

RADIOLOGICAL ANATOMY OF LUNG IN COVID-19 PATIENTS USING HIGH RESOLUTION CHEST CT IMAGING – A CROSS SECTIONAL STUDY

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Abstract

Background: The global outbreak of COVID-19, triggered by the SARS-CoV-2 virus, has primarily impacted the respiratory system. Chest CT scans have proven valuable in identifying and monitoring lung involvement in infected individuals. **Materials and Methods:** This cross-sectional analysis was conducted on 100 RT-PCR-confirmed COVID-19 patients aged 10–90 years, hospitalized across multiple centers in Telangana between 2021 and 2022. High-resolution chest CT scans were performed in the supine position, and images were examined for structural alterations, including lobe and segment involvement, pleural changes, and bronchial abnormalities. **Result:** Predominant changes observed included ground-glass opacities, septal thickening, and pleural effusions in the CT of COVID-19 patients. Male gender is observed to be affected more frequently than the female gender. The right lung is most frequently affected. A correlation was observed between age, and severity of findings. **Conclusion:** CT imaging is instrumental in assessing lung pathology in COVID-19 cases and supports timely clinical decision-making, enhancing patient care in moderate to severe presentations.

INTRODUCTION

The corona virus was first identified in December 2019 in Wuhan, China which produced a large cluster of pneumonia cases, hence the virus was initially called as “Wuhan virus”.^[1,2] The World Health Organisation later named the novel corona virus responsible for the outbreak as Corona Virus Disease 2019 [COVID-19]. It is highly contagious and can cause severe respiratory symptoms leading to death.^[3]

Corona Virus disease 2019 caused by severe acute respiratory syndrome corona virus 2 {SARS COV-2} has become a global pandemic. According to previous studies, the corona virus is estimated to cause injuries in multiple organs but with extensive pulmonary involvement. Elderly people and others with underlying comorbidities are more likely to severe forms of COVID-19 as compared to adults. In SARS patients, men and women have the same prevalence but men with COVID-19 are at more risk for worse outcomes and death, independent of age than women.

The virus can spread from an infected person's oral cavity or nose through the aerosols. The best way to prevent the disease is by creating awareness among the public about the transmission of virus. The protection from infection is achieved by maintaining

social distance, wearing a properly fitted mask and washing hands frequently, isolating at home until the individual recovers from the illness and by getting vaccinated as early as possible. Patients infected with this novel virus manifested with symptoms of severe pneumonia, including fever, fatigue, dry cough and acute respiratory distress.^[4]

At present, diagnosis of COVID-19 is confirmed by the real time reverse transcription polymerase chain reaction [RT-PCR] test, which has high specificity but low sensitivity for diagnosing the disease.^[4,5] Radiological imaging especially thin slice CT, has important roles in the diagnosis, management and follow-up of patients with COVID-19 pneumonia. Chest CT can detect early phases of infection and enable early isolation of patients.^[6,7]

Chest CT has been an effective and important supplement to RT-PCR testing in the diagnosis of COVID-19.^[8] The hallmark of COVID -19 is the bilateral presence of patchy ground glass opacities [GGO's], consolidative lesions. It may also show other CT findings such as interstitial thickening and bronchiectasis. The ground glass opacities are defined as hazy lung opacities that doesn't obscure the underlying broncho-vascular markings, and often these opacities have been noted to be rounded, peripheral and bilateral in distribution. Whereas, consolidations are due to complete replacement of alveolar air spaces by pathological fluid or cells,

leading to an increase in parenchymal density that obscures the underlying vessels and bronchial walls. The predominant CT pattern in COVID-19 is bilateral GGO's associated with consolidations, but the findings may vary from patient to patient. The bronchial obstruction and bronchial inflammatory damage leading to destruction of bronchial wall structures tend to the development of fibrosis and to consequent bronchiectasis. The most frequent pleural change in COVID-19 patients is pleural thickening.^[9] The current study aimed to evaluate CT imaging features COVID-19 for the presence of Ground Glass Opacities, consolidations and other findings noted such as presence of septal thickening, sub pleural bands and traction bronchiectasis in the lungs. The current study helps in prospectively assessing the structural changes in the lung using chest CT imaging. Thus the clinical implications of the pulmonary structural changes in COVID-19 patients helps in establishing a perfect treatment plan to cure the disease with effective prognosis and treatment by the physicians and pulmonologists. Hence in this regard, I feel my study is apt and will definitely add to the expertise required while handling the COVID-19 patients.

