High Resolution Computed Tomography (HRCT) Imaging Features and Disease Severity in Patients with Clinically Severe COVID-19 Pneumonia Having Diabetes Mellitus and Hypertension Using Chest CT Severity Score (CHEST CT-SS)

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ABSTRACT

Objective: To determine the association of diabetes and hypertension with the severity of disease by evaluation through High-Resolution Computed Tomography, keeping a Chest CT severity score of 19.5 or greater as a reference for severe disease.

Study Design: Cross-sectional study.

Place and Duration of Study: Department of Diagnostic Radiology Combined Military Hospital, Okara, Pakistan from Apr 2020 to Mar 2021.

Methodology: A total of 60 patients, both male and female, aged 50 years and above, having SARS -C0V-2 infection confirmed through polymerase chain reaction presenting with the severe disease diabetes, hypertension or both as comorbid were selected. Patients' clinical information was taken from medical records from our data collection centre after informed consent from attendants.

Results: Forty-five (75%) out of 60 patients presenting clinically with severe COVID–19 *pneumonia* having diabetes mellitus, hypertension, or both as co-morbids had Chest CT severity score of 19.5 or greater. 15(25%) patients had Chest CT severity scores of less than 19.5. All the patients had bilateral multi-lobe involvement. 54(90%) patients demonstrated typical imaging features, and 14(23.3%) demonstrated atypical ones.

Conclusions: Patients aged 50 years and above having diabetes, hypertension or both as comorbid presenting clinically with severe disease developed severe critical COVID-19 pneumonia with Chest CT – severity score of 19.5 or greater having typical imaging features on High-resolution computed tomography.

Keywords: Bronchiectasis, COVID-19, Chest CT severity score, Ground glass opacities, High-resolution computed tomography, Pleural effusions, Severe critical COVID-19 pneumonia.

INTRODUCTION

Severe disease of SARS-COV-2 infection is described as a patient having a respiratory rate equal to or greater than 30 breaths per minute, blood oxygenation saturation SpO2 levels equal to or less than 93%, PaO2/FiO2 ratio of less than 300 mm of Hg along with lung opacities >50 % within the initial 24 to 48 hours.[1,2] Typical HRCT imaging findings of COVID-19 *pneumonia* include peripheral/posterior ground glass opacities (GGOs) with multi-lobe involvement, sub-segmental pulmonary vessel enlargement, crazy paving, consolidations, halo sign, reverse halo sign interstitial septal thickening and consolidations with air bronchograms in more severe lobar involvement.[3,4] Less common imaging findings include bronchiectasis, cavitation, pleural/pericardial effusions and lymphadenopathy.[5] Previous study reported that out of 173 patients with confirmed severe COVID-19 pneumonia, 23.7% had hypertension, and 16.2% had diabetes mellitus due to increased ACE 2 expression, causing increased severity of COVID-19, thus leading to increased mortality.[6] Several studies have shown a significant impact of diabetes mellitus on mortality, morbidity and disease severity in COVID–19 *pneumonia*, with a large number of patients infected dying having diabetes mellitus as an underlying comorbid.[7-9]

There has not been any significant study that could establish the direct association of COVID-19 *pneumonia* disease severity with diabetes mellitus and hypertension in our population, till now. The main aim of this study is to evaluate patients with severe disease in our population, considering the impact of comorbidities on the severity of COVID-19 *pneumonia*. The study also aims to establish the Chest CT severity

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score as an effective tool for categorising severe infection and predicting disease outcomes in our population with clinically severe COVID-19 *pneumonia*.

METHODOLOGY

The cross-sectional study was conducted at the Department of Diagnostic Radiology, Combined Military Hospital, Okara Pakistan, from April 2020 to March 2021 with the approval of the Institutional Review Board/Ethics Committee (certificate no IERB/OBS/2021/08).

Sample size was calculated using a WHO sample size calculator with 21% reported prevalence.[10]

Inclusion Criteria: Patients aged 50 years and above, with diabetes, hypertension or both as comorbid, cases with SARS-COV-2 infection with confirmation through PCR (polymerase chain reaction), presenting with clinically severe disease having respiratory rate of equal to or greater than 30 breaths per minute, blood oxygenation saturation SpO2 levels of equal to or less than 93%, PaO2/FiO2 ratio less than 300 mm of Hg along with lung opacities >50% within the initial 24-48 hours, were included.

Exclusion Criteria: Patients with negative PCR (polymerase chain reaction) test, patients with previous history of respiratory disease and pulmonary tuberculosis, patients having mild *pneumonia* with mild symptoms without shortness of breath, respiratory rate of less than 30 breaths per minute, blood oxygenation saturation SpO2 levels of greater than 93 %, PaO2/FiO2 ratio greater than or equal to 300 mm of Hg, were excluded.

