Original Articles

A Retrospective Correlation study between HRCT Thorax finding and Severity of Disease in Covid-19 positive Patients at time of admission to Hospital.

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Keywords : Novel coronavirus disease 2019 (COVID-19); HRCT (High Resolution Computed Tomography); RT-PCR; ground-glass opacity.

ABSTRACT

Background : India had reported the 1st case of novel corona virus (COVID-19) on 30 January 2020.Since then there is constantly and rapidly increasing number of cases. So clinical and radiological findings are needed to be studied and explored so that the physicians, radiologist and researchers could gain proper information and guidelines to save more lives. **Objective:** To analyze COVID-19 patients for determining the correlation between HRCT (High Resolution Computed tomography) thorax finding and severity of disease on admission. **Materials and Methods:** To provide extensive information pertaining clinical and radiological characteristics of COVID-19, a retrospective study was conducted including 100 consecutive hospitalized patients at GMERS Medical College and General Hospital Himmatnagar. The study was done by ENT department; under guidance and support of Medicine and Radiology department. The patients were confirmed cases of disease positive by RT-PCR test. Patients' demographics, comorbidities, clinical findings, chest CT results were recorded. The CT findings were correlated with clinical data. **Results:** According to the data, old age (45-65 years) people with most common comorbidity like hypertension were most affected. Fever was the commonest symptom seen among the patients.3,32,51,14 patients were categorized into mild, moderate, severe and critical groups according to clinical severity respectively. 4, 37, 54 and 5 patients were radiologically categorized correspondingly to grade 0, grade 1, grade 2 and grade 3. Ground glass opacity was the main pulmonary manifestation with bilateral distribution. The statistical result was kappa =0.632 and $P<0.05$. So it was statistical significant and there was a positive correlation between Ct findings and clinical severity of disease. **Conclusions:** Deformities on HRCT Thorax can occur in an early stage of COVID-19 patients, even when RT-PCR results are negative, which can be used in early recognition & evaluation with prompt management of disease.

INTRODUCTION

The rapid outbreak of corona virus disease had started since November 2019 (COVID-19), which arose from severe acute respiratory syndrome corona virus 2 (SARS-CoV-2) infection. The disease has become a public health emergency of international level.[1] COVID-19 has contributed to an enormous adverse effect world widely. COVID-19 infection can lead to a range of clinical outcomes, from asymptomatic to severe life-threatening course or even death. That's why we should characterize epidemiological and clinical comorbid features including recovery and mortality of COVID-19 which are crucial for development and implementation of effective control and management strategies. A current predictive estimate for the incubation period of disease is usually from 3 to 7 days; up to 14 days. [2] As per literature median age of patients is 47–59 years with around 41.9–45.7% of patients are females.[3] The old age people with comorbidities are more susceptible to become seriously ill after infection.[4] Children and infants are also prone for infection. On admission, maximum patients are reported as having at least one or more comorbidities like diabetes, hypertension, and cardiovascular and cerebrovascular diseases, renal failure.[5,6] The most common presenting clinical symptoms are fever and cough with addition to other non-specific symptoms including breathlessness, headache, muscle soreness, fatigue and tachycardia. [9]

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About 20% of cases are severe, and mortality is approximately 3% [10]. The World Health Organization (WHO) had declared a global health emergency situation on January 30, 2020 [11].

Thoracic radiology is often a gateway to the evaluation of patients suspected for COVID-19 infection. Early recognition of disease is valuable to ensure proper management and rapid patient isolation for containment of this communicable disease.

A Reverse Transcriptase Polymerase chain reaction gives confirmed diagnosis of COVID-19 infection. It requires identification of viral nucleic acid [13]. The CT Thorax imaging results show bilateral pulmonary parenchymal ground-glass and consolidative pulmonary opacities in peripheral lung distribution. There are no lung cavitation, discrete pulmonary nodules, pleural effusions, and lymphadenopathy seen. [13]

In this study, we compared the severity of disease, radiologist interpretation and clinical variables in Covid-19 patients.