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REVIEW OF LITERATURE

COVID-19 is a dreadful and an emerging disease which has led to the destruction of a large part of the population, emphasizing the need to develop various treatment methodologies to cure and prevent the disease progression. However, without optimizing our knowledge about the efficient diagnosis along with the detection of various risk factors involved, it is difficult to reduce the infection and the associated mortality rates. Thus various studies were performed all throughout the world to help in the early detection, diagnosis and management of the cases.

Jian-Min Jin et al,^[10] in a study reported that the deceased patients were significantly older noted to be 51-70 yrs of age. While male and female have the same prevalence.

In a study by Yicheng Fang et al,^[11] that the deceased patients were observed to be 39-55yrs of age. Number of males affected were more than females.

A study conducted by Sara Haseli,^[12] revealed that the males were affected more than the females. The prevalence of the disease was seen to be more in the elderly people aged above 60 years compared to the younger population. The results obtained in the present study also shows older individuals 61-70 yrs were more affected with COVID-19 and number of males affected more than females.

A study done by Adam Bernheim et al,^[13] the presence of only ground glass opacities in chest CT films is comparatively less than the presence of ground glass opacities with consolidation.

In a similar study done by Sara Haseli et al,^[12] the presence of peripheral ground glass opacities were observed more.

In a study by Sudhir Bhandari et al,^[14] reported equal number of cases with only ground glass opacities and ground glass opacities with consolidation. The present study, shows more number of cases with only ground glass opacities than ground glass opacities with consolidation.

According to Adam Bernheim et al,^[13] have reported bilateral lung disease in more number of cases than unilateral lung involvement. In a similar study done by Sudhir Bhandari et al,^[14] bilateral lung disease was observed in more number of cases than unilateral lung disease. Sara Haseli et al,^[12] observed bilateral lung involvement cases more than unilateral lung involvement. A similar observations can be drawn from the findings of the present study with bilateral lung disease in more number of chest CT cases than unilateral involvement of lung

According to Adam Bernheim et al,^[13] found the right lower lobe involvement is more number of chest CT cases. As per Sudhir Bhandari et al,^[14] the frequency of lobar involvement in right lung showed, lower lobe involvement in higher number of cases. Ming- Yen Ng et al,^[15] in his study observed that in chest CT findings right lower lobe involvement reported in more number of cases. The present study shows right lower lobe involvement in more number of cases.

Ming -Yen Ng et al,^[15] found, left lower lobe involvement is comparatively more out of 21 chest CT cases. A study done by Adam Bernheim et al,^[13] reported left lower lobe involvement in more number of cases. As per Sudhir Bhandari et al,^[14] left lower lobe in higher number of cases. A similar observations can be drawn from the present study with left lung lower lobe involvement in more number of cases.

According to Jiong Wu et al,^[16] and Sara Haseli et al,^[12] the septal thickening and sub pleural bands findings observed in less number of cases. The current study shows, septal thickening and subpleural bands in few cases which indicates these findings are less frequent than ground glass opacities or consolidation.

According to AdernBernheim et al,^[13] bronchiectasis in 1 case. The current study shows bronchiectasis in 4 cases which indicates this finding is less frequent.

In general from all the above findings it can be understood that age and sex were the important predictors of disease severity among the set of data typically collected on admission. Along with it the side of the lung involved, presence of ground glass opacities or ground glass opacities with consolidation, sub pleural band, septal thickening and bronchiectasis serve as the appreciable findings in chest CT images of COVID-19 and thus helps in early detection, diagnosis and treatment of the disease.

