Original Research Article

CT Severity Scoring Index and Chest Radiography findings in COVID-19 cases in Pediatric and Adolescent age group- A Retrospective analysis

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Abstract

Background: The initial cases of novel corona virus reported in Wuhan city in December 2019. Then it became global outbreak. The World Health Organization (WHO) on March 11, 2020, declared the novel coronavirus (COVID-19) outbreak a global pandemic[1,2]. The disease had spread to more than 150 countries around the world and the death number has constantly increased. Most of pediatric patients were initially asymptomatic. Transmission in children is critical problem. Radiological manifestation varies between age group. We aimed to determine radiographic chest finding in pediatric COVID-19 in tertiary Centre. **Aim:** To evaluate CT Severity Scoring Index and Chest X Ray findings in COVID-19 cases in Pediatric and Adolescent age group. **Methods:** 54 patients of pediatric and adolescent age (up to ≤18yrs) with RT-PCR positive who were admitted in our tertiary centre were retrospectively included in this study. CT scan and chest radiographic data of the patients were collected from medical records. The data was summarized. The CT chest and chest radiographic pattern of COVID 19 positive in pediatric and adolescent age group of ≤ 18yrs were analyzed. **Results:** 54 patients were admitted in our hospital with COVID-19during study time. CT chest was done in 42 patients and Chest radiograph was done in all 54 patients. Characteristic CT findings were ground-glass opacities or consolidation and combination of both. Ground-glass opacities 15/21 (71.4%) were more often encountered in our study, and when consolidation opacities were identified, they were most of time accompanied by a ground-glass opacity 5/21(23.8%). Chest radiograph finding was ground glass opacity. Lower lobes were most commonly involved in both modalities. Female and male patients were infected with equal frequency. Apart from above pattern in CT, linear opacity, crazy paving pattern, halo sign and reverse halo sign also noted in some patients. Majority of patients showed peripheral distribution of opacities. **Conclusion:** This review of available studies of COVID-19 pneumonia in pediatric patients provides insight into CT imaging findings of the disease in this specific population. The most common CT and Chest radiographic findings were ground-glass opacities typically with lower-lobe predominance. Our findings were matching with previous studies. Severe category of lung involvement was seen in few case but had full recovery. Chest CT can be employed in the early diagnosis and management of selected symptomatic pediatric patients, if clinically warranted.

Keywords: CT Severity Scoring Index, Chest Radiography findings, COVID-19, Pediatric, Adolescent

Introduction

The initial cases of novel corona virus reported in Wuhan city in December 2019. Then it became global outbreak.

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The World Health Organization (WHO) on March 11, 2020, declared the novel coronavirus (COVID-19) outbreak a global pandemic[1,2]. SARS-CoV-2 can spread through both direct means (droplet and human-to-human transmission) and by indirect contact (contaminated objects and airborne contagion). Droplets typically cannot traverse more than six feet (almost two meters) and remain in the air for a limited time. However, SARS-CoV-2 remains intact and contagious in droplets (less than five microns in diameter) and can be suspended in the air for up to three hours. The spread of SARS-CoV-2 from asymptomatic individuals (or individuals within the incubation period), without any radiological findings, has also been reported [3].

Clinical manifestations differ with age. In general, older men (>60 years old) with co-morbidities are more likely to develop severe respiratory disease that requires hospitalization or even die, whereas most young people and children have only mild diseases (non-pneumonia or mild pneumonia) or are asymptomatic. On infection, the most common symptoms are fever, fatigue and dry cough. Less common symptoms include sputum production, headache, hemoptysis, diarrhea, anorexia, sore throat, chest pain, chills and nausea and vomiting in studies of patients in China. Most people showed signs of diseases after an incubation period of 1–14 days (most commonly around 5 days), and dyspnea and pneumonia developed within a median time of 8 days from onset of illness[4].

In contrast with infected adults, most infected children appear to have a milder clinical course[5]. Fever, cough and sore throat were the most common symptoms of COVID-19 after SARS-CoV-2 infection in children. Children typically present as a mild or moderate upper respiratory tract infection which is rarely severe or critical[6]. Probably due to lower frequencies of exposure to SARS-CoV-2 and less matured angiotensin-converting enzyme-2 receptors[7].