MATERIALS & METHOD

Study Design: The present retrospective study analysis was done on 100 randomly selected patients admitted in GMERS Medical college and general hospital, Himmatnagar, Gujarat, from 1st August to 31st October 2020.The patients with clinical symptoms including fever ,chills ,fatigue ,myalgia, cough ,sputum production, sore throat, chest pain, shortness of breath, headache, anorexia, nausea, and vomiting, diarrhea and loss of consciousness with or without associated comorbidities were presented to our hospital. The patients were divided into 3 groups according to years; Group 1(25-45 years), Group 2 (46-65 years),Group 3(66-85 years). All Patients were assessed for temperature, pulse, blood pressure, respiratory rate, capillary oxygen saturation (spo2) are measured. Patient with breathlessness, hypoxemia (spo2<93%), rapid respiratory rate (> 30 per minute), fever (temperature >37.8 degree Celsius) with risk factors (cardiovascular disease, hypertension, diabetes mellitus, renal dysfunction, immunocompromised patient {HIV positive, malignancy, corticosteroid therapy, chemo-radio therapy, organ transplantation} etc.) any of above symptoms or disease were tested for RT-PCR and HRCT Thorax.

According to National institute of health (NIH) latest guidelines; Adults with SARS-CoV-2 infection can be grouped into the following severity of illness categories. (However, the criteria for each category may overlap or vary across clinical guidelines and clinical trials, and a patient's clinical status may change over time.)

Severity of illness categories:

- Asymptomatic or Presymptomatic Infection: Individuals who test positive for SARS-CoV-2 using a virologic test [i.e., a nucleic acid amplification test (RT-PCR) or an antigen test], but who have no symptoms that are consistent with COVID-19.
- Mild Illness: Individuals who show any signs and symptoms (e.g., fever, cough, sore throat, malaise, headache, muscle pain, nausea, vomiting, diarrhea, loss of taste and smell) but who do not have shortness of breath or abnormal chest imaging.
- Moderate Illness: Individuals who are suggestive of lower respiratory infection during clinical assessment or imaging and who have saturation of oxygen (SpO2) ≥94% on room air.
- Severe Illness: Individuals who have SpO2 <94% on room air at sea level, a ratio of arterial partial pressure of oxygen to fraction of inspired oxygen (PaO2/FiO2) <300 mmHg, respiratory frequency >30 breaths per minute, or lung infiltrates >50%.
- Critical Illness: Individuals who have respiratory failure, septic shock, and/or multiple organ dysfunctions.

Patients having underlying comorbidities are at a greater risk of development of severe disease.

The patients underwent multislice high resolution CT scan of the thorax. It was performed using volume acquisition from the apices to the lung bases; using thin cuts on a 16 slice MDCT, without IV administration of contrast. The results were classified as CO-RADS, as given below.

[CO-RADS, the COVID-19 Reporting and Data System]

Below there is overview of CO-RADS Categories and the Corresponding Level of Suspicion for Pulmonary Involvement in COVID-19 given in description.

CO-RADS Category	Level of Suspicion for Pulmonary Involvement
0	Not interpretable Scan technically insufficient for assigning a score
1	Very low Normal or noninfectious
2	Low Typical for other infection but not COVID-19
3	Equivocal/unsure Features compatible with COVID-19 but also other diseases
4	High Suspicious for COVID-19
5	Very high Typical for COVID-19
6	Proven RT-PCR positive for SARS-CoV-2

CO-RADS Category ^{0}

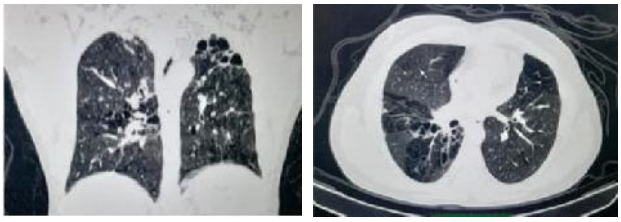
It is taken if none of the categories can be assigned due to scans are incomplete or of insufficient quality e.g. severe artifacts due to coughing or breathing or uncooperative patients' movement.

