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The Role of HRCT chest in COVID-19 Pneumonia

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

COVID-19 pneumonia is a recently identified lung infection, the hazardous factor of this pneumonia is pandemic dissemination of infection by corona virus. Due to its high mortality and morbidity it has become a threat to the human life. As pneumonia is the commonest manifestation chest x-ray becomes the primary modality of investigation however many symptomatic patients do not have a positive chest X-ray findings hence, HRCT is used as primary modality for both screening as well as a diagnosing COVID-19 pneumonia. It has been observed that in many situations RT-PCR test are negative or inconclusive but the HRCT in such cases is useful and conclusive.

Aim of the article is to highlight the role of HRCT in diagnosing COVID-19 pneumonia and providing proper guidance to the Clinicians for assessing the response and therapeutic purpose for covid19 pneumonia. recently, HRCT score have also been used to provide the clinicians an idea about the Prognosis of this disease progress.

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Keywords: COVID-19; pneumonia; pandemic; computed tomography (CT); ground glass opacity (GGO).

1. INTRODUCTION

Novel coronavirus was firstly reported in the late 2019 in Wuhan China, within a span of 2 to 3 months it has spread all over the world. On January 30, 2020, the first case of coronavirus in india was identified [1,2]. In view of high mortality and morbidity associated with coronavirus it was very important to diagnose infection at an early stage to isolate the patient in hospital and prevent spread.

Among the diagnostic modality available with laboratory test such as Real-time PCR (RTPCR) having diagnostic accuracy 60 to 70% was available to clinicians [3] it was observed that in many patient's HRCT had significant findings when RTPCR was negative, with more experience it was realised that HRCT a useful screening method in suspected cases to where rt-pcr was inconclusive.

In view of this it is extremely important to know the HRCT features in COVID-19 pneumonia along with its prognostic ability, in this article We will be discussing about the HRCT, appearance of COVID-19 pneumonia during 1st - 5th day of infection, its subsequently progress and lastly the significance of HRCT.

Epidemiology: As reported that the maximum number of patients and most transmission are because of droplet generated by sneezing or coughing, fomites transmission, near personal contact, such as hand shaking or touching and rarely by fecal transmission [4].

On January 30, 2020, the first case of coronavirus in India was identified, with origin from China. In India, the confirmed case count is now over 99,07,040 of which 3,39,611 cases are active. Recovery rate is over 94,22,564 and the death toll stands at 1,44,865 [5].