Chest CT imaging plays a valuable role in the screening and dynamic evaluation of patients with COVID-19. Most patients with COVID-19 have typical CT imaging features of multiple ground glass opacities (GGO) and/or consolidation in a peripheral distribution, which also reflects the severity of pulmonary inflammation. We assumed the CT chest features and dynamic changes may serve as an important biomarker for the risk stratification, prognosis prediction, and therapy decision of severe patients with COVID-19[8]. These studies mainly focused on adult cases. We assume CT findings can play important role in rapid and accurate diagnosing of COVID 19 in pediatric population.

It seems that SARS-CoV-2 is less common in children and adolscent than in adults. SARS-CoV-2 may result in multisystem inflammatory syndrome in children associated with fever, severe illness, the involvement of two or more organ systems in presence of increased inflammatory markers which may be caused by the post infectious immune dysregulation. Transmission from children to older family members would be a critical problem for older family members owing to the reported higher frequency of severe illness. Additionally, the number of the affected children who are asymptomatic especially in the initial phases of the COVID-19 increases in the setting of family clusters[7].

Most of clinical and radiological findings focused on adult patients. Chest radiography findings vary with age group. In this study, we analyzed radio graphic manifestation ≤18yrs. Facing this unknown and emerging pathogen, we aimed to collect current evidence about COVID-19 in children and adolescents.

Aim

To evaluate CT Severity Scoring Index and Chest X Ray findings in COVID-19 cases in Pediatric and Adolescent age group.

Material and methods

Study design and participants

In this retrospective study, we included patients of age group below 18yrs with RT-PCR positive and cases of COVID-19 who admitted between 1 April 2021 and 31 may 2021 in J K Hospital and LN Medical College & Research Institute Bhopal (MP).

Inclusion criteria

1. All admitted patients of age group below 18yrs with RT-PCR positive report.

Exclusion criteria

1. Any admitted patients of age group above 18yrs with RT-PCR positive report.
2. Any patients of age group below 18yrs with RT-PCR negative report.

Definitions

Radiological diagnosis of COVID-19 disease

CT imaging is more reliable, feasible, and rapid method to diagnose and assess COVID-19 in comparison to RT-PCR[9,10]. We used chest radiography or CT chest for disease evaluation.

Chest CT acquisition

All chest scans images were obtained with one CT system (Optima 660, GE). The patients were scanned in supine position during breath holding. The main imaging parameters were: tube voltage = 120 kVp, automatic tube current modulation (30-70 mAs), pitch = 0.99-1.22 mm, matrix = 512 x 512, slice thickness = 10 mm, FOV = 350 mm X 350 mm. All images were then reconstructed with a slice interval of 0.625 to 1.250 mm.

CT image analysis [11]

All CT images were analyzed by three chest radiologists in consensus. The main features of CT images were described as the following four patterns: ground glass opacity, consolidation, ground glass opacity with consolidation and other (linear opacities, crazy paving, halo and reverse halo sign). Each of the twenty segments of six lung lobes was visually scored for the degree of lung involvements using a 2-point scale: 0, no involvement; 1, < 50% segment involvement; 2, > 50% segment involvement. The total CT severity score (the extent of pulmonary disease) was the sum of the twenty segments of six lobes of lung and defined as follows: 0, none; < 13, mild; 13-19.5, moderate; > 19.5, severe involvement of lung (white lung)[12]. Table [1]

Table 1:CT severity scoring index[12]

RIGHT LUNG SEGMENTS	SCORE	LEFT LUNG SEGMENTS	SCORE
UPPER LOBE – APEX	0	UPPER LOBE – APEX	0
UPPER LOBE – ANTERIOR	0	UPPER LOBE – ANTERIOR	0
UPPER LOBE – POSTERIOR	0	UPPER LOBE – POSTERIOR	0
MEDIAL MIDDLE LOBE	0	SUPERIOR LINGULA	0
LATERAL MIDDLE LOBE	0	INFERIOR LINGULA	0
LOWER LOBE - SUPERIOR	0	LOWER LOBE - SUPERIOR	0
ANTERIOR BASAL	0	ANTERIOR BASAL	0
POSTERIOR BASAL	0	POSTERIOR BASAL	0
MEDIAL BASAL	0	MEDIAL BASAL	0
LATERAL BASAL	0	LATERAL BASAL	0
RIGHT LUNG TOTAL	**0**	**LEFT LUNG TOTAL**	**0**
CT Severity Score – 0/40 (0 % Lung Involvement)			

