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Pneumonia in Hospitalized Children During COVID-19 Pandemic. Characterization of SARS-COV2 Pneumonia. Multi-Center Cohort Study

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Abstract

Introduction and objectives: Although COVID-19 is milder in young than adults. However, it can cause pneumonia in children eventually requiring hospitalization. Clinical similarity between COVID-19, other viral, and bacterial pneumonia at initial presentation of the disease caused a great challenge. We aimed to differentiate COVID-19 pneumonia from other viral and bacterial pneumonia in children, and to characterize it.

Materials and Methods: This study included 300 children, who were hospitalized with clinically and radiologically confirmed pneumonia during COVID-19 pandemic. Clinical symptoms were collected and analyzed. Cultures, real time polymerase chain transcriptase test for some respiratory viruses and SARS-COV2, C-reactive protein, serum procalcitonin, serum ferritin, complete blood counts, and ferritin/procalcitonin ratio were done for all patients.

Results: This study showed that COVID-19 pneumonia was only 15 % of all admitted pneumonia cases. It had low proportion of high fever, mild course, significant lymphopenia, significant thrombocytopenia, low procalcitonin, low C-reactive protein, higher ferritin/procalcitonin ratio, and higher neutrophil/lymphocyte ratio, significant high percentage of ground glass, and less percentage of consolidation in CT images.

Conclusion: During (COVID-19) outbreak characterization of COVID-19 pneumonia and taking naso- pharyngeal swabs for multi-respiratory pathogen, including SARS-COV-2, help not to attribute pneumonia due to other causes to be due to COVID-19. Pneumonia due to COVID-19 is less common, and less severe than that caused by other viruses or bacteria in children. However, further large-sample studies are needed to have full blown picture about COVID-19 pneumonia in children.

Keywords: Children- COVID-19- SARS-COV2- Pneumonia.

Introduction

Coronaviruses are non-segmented highly contagious RNA viruses, with protrusions on their surface resembling a corona, and the RNA genome is surrounded by a protein envelope [1]. A new virus named Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2), was denominated at the beginning of 2020 by the International Committee on Taxonomy of Viruses [2]. SARS-CoV-2 is the causative agent of the disease named (COVID-19), which represent an abbreviation decided by the World Health Organization (WHO). So (SARS-CoV-2) is the etiologic agent, while COVID-19 is the disease. COVID-19 was declared by WHO as a pandemic in march 2020

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[3]. Being highly contagious, SARS-CoV-2 could cause infection of all ages including young children. However, the proportion of SARS-CoV-2 infection in children appears to be lower than that in adults [4]. Although the course of the infection is generally milder in children than adults, pediatric SARS-CoV-2 can cause pediatric pneumonia, that may require hospitalization [5]. The clinical similarity between COVID-19, other viral and bacterial pneumonia caused a great challenge for differentiation for the health care providers, particularly at time of presentation. During the COVID-19 pandemic, most cases of pediatric pneumonia were possibly attributed to be due to SARS-CoV-2 infection, even those lacking etiologic confirmation or clear history of exposure [6]. On the other hand the clinical similarity between COVID-19 and bacterial pneumonia has resulted in concomitant miss-use of antibiotics in up to 100% of COVID-19 pediatric patients [7]

Clinical characteristics of COVID-19 pneumonia in pediatric age are not well established, and till now, only few studies have focused on it. Differentiating (COVID-19) pneumonia from other viral and bacterial pneumonia is critical, as early diagnosis enables expeditious use of appropriate antiviral or antibacterial treatments, minimizes cost and adverse effects resulting from empirical therapies [8]. Also, it can facilitate infection control measures against COVID-19 [9].

Real-time reverse transcriptase polymerase chain reaction (RT-PCR), is the gold standard test for diagnosis of COVID-19, but It needs at least 24 hours to return back from central laboratories and can take more than 48 hours in low-resource settings. Also, its sensitivity and specificity in children is not well defined [10]. Other rapid antigen or molecular-based tests has not been well- established. So we conducted this study to elucidate similarities, and differences between COVID-19 and other viral and bacterial pneumonia in children, in terms of disease onset, clinical manifestations, laboratory tests and radiological characteristics, and to characterize COVID-19 pneumonia in children.