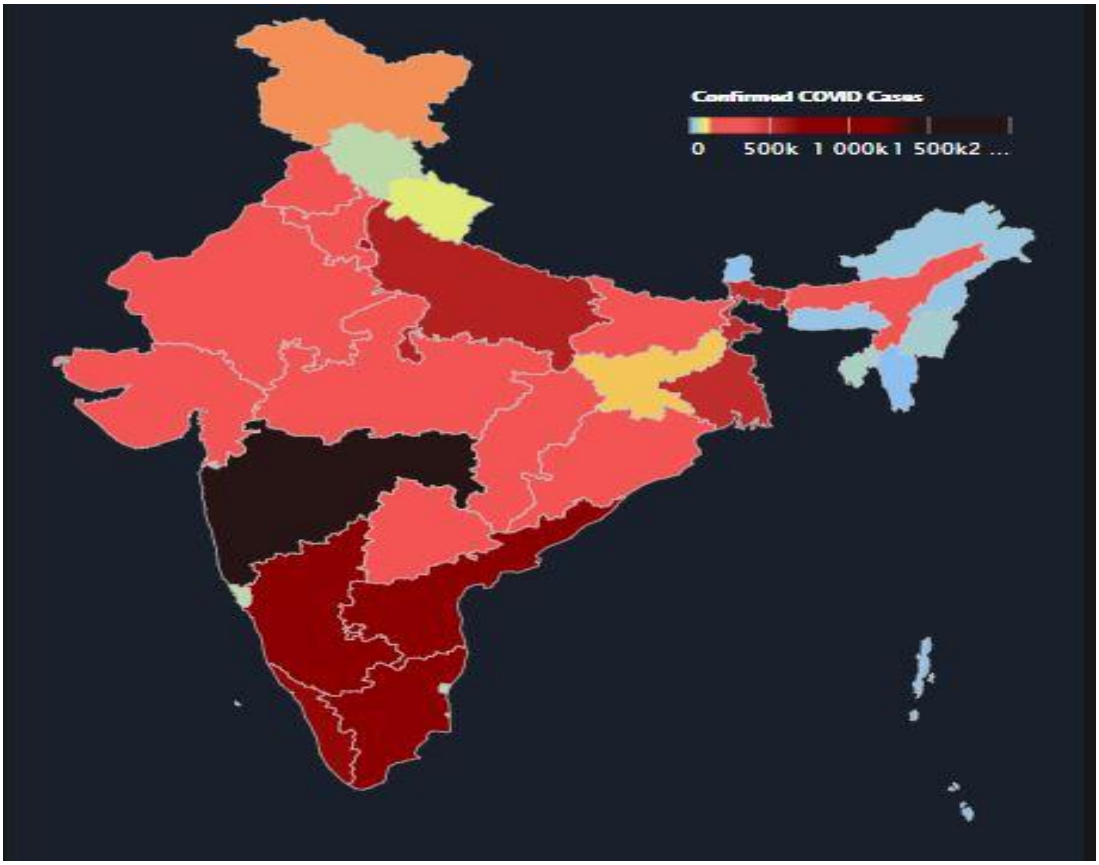


Fig. 1. Map of study area
Ref: [6], [Source: http://covidindia.org/]

Table 1. Confirmed cases of corona virus in different state

State	Confirmed Cases	Recoveries	Death
Andamanand Nicobar Islands	4834	4681	61
Andhra Pradesh	875836	864049	7059
Arunachal Pradesh	16536	16243	55
Assam	214803	210296	1002
Bihar	243673	237372	1325
Chandigarh	18714	17698	302
Chhattisgarh	258635	236588	3116
Dadar & Nagar Haveli; Daman & Diu	3359	3338	2
Delhi	608830	583509	10074
Goa	49474	47737	707
Total	9907040	9422564	144865

Ref: [6], [Source: covidIndia.org]

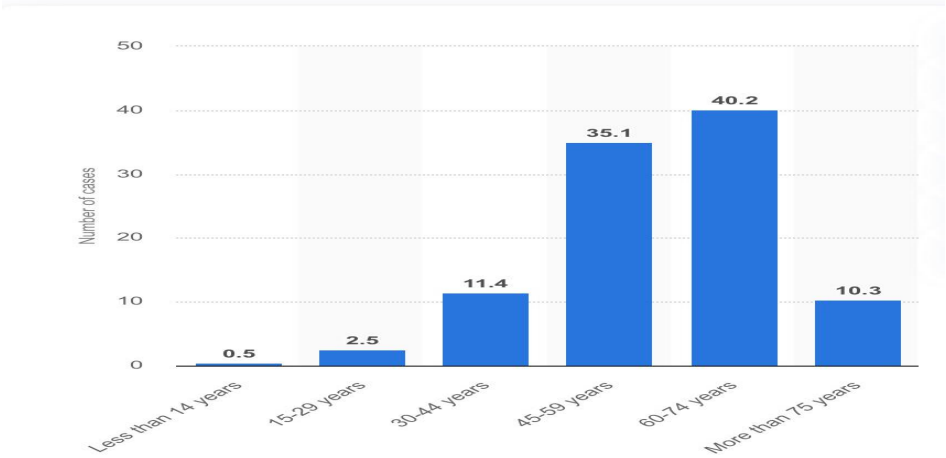


Fig. 2. Age and gender bias study result

Impact on age and gender bias: All over the world elderly population has been adversely affected by the pandemic in different ways, causing unprecedented fear, anxiety, distress, worry, and despair. In the case of the elderly, the illness tends to be more serious, more aggressive and more unpredictable, resulting in greater mortality and morbidity. The highest incidence of extreme COVID-19 disease rises with advancing age, with males more involved than females. Factors such as reduced immune system ageing, exposure to pathogens and viruses, decreased body and metabolic stores, and various related comorbidities this results to a higher risk of COVID-19 diseases.

According to the Indian Council of Medical Research results, the prevalence of COVID infection (per million) by age was highest among those aged 50-69 years (63.3 percent)and higher among males (41.6 percent)than females (24.3 percent) [6,7].

Physical examination: COVID19 is a rapidly evolving situation and a heterogenous disease entity. The common physical exam results among coronavirus-infected patients are Fever, cough, and shortness of breath. On examination, the patient may have abdominal pain and tenderness. The general appearance of the patient infected with coronavirus-19 depends on the severity of the illness.

Physical examination in case of suspected or confirmed patient should be done in a private room, The examiner should have Personal protective equipment (PPE) Due to the risk of aerosol spread of the SARS-CoV-2 virus, centres for disease control and prevention (CDC) recommends that protective eyewear should cover the front and sides of the face with no gaps between glasses and the face. If possible and the patient is in no respiratory distress, patient should wear a surgical mask [8,9,10].

2. CLINICAL MANIFESTATION

In Clinical presentation we have referred 13 cases from 36 review articles as mentioned in the bibliography. The common clinical presentation in these cases are :

Rare clinical presentation includes ARDS (most common complication), sepsis and septic shock, myocarditis, acute renal injury, disseminated intravascular coagulation, rhabdomyolysis [5].

In all these cases the laboratory test consisted of antigen test and RT-PCR. most of the cases were subjected to CHEST X-RAY and HRCT.

