Original Research Article

HRCT Chest Imaging in Pediatric, Adult, and Geriatric COVID-19 patients, with analysis of clinical presentation – A study conducted in Odisha COVID Hospital, KIMS, India

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Abstract

Background: Coronavirus Disease 2019 (COVID-19), a severe acute respiratory syndrome documented as a pandemic by WHO, known to affect patients of all ages.**Purpose:** The purpose of our study is to characterize the HRCT chest features of COVID-19 patients and analyze the imaging pattern inpediatric, adult and geriatric patients.**Materials and Methods:** A cohort study of 1208 laboratory-confirmed COVID-19 and HRCT positive patients were undertaken, between May 1, 2020 to July 31, 2020. Patients were divided into 3 groups: Pediatric patients (6 to 18 years), Adults (18 to 60 years) and Geriatric patients (older than 60 years). The demographic, clinical, laboratory and HRCT chest findings were assessed and analyzed between the three groups.**Results:** A total of 1208 patients with laboratory confirmed COVID-19 infections were assessed. There was a male predominance overall with statistical difference where males are more common affected in adults (86.6%) in compare to pediatric (71%) and geriatric patients (70%). Most of the patients were asymptomatic or had mild symptoms, fever was the most common clinical presentation in pediatric (46.5%), adults (44%) and geriatric patients (52.8%). Increased C-reactive protein was noted in all the three groups with p-value<0.05. Geriatric patients have higher CT positivity (97.1%) and CT severity (10.59±6.7) in comparison to pediatric (66.6%, 4.04±4.6) and adult patients (79.4%, 5.96±6.5). Bilateral and peripheral sub-pleural distribution of pulmonary opacities was the most common pattern seen in both adults and pediatric groups, 56.7% and 50% respectively while diffuse and peripheral distribution predominance in geriatrics (45%) **Conclusion:** Pediatric, adult and geriatric patients showed distinctive clinical and CT chest finding with pediatric patients have relatively milder symptoms with higher prevalence of negative CTs and lesser extension on imaging while geriatric patients have more symptoms with higher prevalence of positive CTs and more extensive involvement in comparison to adult patients.

Keywords: COVID-19, pediatrics, adults, geriatrics, HRCT chest

Introduction

In December 2019, an outbreak of febrile lower respiratory infection of unknown etiology was reported in Wuhan city of China,which was later found to be caused by the novel Coronavirus, a severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2)[1]. Coronavirus disease (COVID-19) was declared a pandemic by WHO on March 11, 2020[2,3]. Coronavirus is known to affect patients of all age groups, like the other strains including severe acute respiratory syndrome (SARS), and Middle East respiratory syndrome (MERS) outbreak. Some of the patients with COVID-19 infections were asymptomatic or presented with non-specific symptoms like fever, cough, shortness of breath and generalized weakness[4,5]. High resolution computed tomography (HRCT) chest becomes a valuable diagnostic tool for identifying patients infected with COVID-19 in the early stage, where patients may be asymptomatic or with nonspecific pulmonary symptoms. World Health Organization (WHO) and Centre for disease Control and Prevention (CDC) have recommended CT as the major diagnostic tool in COVID-19 infection outbreak[6-9].

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HRCT chest may be used not only to confirm the disease but also to plan the treatment and to assess the prognosis of the disease Recently, demographic, clinical and radiological imaging studies of COVID-19 have emerged, but most of the available literature has been focused on adults with very few literature pertaining to geriatrics and children. The purpose of our study is to characterize the HRCT chest features of COVID-19 patients and analyze the imaging pattern in pediatric, adult and geriatric patients.

Material and methods

*Study Design:*A cohort study of 1208 COVID-19 patients who had undergone HRCT chest was undertaken and blindfolded to Radiologist with anonymized images, at the Odisha COVID Hospital, KIMS, between May 1,2020 to July 31, 2020. An exclusive CT Scanner was installed for this COVID Hospital for dedicated study and analysis, for appropriate patient management.