CO-RADS Category ^{1}

It suggest a very low level of suspicious for lung involvement by COVID-19 depend on either normal CT results or CT findings of noninfectious origin diseases like congestive cardiac failure, sarcoidosis, histoplasmosis. This category is defined as "negative for pneumonia" category of the RSNA consensus statement [13].

CO-RADS Category ^{2}

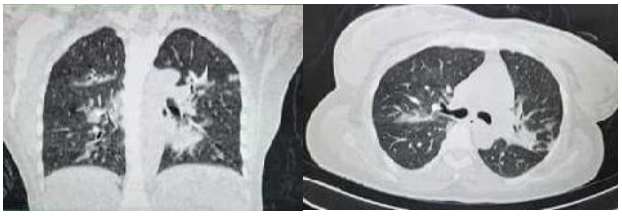
It suggests level of suspicion of COVID-19 infection is low based on CT findings in the lungs typical of infectious origin like bronchitis, infectious bronchiolitis, bronchopneumonia, lobar pneumonia, and pulmonary abscess. [11]



Above picture shows mosaic pattern of attenuation in right upper, middle & lower lobes and left lower lobe. Traction and cystic bronchiectatic changes noted in left upper and right lower lobe.

CO-RADS Category 3

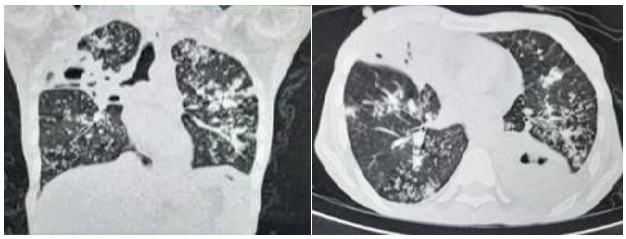
It implies equivocal findings for lung involvement of COVID-19 patients based on CT features which are similar to viral pneumonias or noninfectious causes. Findings include perihilar ground-glass opacity, homogenous extensive ground-glass opacity with or without sparing of some secondary pulmonary lobules, or ground-glass opacity together with smooth interlobular septal thickening with or without pleural effusion in the absence of other typical CT findings(11).



Above picture shows multiple patches of ground glass opacities with interlobular septal thickening in bilateral perihilar region & also consolidation also seen.

CO-RADS Category 4

The suspicion level is very high for pulmonary involvement by COVID-19 based on CT findings that are typical suggesting for COVID-19. Findings include U/L ground glass opacity, multifocal consolidation without any other typical findings. They are similar to findings of CO-RADS category 5; however, they are not in contact with the visceral pleura.(11)

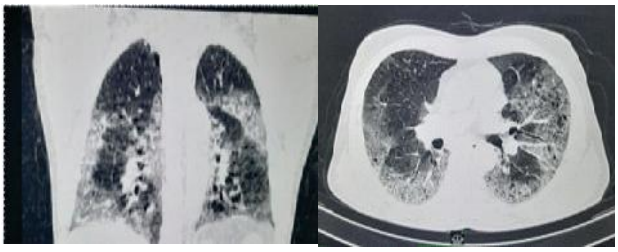


Above picture shows few patchy areas of ground glass opacities and fibro-cavitary lesions with multiple thick wall cavities.

CO-RADS Category 5

It advocates a very high level of suspicion for lung involvement by COVID-19 based on typical CT findings

include bilateral distribution of multifocal ground-glass opacities with or without consolidations in lung regions close to visceral pleural surfaces, including the fissures, the minor or major fissure is also typical. The crazy paving pattern might appear later in the course of the disease, it shows visible intra-lobular lines. It is largely identical to the typical appearance of the RSNA consensus statement (11).



