, Sarma P, Bhattacharyya A, Sharma DJ, Prajapat M, et al. Serum ferritin as a predictive biomarker in COVID-19. A systematic review, meta-analysis and meta-regression analysis. J Crit Care 2022;67:172-181.
20. Li Y, Yang Z, Ai T, Wu S, Xia L. Association of "initial CT" findings with mortality in older patients with coronavirus disease 2019 (COVID-19). Eur Radiol 2020;30(11):6186-6193.