

## Radiological Evaluation of Imaging of CT-Thorax Among Comorbid And Vaccinated Covid Positive Patients

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### Abstract

**Introduction:** The current pandemic of corona virus disease 2019 (COVID-19) caused by the new virus Severe Acute Respiratory Syndrome Corona Virus 2 (SARS-CoV-2), started in Wuhan, China and spread rampantly throughout the globe, causing serious health threats to humans. Second wave in India was seen peaking in early month of May 2021. CT Thorax is extensively used by doctors in COVID-positive patients. The objective of the present study is to compare the pattern and severity of lung involvement in COVID-positive patients based on comorbidities and vaccination status. **Methodology:** Present study is a cross-sectional study of 805 COVID-positive patients who were referred to Dept of Radiodiagnosis, Basaweshwara Hospital attached to MRMC, Gulbarga, for CT thorax to look for lung involvement of COVID, for period of two months from March to April 2021. Imaging findings and data collected were spread on excel sheet and analysed, and results were represented in tables, graphs and charts. **Results:** Among 805 patients, 37.80% of patients belonged to 41-59 years age group, with male to female ratio of 1.7:1. Of the total, 23.70% were comorbid patients, among which 52.80% patients were above 60 years age group. HTN was the predominant comorbidity seen in 17.30% cases, followed by DM in 11.80%. Comorbid patients were prone to have a severe lung involvement and higher CT Severity Score. Among 805 patients, 13.40% were vaccinated, and patients with complete vaccination had a tendency of milder lung involvement and lesser CT Severity Score. **Conclusion:** CT Thorax is an important investigation to look for the severity of lung involvement. COVID-positive patients with comorbidities have a higher lung involvement as assessed by CT severity score as compared to that of non comorbid patients. COVID positive patients with complete vaccination have a reduced lung involvement as compared to non-vaccinated and patients vaccinated with a single dose of vaccine.

**Keywords:** COVID, CT thorax, Comorbid patients, Vaccination status.

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### Introduction

The current pandemic of corona virus disease 2019 (COVID-19) caused by the new virus Severe Acute Respiratory Syndrome Corona Virus 2 (SARS-CoV-2), started in Wuhan, China and spread rampantly throughout the globe, causing serious health threats to humans.

India has seen a two-wave pattern of COVID-19 cases with current ongoing third wave starting in early month of January 2022. Second wave was seen peaking in early month of May 2021. As of May 31<sup>st</sup> 2021 India reported 914,539 confirmed cases with 20,787 deaths[1]. India is currently taking preventive measures and immunising the general population by vaccination in order to curb the COVID-19 pandemic in India.

The characteristic imaging features of COVID pneumonia on CT Thorax not only aids in being a accessory tool for its diagnosis, though not recommended, but also helps in accessing the percentage of lung involvement and assessing the complications, and assist physicians in their treatment protocol with aggressive management in clinically stable patient with severe lung involvement. Hence radiological evaluation of various patients including patients with comorbidities and patients who are vaccinated, becomes important for physicians in better treatment of patients.

CT Thorax is extensively used by doctors all over the world to look for severity of lung involvement in COVID+ patients, has a pooled sensitivity of 94.6% (95% CI: 91.9%, 96.4%) and a pooled specificity

of 46.0% (95% CI: 31.9%, 60.7%) in the detection of COVID-19[2]. The typical features of COVID pneumonia includes peripheral, subpleural, bilateral, ground-glass opacities with or without consolidation or visible inter and intralobular septal thickening forming “crazy-paving” pattern. Isolated lobar or segmental consolidation without ground-glass opacities, discrete small centrilobular nodules, tree-in-bud opacities, lung cavitation, smooth interlobular septal thickening with pleural effusion are a few atypical features of COVID pneumonia[3].

The objective of the present study is to compare the pattern and severity of lung involvement in COVID+ patients based on comorbidities and vaccination status. This will further improve the management protocol in physicians by adopting a better approach to treatment in comorbid and non-vaccinated patients.

### Material and methods

#### Source of data

The data for the study was collected from outpatients and inpatients referred for CT-Thorax to Department of Radiodiagnosis, Basaweshwara Teaching and General Hospital attached to Mahadevappa Rampure Medical College, Kalaburagi-585105

#### Method of collection

#### Study design

Cross-sectional Study

#### Study Setting

Department of Radiodiagnosis, Basaweshwara Teaching and General Hospital attached to Mahadevappa Rampure Medical College, Kalaburagi-585105

#### Sample size

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Sample size was calculated considering 35% previous proportion for 'reverse halo sign' finding in previous study titled "CT chest analysis of 2019 novel corona virus pneumonia: An Indian perspective" at 99% confidence intervals.

Design effect - 1

Sample - 604 + 10% frequency errors = 664

A total of 805 COVID positive patients who underwent CT-Thorax in our study setting for a period of 2 months from March 1<sup>st</sup> to April 30<sup>th</sup> 2021 during the second wave of COVID in India, were included in the study.