Patients and Methods

Study Design

A total of 300 children, less than 14 years of age with clinically and radiologically confirmed pneumonia who were admitted in 3 COVID 19- isolation hospitals in (Al-Gharbia) - Egypt, between March and December 2020, were included in the study. At first all children were admitted in suspected COVID -19 ward under complete infection control precautions, where nasopharyngeal swab was taken for real time polymerase chain transcriptase (RT-PCR) for SARS-COV2 for all patients [11]. After results, the positive cases were shifted to (COVID-19) isolation ward for isolation and further treatment, while negative cases were shifted to pediatric

Table 1: Shows the epidemiological and baseline characteristics of all participants

Item	COVID-19 pneumonia cohort	Other viral pneumonia cohort	Bacterial pneumonia cohort	P value
	n= 45	n=150	n= 105	
Age (years)				
Mean	8.4	3.8	3.9	P =0.07
SD ±	± 0. 62	±0. 88	0.65±	
Sex				
Male	48.8% (22/45)	52% (78/150)	51.4% (54/105)	P =0.08
Female	51.2% (23/45)	48% (72/150)	48.6% (51/105)	
History of exposure to Corona virus positive case				
Clear history	40/45	0/150	0/105	P =0.01
Unclear history	May-45	0/150	0/105	P =1.08
Household contacts	36/40	0/150	0/150	P =0.01
Other contacts	Apr-40	0/150	0/150	P= 0.08
Underlying chronic illnesses				
present	5/45 (11.1%)	15/150 (10%)	11/105 (10.5%)	P =1.08
Not present	40/45 (88.9)	135/150 (90%)	94/105 (89.5%)	P =0.09

P >0.05 = Insignificant, P < 0.05 = Significant

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ward for further management. All patients baseline data, like age, gender, weight, underlying chronic disease, residential address with emphasis on clear history of recent exposure to positive cases of COVID-19 infection in addition to any associated clinical manifestations as respiratory symptoms and signs of gastrointestinal symptoms (diarrhea, vomiting, and abdominal pain), neurological symptoms (consciousness, or convulsions) and systemic symptoms (fever, fatigue, and muscle aches) were recorded. Pneumonia was diagnosed on clinical bases of high fever, cough, dyspnea and grunting and radiologically by evidence of consolidation [12]. Pneumonia cases with positive nasopharyngeal swab PCR for SARS-COV2 were considered SARS-CoV-2 associated pneumonia and termed as COVID-19 cohort.

Infection Control Measures, Radiological, Cultures, and Laboratory Investigations

All cases were subjected to complete clinical- examination under complete COVID-19 precautions and infection control preventive measures according to isolation protocols. Chest X ray and CT were done at admission and evaluated by an expert consultant of radiology. Blood sample for serum procalcitonin (PCT), C-reactive protein (CRP), serum ferritin, full blood count including white cell counts (WCC), absolute neutrophil counts (ANC), lymphocyte count, platelets and mean platelet volume (MPV), neutrophil/lymphocyte ration (NLR), CRP/MPV ratio, and ferritin/PCT ratio were measured on admission. Cultures, of nasopharyngeal swabs for additional microbiologic studies were carried out according to the physician's orders, including PCR for Bordetella pertussis and other respiratory viruses, and Mycoplasma pneumoniae or Chlamydia pneumoniae serology for every child. Pneumnia cases with positive cultures for bacteria was named as bacterial pneumonia cohort and those with positive culture for other respiratory viruses were named as other viral pneumonia cohort. The study was approved by the local Ethics Committee.

Statistical Analyses

The obtained data were tabulated and statistically analyzed using SPSS (16) for Windows. Qualitative data were expressed as absolute and relative, and quantitative variables were expressed as mean ± standard deviation and categorical variables were expressed as numbers and percentages. An evaluation association in categorical data between groups was using Chi-square, Student and ANOVA tests. ($p < 0.05$ is significant).

Results

A total of 300 children admitted with clinically and radiologically- confirmed pneumonia were included in this study during COVID-19 pandemic. Only Forty-five cases (15%) were COVID -19 positive (COVID associated pneumonia cohort), while 150 cases (50%) were due to other viral pneumonia and 105 cases (35%) were due to bacterial pneumonia. No significant statistical differences were found between COVID-19 associated pneumonia, other viral and bacterial pneumonia cases as regard sex distribution. Males were (48.8% (22/45), vs. 52% (78/150), vs. 51.4% (54/105 $p > 0.05$) respectively. As regard the age, children with COVID-19 associated pneumonia were relatively older than those in the other viral pneumonia cohort, and bacterial pneumonia group (8.4 ± 0. 62 vs. 3.8 ± 0. 88 vs. 3.9 ± 0. 65 years) respectively.