Aims and Objectives

The purpose of the study is:

- 1) To analyse/ evaluate the anatomical changes in the lungs using cross sectional CT Scan findings in COVID-19 Patients of this epidemic disease.
- 2) The current study aims in finding out the role of age, gender in influencing the frequency of the disease and helps in assessing about the most frequently affected side of the lung, lobe of the lung involved and compare it with earlier studies.
- 3) To know the clinical implications of structural changes in the lung.

MATERIALS AND METHODS

Type of Study and study design: Cross-sectional study

Sample size: 100 hospitalized COVID -19 Patients

Selection Criteria

Inclusion Criteria

Adults and children aged between 10 to 100 years.

Exclusion Criteria

Neonates and children below 10 yrs.

Study Period: The study sample data is collected from various hospitals located in Telangana state from 2021 to 2022.

Data Collection: The study is carried out by collecting 100 chest CT films of COVID-19 Patients.

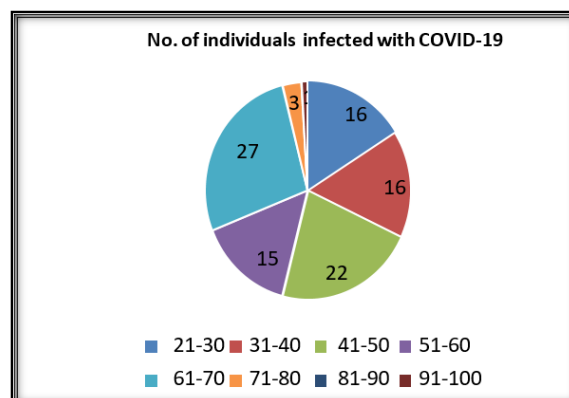
Procedure and Instruments Used: All patients are diagnosed by Naso-pharyngeal swab tests or RT-PCR and underwent High Resolution Chest CT scan to determine pulmonary changes. All images are obtained using CT scan with patients in the supine position from the thoracic inlet till the domes of diaphragm without IV contrast at 5mm collimation. The distribution of lesion patterns such as lobar changes, only ground glass opacities, ground glass opacities with consolidation, only consolidation, bronchopulmonary segment involvement, dilatation of bronchial vessels, intra- lobar septal thickening, sub pleural thickening, pleural effusion with obliteration of costo- diaphragmatic recess and costo-mediastinal recess are analyzed.

Confidentiality: Details of the patient will not be revealed and will be kept confidential.

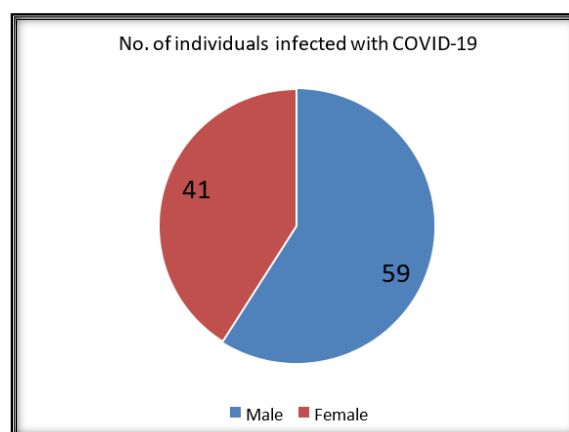
Statistical Tools: Statistical analysis was carried out using Microsoft Excel.

Ethical clearance: Our research is conducted in accordance with the relevant guidelines and regulations and ethical approval from the Institutional Ethics Committee.