**Sampling procedure**

Study subjects will be selected after applying inclusion-exclusion criteria. Information is collected through prepared proforma from each patient. All patients diagnosed with COVID positive state will be included in the study. Informed written consent will be taken from all the patients.

CT-Thorax of the patients will be done in Philips 16 slice CT machine as per standard imaging protocol.

**Duration of Study**

3 months i.e, from March 1<sup>st</sup> to May 30<sup>th</sup> 2021.

March 1<sup>st</sup> to April 30<sup>th</sup> 2021 for sample collection.

May 1<sup>st</sup> to May 30<sup>th</sup> 2021 for analysis.

**Inclusion Criteria**

1. All laboratory proven (RT-PCR) COVID positive patients above the age of 18years irrespective of gender, undergoing CT-Thorax study
2. Patients willing to give consent to be a part of the study.

**Exclusion criteria**

1. All pregnant and lactating women.
2. Patients not willing to be a part of the study.

**Informed consent**

Written and informed consent will be taken from the patient or the attenders in their own vernacular language.

**Methodology**

Study subjects were selected after applying inclusion-exclusion criteria. Information was collected through prepared proforma from each patient. All COVID positive patients above the age of 18years, irrespective of gender were included in the study. Informed written consent was taken from all the patients.

CT Study of Thorax was done in Philips 16-slice CT machine. It is obtained in supine position at full inspiration using a 16 detector channel. The CT tube voltage and current were 120kVp, and a standard-dose or low-dose setting with automatic exposure control used according to institutional protocol. Contiguous helical axial sections of thickness 5mm of thorax was obtained, which was reconstructed with a slice thickness of 1.25mm in lung window and 2mm for mediastinal window. All images were viewed in a range of lung and mediastinal soft tissue window settings.

Radiological characteristics of the lesions were analyzed and described along with appropriate clinico-pathological findings.

**Statistical Analysis**

The statistical data, imaging findings collected were spread on excel sheet, and analysed by using IBM SPSS software version 20.0 and Open AP software. Percentage and proportion was used for qualitative data. Results were represented using graphs and tables.

**Observations and results**

A Cross-Sectional Observational study was done on 805 patients referred to CT-Thorax to Department of Radiodiagnosis, Basaweshwara Teaching and General Hospital attached to Mahadevappa Rampure Medical College, Kalaburagi, for a period of 2 months from March to April 2021. The imaging features of all COVID+ patients with and without comorbidities, with and without vaccination were analysed and compared.

**1. Age and gender wise distribution**

All patients above the age of 18 yrs were included in the study. Total of 805 patients were divided into 3 groups of 18-40yrs, 41-59yrs, and above 60yrs. Age of the patients ranged from 18 to 91 years, with a mean of 50.3 years. 37.80% of patients predominantly belonged to the age group of 41-59 years, among which 508 were males and remaining 297 were females, with a male to female ratio of 1.7:1

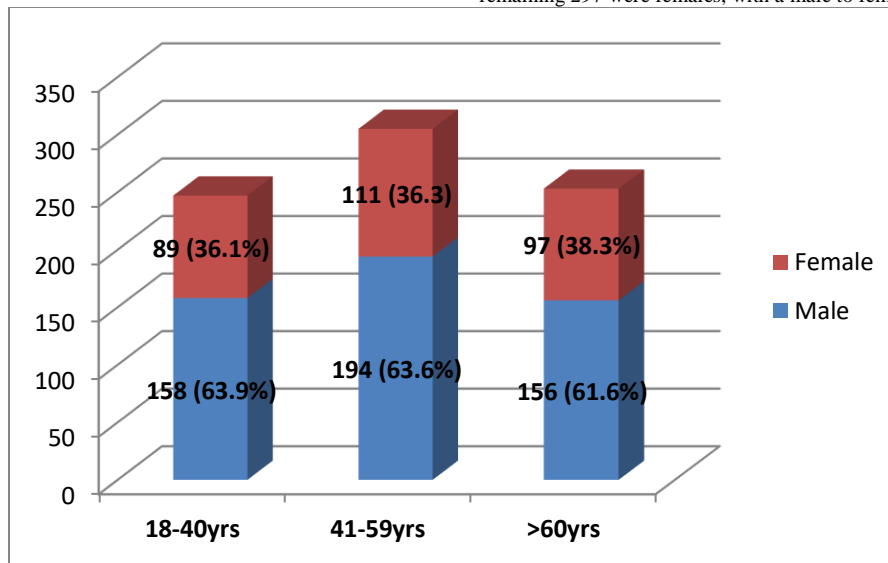


Figure 1: showing age and gender wise distribution among age groups

**2. Symptom wise distribution**

92.20% (743 of total 805 cases) were symptomatic, and rest 7.70% were asymptomatic with contact history with positive patients. Presenting symptoms were fever, cough, sore throat, breathlessness, myalgia, loss of taste and headache.