Diagnostic criteria were based on CDC guidelines.[11] Patients' clinical information regarding comorbidities was taken from medical records from our data collection centre after obtaining informed consent from the attendants.

The sampling strategy was non-probability consecutive sampling. HRCT chest was done in a supine position on a Hitachi Eclos 16-slice CT scan machine. Chest CT severity score of 19.5 or greater was taken as a reference for severe disease with CT-SS less than 19.5 eliminating severe critical COVID-19 *pneumonia.*

Data was recorded on Excel sheets, and Statistical Package for Social Sciences (SPSS) version 24.0 was used for the data analysis. Quantitative variables were expressed as Mean±SD and qualitative variables were expressed as frequency and percentages. Chi-square test was applied to explore the inferential statistics. The *p*-value of ≤0.05 was considered statistically significant

RESULTS

A total of 60 patients with ages 50 years and above were included in the study. Male patients were 36(60%) and female patients were 24(40%). 34(56.6%) patients had both diabetes mellitus and hypertension, 17(28.3%) patients had only diabetes mellitus and 9(15%) only had hypertension. All patients presented clinically with severe COVID-19 *pneumonia* confirmed through positive PCR (polymerase chain reaction) laboratory investigation. The distribution of Co-morbids in patients presenting with clinically severe COVID-19 pneumonia is shown in Figure-1.
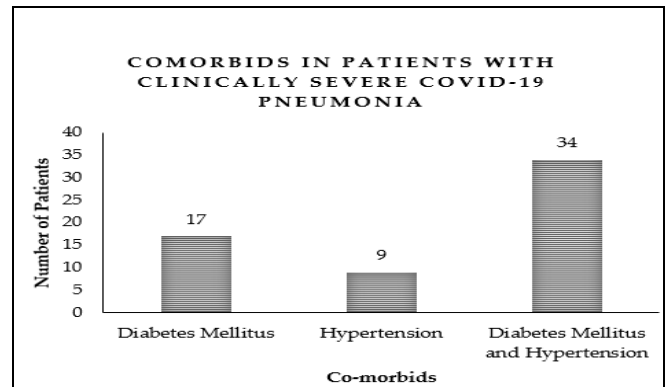

Figure-1: Co-morbids in Patients with Clinically Severe COVID-19 Pneumonia (n=60)

Chest CT severity score (CT-SS) of all 60 patients with a threshold value of 19.5 or greater is shown in Figure-2.
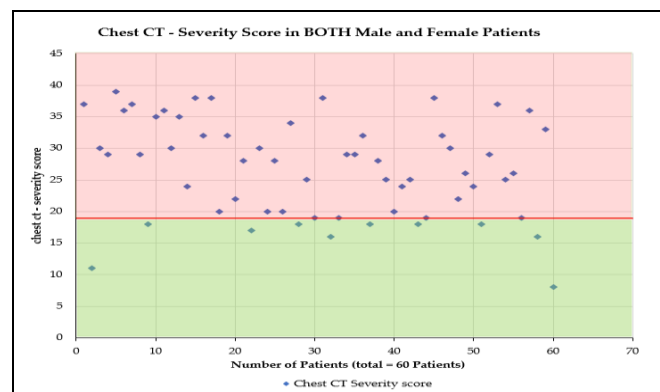

Figure–2: Chest CT - Severity Score in Patients Aged 50 and above with Diabetes Mellitus and Hypertension as Co-Morbids (n=60)

Gender distribution, along with the percentage of Chest CT severity score (CT-SS) of 60 patients, is shown in Table-I.

Table-I: Chest CT Severity Score (CT-SS) of Male and Female Patients (n=60)

Chest CT severity score CT-SS	Number of cases n (%)	Male Patients n (%)	Female Patients n (%)	p-value
19.5 or greater	45(75)	28(62.2)	17(37.7)	<0.001
Less than 19.5	15(25)	8(53.3)	7(46.6)	

All the patients had bilateral multi-lobe lung involvement. 54(90%) patients had central and peripheral distribution. Out of said 54 patients, 29 (53.7%) patients had ground glass opacities (GGOs) along with demonstrable septal thickening, 18(33.3%) patients had ground glass opacities (GGOs) along with demonstrable septal thickening and consolidations with internal air bronchograms and 7 (12.9%) patients only had consolidations with internal air bronchograms. 6(10%) patients had only peripheral distribution. Out of said six patients, 5(83.3%) patients had ground glass opacities (GGOs) along with interstitial septal thickening and 1(16.6%) patient had peripheral consolidations with HALO sign. Associated atypical imaging features were seen in 14(23.3%) patients. Unilateral/Bilateral pleural effusions were seen in 11(18.3%) patients; out of these, 7(63.6%) were male, and 4(36.3%) were female patients (Table-II).