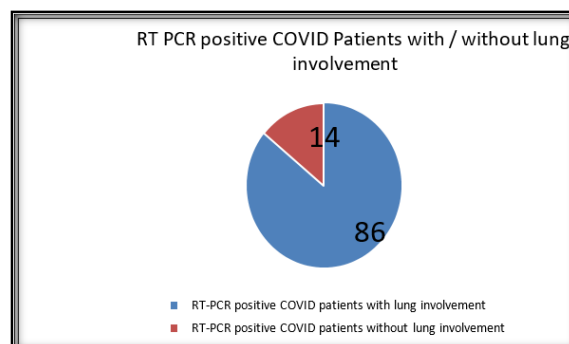
RESULTS



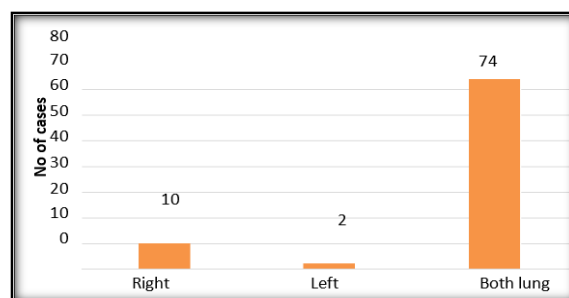
Graph 1: Age wise distribution of COVID 19 cases



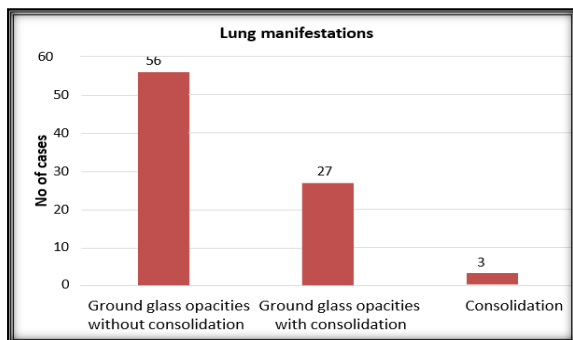
Graph 2: Gender wise distribution of COVID-19 cases



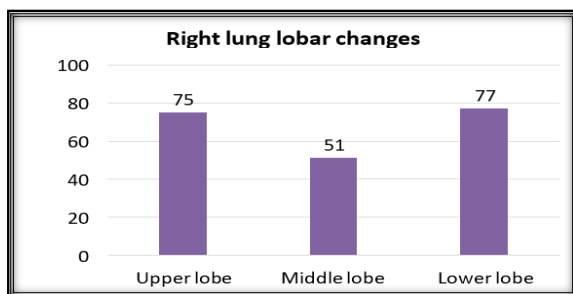
Graph 3: No of RT PCR positive COVID patients with / without Lung involvement



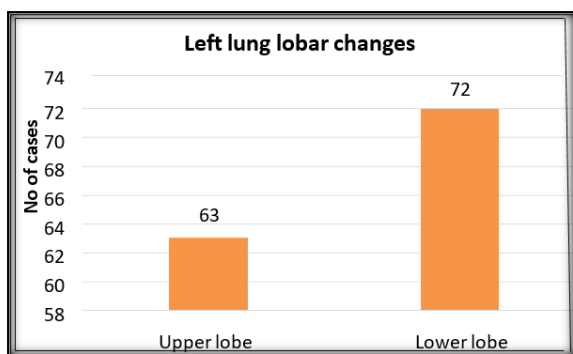
Graph 4: Showing lung parenchymal changes



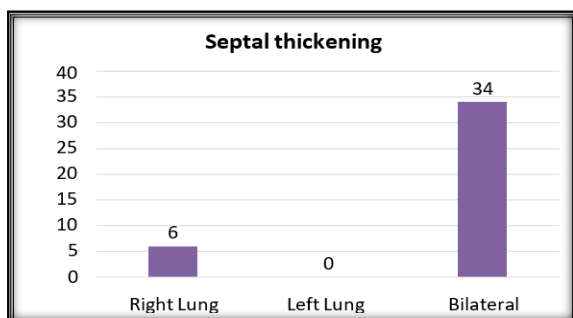
Graph 5: Data showing lung manifestations



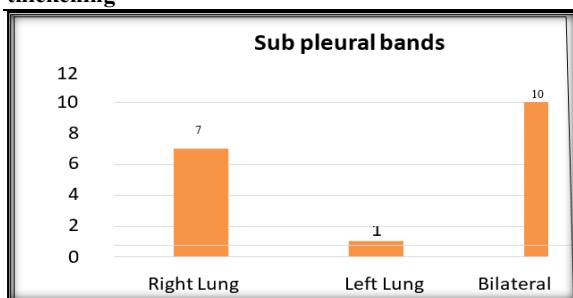
Graph 6: Frequency of right lung lobar changes