The result of HRCT were available immediately and therefore was the preferred modality as compare to RT-PCR.

2.1 Blood Picture (Hematological Involvement)

For COVID-19 patients, the major routine test includes: WBC, RBC, haemoglobin, platelets neutrophils, lymphocytes, monocytes, eosinophils, basophils, hematocrits, mean corpuscular volume, mean corpuscular haemoglobin , platelet distribution width and C-reactive protein counts [11].

3. METHODS

By Using PubMed, Web of Science, and Google scholar, a literature review search was carried out.

The above mentioned keywords were used to identify radiology articles based on the importance of HRCT in patients with COVID-19 and to compare other approaches available for evaluating the diagnostic effectiveness of imaging modes such as computed tomography (CT) [12].

This review article includes more than 30 references and HRCT Chest an overview of the imaging and management of COVID-19 patients and discussion of topics, including

A) Protocol for HRCT chest
B) HRCT findings and complications in Covid19
C) HRCT accuracy and its significance in diagnostics and decision-making

And additionally the clinical manifestation of COVID-19.

3.1 Protocol Used for HRCT : [13]

HRCT method and imaging protocol for suspected Covid-19 pneumonia:

Referred patients should undergo plain HRCT. CT images should be obtained by inspiratory phase of respiration. HRCT examination is performed during a single inspiratory breath hold. Scan extending from apex of the lung to the domes of diaphragm. Specific breath holding instructions must be given to the patient prior to their scan.

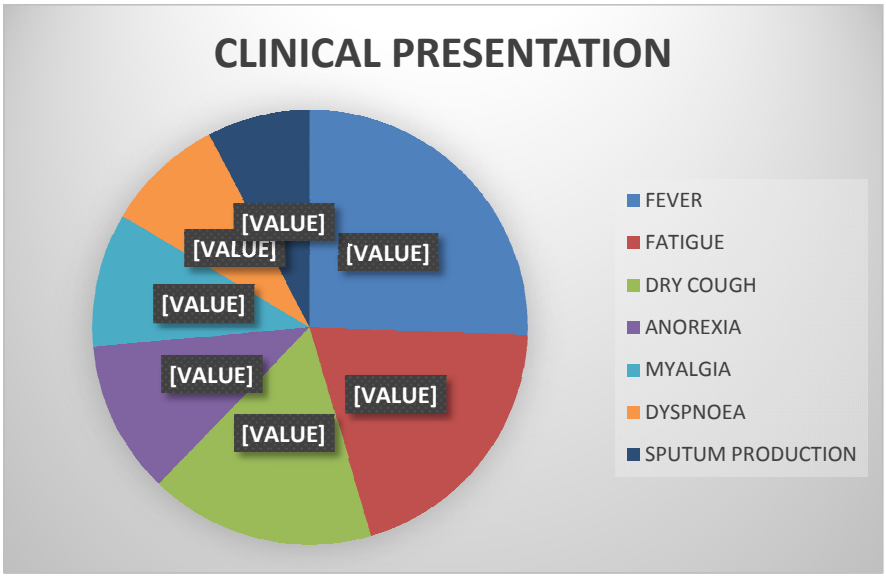


Fig. 3. Clinical presentation

HRCT scanning parameters are as follows:

i. Position of patient: supine
ii. Phase of respiration:inspiration
iii. Extension of scan : apices to diaphragm
iv. Pitch: 1mm
v. KV:120 ,MAS:110
vi. Slice thickness:<1.5mm
vii. Window: lung window

The scan is performed in supine position with faster gantry rotation protocol and higher pitch values (1 mm) because patient having lung disorders and have breathing difficulty. Field of view (FOV) From apex of lungs to domes of diaphragm. 5 mm primary and 1mm reconstructed images are acquired in sagittal, axial, and coronal with 0.5mm increment in lung window. Tube voltage 120KV and 110mA tube current [14.]

Scanning protocol may very from machine to machine and the operator but main goal is to acquire best quality images with low dose and shorter scan time without compromising diagnostic quality

As there are various disease that could have similar pattern diagnosis using Xray or computed tomography images are not confirmatory [15].

The chest HRCT, One of the key instruments used to diagnose symptomatic infection with COVID-19 together with rRT-PCR and clinical symptoms. For disease treatment and control, early diagnosis of Covid-19 is crucial, high resolution computed tomography (HRCT) chest a more reliable, practical and quick way of diagnosing and evaluating COVID-19 compared to RT-PCR, particularly in the epidemic area. the author wrote [16,17].