Score Guide **Total score=40**

Area of involvement	Score
No involvement	0
< 50% Involvement	1
> 50% Involvement	2

CT Severity Score: -

Severe: - > 19.5 > 50% Lung Involvement

Moderate: -	13 – 19.5	30 – 50% Lung Involvement
Mild: -	<13	< 30 % Lung Involvement

Chest Radiograph acquisition

All examinations were obtained using a fixed and portable X-ray device (Allenger line frequency X-ray machine 100CBM) reserved for the COVID-19 outbreak in the pandemic unit. Single view postero anterior chest radiography examinations were performed in an erect posture with breath-hold in cooperative patients. Respiratory or motion artifacts preventing the evaluation were not observed on the radiographs of the patients who could not hold breath. Therefore, all examinations were included for investigation. The exposure dose was adjusted based on the patient's age and weight, varying between 55kVp, 5 mAs, and 100 kVp, 100 mAs.

Results

Table 2: Age and Sex distribution of patients

Age group (years)	Sex	Number	Total
0–2	M	1	4
	F	3	
3-4	M	2	3
	F	1	
5-6	M	3	4
	F	1	
7-8	M	1	2
	F	1	
9-10	M	3	5
	F	2	
11-12	M	3	10
	F	7	
13-14	M	4	6
	F	2	
15-16	M	3	5
	F	2	
17-18	M	8	15
	F	7	
total			54

CT Chest Findings

Table 3: CT Chest Findings

Observation	No. (%) of patients
No. of lobes affected	
1	5 (23.8%)
2	7 (33.3%)
3	5 (23.8%)
4	3 (14.3%)
5	1 (4.8 %)
6	0 (0%)
Opacities	
Ground-glass opacities with consolidation	5 (23.8%)
Ground-glass opacities only	15 (71.4%)
Consolidation only	1 (4.8%)
Frequency of lobe involvement	
Right upper lobe	4 (19 %)
Right middle lobe	5 (23.8%)
Right lower lobe	15 (71.4%)
Left upper lobe	3 (14.3%)
Left lingular lobe	4 (19%)
Left lower lobe	16 (76.2%)
Total CT severity score, mean (range)	8.3
Opacification distribution and pattern	
Rounded shape	7 (33.3%)
Linear opacity	2 (9.5%)
Crazy paving pattern	5 (23.8%)
Reverse halo sign	1 (4.8%)
Halo sign	4 (19 %)
Peripheral distribution	14 (66.6 %)
Cavitation	0

Other findings	
Discrete pulmonary nodules	0
Pleural effusion	1 (4.8%)
Lymphadenopathy	1 (4.8%)
Pulmonary fibrosis	0

CT chest was done in 42 patients out of total 54 patients.

Presence of abnormalities

21 of 42 patients (50%) had normal CT findings without ground-glass opacities or consolidation. 21 of 42 patients (50%) had positive chest CT findings (Table 2), with ground glass opacities, consolidation, or both findings observed in at least one lobe.

Types of abnormalities

Of the 21 patients with positive CT findings, 15 (71.4%) had ground-glass opacities only (with no consolidation), one patient (4.8%) had consolidation in the absence of ground-glass opacities, and 5 (23.8%) had both ground-glass opacity and consolidation. A crazy paving pattern was identified in five patients (23.8%), and a reverse halo sign was identified in one patient (4.8%). A halo sign was also identified in 4 patients (19%).These signs were seen in patients older than 13 years old who underwent CT at least 6 days after symptom onset, with no sex predilection noted. Fourteen patients (66.6%) had findings with a peripheral lung distribution. Pleural effusion seen in one patient (4.8%) and lymphadenopathy seen in one patient (4.8%). Findings that were absent in all patients included pulmonary nodularity and fibrosis.