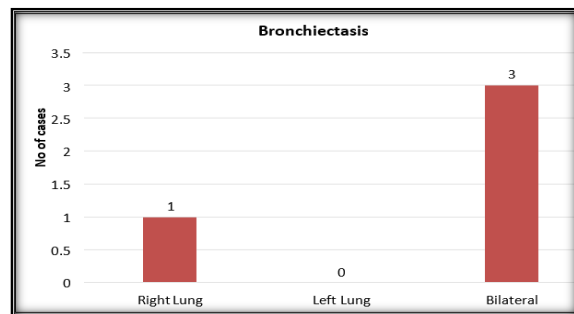
Graph 7: Frequency of left lobar changes



Graph 8: No. of COVID chest CT films with septal thickening



Graph 9: No. of COVID chest films with sub pleural bands



Graph 10: No. of COVID chest CT films with bronchiectasis

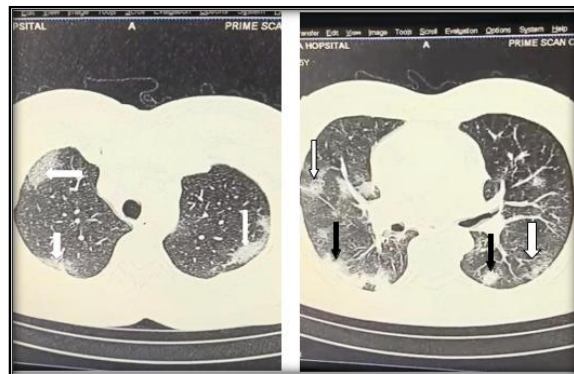


Figure 1 A,B: Axial view of serial chest CT images of a patient aged 45yrs, Male

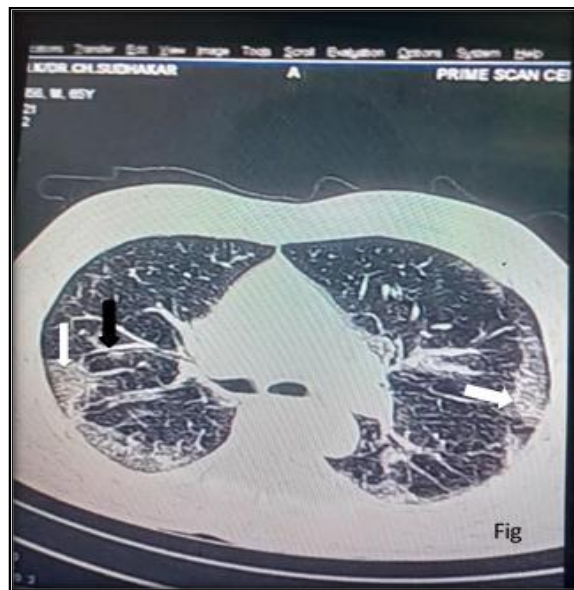


Figure 2: Axial view of serial chest CT image of a patient aged 65yrs, Male showing bronchiectasis.

Table 1: Age wise distribution of COVID-19 cases.

Age	No. of individuals infected with COVID-19	Percentage
10-20	-	-
21-30	16	16%
31-40	16	16%
41-50	22	22%
51-60	15	15%
61-70	27	27%
71-80	3	3%
81-90	-	-
91-100	1	1%

In our study, the number of cases between 21-30yrs of age were 16, the cases between 31-40 yrs were 16, 41-50yrs age group were 22, 51-60yrs age group were 15, 61-70 yrs were 27, 71-80 yrs were 3 and 1

case reported between 91-100yrs of age group. The maximum prevalence observed between the 61-70 yrs of age with the median age found to be 45. [Table 1 & Graph 1]

Table 2: Gender wise distribution of COVID-19

Gender	No. of individuals infected with COVID-19	Percentage
Male	59	59%
Female	41	41%

In the present study out of the total 100 cases, 59 were male and 41 were female. [Table 2 & Graph 2]