4. HIGH RESOLUTION COMPUTED TOMOGRAPHY OF CHEST

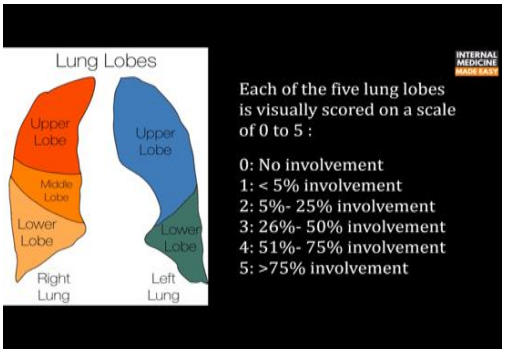
CT imaging is firmly prescribed in light of the fact that it is extremely delicate to recognizing early sickness, lesion characteristic, extent of lung involvement and to detect the stages of the disease The following factors may decide the appearance of disease in imaging modalities: Distribution, , shape, quantity pattern, density and concomitant signs [18].

4.1 Interpretation of HRCT

CT score: The severity score of HRCT chest may be used to easily identify patients with severe forms of coronavirus disease 2019 [19].

Table 2. The typical feature of covid19 on CT imaging

Parameter	Characteristic CT imaging manifestations
Density	Consolidation and ground glass opacity with potential thickening of interlobular septa
Shape	sub-segmental, segmental, Patchy
Distribution	Bilateral involving middle and lower region around the broncho-vascular bundles.
Location	Peripheral and sub-pleural area involving the parenchyma of lung
Concomitant Signs [Variable]	Air bronchogram- no apparent lymphadenopathy, a slight volume of plural effusion.



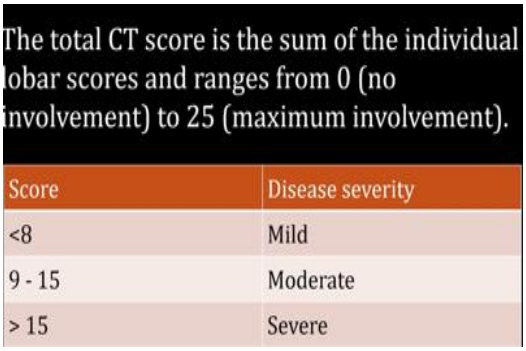


Fig. 4. CT score

The common High resolution computerize tomography imaging attributes of COVID19 are corporate various the bilateral, patchy, sub-segmental or segmental peripheral opacity of ground glass and area of consolidation. The most commonly recognised HRCT chest findings in infected patients are ground glass opacity in peripheral area [18,19].

For diagnosing COVID-19 thoracic CT plays a critical role and is the mode of choice for imaging and it has extreme sensitivity for detection of Covid-19 . By using CT scan the X-ray are passed through the chest of the patient which are then recognized by detector and is recreated into high resolution clinical images. In a chest CT scan, there are some structures to look out for which present themselves in distinct characteristics manifestations. Ground glass opacities (GGO) crazy paving, consolidation, air bronchograms, reverse halo, and perilobular pattern are possible findings within 100 percent conviction for Covid-19 in CT images of the thorax [20].

In more than 70 percent of RT-PCR samples, multiple chest CT results have been reported Covid-19 cases, involving ground glass opacities, lower lobe involvement and posterior preference for bilateral anomalies, vascular enlargement [21].

CORADS stands for 'coronavirus disease 2019 reporting and data system' , a categorical CT evaluation developed by Dutch radiological society on April 7, 2020.

It is based on other standards such as lung-RADS or BI-RADS which determine the involvement of lung in Covid-19 on a scale numbering from 1 to 5 as very low to very high.

A CT-based tool designed to be considered in those patients having mild to extreme symptoms of COVID-19.

It should also be noted that other evidence, such as test reports, clinical observations and period, of the symptoms should be taken into consideration when analysing

The CO-RADS Categories that are followed [22].

1.CO-RADS-0: when incomplete scan or poor-quality images or suspicious cases and does not included in severity.

2.CO-RADS 1: a lower degree of doubt for lesion in lung because of COVID19 in light of normal CT findings of unequivocal non infections aetiology. For example, Mild or severe emphysema, perifissural nodules lung tumors, or fibrosis, considered as CO-RADS 1.

3.CO-RADS 2: a lower degree of lesion in lung hypothesis due to covid19 infection in light of Etiology-typical CT findings in the lungs suggesting infection excepting COVID19, consisting of, pulmonary abscess, bronchopneumonia, lobar pneumonia, infectious bronchiolitis, and bronchitis The findings can include a tree-in-bud sign, a lobar or segmental consolidation, centrilobular nodular pattern, and cavitation of the lung.

Table 3. Overview of CO-RADS

CO-RADS Category	Level of Suspicion for Pulmonary Involvement ofCOVID-19	Summary
0	Not interpretable	Scan technically insufficient for assigning ascore
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 alsc» other diseases
4	High	Suspicious for COVID-19
5	Very high	Typical for COVID-19
6	Proven	RT-PCR positive for SARS-CoV-2

Note——CO-RADS = COVID-19 Reporting and Data System, COVID-19 = coronavirus disease 2019, RT-PCR: = revecse~transcription- polymerase chain reaction, SARS-CoV-2 = severe acute respiratory syndrome c >ronavirus 2
Ref: [22]

4.CO-RADS 3: CT results obscure due to covid19 for pulmonary involvement, also used in multiple kinds of viral pneumonia or non-infectious etiologies. PGG, homogeneous extensive ground-glass with or without sparing any secondary pulmonary lobules, or GG with smooth interlobular septa thickening with or without pleural effusion and without other usual CT revelation are included.