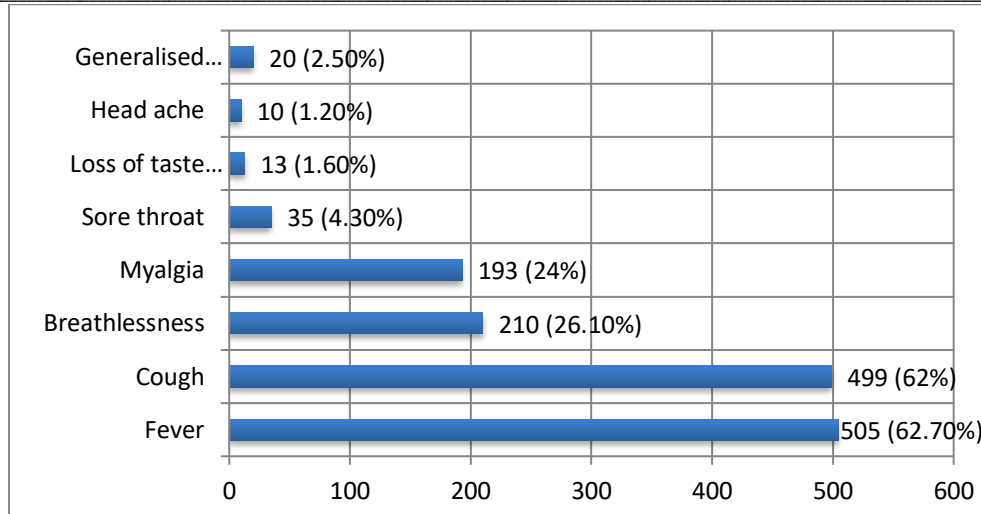


Figure 2: Column chart showing symptom distribution among study group

Most of the patients had overlapping symptoms. Fever with or without cough was the predominant presenting complaint seen in approximately 62.70% (505 patients of total 805 patients) of cases, with symptoms ranging over a week. Breathlessness and Myalgia were seen in 26.10% and 24% of the cases respectively. Small proportion of patients i.e., 4.30% had sore throat seen in 35 cases. Headache and loss of taste were seen in 1.20% and 1.60% of the cases respectively.

**3. Comorbidity status**

Of total 805 patients, 191 of them (23.70%) had comorbidities. Hypertension (HTN), Diabetes Mellitus (DM), Ischemic Heart Disease(IHD), Tuberculosis (TB) were among the predominant comorbidities among all.

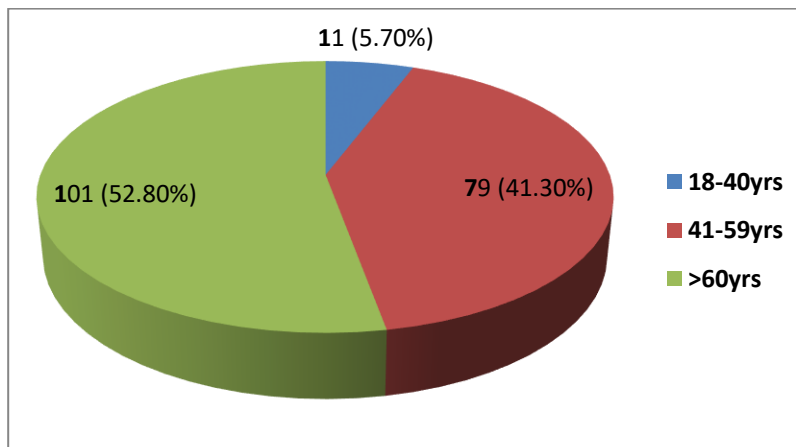


Figure 3: Pie chart showing distribution of comorbid patients among all age groups

Most of the comorbid patients belonged above 40 years, with 51.80% above 60 years of age and 41.30% in 41-59 year age group. Only 5.70% (11 cases) belonged to 18-40 years age group.

HTN was the predominant comorbidity seen in 139 patients (17.30%) followed by DM seen in 95 patients (11.80%), with a few patients having combined HTN and DM. 2.60% (21 cases) had previous history of IHD, and 2 cases had active TB. Other comorbidities were seen in 32 cases (3.90%) which were hypothyroidism, asthma, known

primary CA on treatment, Rheumatic Heart Disease (RHD) and seizure disorder on treatment.

**4. Vaccination status**

Among 805 patients, vaccination with either 1 or 2 doses were taken by 108 patients comprising of 13.40% of the total cases. 79 patients (9.80%) had taken 1 dose of vaccine and 29 patients (3.60%) had completed their vaccination with 2 doses.