Table 3: No of RT PCR positive COVID patients with / without Lung involvement

No of RT PCR positive COVID patients with / without Lung involvement	No. of cases	Percentage
With lung involvement	86	86%
With out lung involvement	14	14%

In our study, we observed the number of RT-PCR positive patients with lung involvement were 86

(86%) and without lung involvement patients were 14 (14%). [Table 3 & graph 3]

Table 4: Showing lung parenchymal changes

Lung parenchymal changes	No. of COVID- 19 chest CT films	Percentage
Rt. Lung	10	10%
Lt. lung	2	2%
Both lung	74	74%

In our study bilateral involvement of lung observed in 74 cases (74%), only right lung involvement in 10 cases (10%) and only left lung involvement in 2 cases (2%). [Table 4 & Graph 4]

Table 5: Data showing lung manifestations

Lung Manifestations	No. of COVID- 19 chest CT films	Percentage
Ground glass opacities with out consolidation	56	56%
Ground glass opacities with consolidation	27	27%
Consolidation	3	3%

The current study showed, neither ground glass opacity or consolidation in 14 cases (14%), ground glass opacities without consolidation in 56 cases

(56%), ground glass opacities with consolidation in 27 cases (27%) and presence of only consolidation in 3 cases (3%). [Table 5 & Graph 5]

Table 6: Frequency of right lung lobar changes

Right lung Lobar changes	No. of COVID-19 cases	Percentage
Upper	75	75%
Middle	51	51%
Lower	77	77%

The present study showed, right lung upper lobe involvement in 75 cases (75%), right lung middle lobar changes in 51 cases (51%) and involvement of right lung lower lobe in 77 cases (77%). [Table 6 & Graph 6]

Table 7: Frequency of Left lobar changes

Left lung lobar changes	No. of COVID-19 Cases	Percentage
Upper	63	63%
Lower	72	72%

In our study, the number of left lung upper lobe involvement were seen in 63 cases (63%) and left lung lower lobar changes in 72 cases (72%). [Table 7 & Graph 7]

Table 8: No. of COVID chest CT films with septal thickening

Septal thickening	No. of COVID-19 cases	Percentage
Right lung	6	6%
Left lung	-	-
Bilateral	34	34%

The presence of septal thickening noted, in 34 cases (34%) bilaterally and in 6 cases (6%) the septal thickening found to be in only right lung.

Table 9: No. of COVID chest CT films with sub pleural bands

Sub Pleural bands	No. of COVID-19 cases	Percentage
Right lung	7	7%
Left lung	1	1%
Bilateral	10	10%

In our study, the bilateral sub pleural bands in the lung were observed in 10 cases (10%), in right lung the subpleural bands noted in 7 cases (7%) and in left

lung the subpleural bands showed in 1 case (1%). [Table 9 & Graph 9]

Table 10: No. of COVID chest CT films with traction bronchiectasis

Bronchiectasis	No. of COVID-19 cases	Percentage
Right	-1	1%
Left	-	-
Bilateral	3	3%

The presence of traction bronchiectasis noted in 3 cases (3%) bilaterally and in only right lung observed in 1 case (1%). [Table 10 & Graph 10]



Figure 3: Axial view of chest CT image of a 70yrs, Male showing bilateral Ground glass opacities with septal thickening



Figure 5: Axial view of Chest CT image of a patient aged 75yrs, male showing Bilateral Ground glass opacities of lung with sub pleural band in left lung depicted by white arrow.

DISCUSSION

The study included a total of 100 HRCT chest films of Covid-19 patients and the findings were evaluated for the presence of Ground Glass Opacities, consolidation, other findings noted are presence of septal thickening, subpleural bands and bronchiectasis in the lungs. In the present study an attempt was made to outline the distribution of age, gender, unilateral or bilateral involvement of lung, the lobar distribution of lesions and various other radiological abnormalities.

In the present study the affected Covid 19 patients spanned from 21 to 94 yrs of age, the maximum prevalence occurred between the age group of 61-70yrs with median age observed to be 47. According to the Jian- Min Jin et al,^[10] the median age was 62(51-70yrs). Yicheng Fang et al,^[11] in his study the median age observed was 45(39-55yrs).



