

## Chest radiological features and their association with clinical manifestations in COVID-19 positive neonates and young infants

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### Abstract

We report the Radiological findings in relation to the clinical features of coronavirus disease (COVID-19) in 37 symptomatic neonates and young infants (<2 months of age) who presented with a sepsis-like picture and proved to be infected with COVID-19.

**Patients and methods:** We reviewed, recorded, and analyzed the clinical findings in relation to the imaging features of coronavirus disease (COVID-19) in 37 symptomatic neonates and young infants (<2 months of age) who presented with sepsis-like picture (fever, hypotonia, hypoactivity, cough, and poor feeding) and proved to be infected with COVID19 (PCR) between January 1, 2020, and June 1, 2020.

**Results:** Our symptomatic newborns with COVID-19 infection had increased pulmonary vascularity in 6.2%, slightly accentuated central lung vascularity in 12.5%, and prominent hilar shadows with increased linear lung shadowing in the perihilar and precardiac in 34%. Increased linear lung shadowing with a tiny beaded-like appearance more distributed peripherally and at lower lobes occurred in 28%. Superadded peri-bronchial cuffing and perivascular haziness and lace-like fine linear appearance of interstitium occurred in 9.3%. Ground glass fine opacities (GGO) scattered in two or more lobes of both lungs appeared in 15.6%. Only 6.2% of symptomatic newborns showed superadded consolidations in both lungs, mainly peripherally oriented. Correlation with clinical severity of the disease (requirement of oxygen and assisted ventilation) proved that the appearance of GGO without consolidations was associated with moderate clinical severity, while the appearance of consolidations was associated with marked disease severity.

**Conclusions:** These findings brought more attention and understanding of the radiological manifestations and their association with the clinical severity in COVID19 positive newborns and young infants.

**Key Words:** Coronavirus Disease 2019 (COVID-19); Neonates; Young Infants; Chest X Ray; Clinical Severity

### 1. Introduction

The diagnosis of SARS-CoV-2 neonatal infection should meet all of the following criteria: (1) at least one clinical symptom, including unstable body temperature, low activity or poor feeding, or shortness of breath, (2) chest radiographs showing abnormalities, including unilateral or bilateral milled glass opacities, (3) a SARS-CoV-2 infection

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diagnosis in the patient's family or caregivers, and (4) close contact with people who may have or have confirmed SARS-CoV-2 infection, patients with unexplained pneumonia. (1)

Despite the increasing number of published studies on COVID-19 in pregnancy, there are insufficient good-quality data to draw unbiased conclusions with regard to the severity of the disease or specific complications of COVID-19 in newborns and young infants < 2 months of age. (2,3)

Wei M et al, reported 9 young infants between 1 and 11 months of age. Of the nine infants, four had fever, two mild upper respiratory symptoms, one asymptomatic, and two no information on symptoms. The time between admission and diagnosis was 1–3 days. (4) All nine infants did not require intensive care or mechanical ventilation and had no serious complications. Lu X et al reported 31 infants under 1 year, 19 % had symptoms of upper respiratory tract infection and 20 % had pneumonia, the rest were asymptomatic. (3)

Yan-Ting et al reported A considerable number of, but not all, neonates born to COVID-19-infected women developed COVID-19 (5/30) or had pneumonia-like radiological features (17/30). In their series those with CT features of pneumonia were mainly asymptomatic. (5)

Case reports stated some chest radiograph findings including pneumonia, increased lung marking, thickened texture, or high-density nodular shadows, and reported non-specific biochemical variables. The link between radiological and clinical symptoms was not completely entertained. (3,5,6)

Given the paucity of studies at this time, the chest radiographic changes in COVID19 positive newborns and young infants and their association, if any, with clinical manifestations have not been obviously studied.