5.CO-RADS 4: Due to Covid-19 high degree of suspicion for pulmonary lesion , In light of regular CT findings however showing some overlap with different sorts of (viral) pneumonia. The findings not associated with the visceral pleura or are found in a purely unilateral location, transcendent peribronchial distribution or overlap with extreme diffuse prior pulmonary anomalies.

6.CO-RADS 5: Based on standard CT findings, superior degree of uncertainty for pulmonary lesion because of COVID-19.The characteristics are GGO , similar to visceral pleural structures, like fissures, with or without convergence, and a bilateral multifocal distribution.

4.2 Indications for HRCT Chest (COVID-19): [23]

- Suspected of developing COVID-19 with moderate clinical characteristics, imaging is not recommended until they have any risk for progression of disease
- COVID-19 with declining respiratory status
- The patients having suspicion development of Covid-19 with mild to severe clinical signs and symptoms and having high risk for disease pre-testing, imaging is advised for medical screening in a resource strained environment.
- After recovery, in patients with functional deficiency or hypoxemia In patients that were unintentionally observed to have results indicative of Covid-19 on a CT scan, Covid-19 testing is suggested.
- Moderate to severe Covid-19 characteristics, scanning is recommended, regardless of the results of the Covid-19 evaluation. [23]

5. CORRELATION OF HRCT CHEST AND RT-PCR TESTING

The initial false negative results can be provided by RT-PCR. In order to prevent misdiagnosis, we recommend that in cases where positive CT identification but negative RT-PCR outcomes isolation is must , and Lab test should be repeated [24].

RT-PCR may sometimes be misdiagnosed and needs to be cross validated and demands repeated testing. It is considered that the one-to-one dissemination of COVID-19 is largely transmitted through respiratory droplets with a median incubation time of 4 days. A standard test is currently considered to be the reverse-transcription polymerase chain reaction (RTPCR). RT-PCR usually takes a few hours to finish, but the time required to transport and prepare test samples is limited. As RT-PCR screening grown rapidly, laboratories have been overwhelmed with samples, lead to significant delayed diagnosis period and excessive use of personal protective devices (PPE). The variable susceptibility of RTPCR and lengthy wait times for outcomes mean that it is not possible to classify several patients with COVID-19, causing more infection in stable populations.

Although RT-PCR is considered the definitive diagnostic ideal standard, its availability, susceptibility to COVID-19 detection, and prolonged waiting times for results are limited.

In addition, inter-operator uncertainty may also impact the accuracy of the sample collected and result to a false negative test.

Due to the longer hospital stay and extra usage of PPE. HRCT a quick & cost-efficient alternate to RTPCR. Chest CT reveals common radiographic characteristics of COVID-19 victims, including multifocal patchy convergence and/or interstitial changes with a peripheral distribution and GGO These results, together with high clinical suspicion, give COVID-19 an extremely precise diagnosis [25,26].

In patients with mild to extreme respiratory disease symptoms and any pre-test probability of infection with Covid-19 when the findings of the RT-PCR test are negative or when RT-PCR not available easily or not conducted [27].

HRCT chest is a rapid scanning to be performed and can help in COVID-19 detection, especially in the environment where most of laboratories being overrun.

It is necessary to note that high resolution computed tomography a preferred standard for COVID- 19 detection , its findings help to show in the appropriate diagnosis. Correlating chest CT

results with epidemiological history, clinical appearance, and the outcome of the RT-PCR test seems to be important.

In initial false-negative RT-PCR result, CT findings have made a confirmatory diagnosis in many patients. In these cases, HRCT Chest can be considered a initial tool for detecting existing COVID-19 in outbreak regions [28].

Previous authors form china in their studies suggest HRCT comes with relatively higher sensitivity in COVID19 patients than initial RT-PCR swab sample test [29].

A negative CT results does not mean the patient is not infected with COVID19; this happens due to some other overlapping diseases including other viral pneumonias [22].

Our analysis suggest that identification of Covid-19 in hospitalized patients, the initial HRCT chest was more efficient than RT-PCR.

6. CHEST CT FINDINGS IN COVID19

An assortment of CT findings in COVID19 have been accounted for in the various studies however all investigation source that the fundamental CT highlight of COVID19 pneumonia is the presence of ground glass opacities (GGO) ordinarily with a peripheral and sub-pleural distribution. In most of the patient associated with COVID19 involves multiple lobes especially the lower lobe Linear consolidation and other signs suggesting organizing pneumonia for example the reverse halo sign is regularly noticed generally in patients a few days after the onset of disease [30,31].