Patients: Ethical approval for our study was been obtained from the Institutional Ethical Committee, KIMS, Bhubaneswar. All the patients in this study group were positive for COVID-19 confirmed with real-time reverse transcriptase-polymerase chain reaction (RT-PCR).Samples were collected from the respiratory secretion obtained by the oropharyngeal and nasopharyngeal swab. The high resolution computed tomography (HRCT) of the chest was done within 3 days from the initial swab test. Patients younger than 6 years and pregnant patients were not included in our study. Patients with negative CT

findings and suboptimal scans due to motion artifacts or technical issues, also have been excluded. All the patients have been divided into three categories: patients under 18 years of age were considered as pediatric, between 18 to 60 years of age as an adult, while patients more than 60 years were included in the geriatric group.

Protocol of HRCT: High-resolution computed tomography (HRCT) chest was obtained using a multi-slice helical CT scanner (64 sliceSiemens 'SOMATOM go. Up'scanner) with SAFIRE (Sinogram Affirmed Iterative Reconstruction) software. All the scans were taken during end-inspiration with patients in the supine position without the use of intravenous contrast agents, from thoracic inlet level to bilateral costophrenic angle level at the lowest level. The imaging parameters for pediatrics: tube voltage- 100-110kV, effective mAs- 50-70mAs, pitch- 0.8, slice thickness- 0.5mm, interslice gap-0mm and for adult and geriatrics: tube voltage- 110-120 kV, effective mAs- 70-120mAs, pitch- 0.8, slice thickness-0.5mm, interslice gap-0mm.

Analysis of HRCT chest findings: Each of the patient's scan was evaluated for the presence of ground-glass opacities (GGO) which is due to filling of airspaces with preserved bronchovascular marking, consolidation (airspace opacification with the abutment of bronchovascular spaces), crazy paving (Ground-glass opacification with septal thickening), reverse halo (Consolidation surrounding ground-glass opacities) and soft tissue nodules. The laterality (bilateral or one lobe) along with the distribution of the pulmonary opacities (peripheral, central or diffuse) were also assessed. Other findings like subpleural curvilinear opacities, cavitation, pleural thickening, atelectatic changes, lymphadenopathy and presence of underlying lung disease like fibrosis, bronchiectatic changes or emphysema were also noted.CT findings were classified into 4 categories, proposed by the RSNA Expert Consensus Statement for COVID-19[10], as *Typical*, *Indeterminate*,*Atypical* and *Negative* (Table 1). A semi-quantitative CT severity score proposed by Pan et al was used to calculate based on a percentage of individual area involvement of lobes of both lungs and has been graded as Score 1 (<5%), Score 2 (5-25%), Score 3 (25-50%), Score 4 (50-75%) and Score 5 (75-100%)[11]

Table 1: RSNA Expert Consensus Statement for COVID-19 for COVID-19 pneumonia imaging classification

COVID-19 pneumonia Imaging classification	Rationale	CT Findings
Typical Appearance	Commonly reported imaging features of greater specificity for COVID-19 Pneumonia	Peripheral, bilateral, GGO* with or without consolidation or visible intralobular lines ("crazy-paving") Multifocal GGO of rounded morphology with or without consolidation or visible intralobular lines ("crazy-paving") Reverse halo sign or other findings of organizing pneumonia (seen later in the disease)
Indeterminate appearance	Nonspecific imaging features of COVID-19 pneumonia	**Absence of typical features and Presence of:** Multifocal, diffuse, perihilar or unilateral GGO with or without consolidation lacking a specific distribution and are non-rounded and non-peripheral distribution**.** Few very small GGO with a non-rounded and non-peripheral distribution
Atypical Appearance	Uncommonly or not reported features of COVID-19 pneumonia	**Absence of typical or indeterminate features and Presence of:** Isolated lobar or segmental consolidation without GGO Discrete small nodules (centrilobular, "tree-in-bud") Lung cavitation Smooth interlobular septal thickening with pleural effusion
Negative for pneumonia	No features of pneumonia	No CT features to suggest pneumonia
*GGO = ground glass opacity		

Statistical Analysis: The statistical analyses were performed in SSPS (version 21). Categorical variables were represented as a percentage of the total while continuous numerical variables were represented as mean ± standard deviation. The Chi-square test was used to test the difference in the categorical data between the three groups and a two-tailed p-value was calculated. P-value between the categorical data less than 0.05 indicated a statistically significant difference.