### 1.1. Patients and methods

We reviewed, recorded and analysed the clinical findings in relation to the imaging features of coronavirus disease (COVID-19) in 37 symptomatic neonates and young infants (<2 months of age) who presented with sepsis like picture (fever, hypotonia, hypoactivity, cough and poor feeding) and proved to be infected with COVID19 (PCR) between January 1, 2020, and June 1 2020. All neonates and young infants of our study were outpatients who were found positive for SARS-CoV-2 in the emergency department and were admitted to the dedicated COVID-19 Unit of our hospital. Confirmed cases were defined through nasal and/or pharyngeal swabs positive for the presence of SARS-CoV-2 viral RNA using an in-house Taqman rt-real-time PCR assay targeting E and RdRP genes. Assay validation was performed in line with ISO 15189: 2012 requirements. The quality of COVID-19 diagnostic testing was supported and ensured by proficiency testing panels, i.e., external quality assessment (EQA) schemes provided by ECDC and WHO.

The ethical committee of Hamad Medical Corporation approved the protocol of the study (MRC-01-20-566).

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## 2. Results

The clinical characteristics of the COVID19 positive newborns are presented in table 1. Fever, nasal congestion/block, cough and hypoactivity were the main presenting manifestations.

The radiological changes of our patients are presented in (table 2) Plain X ray chest changes of the newborns with positive PCR for covid 19 are reported to be mostly mild. Our symptomatic newborns with COVID19 infection showed clear lung fields and normal pulmonary vascularity in 6.2%, slightly accentuated central lung vascularity in 12.5%, prominent hilar shadows with increased linear lung shadowing in the perihilar and precardiac in 34%. Increased linear lung shadowing with tiny beaded like appearance more distributed peripherally and at lower lobes occurred in 28% of them. Superadded peribronchial cuffing and perivascular haziness and lace like fine linear appearance of interstitium occurred in 9.3%. Ground glass fine opacities (GGO) scattered in two or more lobes of both lungs appeared in 15.6%. Only 6.2% of symptomatic newborns showed superadded consolidations in both lungs, mainly peripherally oriented.

The degree of severity of chest changes in relation to clinical severity are presented in (table3). Correlation with clinical severity of the disease (requirement of oxygen and assisted ventilation) proved that the appearance of GGO without consolidations was associated with moderate clinical severity, while the appearance of consolidations was associated with marked disease severity. Fine beaded appearance (Fig 1), GGO (Fig 2) and peripheral lung consolidations (figures 3 and 4) appear to be relatively specific radiological manifestations of Covid 19.

**Table 1** Clinical manifestations of COVID19 positive newborns and young infants

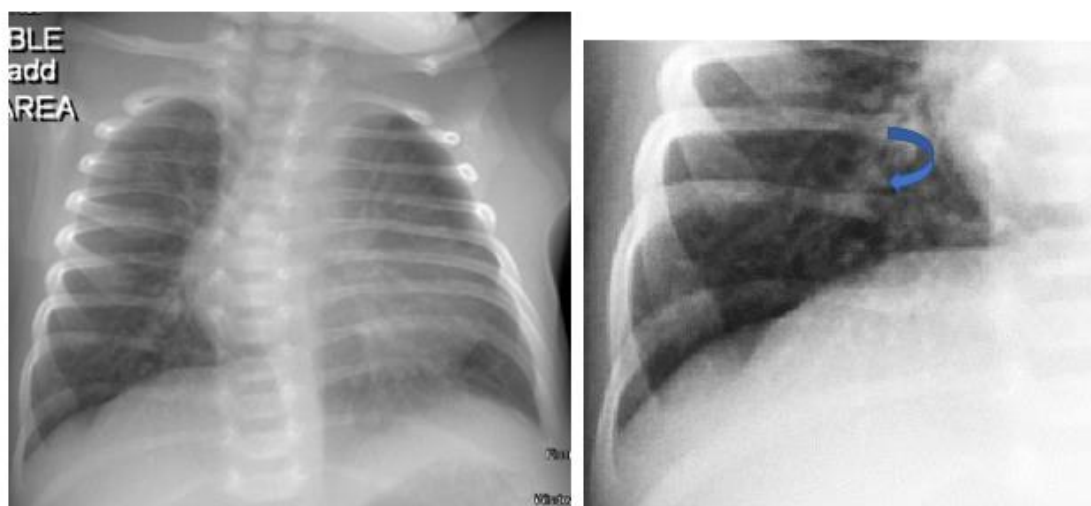
Symptoms N (%)	COVID-19 positive neonates (N = 37)
Fever	90%
Nasal congestion/block	39%
Cough	29%
Poor feeding	22%
Hypo-activity	12%
Irritability	12%
Diarrhoea	15%
Vomiting	7%
Signs N (%)	
Tachypnea	5%
Chest retraction	2%
pallor	5%
Vital signs N (%)	
Temperature (36.5-37.5) axillary	38.10 (36.6-39.2)
Heart rate (normal range 110-160)	165 +/- 12
Respiratory rate (normal = 30-60)	45 +/- 5
Blood pressure systolic (normal =65-85)	88 +/- 7
Blood pressure diastolic (normal = 45-55)	52 +/- 4