Table 1: showing vaccination status among patients

	Number	Percentage
Not Vaccinated	697	86.50%
Vaccinated: 1 dose	79	9.80%
Vaccinated: 2 dose	29	3.60%
	805	100

**5. CT Thorax features among study group**

CT Thorax features of COVID patients were Ground glass opacities with or without septal thickening and consolidation, Nonspecific nodular opacities, Pleural and Pericardial effusion, Lymphadenopathy, Cardiomegaly, Tree-in bud opacities, Vascular dilatation, Pneumothorax and Pneumomediastinum. Coexistent features suggestive of old TB were also present in patients with old history of tuberculosis.

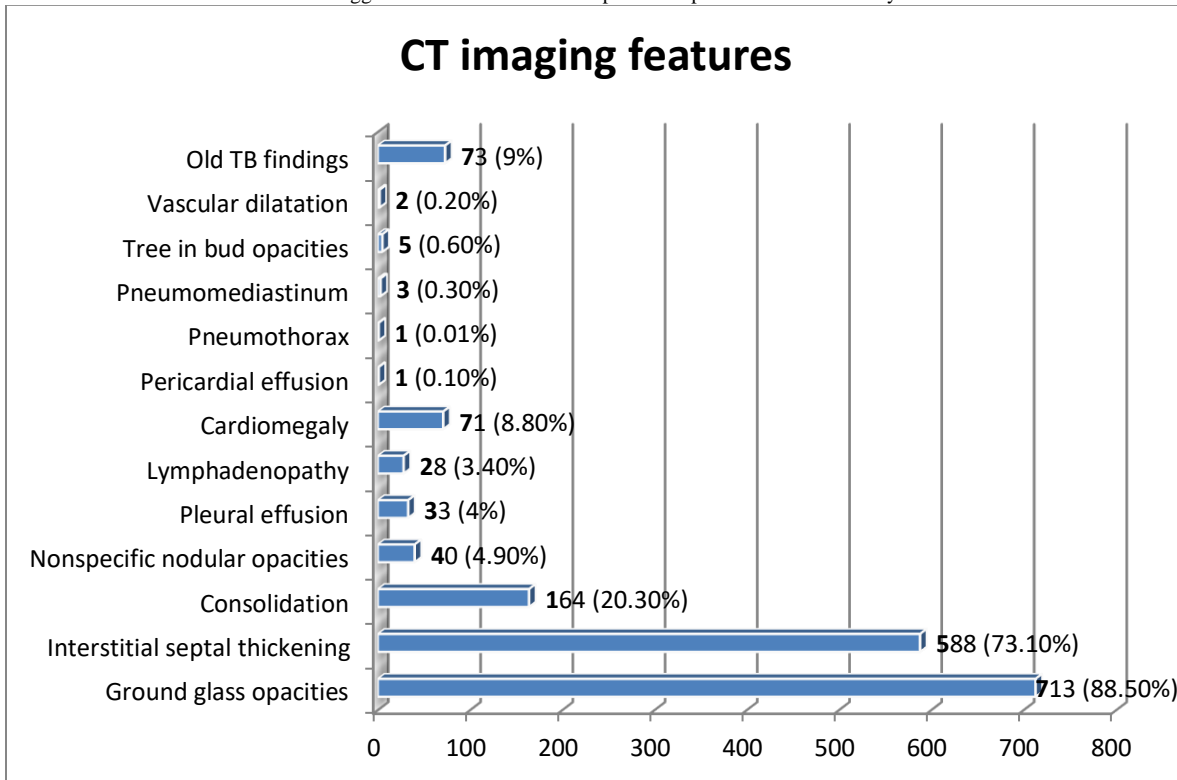


Figure 4: showing various imaging findings in COVID+ patients

Predominant feature of COVID was ground glass opacities seen in 88.50% of the total cases (713 out of total 805 patients), with consolidation in severe cases seen in 20.30% cases (164 patients). Next most common finding was Cardiomegaly seen in 8.80% cases (71 patients), followed by non specific nodular opacities in 4.90% cases (40 patients). Pleural effusion was seen in 4% cases (33 patients), and Lymphadenopathy in 3.40% cases (28 patients). Pneumomediastinum and Vascular dilatation was seen in 3 (0.3%)

and 2 patients (0.2%) respectively. Pneumothorax and Pericardial effusion were seen in 1 patient (0.1%) each.

92 patients (11.40% cases) had normal CT thorax study. 73 patients (9% cases) had co-existing CT features of old tuberculosis.

**6. GGO distribution in bilateral lungs**

Ground glass opacities (GGO) are the predominant finding of lung involvement in CT thorax in COVID infection.