Five out of 45 children in the COVID-19 cohort, and 15 out of 150 children in the viral pneumonia cohort and 11 out of 105 children in bacterial pneumonia cohort had underlying chronic diseases. Forty cases of the COVID-19 pneumonia group had clear history of contact with COVID-19 positive cases most of them were household contacts (36/40).

Table 2: shows the microbiological and epidemiological characteristics of the studied groups most cases of other viral infection pneumonia were due to Influenza A and B viruses and most cases of bacterial pneumonia were due to streptococcal pneumonia.

Children with COVID-19 pneumonia had significant more gastrointestinal symptoms like vomiting, diarrhea, and abdominal pain than those with other viral infections than those with bacterial pneumonia (30 /45 vs. 20/150 vs. 10 /105($P < 0.05$)) respectively, on the other hand the proportions of cases with high fever >39.0 °C were lower in the COVID-19 pneumonia cohort than in the other viral pneumonia cohort than bacterial pneumonia group. (5/45 vs. 45/150 vs. 50/105, ($P < 0.05$) Respectively. In addition,

Table 2: Shows the microbiological and epidemiological characteristics of studied groups

Item	Microbiological and epedimiological characteristics of the studied groups n=300								
Pathogen	COVID-19 pneumonia cohort	Other viral pneumonia cohort				Bacterial pneumonia cohort			
	SARS-CoV-2	Influenza A and B Pneumonia	Parainfluenza virus pneumonia	Human adenovirus Pneumonia	RSV Pneumonia	Mycoplasma pneumonia	Staph-Cocci.	Group B strept	Streptococcal pneumoniae
	(n =45)	(n = 60)	(n = 30)	(n = 32)	(n = 28)	13	5	32	55

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the mean duration of fever was shorter in the COVID-19 pneumonia cohort than that in the other viral pneumonia cohort than in bacterial pneumonia group [(2 ±0.25 vs. 3±0.25 d vs. 4 .5 ±0.5) d vs. 5. 5 ± 2, (P < 0.05)] respectively. Only one child was in critical condition in the COVID-19 pneumonia cohort, with clinical manifestations including shortness of breath, neurological symptoms (drowsiness), three signs of depression, low blood oxygen saturation and increased on admission, and had received intubation and invasive ventilator-assisted ventilation immediately after admission. The proportion of children who developed severe course of the disease and admitted to ICU was lower in the COVID-19 pneumonia cohort than in the other viral pneumonia cohort than in bacterial pneumonia cases (4/40 vs. 30 /150 vs. 20/105, P = 0.048), and they had less days of oxygen therapy, as shown in Table 3. On admission, mean white blood cells count, neutrophils and lymphocytes in COVID-19 pneumonia children were significantly lower than those of other viral pneumonia cohort than those of bacterial pneumonia (3.9± 0.15 $\times 10^9$ L vs. 8.6± 0.33 $\times 10^9$/L **vs.** 15± 0.06 $\times 10^9$ L P < 0.05 and 1.3 ±0.20 $\times 10^9$ L vs. 1.4± 0.15× 10^9 L vs. 8.4± 0.80$\times 10^9$ L P < 0.05 and 1.4± 0.15 $\times 10^9$ L vs. 1.7± 0.23 $\times 10^9$ L vs. 3.7 ±0.78 $\times 10^9$ L P < 0.05) respectively. The mean platelets count, in COVID-19 pneumonia children were significantly lower than those of other viral pneumonia cohort than those of bacterial pneumonia (150± 15 $\times 10^9$ L vs. 170± 15 $\times 10^9$/L **vs.** 400±40 $\times 10^9$ L P < 0.05.

The proportion of cases with leucopenia (white blood cell counts < 5.5 × 109/L) and thrombocytopenia (platelets less than 120 × 109/L) was significantly, higher in the COVID-19 cohort than other viral pneumonia cohort than bacterial pneumonia cohort (30/40 vs. 75/150 vs. 0/105) P < 0.05 and 30/45 vs. 15/150 vs. 0/105 p<0.05) respectively. Neutrophil/lymphocyte ratio (NLR) is significantly higher in COVID-19 cohort than other viral pneumonia cohort and bacterial pneumonia cohort. Also CRP/ mean platelet volume ratio (CRP/MPV) was significantly lowern in COVID-19