**Table 2** Radiological chest changes in COVID19 positive symptomatic newborns and young infants.

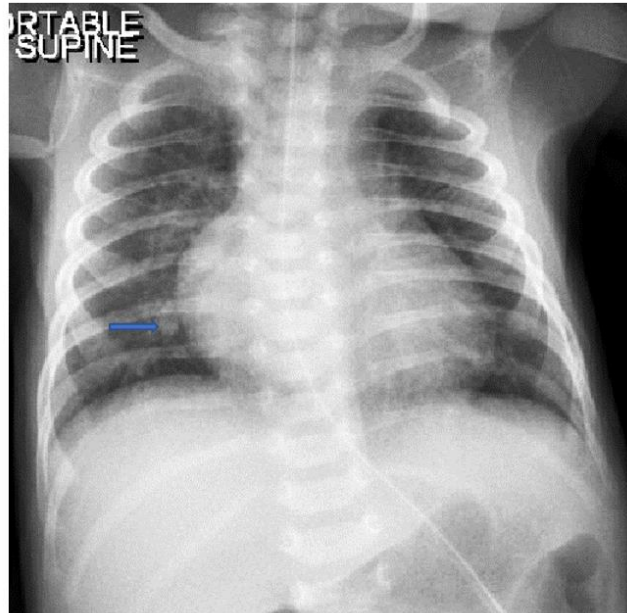
Radiological changes	No. of Patients	%
Clear both lungs and normal pulmonary	2	6.2%
Accentuated central lung vascularity	4	12.5%
Prominent hilar shadows +increased linear shadows	11	34.3%
The above + tiny beaded appearance	9	28.1%
Above + peribronchial cuffing, perivascular haze, lace-like fine lung reticulations	3	9.3%
Above + GGO (ground glass opacities)	5	15.6%
Above + consolidation	2	6.2%
Hilar enlargement	1	3.1%

**Table 3** The degree of severity in relation to chest X ray changes in patients (newborns and infants) with Covid 19 positive PCR