Extent of abnormalities

Five patients (23.8%) had opacities in one lobe, seven (33.3%) had opacities in two lobes, five (23.8%) had opacities in three lobes, three (14%) had opacities in four lobes, one (4.8%) had opacity in five lobe and no patients had disease affecting all six lobes including lingular lobe. The lower lobes were most commonly involved and were affected in 16 of 21 patients (76.2%). Of note, the crazy paving pattern, halo sign, and reverse halo sign were seen exclusively in the lower lobes. The right upper lobe was involved in 4 patients (19%), the right middle lobe was involved in 5 patients (23.8%), the right lower lobe was involved in fifteen patients (71.4%), the left upper lobe was involved in three patients (14.3%), left lingular lobe was involved in 4 patients (19%) and the left lower lobe was involved in sixteen patients (76.2%) and a mean severity score of 8.

Chest Radiograph findings

Table 4: Character patients with positive findings

S.No.	Age	Sex	Symptoms	CT severity score	Chest radiograph findings (zone wise)
1	18	M	Fever and cough	12	Bilateral lower and right middle zone opacity
2	18	F	Fever and cough	10	Bilateral lower zone opacity
3	11	F	Fever sore throat	5	Right lower and left middle zone opacity
4	11	M	Fever	8	Bilateral lower zone opacity
5	18	M	Fever and cough	7	Bilateral lower zone opacity
6	9	M	Sore throat	4	Normal
7	16	M	Fever and cough	7	Bilateral lower and left upper zone
8	15	M	Fever ad cough	6	Bilateral middle and left lower zone
9	12	F	Fever and sore throat	4	Normal
10	6	M	Sore throat	2	Lt lower zone
11	18	M	Sore throat	19	Bilateral lower and right middle
12	14	F	Fever and sore throat	20	Bilateral lower bilateral upper and left middle zone opacity
13	10	M	Fever and cough	6	Bilateral lower
14	17	F	Fever and dyspnea	18	Bilateral lower zone and bilateral middle zone opacity
15	17	F	Fever and cough	4	Rt lower zone opacity
16	8	M	Fever and cough	3	Normal
17	3	M	Fever	2	Normal
18	5	F	Fever and sore throat	2	Normal
19	17	F	Fever and dyspnea	30	Bilateral lower middle and upper zone
20	2	M	Fever	2	Normal
21	7	M	Fever and cough	3	Left lower zone

Table 5:Chest Radiograph findings

Parameter		0 -6 years (n=4) Number (percentage, %)	7- 12 years (n=7) Number (percentage, %)	13 -18 years (n=10) Number (percentage, %)
Number of patients with opacity		1	4	10
Zone wise Location of opacity	Right upper	-	-	2
	Right middle	-	-	5
	Right lower	-	4	9
	Left upper	-	-	3
	Left middle	-	1	4
	left lower	1	3	9

Chest radiography examination results are given in Table 4. Abnormal findings on chest radiography were depicted in 15/54 (27.8%) of the patients, one in 0 – 6 years, 4 in 7 – 12 years, and 10 in 13-18 years of age group. Bilateral lower lobe opacity 10/15(66.6%) was most common finding in our study. No significant differences were found regarding left or right lower lobe involvement. Six patients with normal chest radiography showed positive CT chest findings.

Discussion

The CT findings for children with COVID-19 may be normal, as seen in 21 of 42 patients (50%) in our study. Patients with positive CT findings in our study had characteristic findings, including airspace disease, which can present as ground-glass opacities or consolidation and combination of both and may involve one or more lobes. Ground-

glass opacities 15/21 (71.4%) were more often encountered in our study, and when consolidative opacities were identified, they were most of time accompanied by a ground-glass opacity 5/21(23.8%). Of note, pleural effusions and lymphadenopathy were seen in one patient each (4.8%). Five patients (23.8%) had opacities in one lobe, seven (33.3%) had opacities in two lobes, five (23.8%) had opacities in three lobes, three (14%) had opacities in four lobes, one (4.8%) had opacity in five lobe and no patient had disease affecting all six lobes including lingular lobe. Frequency of lobe involvement in our study as right upper lobe involved in 4 patients (19%), right middle lobe involved in 5 patients (23.8%), right lower lobe involved in 15 patients (71.4%), left upper lobe involved in 3 patients (14.3 %), left lingular lobe involved in 4patients (19%) and left lower lobe involved in16 patients (76.2%). Average CT severity score was 8.3. Distribution and pattern of opacity was 7 patients (33.3%) had rounded shape opacity,2 patients (9.5%) had linear opacity, 5 patients (23.8%) had crazy paving pattern, 4 patient (19%) had halo sign, one patient (4.8%) had reverse halo sign and 14 patients had (66.6%) had peripheral distribution of opacity. Cavitation and pulmonary fibrosis was not seen in any patients. These characteristic CT features are consistent with the typical findings published in the Radiological Society of North America's expert consensus statement on reporting chest CT findings in adults with COVID-19, including peripheral and bilateral ground-glass opacities, a crazy paving pattern, and a reverse halo sign[13].Chest radiographic findings in our study was normal in most of the covid 19 positive children (72.2%). Abnormal findings on chest radiography were depicted in 15/54 (27.8%) of the patients, one in 0 – 6 years, 4 in 7 – 12 years, and 10 in 13-18 years of age group. Bilateral lower lobe opacity was most common finding in our study. No significant differences were found regarding left or right lower lobe.