Table 2: showing distribution of GGOs in bilateral lungs

Ground glass opacities	Frequency	Percentage
Right Upper Lobe (RUL)	542	76.00%
Right Middle Lobe (RML)	493	69.10%
Right Lower lobe (RLL)	626	87.70%
Left Upper Lobe (LUL)	549	76.90%
Left Lower Lobe (LLL)	600	84.10%

GGOs predominantly occupied both lower lobes (right > left), with 87.7% (626 out of 713 cases) involvement of Right Lower Lobe and 84.10% (600 out of 713 cases) involvement of Left Lower Lobe. Right upper lobe was involved in 76% (542 out of 713 patients) cases and Left Upper Lobe was involved in 76.90% cases (549 out of 713 patients). Least involvement was seen in Right Middle Lobe with 69.10% involvement (493 out of 713 cases).

**7. Characteristics of GGOs involvement in bilateral lungs**

GGOs involvement was predominantly multifocal, patchy in peripheral distribution in bilateral lung fields. Diffuse, central involvement of GGOs in bilateral lung fields was seen in severe cases.

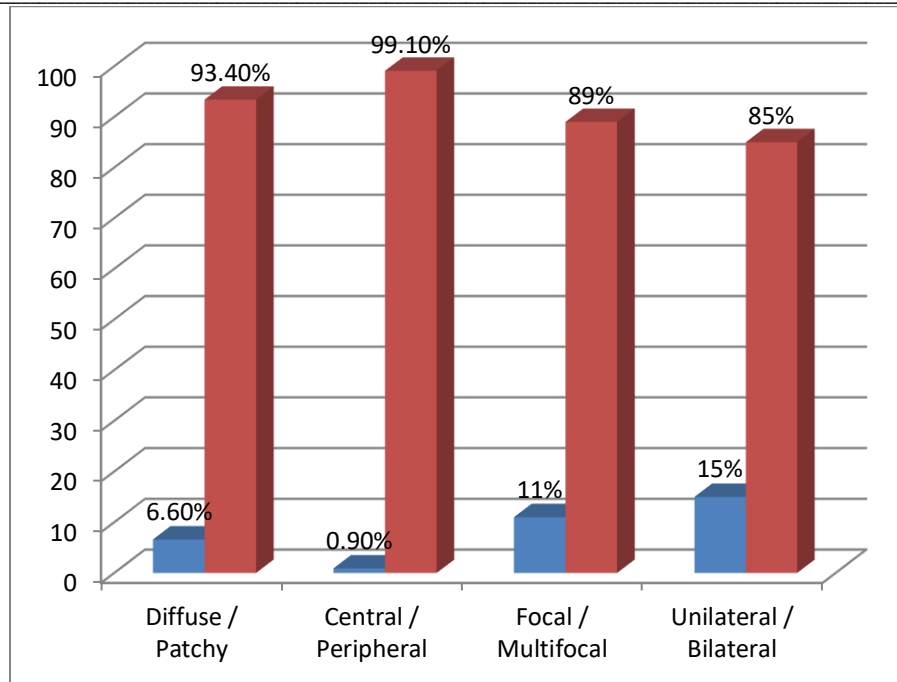


Figure 5: showing characteristics of GGO involvement in bilateral lung fields

**8. Severity of lung involvement in study group**

Lung involvement in COVID was based on CT severity score[4,5]. Score of <8 was classified as mild, 9-14 as moderate and >15-25 classified as severe lung involvement.

Table 3: showing severity of lung involvement in study subjects

CT Severity Score	Frequency	Percentage
Normal	93	11.50%
Mild (<8)	366	45.40%
Moderate (9-14)	203	25.20%
Severe (>15-25)	143	17.70%
<b>Total</b>	<b>805</b>	<b>100%</b>

45.40% of the patients had mild lung involvement, followed by 25.20% of patients having moderate lung involvement.

**9. Lung involvement among non-comorbid and comorbid patients**

Study group was divided into 2 groups, one without any comorbidities and another with one or more comorbidities. HTN, DM, IHD, Hypothyroidism are among the other comorbidities considered. CT severity score was compared among those two groups.