Results

Demographics: The study was conducted in 1208 COVID-19 positive patients, where the age ranges from 6 years to 97 years (mean, 38.52 ± *14.94 years*). There were 93 patients in the pediatric group (aged from 6 years to 18 years, mean: 15.21 ± *3.99 years*), 975 patients in the adult group (aged from 22 years to 60 years, mean: 36.64 ± *9.96 years*), and 140 patients in the geriatric group (aged above 60 years, mean: 66.85 ± *6.42 years*). Among the total studied COVID-19 patients were 1008 (83.4 percent) males and 200 (16.6 percent) females, with a ratio of 126:25 male-to-female. In pediatric, adult and geriatric groups the male-to-female ratio was 22:9, 6.4:1 and 7:3 respectively. There is a statistical difference found between the three groups in gender predisposition, with males are more commonly affected in the adult group compared to pediatric and geriatric patients (844/975, 86.6% vs 66/93, 71% vs 98/140, 70%, p=<0.001).

*Clinical Presentation:*Most of the patients admitted to our institution were asymptomatic or had mild pulmonary symptoms. Majority of the patients presented with fever (546/1208, 45.2%), cough (346/1208, 28.6%), sore throat (463/1208, 38.3%), dyspnea (120/1208, 10%) and weakness (72/1208, 6%). Less commonly presented were diarrhea (37/1208, 3%), vomiting and headache. In pediatric patients, fever was the most common symptom (41/93, 44%), followed by cough (20/93, 21.5%), sore throat (11/93,11.8%) and diarrhea (4/93, 4.3%) while in adult group, fever, sore throat, cough and diarrhea were seen in 46.5%(431/975), 40% (392/975), 29.9% (277/975) and 2% (20/975) respectively and in geriatrics, fever, sore throat, cough and diarrhea were seen in 52.8% (74/140), 42.8% (60/140), 35% (49/140) and 9.2% (13/140) respectively. Overall, sore throat was less commonly seen in pediatric aged patients in comparison to adult and geriatrics (11/93, 11.8% vs 392/975, 40% vs 60/140, 42.8%, p=0.00). No significant statistical difference was found between the three groups in clinical presentation including fever, cough and diarrhea (p=>0.05). The prevalence of increased C- reactive protein in pediatric, adult and geriatric groups was 37/93 (39.7%), 266/975 (27.2%) and 62/140

(44.2%) respectively. There was a significant difference between the three groups, geriatric patients with a high prevalence of increased C-reactive proteins (p=<0.001).

CT Positivity: CTs were abnormal in 97.1% (136/140) of geriatric patients, compared with 79.4% (775/975) in adult patients and 66.6% (62/93) in pediatric patients, resulting in a statistically significantly difference (p = <0.001).

CT Analysis: The imaging characteristics of 973 COVID-19 patients with positive CT findings, and the comparisons of CT features between pediatric, adult and geriatric patients are summarized in Table 2.

Table 2: Comparison of GGO and Consolidation in HRCT Chest in between pediatrics, adult and elderly COVID19 positive patients