On Comparison of CT and chest radiography in our study, female and male patients were infected with equal frequency. Lower lobes were most commonly involved in both modalities. Frequency of left and right lower lobe was approximately same. Furthermore, in our study, there was a correlation between increasing age and increasing CT severity score. However, the association between imaging severity and clinical symptoms has not been definitively established. In our study chest radiography was done in all 54 patients, among them only 15 (27.8 %) patients had positive finding. And CT chest was done in 42 patients out of 54 patients and positive finding were found in 21 patients (50%). Six patients with normal chest radiograph had positive CT findings, also indicate CT is more sensitive for diagnosing COVID 19 findings in pediatric age group.

Recognizing the common CT pattern and distribution of findings of COVID-19 in children is crucial for prompt isolation and disease containment. Although children have milder symptoms overall, severe cases do occur in the pediatric population[14,15]. Identifying these patterns and signs can help radiologists to distinguish COVID-19 pneumonia from other diseases such as a lobar pneumonia, which is more likely to present as consolidation rather than ground-glass opacity and is likely contained to a single lobe. in the United States and elsewhere, and with rRT-PCR having a reported sensitivity of 60–89% compared with 98% for chest CT[15-18]. Many have proposed chest CT as an important component of the diagnostic algorithm for adults and children with suspected COVID-19, especially in settings where disease prevalence is high and the availability of PCR testing is low[19,15]. If chest CT is deemed necessary, additional workflow complexities must be addressed. Clinicians, CT technologists, and chaperones for young pediatric patients need to use appropriate precautions during patient contact, including hand hygiene, airborne measures (N95 respirator masks), and contact precautions as described by the Centers for Disease Control and Prevention[20]. Cleaning of all imaging equipment and rooms is an important and limiting factor, and appropriate use of infection control measures is necessary to prevent transmission to health care workers. Of importance, when these findings are encountered on pediatric CT, the radiologist must notify the referring physician as well as CT technologists and nursing staff. This will ensure initiation of the proper sanitization protocols in the CT suite and patient areas, notification of staff who may have been exposed, and prompt isolation of the patient.

Images of representative cases–

1(a) **1(b)**

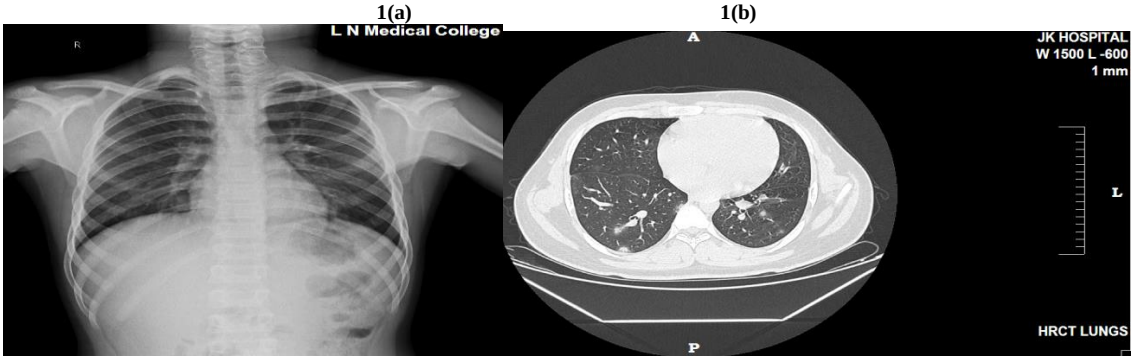

Fig 1(a)-Chest radiograph of 12yrs old RTPCR positive patient showing normal findings. 1(b)-HRCT of same patient showing multiple discrete patches of GGO seen in both lower lobes. CT severity score; 5 (Mild lung involvement).