Above picture shows Diffuse patches of ground glass opacities with interlobular and intralobular septal thickening with crazy paving pattern.

CO-RADS category 6

It indicates proven case of COVID-19 with positive RT-PCR tests, similar to BI-RADS category 6. (11)

Above picture shows multiple areas of ground glass opacities with interspread septal thickening giving crazy paving pattern bilaterally.

The HRCT thorax was done in all patients after doing RT-PCR. The CT thorax images were evaluated for the different following characteristics as mentioned above in CORAD categories: (1) ground-glass opacity (GGO); (2) consolidation; (3) crazy-paving pattern; (4) cavitation; (5) nodular pattern (6) lymphadode status; (7) pleural effusion. The number of lung lobs involvement and the lesion distribution in different areas were also noted. Ground glass opacity was defined as hazy area with increased lung attenuation with preservation of bronchial and vascular margins, and consolidation was defined as opacification of area with obscuration of margins of vessels and airway walls. Crazy paving pattern was defined as the appearance of GGO area with overlapping interlobular and intralobular septal thickening. (12)

Statistical analysis:

The clinical features and incidence of chest CT findings were described as frequency rates and percentages. Correlation between severity of pulmonary involvement on chest CT and clinical classification was assessed using kappa test. Statistical analysis was performed using QuickCals from GraphPad, a versatile statistics tool.

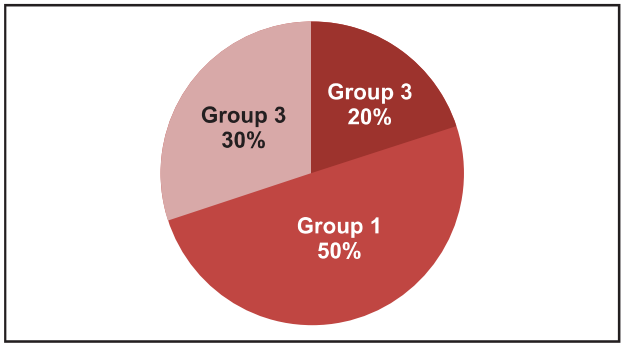
Results:

Starting from 1st August to 31st October 2020, serial data from 100 patients was collected from which 98 patients were RT-PCR positive for Covid-19 and 2 patients were negative RT-PCR but suspected for Covid-19 clinically. The group 2 which involve age from 46 to 65 years had highest number of distribution i.e.50 patients (50%). Males (58%) were predominant over Females (42%). Hypertension [54 patients (54%)] was the most common comorbidity seen in several aged patients. Other comorbidities were diabetes in 35 patients (35%), ischemic Heart disease in 8 patients (8%), malignancy in 4 patients (4%), cerebrovascular disease (Stroke) in 2 patients (2%), Tuberculosis in 3 patients (3%),COPD in 8 patients (8%), chronic kidney disease in 2 patients (2%) ,chronic liver disease in 4 patients (4%),hypothyroid disease in 5 patients (5%), asthama in 3 patients (3%) .Fever was the most common symptom seen in 87 patients (87%) followed by dry cough in 70 patients (70%). Other symptoms were seen as following dyspnea in 55(55%), fatigue in 45(45%), headache in 30(30%), muscle pain in 25(25%), throat pain in 25(25%), abdominal pain in 21(21%), diarrhea in 21(21%), nausea in 20(20%), dizziness in 12(12%) and vomiting seen in 12(12%) patients. The oxygen saturation was above 94% seen in 35 patients (35%) and below 94% seen in 65 patients (65%). The days from starting of symptoms to visit to hospital ranges from 2 to 10 days (median 6 days). According to NIH latest guidelines we summarized above data and categorized patients into 4 different types as following mild, moderate, severe and critical as 3 patients, 32 patients, 51 patients, 14 patients.