Figure 4: Axial view of Chest CT image of a patient aged 28yrs, female with Bilateral Extensive involvement of lungs

In the current study Males are more affected than females. Among 100 Covid 19 patients, 59 were males and 41 were females. In a similar study by Sara Haseli et al,^[12] 38 patients were males and 25 patients were females. Yicheng Fang et al,^[11] in his study included, 29 male patients and 22 female patients. Adam Bernheim et al,^[13] observed that out of 121 patients, the affected male patients were 61 and female patients were 60. As per Arun gaur et al,^[17] the study included 26 covid patients out of which 16 were males and 10 were females. According to a study by Tao Ai MD et al,^[18] out of 580 COVID infected cases, 272 were males and 308 were females. In the current study, among 100 RT PCR positive, CT chest films, 86 CT films are with lung parenchymal changes, 14 CT films are normal with out any findings. Sudhir Bhandari et al,^[14] observed out of 80 patients, 51 were found to be radiologically positive on HRCT chest while 29 patients had normal CT. A study done by Adam Bernheim et al,^[13] observed out of 121 patients, 94 cases showed lung disease and 27 cases are without lung involvement. Sara Haseli et al,^[12] study included 63 RT-PCR positive COVID pneumonia patients and all patients had abnormal chest CT scan consistent with viral pneumonia.

The virus first invade the pulmonary interstitium which was characterized by edema and thickening of peri bronchovascular interstitium, manifesting as GGO.^[19] In our present study, out of 86 positive lung chest CT findings, we observed 56 chest images with only Groundglass opacity, 27 films presented groundglass opacity with consolidation and 3 films are with only consolidation. A study done by Adam Bernheim et al,^[13] observed out of 94 Chest CT findings, the presence of Ground glass opacities without consolidation in 41 CT films, presence of ground glass opacity with consolidation in 50 and presence of consolidation without ground glass opacities observed in 2 CT images. In a similar study done by Sara Haseli et al,^[12] out of 63 films, the peripheral ground glass opacities are found in 58 CT images and consolidation in 27 patients. Sudhir Bhandari et al,^[14] found that among 51 HRCT findings, 25 cases presented with groundglass opacities, other 25 CT films showed ground glass opacities with consolidation and 1 chest CT film with consolidation. In our current study, lung parenchymal changes found to be bilateral in 74 cases out of 86 cases, right lung involvement in 10 cases and the remaining 4 cases showed left lung involvement. According to Adam Bernheim et al,^[13] 73 cases had bilateral lung disease, 13 cases are with only right lung involvement and 7 cases showed only left lung parenchymal changes. In a similar study done by Sudhir Bhandari et al,^[14] bilateral lung disease was observed in 39 cases and unilateral lung disease in 12 cases among 51 lung disease CT cases. Sara Haseli et al,^[12] observed among 63 Chest CT cases, 53 cases with bilateral lung involvement and 10 cases showed unilateral lung involvement.

The frequency of lobe involvement in right lung of our study showed, upper lobe lung disease in 75

cases, middle lobe lung involvement in 51 cases and lower lobe in 77 cases. According to Adam Bernheim et al,^[13] the right upper lobe lung involvement found to be in 53 chest CT films, right middle lobe involvement in 50 cases and right lower lobe involvement in 76 cases out of 94 chest CT cases. As per Sudhir Bhandari et al,^[14] the frequency of lobar involvement in right lung showed, upper lobe changes in 30 cases, middle lobe involvement in 29 cases and lower lobe involvement in 42 cases out of 51 cases. Ming- Yen Ng et al,^[15] in his study observed that out of 21 chest CT findings, right upper lobe involvement in 14 cases, right middle lobe affected in 10 cases and right lower lobe involvement in 16 cases. This may be because of the innate anatomic features of the right inferior or lobar bronchus. The bronchus of right lower lobe of lung is straighter and steeper than other bronchial branches and angle between the right lower lobe and the long axis of the trachea is smaller, so in the early phase of the disease the virus is more likely to invade the branches of the right inferior lobar bronchus and cause infection.^[19]

In our study the left upper lobe involvement seen in 63 cases and left lower lobe changes observed in 72 cases. Ming –Yen Ng et al,^[15] found, left upper lobe involvement in 16 cases and left lower lobe involvement in 17 cases out of 21 chest CT cases. A study done by Adam Bernheim et al,^[13] reported left upper lobe changes in 58 cases and left lower lobe involvement in 76 cases out of 94 cases. As per Sudhir Bhandari et al,^[14] left upper lobe involvement found in 36 cases and left lower lobe in 43 cases out of 51 cases.