CT DISTRIBUTION	Pediatric (%)	Adult (%)	Geriatric (%)	P-value
Bilateral Involvement	28/62 (45.1%)	434/775 (56.0%)	112/136 (82.3%)	**<0.001**
Number of lobes involved				
1 lobe	11/62 (17.7%)	144/775 (18.5%)	8/136 (5.8%)	**<0.001**
2 lobes	15/62 (24.2%)	158/775 (20.3%)	22/136 (16.1%)	0.37
3 lobes	4/62 (6.4%)	22/775 (2.8%)	5/136 (3.6%)	0.27
4 lobes	2/62 (3.2%)	23/775 (2.9%)	9/136 (6.6%)	0.09
5 lobes	14/62 (22.5%)	259/775 (33.4%)	82/136 (60.3%)	**<0.001**
Opacity distribution				
Peripheral	31/62 (50.0%)	440/775 (56.7%)	61/136 (44.9%)	**0.02**
Central	2/62 (3.2%)	23/775 (3%)	3/136 (2.2%)	0.95
Diffuse	13/62 (21%)	143/775 (18.5%)	62/136 (45.6%)	**<0.001**
Density				
GGO	43/62 (69.3%)	502/775 (64.7%)	112/136 (83.8%)	**<0.001**
GGO and Consolidation	2/62 (3.2%)	34/775 (4.3%)	2/136 (1.5%)	0.35
Consolidation	2/62 (3.2%)	13/775 (1.6%)	2/136 (1.5%)	0.91
Nodule without GGO and consolidation	3/62 (4.8%)	88/775 (11.3%)	6/136 (4.4%)	**0.03**
GGO Patterns				
Mosaic attenuation	7/62	103/775	15/136	
Crazy Paving	10/62	80/775	25/136	
With surrounding consolidation	5/62	122/775	27/136	
Reverse Halo	3/62	31/775	4/136	
Associated Findings	32/62 (51.6%)	176/775(22.7%)	56/136(41.1%)	**<0.001**
CT severity score	4.04±4.6	5.96±6.5	10.59±6.7	

Note: All the data are presented as counts with percentage of the total or mean ± standard deviation. Chi-square test was used for the nominal variable. Bold values indicate statistically significant difference. A two-tailed p-value <0.05 indicates statistical significance. *P<0.05(n=62, n=775, n=136, CT negative in 31 children, 200 in adults and 4 in geriatric)

The bilateral involvement of lungs in geriatric patients was seen in 82.3% (112/136) which was significantly higher when compared to 42.1% (28/62) of pediatric patients and 56% (434/775) of the adults (p = <0.001). Pulmonary opacities including ground-glass opacities (GGO) and consolidation involving the number of pulmonary lobes were significantly higher in geriatric patients when compared to pediatric and adult patients (p= <0.001). Peripheral sub-pleural distribution was the most common pattern seen in both adults and pediatric groups, 56.7% (440/775) and 50% (31/62) respectively. In geriatric patients, there was an almost equal distribution of parenchymal opacities in a diffuse and peripheral region of lobes (approximately 45%). Central distribution was the least common pattern and no significant difference was seen in all the three groups, 3.2% (2/62) of the pediatric, 3% (23/775) of the adult and 2.2% (3/136) of the geriatric patients (p=0.09)In the *pediatric* age group, GGO was the common CT feature (43/62, 69.3%), followed by both GGO with consolidation and only consolidation without GGO (2/62, 3.2%). In adults, GGO accounted for 64.7%(502/775), followed by GGO with consolidations 4.3% (34/775) and consolidation without GGO 1.6% (13/775). In the geriatric group, GGO seen in 83.2% (112/136), both GGO with consolidation and consolidation without GGO occurred in 1.5% (2/136) of the CTs. Nodular opacities were seen in 11.3% (88/775) of the adults which were significantly higher than in pediatric (3/42, 4.8%) and geriatric patients (6/136, 4.4%) (p=0.03). The distribution of pulmonary opacities between pediatric, adult and geriatric patients have been illustrated in Figure 1(A).Other associated abnormalities include atelectatic changes, subpleural linear opacities, lymphadenopathy, bronchiectasis, emphysematous change, cavitation and pleural effusion as described in Table 3.