The appearance we can see of each CT characteristics is describes in order from low to high as (+~++++) ;E, A,S, and D stands for stage early, advance, severe and dissipation.

CT stages:

Currently, HRCT Chest is the imaging modality of choice for screening Covid-19 There are 4 different stages depending upon the CT scans of the lungs, and evolution of the lesions the scanning is performed in various stages [32,33,34].

- **Early Stage:(0-4 days)**: CT reveals one/several dispersed patchy or conglomerate ground glass opacity, involving mid and lower third of lungs, surrounding broncho-vascular bundles. In peripheral and sub-pleural regions of the lung, these ground glass lesions are frequently found. An crazy paving pattern may be offered by intra and interlobular thickening of septa often visible in the areas of ground glass opacity. During this period, the pathological changes alveolar septal capillary dilation and congestion, fluid exudation in the alveolar cavity, and interlobular interstitial edema. At initial diagnosis, one patient had regular chest CT; but, after three days, illness advanced and a solitary rounded ground glass lesion in the right lower lobe formed, suggesting that this pattern may constitute the very first radiologically visible appearance in SARSCOV-2 patients.

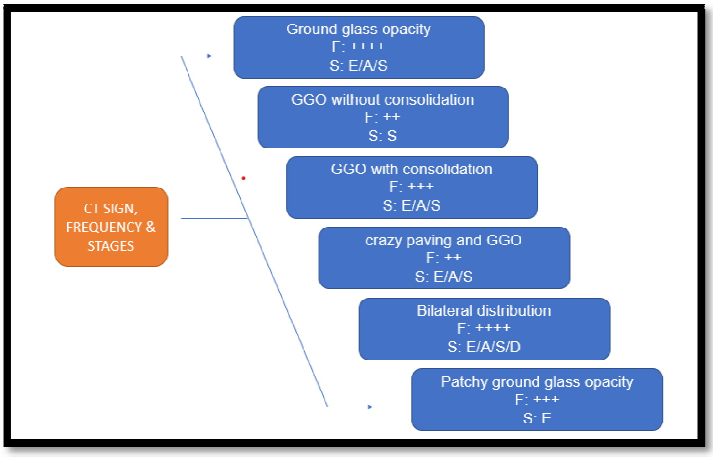


Fig. 5. Frequency of HRCT chest findings in COVID19, [31]