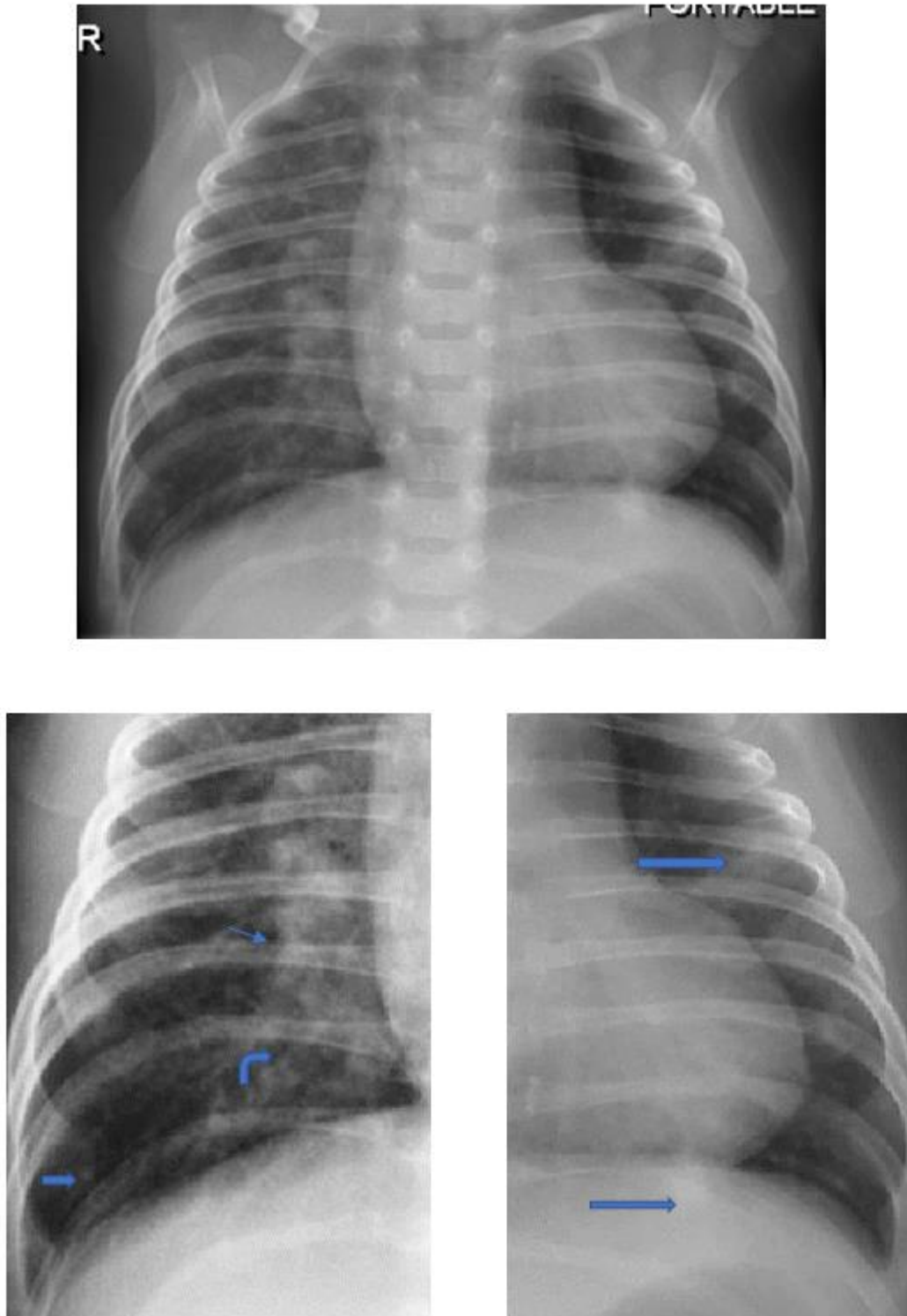
Radiological severity in CXR	No. of Patients	%	Clinical severity
No changes	2	6.2%	Mild fever
Mild changes	23	72%	Mild fever- cough
Moderate changes	5	15.6%	Moderate Fever, hypoactivity, cough and 3 required Oxygen supplement
Severe changes	2	6.2%	Severe respiratory distress - required assisted ventilation



**Figure 1** Chest radiograph (A full chest, B magnified part of Rt lower lung zone) representing accentuated hilar shadows with prominent vascularity, with fine beaded appearance (curved arrow) mainly basal and parietal with prominent fine linear interstitial shadowing appearance denoting mild severity of chest involvement in patient with positive PCR for Covid 19 and presenting with mild clinical manifestation.



**Figure 2** Chest radiograph representing accentuated hilar shadows with prominent vascularity, with small patchy ground glass opacities (GGO) (arrows) mainly Rt basal and parietal with prominent fine linear interstitial shadowing appearance denoting moderate severity of chest involvement in patient with positive PCR for Covid 19 and presenting with moderate clinical manifestation



**Figure 4** Chest radiograph with magnified views for Rt and left lower and med-zones for patient with positive PCR for Covid 19 presented with severe clinical manifestations demonstrating the beaded appearance (solid arrows) , GGO (curved arrow) , prominent vascular markings and peribronchial cuff (fine arrow) , consolidation (long arrow) , enlarged Rt hilar shadow which denote severe chest manifestation.