Table 3: Comparison of associated features on CT: pediatric, adult and geriatric groups

Associated features	Pediatric (%)	Adult (%)	geriatrics (%)
ATelectatic	20/62 (32.2%)	191/775 (24.6%)	33/136 (24.2%)
Lymphandenopathy	4/62 (6.4%)	48/775 (6.2%)	11/136 (8.0%)
BRonchiectatic	3/62 (4.8%)	24/775 (3.1%)	4/136 (2.9%)
Subpleural linear opacities	2/62 (3.2%)	28/775 (3.6%)	2/136 (1.4%)
PNEUMOthorax	1/62 (1.6%)	2/775 (0.2%)	0/136 (0%)
Pleural effsuion	1/62(1.6%)	18/775 (2.3%)	4/136 (2.9%)
EMPHYsema	0/62 (0%)	35/775 (4.5%)	30/136 (24.2%)
CAVITation	0/62 (0%)	2/775 (0.2%)	0/136 (0%)

Note: No fatal cases in all the three groups; all the data are presented as counts with percentage of the total

The most common associated feature in all the three groups observed was atelectatic changes (32.2% of the pediatric, 24.6% of the adults and 24.2% of the geriatrics). Sub-pleural linear opacities were documented in 3.2% (2/62) of the pediatrics, 3.6% (28/775) of the adults and 1.4%

(2/136) of the geriatric patients. There was no statistical significance seen in three groups concerning associated features (p>0.05). Also, CT severity scores were significantly higher in geriatrics (10.59±6.7) when compared with adults (5.96±6.5) and pediatrics (4.04±4.6) (p<0.001). The CT staging among the three groups described in Figure 1(B).

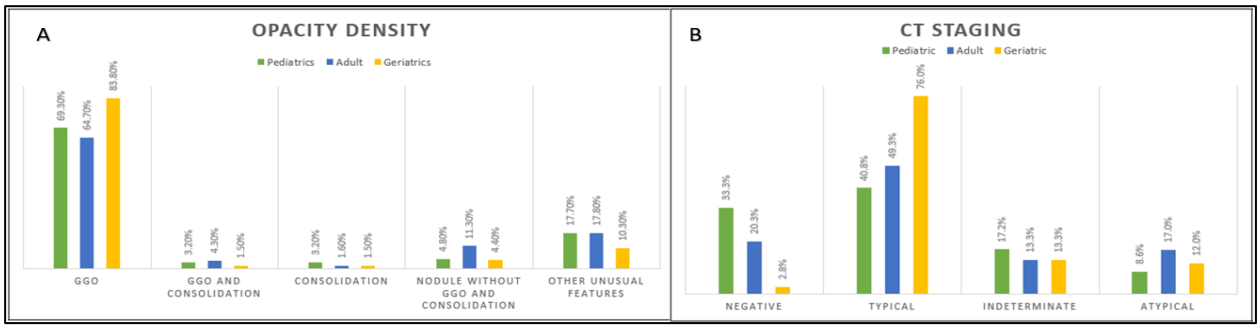

Fig 1:CT Opacity density distribution and Staging between pediatric, adult and geriatric patients

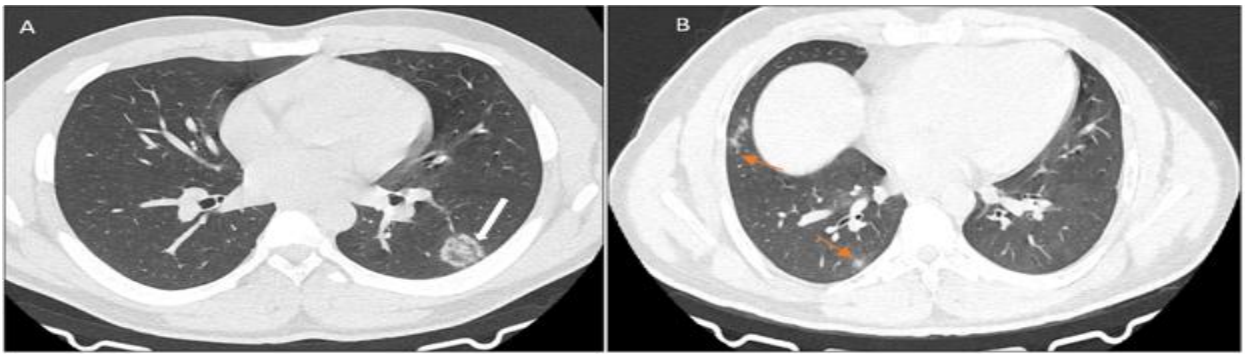

Fig 2: Axial section through HRCT chest in 36-year-old patient reveals (A) rounded subpleural GGO with reverse halo (white arrow) in superior segment of left lower lobe and (B) patchy subpleural GGO (orange arrow) in the basal segments of right lower lobe in the same patient