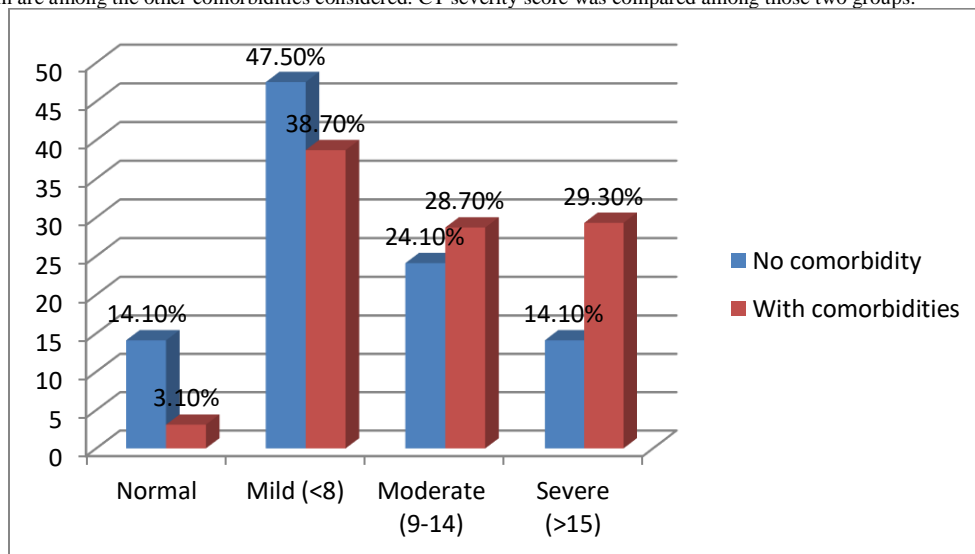


Figure 6: Column chart showing CTSS in patients with and without comorbidities.

Among the patients with comorbidities, severe lung involvement was seen in 29.30% patients compared to only 14.10% in patients with no comorbidities. Similarly moderate lung involvement was seen in 28.70% patients with comorbidities, compared to only 24.10% in patients with no comorbidities. Therefore severe and moderate lung involvement were significantly more in patients with comorbidities. Mean of CTSS in patients with comorbidities is 9.88 (moderate CTSS), and in patients with no comorbidities is 7.09 (mild CTSS). Hence mean of CTSS in patients with comorbidities is higher than in patients with no comorbidities, suggesting increased lung involvement.

The correlation between comorbidities and CTSS is statistically significant [p value = 0.00 (<0.01)] and the Pearson correlation coefficient,  $r = +0.19$  suggests a positive correlation. In presence of comorbidities, the patient is prone to have a severe lung involvement and higher CTSS.

**10. Lung involvement among non-vaccinated and vaccinated patients**

Among 805 patients, 29 patients had been vaccinated with 1 dose of COVID vaccine and 79 patients had received 2 doses of vaccine. CT severity score was compared among those two groups.

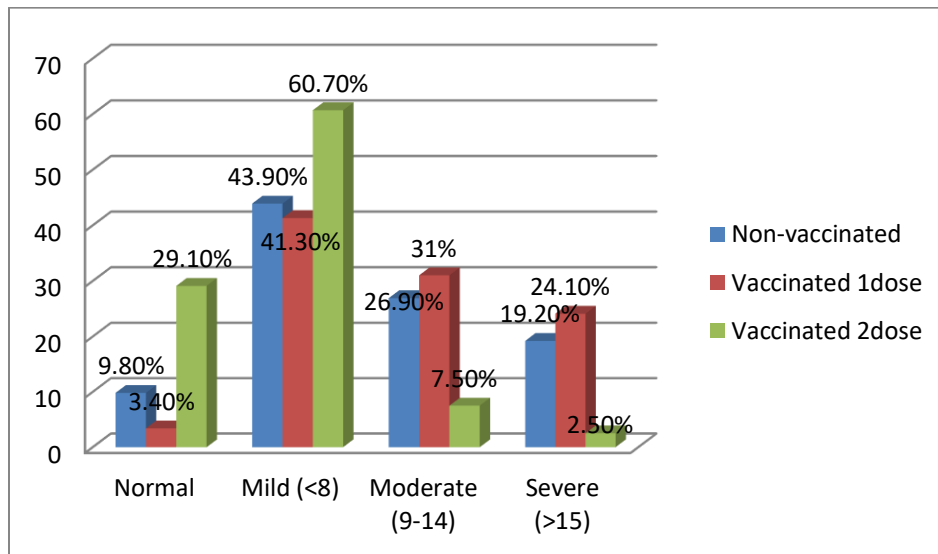


Figure 7: Column chart showing CTSS in patients with and without vaccination

Moderate lung involvement was seen in 7.50% and severe lung involvement in 2.50% of patients who were vaccinated with 2doses of COVID vaccine, which was significantly lower to patients who had not received any vaccine dose (26.90% moderate and 19.20% severe CTSS). Mean of CTSS in patients with completed vaccination is 3.20 (mild CTSS), and in patients with no vaccination is 8.21 (mild CTSS). Hence mean of CTSS in patients with completed vaccination

is lower than in patients with no vaccination, suggesting decreased lung involvement.

The correlation between vaccination status and CTSS is statistically significant [p value = 0.00 (<0.01)] and the Pearson correlation coefficient,  $r = -0.220$  suggests a negative correlation. Patient with completed vaccination status, have a tendency of mild lung involvement and lesser CTSS.