2(a) **2(b)**

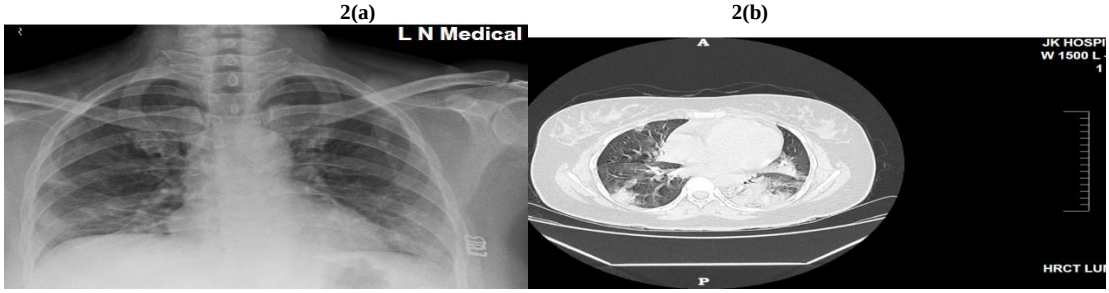

Fig 2(a)-Chest radiograph of 18yrs old RTPCR positive patient showing GGO in bilateral lower zone and middle zone. 2(b)- HRCT of same patient showing multiple discrete and confluent patches of GGO seen in both lower lobes, left lingular lobe and right middle lobe. CT severity score; 10 (Mild lung involvement).

3(a) 3(b)

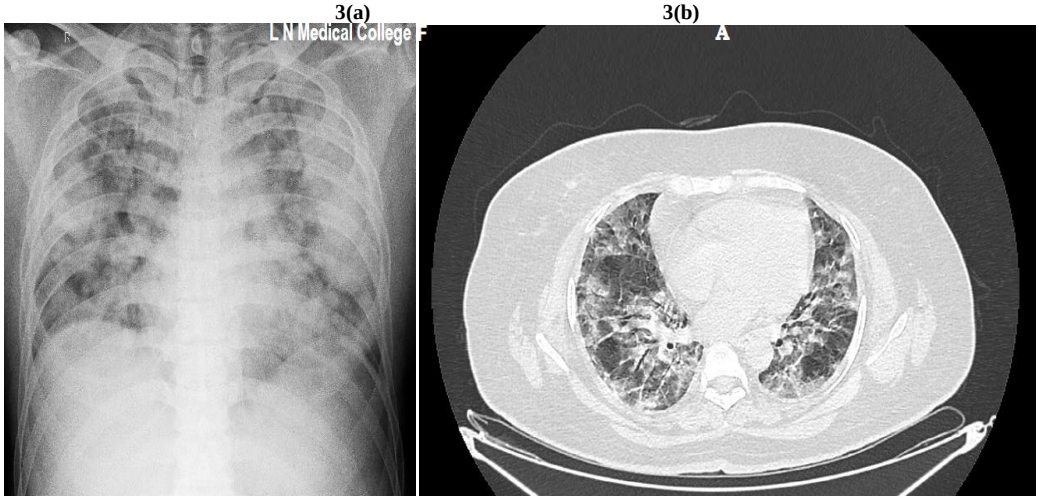

Fig 3(a)-Chest radiograph of 17yrs old RTPCR positive patient showing GGO in bilateral upper, middle, and lower zone. 3(b)-HRCT of same patient showing multiple discrete and confluent patches of GGO and consolidation seen in both lung. CT severity score; 30(Severe lung involvement).