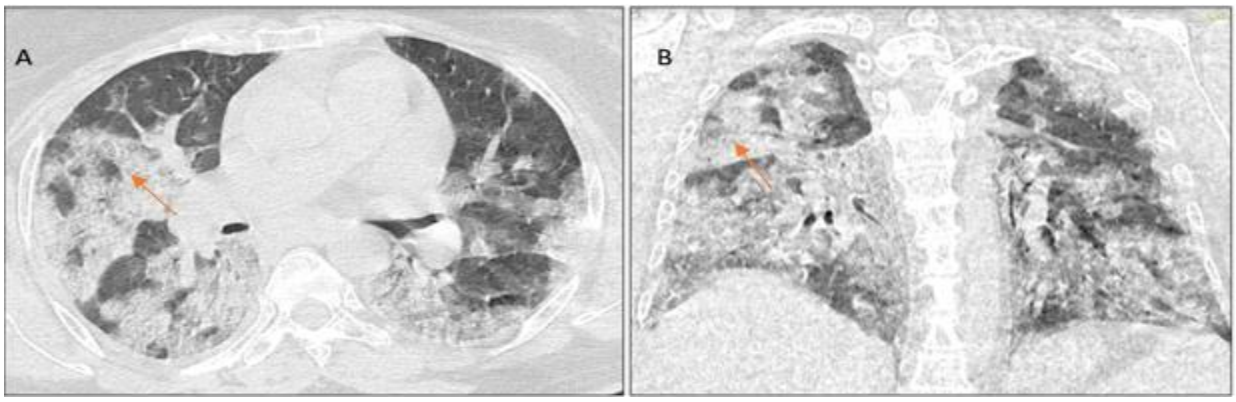

Fig 3: HRCT chest in a 63-year-old male patient A) axial and B) coronal section showing patchy central and diffuse areas of GGO with septal thickening (crazy paving-orange arrow)