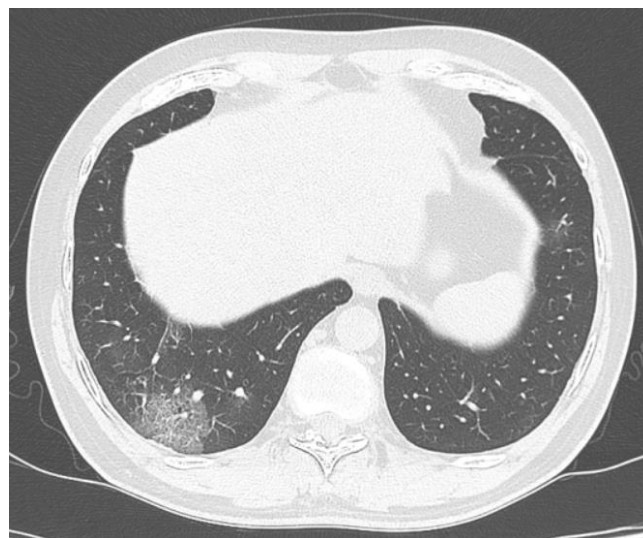
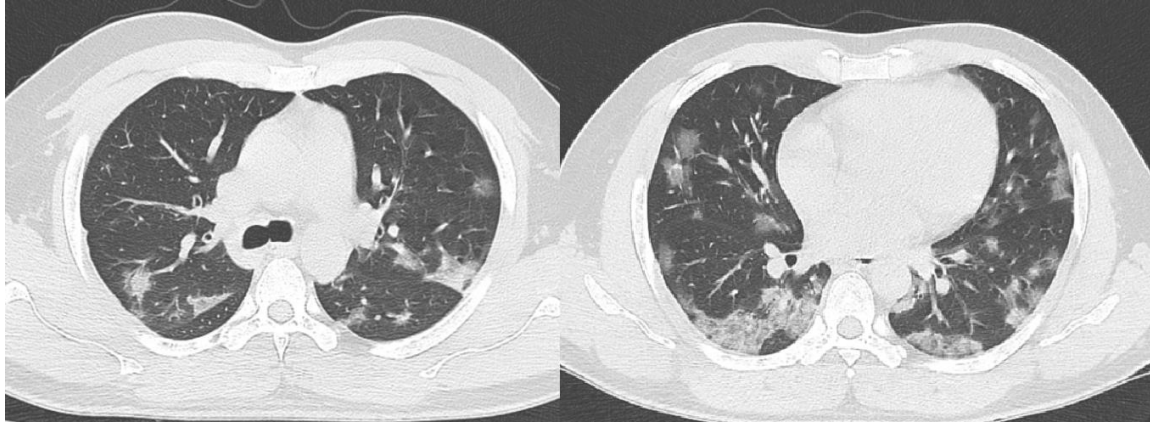
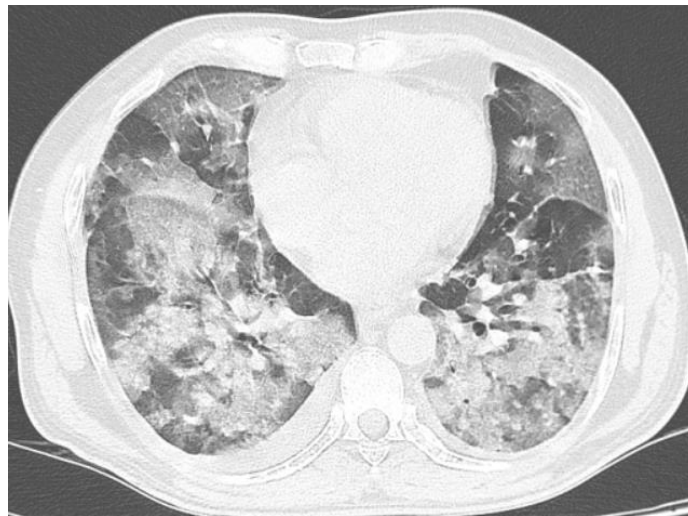


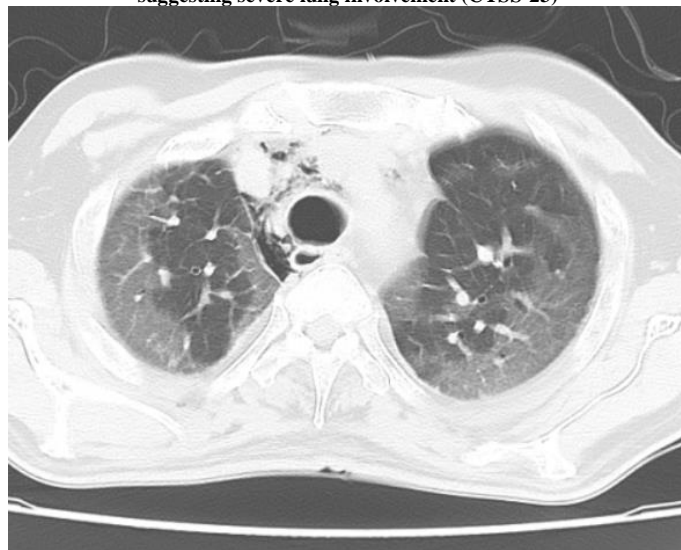
Figure 8: In a completely vaccinated, 56yr old COVID positive pt, axial sections of CT thorax at the level of lower lobes, shows a patch of ground glass opacities with inter and intralobular thickening involving subpleural location of posterobasal segment of right lower lobe. CTSS was 2 (mild).