Table 1: Demographic and baseline characteristics of COVID-19 patients (n = 100).

Age, years	Group 1(25-45) =20(20%)
	Group 2 (46-65) =50 (50%)
	Group 3 (66-85) =30 (30%)
Sex	Male=58 (58%)
	Female=42 (42%)
Comorbidities:	
Hypertension	54 (54%)
Diabetes	35 (35%)
Ischemic Heart disease	8 (8%)
Malignancy	4 (4%)
Cerebrovascular disease (Stroke)	2 (2%)
Tuberculosis	3 (3%)
COPD	8 (8%)
Chronic kidney disease	2 (2%)
Chronic liver disease	4 (4%)
Hypothyroid disease	5 (5%)
Asthma	3 (3%)
Signs and symptoms:	
Fever	87 (87%)
Dry cough	70 (70%)
Dyspnea	55 (55%)
Fatigue	45 (45%)
Headache	30 (30%)
Muscle pain	25 (25%)
Throat pain	25 (25%)
Abdominal pain	21 (21%)
Diarrhea	21 (21%)
Nausea	20 (20%)
Dizziness	12 (12%)
Vomiting	12 (12%)
Days from onset of symptoms to first	2 to 10 days
Visit to hospital	Median 6 days
Time duration between HRCT Thorax and admission to hospital	24 to 48 hours
Vitals:	**Median**
Heart rate	100 (60 to 140) bpm
Respiratory rate	21 (12 to 30) per min
Mean arterial pressure	95 (60 to 130) mmHg
Saturation of oxygen(SPO2) :	
> 94%	35 (35%)
< 94%	65 (65%)
Clinical severity:Mild	3 (3%)
Moderate	32 (32%)
Severe	51 (51%)
Critical	14 (14%)

Age Distribution of COVID-19 Positive Patients.



Group 2 which include 46 to 65 years had highest predominance for Covid-19.

Each of the lung lobes was assessed by using a particular scoring system: 0= no involvement to a lobe (0%), 1= minimal involvement to a lobe (1–25%), 2= mild involvement to a lobe (26–50%), 3= moderate involvement to a lobe (51–75%) and 4= severe involvement to a lobe (76–100%). An overall score was calculated by summing the cores of five lobe scores (range of possible scores, 0–20). And the severity of pulmonary involvement on CT scan was classified on a 4-point ordinal scaling chart: grade 0 score of 0 (No abnormality present on CT), grade one score of 1–5, grade two score of 6–15 and grade three score of 16–20 (11). If the patient has a series of CT scans, the most severe one during hospitalization was to be assessed using this scoring system.

Table No : 2; CT Thorax finding in (n= 100) COVID-19 patients

Finding	Value
Ground glass opacity	80 (80%)
Consolidation	75 (75%)
Crazy-paving pattern	20(20%)
Nodular pattern	15(15%)
No. of lobes affected	
0	3 (3%)
1	7 (7%)
2	13 (13%)
3	15 (15%)
4	30 (30%)
5	32 (32%)
Central distribution	3(3%)
Peripheral distribution	60 (60%)
Bilateral distribution	85 (85%)
Total lung severity score	
Mean	8
Range of score	0–20
Other findings	
Pleural effusion	1 (1%)
Lymphadenopathy	0 (0%)

As mentioned in Table no. 2; Out of the 100 patients, GGO was demonstrated in 80 cases (80%), consolidation was demonstrated in 75 cases (75%) and crazy-paving pattern was demonstrated in 20 cases (20%) and in 15(15%) cases nodular pattern seen. 60 cases (60%) had a peripheral distribution, 3 cases (3%) had central distribution and 85 cases (85%) demonstrated bilateral lung involvement. Only 1 patient had displayed pleural effusion. None case presented with cavitation or mediastinal lymphadenopathy. The total lung severity score ranged starting from 0 to 20, with a mean score of 8. Furthermore 4, 37, 54 and 5 patients were radiologically categorized to grade 0, grade 1, grade 2 and grade 3, respectively.