### 3. Discussion

Definitive diagnosis of COVID-19 requires a positive RT-PCR test. The threshold for the imaging of patients with potential/confirmed COVID-19 demonstrates a degree of variation globally due to local resources, the published guidelines of individual learned bodies and sociocultural approaches to imaging. (7)

Although chest CT scans may improve diagnostic accuracy, The use of CT as a primary screening tool is discouraged, because of high costs, the need for sedation, and radiation exposure. A meta-analysis, in April 2020, reported a pooled sensitivity of 94% and specificity 37%. In low prevalence (<10%) countries, the positive predictive value of RT-PCR was ten-fold that of CT chest. In addition, the presence of significant CT findings in asymptomatic patients who had benign clinical course reduced the requirement for CT scanning in these asymptomatic COVID 19 positive patients. (8-12)

Although less sensitive than chest CT, chest radiography is typically the first-line imaging modality used for patients with suspected COVID-19 infection. For ease of decontamination, use of portable radiography units is preferred. The previously reported imaging findings in adults and children are most commonly in the form of atypical or organizing pneumonia. The most frequent findings are airspace opacities, whether described as consolidation or, less commonly, ground glass opacity (GGO). The distribution is most often bilateral, peripheral, and lower zone predominant. However, radiological findings in symptomatic newborns and very young infants were not described except in case reports. (10, 13,14,15,16)

In our cohort of COVID19 positive newborns and young infants (n = 37) we reported the different radiological findings including:

- Fine beaded appearance (Fig 1),
- Ground glass opacities (GGO) (Fig 2), and
- Peripheral lung consolidations (Fig 3 and 4)

These features appeared to be relatively specific radiological manifestations of Covid 19. In support to the high frequency of radiological findings in our symptomatic newborns and young infants with COVID19 infection, Wong HYF et al found that in COVID-19 cases requiring hospitalization, 69% had an abnormal chest radiograph at the initial time of admission, and 80% had radiographic abnormalities sometime during hospitalization. (14)

In our infant cohort the degree of severity of radiographic changes was roughly associated with the clinical severity of the disease (table3). The appearance of GGO without consolidations was associated with moderate clinical severity (requiring oxygen supplement), while the appearance of consolidations was associated with marked disease severity (requiring ICU admission). Fine beaded appearance (Fig 1), GGO (Fig 2) and peripheral lung consolidations (figures 3 and 4) appear to be relatively specific radiological manifestations of Covid 19 I newborns and young infants.

The radiological manifestations of COVID-19 pneumonia had its pathophysiological basis. Since the diameter of SARS-CoV-2 is about 60–140 nm, and the size of the alveolar pores is about 10–15 µm, after inhaled through the respiratory tract, SARS-CoV-2 invades the bronchioles, mainly involving the interstitium around bronchioles at the end of lobular bronchioles, causing bronchiolitis and peri-bronchitis, and spreads to the distal end. Therefore, the lesion originates from a round-like nodule in the core of the secondary lung lobule, which are usually shown as round ground-glass opacity at first, and then extends to the whole secondary pulmonary lobules, forming lobular patchy imaging. SARS-CoV-2 mainly invades the interlobular interstitium, resulting in the appearance of prominent linear interstitial shadowing. Inflammatory stimulation leads to thickening of blood vessels in the lesion, which results in a corresponding alteration on imaging. (17,18,19)

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### 4. Conclusion

We reported high frequency of radiological changes in symptomatic COVID19 -positive newborns and young infants and the association between the severity of these changes with the clinical severity of the disease.

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## Compliance with ethical standards

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### *Disclosure of conflict of interest*

There is no conflict of interest among all the authors of this manuscript.

### *Statement of ethical approval*

The ethical committee of Hamad Medical Corporation approved the protocol of the study (MRC-01-20-566).

### *Statement of informed consent*

This retrospective study did not involve information about any individual, survey, or interview, and did not require informed consent. A waiver form was obtained from the ethical committee of Hamad Medical Corporation to obtain the clinical and radiological data retrospectively and the ethical committee approved the protocol of the study (MRC-01-20-566).

### *Authorship contributions*

- Conceptualization: Elsaid M A Bediar , Ashraf T Soliman,
- Data collection and analysis: Manasik Hassan, Ahmed Khalil, Samar Magboul, Ohood Alomari, Tasneim Abdalla, Hafez Alsliman,
- Writing original draft preparation: Elsaid M A Bediar , Manasik Hassan, Ahmed Khalil
- Revision of manuscript for important intellectual content and editing: Ashraf Soliman, Talaat Youssef, Mohamed Elamri

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