Table 3: The clinical characteristics of studied groups

Item	COVID-19 pneumonia cohort n= 45	Other viral pneumonia cohort n=150	Bacterial pneumonia cohort n= 105	P value
Respiratory symptoms				
Cough	(45/45)	(150/150)	(105/105)	P= 0.15
Grunting	(45/45)	(150/150)	(105/105)	P= 0.15
Rhinitis	(25/45)	(150/150)	(63/105)	P= 0.48
GIT symptoms				
Vomiting	77.8% (35/45)	20% (30/150)	20% (21/105)	P= 0.02
Diarrhea	66.6% (30/45)	10% (15/150)	9.5% (10/105)	P= 0.01
Abdominal pain	68.88% (31/45)	3.33% (5/150)	3.8% (4/105)	P= 0.02
Muscle ache	62.22% (28/45)	13.33% (20/150)	2.85% (3/105)	P= 0.03
Fatigue	73.33% (33/45)	8% (12/150)	7.6% (8/105)	P= 0.01
Convulsions	2.22% (1/45)	0% (0/150))	0% (0/105)	P= 0.08
Disturbed consciousness	2.22% (1/45)	0% (0/150))	0% (0/105)	P=0.09
O2 saturation				
> 94%	84.4% (38/45)	74% (111/150)	74.2% (78/105)	P= 0.04
<94%	15.6% (7/45)	26% (39/150)	25.8% (27/105)	P= 0.03
Days of O2 therapy	2±0.25	3±0.00	3.5 ±0.0	P= 0.04
Fever				
37.5 -38	8.88% (4/45)	6.66% (10/150)	9.52% (10/105)	P= 0.09
38-39	80% (36/45)	53.3% (80/150)	42.85% (45/105)	P= 0.03
More than 39	11.11% (5/45)	30% (45/150)	47.63 (50/105)	P= 0.02
(Duration of fever days)	2±0.25	3±0.25	4.5 ±0. 5	P= 0.04
Severe cases need ICU	8.88% (4/45)	20% (30/150)	19.04% (20 /105)	P= 0.03
Critical	4.44% (2/45)	10% (15/150)	16.2% (17/105)	P= 0.04

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cohort than other viral pneumonia than bacterial pneumonia cohort respectively. The proportion of cases of D-dimer >0.5 mg/L, were lower in the COVID-19 pneumonia cohort as compared with the other viral pneumonia cohort than those of bacterial pneumonia (3 /45 vs. 15 /150 vs. 10 /105 P <0.05) respectively. Ground-glass opacity (GGO) of the lung was the most common radiographic presentation of children with COVID-19 pneumonia. The proportion of cases with GGO was significantly higher (40 /45 vs. 0/150 vs. 0/105, P <0.001), while the proportion of cases with consolidation was significantly lower in the COVID-19 pneumonia cohort as compared to other viral pneumonia cohort and bacterial pneumonia group (2/45 vs. 80 /150 vs. 90/105, P <0.001) respectively as shown in Table IV. Other radiographic presentations of COVID-19 pneumonia included tiny nodules, and radiopaque streaks.

Table 4: The laboratory and radiological characteristics of studied groups

Item	COVID-19 pneumonia cohort n= 45	Other viral pneumonia cohort n=150	Bacterial pneumonia cohort n= 105	P value
WBCs ×10⁹/L M± SD	3.9± 0.15	8.6±0.33	15±0.60	P= 0.02
<5.5 × 10⁹/L [n (%)]	30/45 (66.6%)	75/150 (50%)	0 /105 (0%)	P =0.03
Neutrophil × 10⁹/L (M± SD)	1.3±0.20	1.4±0.15	8.4±0.80	P =0.04
<1.1 × 10⁹/L [n (%)]	25/45 (55.55%)	50/150 (33.3%)	0/105 (0%)	P =0.02
lymphocytes [× 10⁹/L; Mean± SD]	1.4±0.15	1.7±0.23	3.7±0.78	P =0.04
Platelets ×10⁹/L				
M± SD	150 ± 15	170±15	400±40	P =0.03
<120 × 10⁹/L [n (%)]	30/45 (66.6%)	15/150 (10%)	0/105 (0%)	P=0.04
NLR	2.9	2.1	2.89	P =0.04
CRP/MPV	6.2	9.8	21.4	P =0,04
CRP	7±2	6±2	100±20	P= 0.02
PCT ng/ml	0.20 ±0.01	0.25±0.03	1.0±0.20	P= 0.04
PCT (>0.25 ng/ml)	2/45 4.4%	9/150 6%	100/105 95.2%	P =0.02
Ferritin ng/mL				
Ferritin / PCT	750±150	220±80	650±50	P= 0.03
D- Dimer	3750	880	650	P =0.02
>0.5 mg/L [n (%)]	3/45 6.6%	15/150 10%	10/105 9.5%	P<0.05
CT Radiological image				
Ground glass opacity	33/45 73.3%	0/150 0%	0/105 0%	P= 0.02
Consolidation	2/45 4.5%	80/150 53.3%	90/105 85.7%	P= 0.02
Tiny nodules	1/45 2.2%	20/150 13.3%	2/105 1.9%	P =0.03
Streak shadow	9/45 20 %	50/150 33.4%	13/105 12.4%	P= 0.04