The current study showed, septal thickening found to be bilateral in 34 CT films and in right lung septal thickening noted in 6 cases. According to Jiong Wu et al,^[16] out of 76 positive CT films, septal thickening observed in 47 cases. A study reported by Sara Haseli out of 63 HRCT positive films, 4 cases presented with septal thickening.

The present study reported bilateral sub pleural bands in 10 cases, in 7 cases subpleural bands noted in right lung and 1 in left lung. According to Jiong Wu et al,^[16] out of 76 positive CT films, sub pleural bands observed in 16 cases. Sara Haseli et al,^[12] observed among 63 Chest CT cases, in 6 cases subpleural bands were reported.

The current study reported bronchiectasis bilaterally in 3 cases and in 1 cases bronchiectasis observed in right lung. According to Adam Bernheim et al,^[13] 73 cases found bronchiectasis in 1 case.

CONCLUSION

In the current study the distribution of age, gender, unilateral or bilateral involvement of lung, the lobar distribution of lesions and various other radiological abnormalities were found. Out of 100 HRCT films, the age group range from 61-70 yrs of patients were affected more with COVID -19, Males are more affected than females of which bilateral lung

involvement more common than unilateral (right lung involvement more than left lung disease), The classical lung manifestation such as ground glass opacities observed in more number of cases, followed by ground glass opacities with consolidation and further with only consolidation. Right lower lobe involvement was common than right upper/middle lobe. Left lower lobe disease common than left upper lobe. The septal thickening, subpleural bands and bronchiectasis were less specific CT findings.

Thus Chest CT plays an important role in diagnosing COVID-19 and assessment of severity of the disease. Our study throws a light on imaging abnormalities of lung in COVID-19 patients and helps in assessing the most frequently affected side of the lung, lobe involvement and also determines the relation between age, gender and morbidity of the disease. As it is an epidemic disease all the medical professionals and undergraduate students must be familiar with the structural changes that may occur in the lung. Hence a sound knowledge about the radiological anatomy of lung involvement in COVID-19 patients helps for timely and better management of the patients.

Summary: To summarize the present study titled, radiological Anatomy of lung in covid-19 patients using high resolution chest CT imaging – a cross sectional study” done on 100 RT-PCR positive cases with HRCT chest CT films, the findings include.

In 61-70 yrs of age group the number of individual affected were 27%, 41-50 yrs age group shows 22% of cases affected, 31-40 yrs showed 16% of cases, 21-30 yrs include 16% of cases, 51-60 yrs with 15% of cases, 71-80 yrs shows 3% cases and 91-100 yrs with 1% cases affected. In 59% of cases males were noted and the remaining 41% of cases observed were females. In 86% of cases RTPCR positive with lung involvement HRCT films noted and in 14% of cases without lung involvement observed. In 74% of cases with bilateral lung involvement, 10% with right lung involvement and in 2% cases with left lung involvement. In 56% of Ground glass opacities without consolidation, in 27% ground glass opacities with consolidation and in 3% of cases with only consolidation. In 77% of cases right lower lobe involvement, in 75% of cases right upper lobe involvement and 51 cases with middle lobe involvement. In 72% of left lung lower lobe and in 63% of cases left lung upper lobe involvement. In 34% of cases showed bilateral septal thickening and in 6% of cases with right lung septal thickening. In 10% cases subpleural bands observed in bilateral lungs, in 7% right lung subpleural bands and in 1% with subpleural bands in left lung. In 3% cases in bilateral lungs, bronchiectasis observed and in 1% case right lung bronchiectasis observed.

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