Table No: 3; Correlation between severity of lung involvement on HRCT Thorax series and clinical severity classification.

Clinical Classification	Extent of severity of lung involvement on chest CT				
	Grade 0	Grade 1	Grade 2	Grade 3	Total
Mild	2	1	0	0	**3**
Moderate	2	28	2	0	**32**
Severe	0	8	43	0	**51**
Critical	0	0	9	5	**14**
Total	4	37	54	5	**100**

There was significant correlation present between severity of lung involvement on chest CT scan and clinical classification (kappa =0.632, Standard error of kappa=0.067, P<0.05, 95% confidence interval: From 0.501 to 0.763).

Figure no 1: It is Graphical Representation of Table no.3

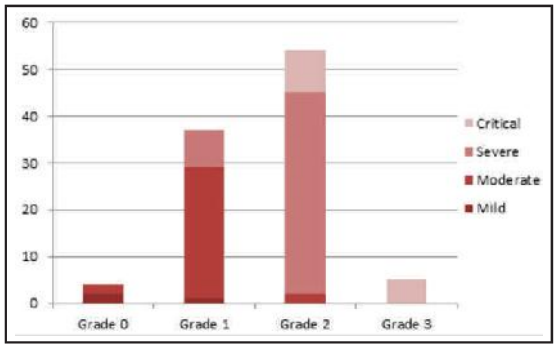


Figure no 2:

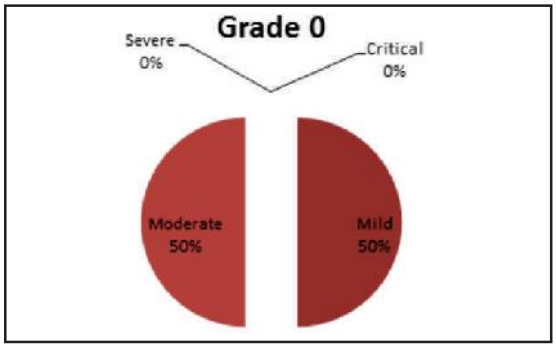
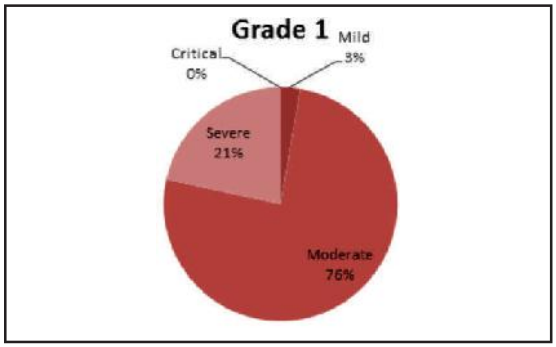


Figure no 3:



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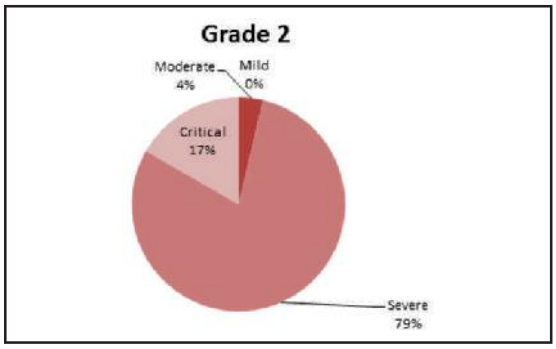

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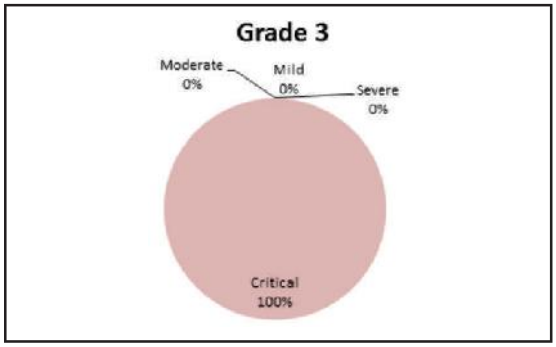

Above figure no 2,3,4,5 show clinical severity of disease in each CT grade separately.