Table-II: High resolution CT (HRCT) imaging findings in Patients Presenting with Clinically Severe COVID-19 Pneumonia (n=60)

High resolution CT (HRCT) imaging findings	Number of cases n(%)
Ground glass opacities (GGOs)	
Ground glass opacities (GGOs) and consolidations with air bronchograms	34(56.6)
Consolidations with air bronchograms	18(30)
Consolidation with HALO sign	7(11.6)
Consolidation with cavitation	1(1.6)
Unilateral/bilateral pleural effusions	1(1.6)
Bronchiectasis	11(18.3)
Vascular engorgement	1(1.6)
	1(1.6)
Right and left distribution	
Equivalent in both lungs	60(100)
Right lung predominant	-
Left lung predominant	-
Transverse distribution	
Central and peripheral	54(90)
Peripheral	6(10)
Central	-
Lung region distribution	
Bilateral multilobe involvement	60 (100%)
Unilateral involvement	-

DISCUSSION

Diabetes mellitus and hypertension are linked by risk factors like obesity, hyperlipidemia, atherosclerosis and endothelial dysfunction. Overexpression of the renin-angiotensin and aldosterone system, reactive oxygen free radicals, increased inflammation and triggering of the immune system may point to a close association between diabetes mellitus and hypertension.[11] Thus, endothelial damage may be associated with severe COVID-19 pneumonia, which would possibly explain significantly high mortality and increased disease severity in patients having diabetes mellitus and hypertension with active SARS-COV -2 Infection.[12]

Nandy et al. showed that the presence of hypertension and diabetes mellitus had a significant association with severe disease in patients with COVID-19, with diabetes mellitus having a significant impact on death in COVID-19 patients with a p-value of 0.004. [13] Guo et al. showed that patients with diabetes mellitus had significantly elevated inflammatory markers, p=<0.001, compared to patients without diabetes mellitus, suggesting that patients with diabetes mellitus as underlying co-morbids are more susceptible to developing severe critical COVID–19 pneumonia.[14]

In our study, it was also seen that patients having diabetes mellitus, hypertension or both as co-morbids developed severe critical COVID–19 pneumonia, with 45(75%) patients having chest CT-SS of 19.5 or greater requiring hospital ICU admission. Chest CT severity score CT-SS less than 19.5 was seen in 15(25%) patients. There was a statistically significant difference between the expected and observed frequencies of patients developing severe COVID- 19 pneumonia having diabetes mellitus, hypertension or both as co-morbids with a p-value of <0.001.

All the patients had bilateral multi-lobe lung involvement. 34(56.6%) patients developed ground glass opacities (GGOs), 18(30%) patients developed ground glass opacities (GGOs) and consolidations and 8(13.3%) patients only developed consolidations. Associated atypical imaging features were seen in 14(23.3%) patients.

Patients with diabetes have a greater probability of developing severe infection compared to non-diabetic patients owing to easy virus entry, diminished or ineffective clearance of the virus and impaired immune response.[15,16] Routine use of angiotensin receptor blockers (ARBs) or ACE inhibitors (ACE-I) for

chronic conditions leads to upregulation of ACE2 expression, leading to ease of access of SARS-COV-2 into pneumocytes subsequently causing severe critical COVID–19 *pneumonia*. It has been observed that transient hyperglycemia or increased blood glucose levels alone may also negatively affect the host's immune response to fight off the infection.[17] The novel coronavirus causing COVID-19 is likely similar to SARS-COV, both using ACE2 receptors to bind and enter host pneumocytes.[18] Owing to its rapid spread and ease of transmission, the main focus is to limit the spread of disease by prompt and early diagnosis of COVID–19.[19,20]

In our study, we utilised High-Resolution CT and HRCT to see imaging findings, assess disease severity, categorise patients with severe infection, and predict disease outcomes. This study has shown a strong association between diabetes mellitus hypertension and severe COVID-19 *pneumonia* in our population. It has highlighted the importance of identifying high-risk patients and helping physicians take a more proactive approach to managing patients with co-morbidities, thus greatly influencing patient outcomes in severe COVID-19 infection.

LIMITATIONS OF STUDY

The sample size was relatively small, and this is a single-centre study. Varied medical treatment regimens may have impacted patient outcomes.

CONCLUSION

In our study, patients aged 50 and above having diabetes, hypertension or both as comorbid presenting clinically with severe disease developed severe critical COVID-19 pneumonia as was seen the world over with Chest CT severity score CT-SS of 19.5 or greater having bilateral multilobed involvement of lungs on High resolution computed tomography HRCT, making it an effective investigation for diagnosis and categorisation of patients into mild and severe disease, thus leading the way for an effective treatment plan for not only management of disease but of comorbid to improve patient outcome.

Conflict of Interest: None.

Authors Contribution

Following authors have made substantial contributions to the manuscript as under:

AH & UK: Data acquisition, data analysis, data interpretation, critical review, approval of the final version to be published.

MAK & SA: Study design, data interpretation, drafting the manuscript, critical review, approval of the final version to be published.

Authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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