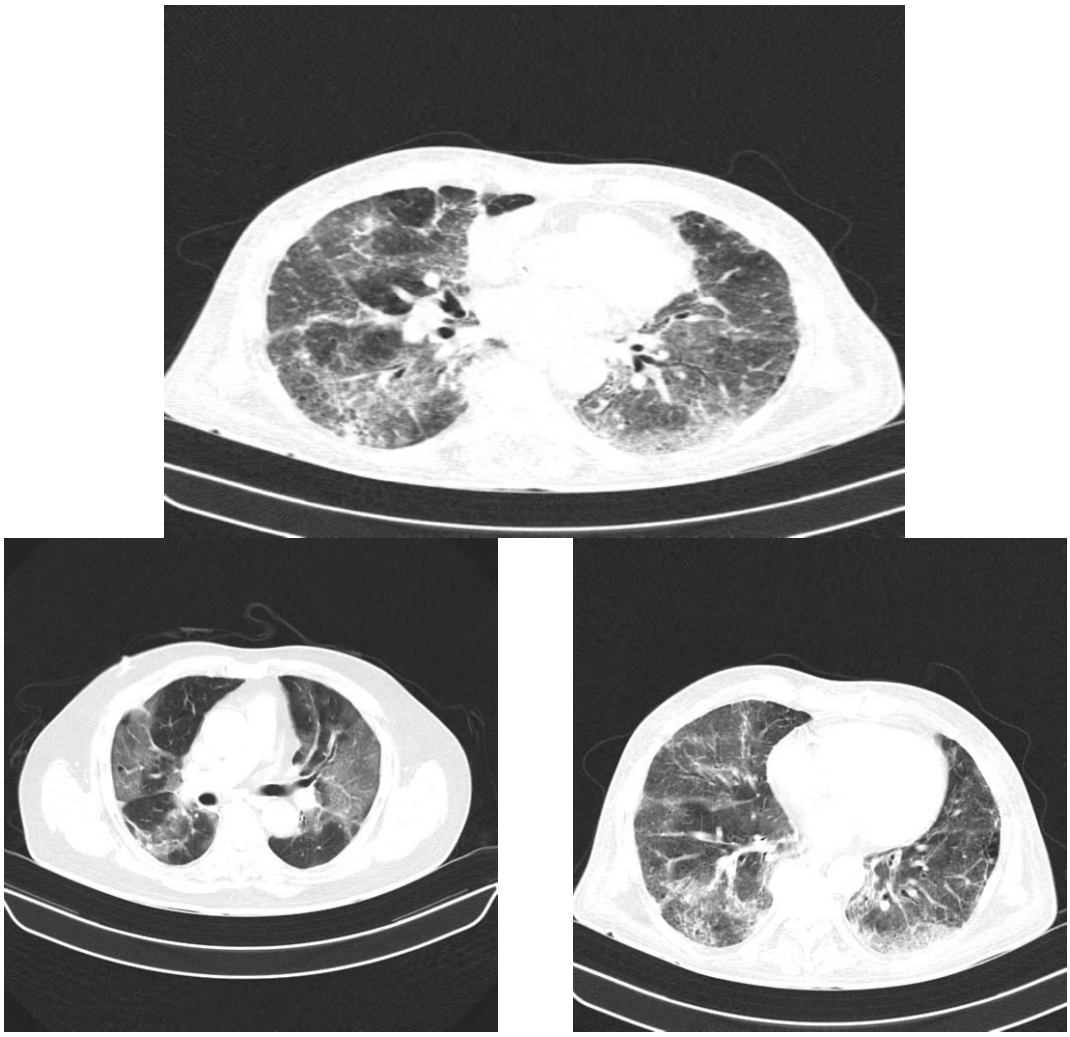


Fig. 6. CT manifestations of covid19 disease a) ground glass opacities b) consolidation c) consolidation with ground glass opacity [31]

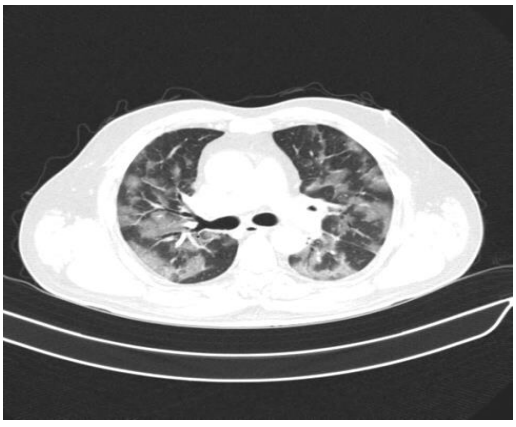


Fig. 7. B/L peripheral and central patchy ground glass opacities

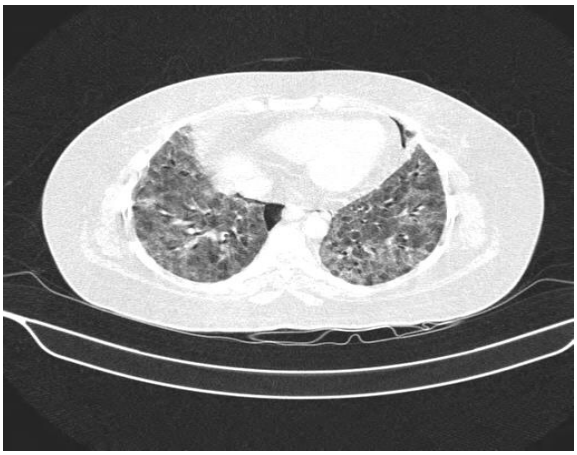


Fig. 8. Diffuse ground glass opacity with interlobular septa thickening giving crazy paving pattern