**Figure 9:** In a non vaccinated, non comorbid, 45 year old, COVID+ patient, axial CT thorax sections at the level of carina (left) and at the level of ventricles (right) reveals typical findings of COVID: Bilateral, multifocal, patchy ground glass opacities in predominant subpleural distribution involving all segments of bilateral lungs. CTSS was 10 (moderate lung involvement of 40-45%)



**Figure 10:** In a 73 year, non vaccinated COVID+ patient with hypertension and diabetes, axial sections of CT thorax reveals: Diffuse multifocal ground glass opacities with inter and intralobular interstitial thickening and consolidation involving bilateral lung fields, suggesting severe lung involvement (CTSS-23)



**Figure 11:** In a diabetic COVID+ patient with severe lung involvement (CTSS-19), axial CT thorax at level of arch reveals subpleural ground glass opacities in bilateral upper lobes along with pneumomediastinum.

## Discussion

In our study of 805 patients with an objective to compare the pattern and severity of lung involvement in COVID+ patients based on comorbidities and vaccination status, had a mean of 50.3 years predominantly in 41-59 years age group, and a male to female ratio of 1.7:1. Patients primarily presented with fever (62.7%), followed by cough (62%), myalgia (24%), breathlessness (26.10%) and lastly loss of taste (1.60%) and headache (1.20%), with patients having overlapping symptoms.

23.70% (n=191) of patients, mainly belonging to >60 years age group (52.80%, n=101), had various comorbidities, among which HTN (17.30%, n=139) followed by DM (11.80%, n=95) were more common. 13.40% (n=108) of patients were vaccinated with 1 dose of vaccination in 9.80% (n=79) patients and 2 doses of vaccination by 3.60% (n=29) patients.

Prime imaging features of CT thorax in COVID+ patients includes multifocal peripheral patchy bilateral ground glass opacities (88.50%, n=713) with inter and intralobular interstitial thickening (73.10%, n=588), Consolidation (22.30%, n=164), Cardiomegaly (8.80%, n=71), Small nonspecific nodular opacities (4.90%, n=40), Pleural effusion (4%, n=33). Small proportion of cases had tree-in-bud opacities (0.60%, n=5), Pneumomediastinum (0.30%, n=3), Vascular dilatation (0.20%, n=2), Pericardial effusion (0.10%, n=1), and Pneumothorax (0.10%, n=1). Various papers on radiological evaluation of COVID-19 show typical presentation of ground glass opacities with or without septal thickening and consolidation in a peripheral, subpleural distribution with lower zone predominance<sup>(6-11, 14)</sup>. These findings are corresponding to results of our study. CT severity score was used to assess the severity of lung involvement in COVID positive patients. 25 scoring system was used with score of <8 classified as mild, 9-14 as moderate and >15-25 classified as severe lung involvement.<sup>(12, 13)</sup> In our study group, 11.50% had normal lung study, 45.40% had mild involvement, 25.20% had moderate lung involvement and 17.70% had severe lung involvement.

Among comorbid patients, severity of lung involvement was higher than in noncomorbid patients, with a mean of 9.88 (moderate CTSS) as compared to mean of 7.09 (mild CTSS) in non comorbid patients. The correlation between comorbidities and CTSS is statistically significant [p value = 0.00 (<0.01)] and the Pearson correlation coefficient, r = +0.19 suggests a positive correlation.

Among vaccinated patients, severity of lung involvement was lower than in non vaccinated patients, with a mean of 3.20 (mild CTSS) as compared to mean of 8.21 (mild CTSS) in non vaccinated patients. This is comparable to a study done by Sonali Modi on vaccinated and non vaccinated patients of COVID-19 pneumonia, which concluded that non vaccinated patients have higher CT severity scores and low survival rate compared to vaccinated patients<sup>[16]</sup>. Another comparative study of Ct severity score among vaccinated and non vaccinated subjects of COVID, also concluded that CT severity scores in individuals receiving both doses of SARS-CoV-2 vaccination were less severe in comparison to those receiving a single dose of vaccine or no vaccine at all<sup>[17]</sup>.

## Conclusion

CT Thorax is an important investigation to look for the severity of lung involvement in COVID infection. COVID positive patients with comorbidities have a higher lung involvement as assessed by CT severity score as compared to that of non comorbid patients. COVID positive patients with complete vaccination have a reduced lung involvement as compared to non vaccinated and patients vaccinated with a single dose of vaccine.

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