DISCUSSION

The Covid-19 becomes a national health emergency since March in India, though 1st case noted in January. Disease progression in patients remains absolutely characterized; early isolation and supportive treatment are recommended for the infected patients at early stage.(13) Therefore prompt recognition of suspected patients is crucial to speed up treatment and quick isolation for better outcome. The data shows that old age patients especially 46 to 65 years with associated comorbidities have higher chances to be affected. This is associated with the standard data.(3) The most common symptoms at time of admission were fever, cough, dyspnea, fatigue and headache. A total of 98 patients from our center were definitively diagnosed as COVID-19 positive by RT-PCR. Though, 2 patients with negative RT-PCR had displayed GGO or consolidations in CT findings. A similar study had reported previously that out of 167 confirmed COVID-19 patients, five cases with initial negative RT-PCR, displayed typical chest CT findings of 2019-nCoV pneumonia (14), so it shows the importance of chest CT examination in patient screening and early disease diagnosis.

HRCT Thorax in our study had shown different variety of patterns in which GGO followed by consolidation was seen in majority of cases. The lesion was distributed bilaterally predominantly in peripheral lung fields. However, our patient sample was unique from other cases of COVID-19 series in relation to that relative brief interval between initial CT scan and onset of symptoms as we were doing CT scan in patients just after RT-PCR test came positive. So this was the limitation of our study and we had not compared the follow up CT scan after a period of time. The other limitations were the whole data in current series came from a single center and then the proportion of critical cases and the mortality in our series might be inconsistent with reports of different studies. On other hand, in our set up many stable patients preferred home isolation with medications; so the ratio of stable patients in grade 0 and 1 is less compare to grade 2 and 3 as we had collected the whole data in admitted patients.

The remarkable thing present in our study that, even if confirmed COVID-19 infection with mild to moderate

clinical severity; four patients out of current series of 100 have normal images on the initial chest CT scan. The negative imaging in confirmed COVID-19 patients shows that HRCT Thorax scan lacks complete sensitivity and cannot alone totally exclude the disease. However, with initial CT chest needs confirmation for prediction of disease and its outcome. Clinical assessment and blood investigations are important supportive factors for estimating the severity and further management of the patient.

The summary of study is; we described a screening coordination using HRCT Thorax combined RT-PCR assay to detect COVID-19 suspected patient and reported the chest CT features of COVID-19 patient. Bilateral lung involvement with peripheral distribution of GGO and consolidation are the most common indices. Abnormalities on chest CT can appear in a very early stage of COVID-19, so it helps in early recognition & evaluation with prompt management of disease. Moreover, we primarily reported that on HRCT thorax, the severity of pulmonary involvement is expressively consistent with clinical severity of COVID-19 positive patients. Then it helps in further management of patients. We hope our data and results might help radiologists, physicians including larger public health surveillance and response systems for better outcome and control of disease.

CONCLUSION

Deformities on HRCT Thorax can occur in an early stage of COVID-19 patients, even when RT-PCR results are negative, which can be used in early recognition & evaluation with prompt management of disease. CT grading can aid to identify patient's risk and calculate outcome of patients with COVID-19.

The severity of CT lesions is highly correlated with clinical staging. Ultimately, our study provisions the use of HRCT Thorax in COVID-19 patients which might be used as an early and effective gatekeeper to rule-out patients with a lower probability of disease.

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Conflict of Interest : Nil

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