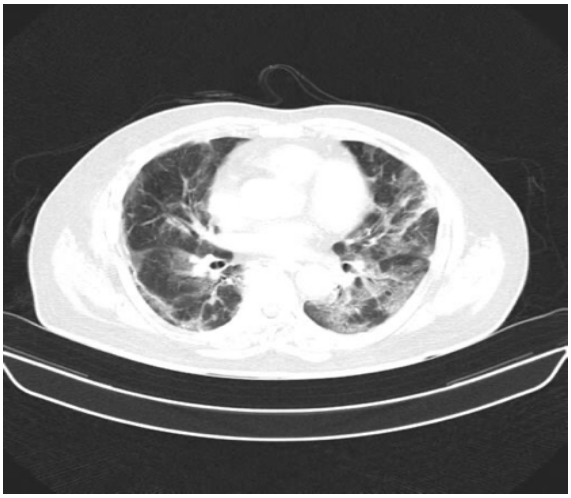


Fig. 9. Diffuse consolidation with white lining

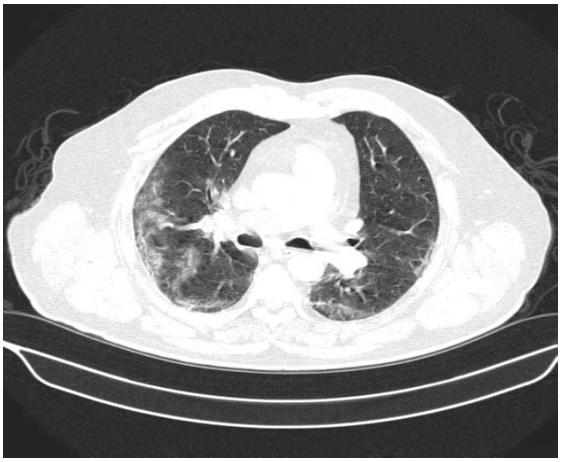


Fig. 10. Resolving patches of consolidation with subplerural band of fibrosis

- **Progressive stage :(5-8days):** CT reveal new lesions during this period that identical to the earlier one. Moreover, the density and scale of early-stage detection of the illness are increasing. Air bronchograms also visible in areas of consolidation as areas of consolidation develop, In this process, the pathological characteristics are aggregation of a cell-rich exudate in the alveolar cavity. The fibrous exudation binds the alveolus to form a fusion state via the inter-alveolar space.

The progressive stage (5-8 days) shows an increased amount of GGO relative to the early phase.

- **Peak stage (10-13 days)** If the condition progresses on, chest CT exhibits diffuse consolidation into the alveolar cavity, air bronchograms, and bronchial dilation of the lungs of variable density secondary to the fibrous exudate. Patchy ground glass opacities occurs in non-consolidated regions of lung. The lungs behave as a "white ling" when more of the lungs are active. The pleura is thickened and a slight amount of pleural effusion can occur.

- **Absorption stage (>14 days)** Incremental resolution and consolidation of GGO in the lungs with any residual fibrosis-compatible curvilinear opacity [32,33,34].

- **Role of co-morbidities:**

Comorbidity is mainly characterised in medical science as a condition occurring at the same time; however, persons have an additional illness or a similar medical problem.

In basic words, comorbidity describes the consequence of all such situations that may be medical or neurological and that a particular patient may have other than the main disorder of concern The combination of a long-term condition such as diabetes and a serious viral infection such as Covid-19 creates a tough challenge for the medical profession to save lives.

Coronavirus disease-2019 is also known as COVID19. It a highly contagious disease with a high risk of mortality commonly involving individuals of age above 65 years as they are at high risk there are several comorbidity that are associated with SARS-COV-2 infection such as high blood pressure , cardiac disorders and COPD and diabetes are regarded as one of the high risk comorbidity, which can influence the survival of infected individual.

Diabetes is one of the conditions and a major risk factor associated with COVID-19 mortality. The immunity of an individual is impaired in diabetes , which has been believed to contribute to increased susceptibility to COVID12 infection, particularly in those with high blood glucose levels. A major donor to COVID-19 morbidity is cardiac disease, a collective comorbidity to endocrine disease comprising of diabetes.

One of the co-morbidities was found to be cardiovascular complications in COVID-19 patients [35].

In the case of people with diabetes, the death rate tends to be almost three times higher compared to the average COVID-19 mortality in China [35,36]. As noted, diabetes was an important risk factor for the earlier cause of mortality in SARS and MERS coronavirus infections [35].

It has also been observed that there is Multi-organ involvement along with the progression of disease which is one of the reasons for comorbidity and extra pulmonary organ injuries in patients suffering from COVID-19 [36,37,38]. Other related studies reflect similar pictures [39,40]. Key studies on pulmonary problems in India and related issues provide the evidence of increased risk of morbidities and mortality in COVID-19 [41,42].

7. CONCLUSION

Because of the global outbreak of Severe acute respiratory syndrome coronavirus 2 disease, it is fundamental to be acquainted with normal and unprecedented imaging discoveries of Covid-19 pneumonia and their development over time on CXR and HRCT. CXR may be utilized as front-line imaging methodology in the zones with significant levels of infection just as in the sequential assessment of hospitalized and fundamentally sick patients. Then again, HRCT shows a low explicitness in zones with low predominance of sickness, and it should be viewed as the methodology of decision in surveying differential conclusion with different infectious and non-infectious lung illnesses and in overseeing patients with previous lung infection. The consciousness of connection

between imaging discoveries and basic pathogenesis encourages radiologists to expand the degree of trust in diagnosing the illness at its first presentation, just as in perceiving potential entanglements and differential conclusion. Based on the all literature we have reviewed, and from that we conclude Imaging changes in novel viral pneumonia are quick. The signs of the novel COVID pneumonia are diverse. In the present circumstance, imaging of COVID-19, especially with HRCT chest, has an extremely high worth since it shows trademark indications and has empowered forefront clinicians having essential finding in their first contact with suspected patients, even with initially false negative lab results. HRCT chest is preferred screening tool rather than RT-PCR Prior conclusion with the guide of imaging considers early regulation and reaction to this transferable sickness just as beating the outbreak at the earliest opportunity through a joint exertion

CONSENT

It is not applicable.

ETHICAL APPROVAL

It is not applicable.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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