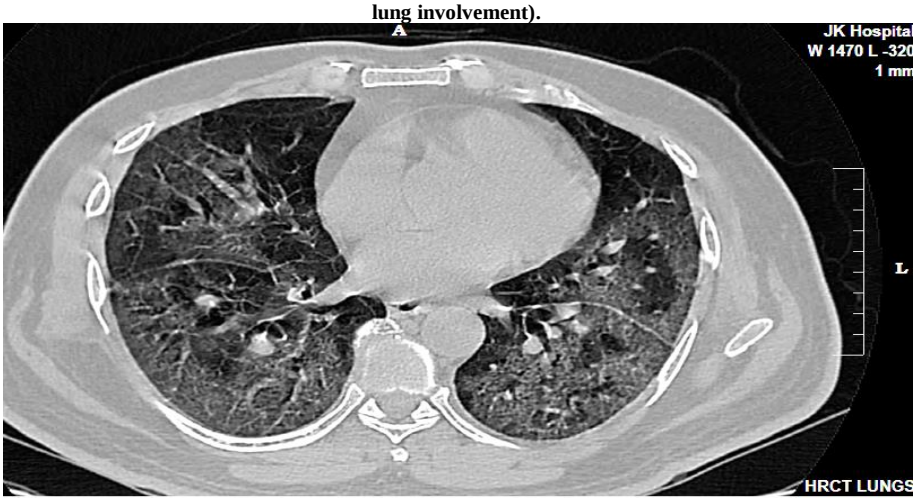

Fig 4-HRCT Chest of 14yr old RTPCR positive patient showing multiple confluent patches of GGO with crazy paving appearence. CT severity score; 20 (Moderate lung involvement).

5(a) 5(b)

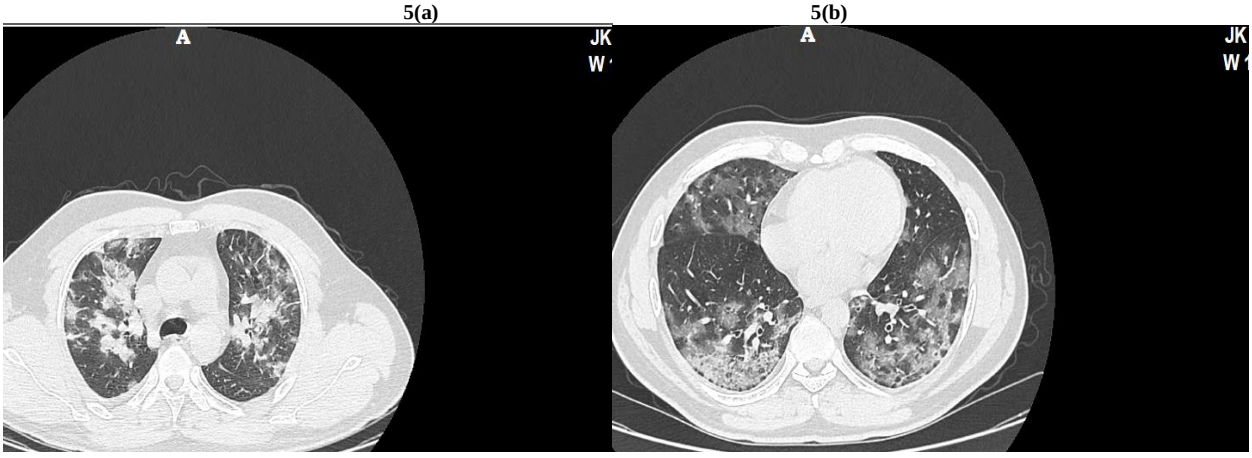

Figure.5(a)& (b)-HRCT Chest of 17yr old RTPCR positive patient showing halo and reverse halo sign respectively with multiple discrete and confluent patches of GGO. CT severity score; 18 (Moderate lung involvement).

Fig 6:HRCT Chest of 16yrs old RTPCR positive patient showing bilateral pleural effusion associated with multiple confluent patches of GGO with crazy paving appearance. CT severity score; 19 (Moderate lung involvement).

Conclusion

This study of COVID-19 pneumonia in pediatric and adolescent patients provides insight into CT and chest radiographic image findings of the disease in this specific population. The most common CT chest and Chest radiograph findings were ground-glass opacities typically with lower-lobe predominance. Chest CT can be employed in the early diagnosis and management of selected symptomatic pediatric patients, if clinically warranted. Mild lung involvement was common observation, though only in few cases, severe lung involvement was seen with full recovery without any mortality.

Abbreviations

COVID-19: Coronavirus disease 2019; CT: Chest Computed Tomography; RT-PCR: Real-time polymerase chain reaction; GGO: Ground glass opacity; WHO: World health organization; SARS-CoV-2: severe acute respiratory syndrome coronavirus 2

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