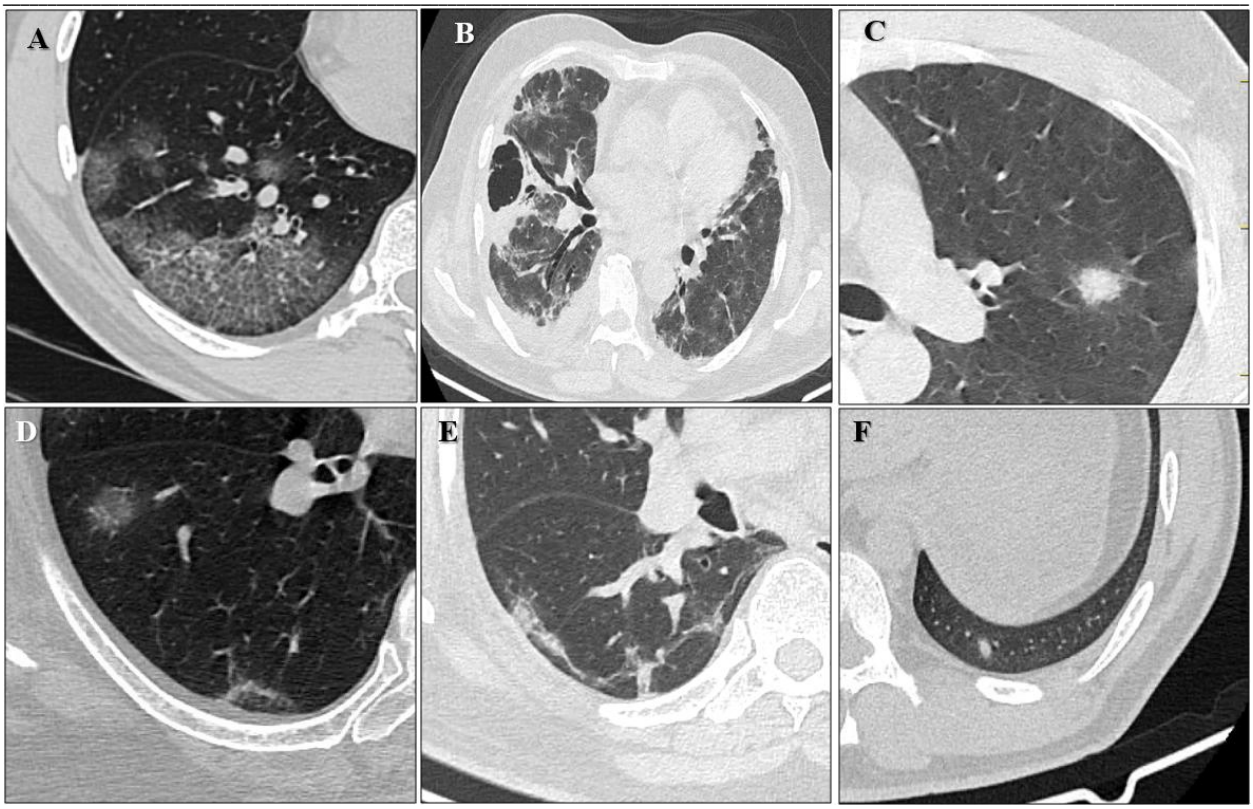

Fig 4:Axial section through HRCT reveals (A) patchy peripheral GGO with crazy paving in right lower lobe, (B) diffuse GGO with a cavitatory lesion with surrounding consolidation in the lateral segment of right middle lobe, (C) rounded consolidation with surrounding GGO (Halo sign) in superior lingular segment, (D) rounded GGO in the anterobasal segment of right lower lobe, (E) subpleural curvilinear band-like opacities in the superior segment of right lower lobe and (F) subpleural GGO nodule in the posterobasal segment of left lower lobe

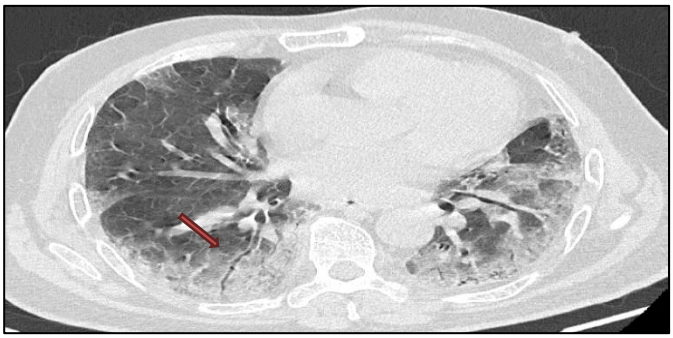

Fig 5 :Axial section through HRCT chest in a 66-year-old male patient shows bronchus deformation due to patchy fibrotic lesion (arrow)

Discussion

Novel coronavirus causes viral pneumonia is highly infectious and contagious. In our cohort study of COVID-19-positive pediatric, adult and geriatric patients, we observed the predominance of males in all three age groups, like in the previous study, where 57% of pediatric males, 59% of adult males and 57% of geriatric males were affected[12,13]. We speculate this preponderance due to the admission of a large proportion of male migrant workers who had either a travel history or had incidental exposure.Most of the patients were asymptomatic or have milder symptoms. Fever, sore throat, cough and weakness were the common clinical presentations among the three groups. However, we also noted that the sore throat was relatively more common in adult (40%) and geriatric patients (42.8%) compare to pediatric patients (11%). All the clinical picture was reported in previous studies after the SARS and MERS outbreak, which was also caused by the different strains of coronavirus[14-16]. In a few cases, other symptoms like diarrhea, vomiting and headache were also reported which was not reported in previous studies, could to the difference in patient population or previously smaller sampled groups. Like other previous studies, C-reactive protein level appears

to be raised in the three groups[17]. According to clinical severity classification proposed by COVID-19 guidelines (Trial version 6) in China[18], pediatric patients were more likely to have milder symptoms with a higher proportion of normal CTs while geriatric patients likely to have a more severe presentation and a higher proportion of abnormal CTs with more extensive involvement of lung parenchyma in comparison to adult patients. This accordance was noted in our cohort study also where 97% of geriatric chest CT and 79.4% of adult chest CT were abnormal.With the sensitivity of as low as 60% and poor availability of RT-PCR kits, the urgent need for an alternative diagnostic tool has given rise to the possibility of utilization of chest CT findings as a diagnostic aid and a screening tool in suspected patients[19,20]. Although the evidence-based role of HRCT in COVID-19 management is lacking, the use of non-contrast CT for the diagnosis, severity assessment and monitoring of disease progression for COVID-19 is still advocated by the current guidelines of the American College of Radiology[21]. In our study we also observed significant pulmonary opacities in many patients who were asymptomatic throughout the disease course or presented with milder symptoms. Therefore, optimal use of CT recommended balancing the benefit vs radiation risk against the common scenario of milder clinical disease or even asymptomatic patients.In concordance with the several recent reports on chest CT in COVID-19 positive patients, in pediatric, adult and geriatric groups, radio-opacities involved multiple lobes in both lungs with predominant sub-pleural and peripheral distribution[22].A smaller proportion of COVID-19 patients with chest CT show central distribution. The explanation for this distribution is still unclear which may be cleared by histological studies. It was also noted that pulmonary opacities were seen involving all the lobes of both lungs in geriatric patients (60.3%) in comparison to adult (33.4%) and pediatric patients (22.5%) where we observed less extensive lobar involvement.Our study has shown that most of the patients in the three groups have ground-glass opacities with or without consolidation (72.5%, 69% and 83.8% respectively)[19-22]. Unlike the previous studies, pure ground-glass opacities were most finding reported in pediatric (69.3%), adult (64.7%), and geriatric patients (83.7%). We speculate this finding due to differences in the day of hospital admission and milder form of viral strain which is still unclear. The only consolidation was seldom seen in all the three grous[2]. As the disease progresses, different patterns of ground-glass opacities like mosaic attenuation, crazy paving (figure 3,4A) and reverse halo (figure 2) were seen involving the lung parenchyma in the three groups. Pediatric patients are likely to have less extensive lung parenchymal involvement (mean CT severity score = 4.04) while geriatric patients have extensive involvement (mean CT severity score = 10.59) in comparison to adult patients (mean CT severity score = 5.96). Several other associated features were also noted along with the ground-glass opacities, of which atelectatic changes and reticular opacities was the common finding followed by lymphadenopathy, bronchiectatic changes and sub-pleural linear opacities among the pediatric, adult and geriatric patients (figure 4,5). Similar associated chest findings in patients with COVID-19 infection were also reported in a few of the recent reports[13].There were several pitfalls in our study. First, the proportion of pediatric and geriatric patients studied in our study were comparatively smaller than that of the adult group. Second, we could not control certain geographic factors as most of the patients studied were migrants who had admitted to returning from different states. However, this geographic variation helps in reflecting the common imaging scenario in India. Third, all the clinical and imaging features were analyzed in the initial days of hospitalization, which need clinical and imaging follow-up to look for the disease course. Due to a lack of prior imaging, most of the available literature has not considered pre-existing ILD patterns in COVID-19 patients. Last, we have not to correlate our findings with the co-morbidities of the patients if any.In conclusion, our study reveals that pediatric patients with COVID-19 infection have relatively milder symptoms with a higher prevalence of negative CTs and lesser extension on imaging while geriatric patients have more symptoms with higher prevalence of positive CTs and more extensive involvement in comparison to adult patients. The most common characteristic chest CT features in COVID-19 patients are ground-glass opacities with or without consolidation with peripheral distribution and bilateral involvement of lungs. The differential characteristic may be related to different immune status among pediatrics, adults and geriatrics and also to the disease course. However, imaging of the chest CT in COVID-19 patients is preliminary and unknown aspects need to be further studied.

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