P < 0.05 = Significant, MPV = Mean Platelet Volume, NLR= Neutrophil/Lymphocyte Ratio

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Discussion

Since December 2019, an outbreak of coronavirus disease 2019 COVID-19) has spread globally. On March 2020 (COVID-19) was declared as global pandemic by World Health Organization. Although the infection is less common and less serious in young than adults however, it can cause pneumonia in children that may require hospitalization. Respiratory illnesses, particularly pneumonia are consistently troublesome for infants and children. Pneumonia, is an inflammation of lung parynchema that is caused by various pathogens. It is a leading cause of hospital admission in children, and it is the main cause of mortality and morbidity in young ages. SARS-CoV-2 is an emerging contagious pathogen that can cause pneumonia in children. Understanding the clinical manifestations of pneumonia in children with COVID-19 and differentiating it from other causes of pneumonia is important for diagnosis, and management of this disease. The results of this multi-center retrospective cohort study provided highlights about features of COVID-19 pneumonia in infants and children, by comparing it with other types of other viral and bacterial pneumonia. Also, this study could identify differences in clinical manifestations, laboratory parameters, and radiological imaging characteristics between COVID-19 pneumonia and other causes of pneumonia in children. Our study described a series of 300 children, hospitalized with pneumonia during COVID-19 pandemic. Only 15 % of these cases were attributable to SARS-CoV-2. Our finding is coincident with Zimmermann P, and Curtis N who found less incidence of COVID-19 pneumonia in infants and children [13]. This low incidence of pneumonia in COVID-19 can be explained by the fact that the immune response of children differs from that of adults, which progressively deteriorates with age as the preschoolers have a repertoire of immune cells 5–10 times larger than that of a 50-year-old, and 20 times larger than that of an 80-year-old. Also the reduced maturity and functionality of ACE2 receptors, and its lower expression in the nasal, and upper respiratory tract epithelium in pediatric populations relative to adults could partly explain children's reduced susceptibility to COVID-19 [14]. In our study, these cases of COVID-19 pneumonia were characterized by relatively, older age, increased incidence of headache, vomiting, diarrhea, muscle ache, and fatigue as an associated manifestations. Clear history of exposure to positive cases of SARS-COV2 was evident in our COVID-19 pneumonia cases, and more than 90% of those contacts were household contacts. These finding is similar to the findings of Ying L. et al. [15] The result of our study showed significantly less proportion of severe cases that needed ICU admission in children with COVID-19 pneumonia cohort than that in other viral pneumonia cohort and bacterial pneumonia group(4/45 vs. 30 /150 vs. 20 /105 $p< 0.05$) respectively, Also patients of COVID-19 pneumonia cohort had significantly short duration of high fever , low proportion of cases with low oxygen saturation and low duration of oxygen therapy than the other studied two groups. All these findings reflect a non- severe course of the disease. The results of our study is consistent with previous results reported by Dong et al and Lu et al. [4,6] who reported mild COVID-19 infection in children.

Compared to pneumonia caused by other viruses and bacterial infection, we found that the inflammatory indicators as CRP, and PCT were significantly lower in COVID-19 pneumonia cases (7± 2 vs. 6±2 vs.100±20 $p< 0.05$ and 0.20 ±0.01 vs. 0.25± 0.03 vs. 1± 0.20 $p <0.05$) respectively. This may indicates that SARS-CoV-2 infection has less effect on excessive activation of the immune system in young. That is why it may be associated with milder clinical manifestations in children. The results of our study showed that cases of COVID-19 pneumonia has significant leucopenia, neutropenia, lymphopenia and thrombocytopenia than cases with other viral pneumonia and bacterial pneumonia. COVID-19 pneumonia has significantly higher neutrophil/ lymphocyte ratio and significantly lower CRP / MPV ratio than other viral pneumonia and bacterial pneumonia cohort. The results of our study showed that cases of COVID-19 pneumonia has significantly less proportion of cases with procalcitonin (PCT) level more than 0.25 ng/ml and D dimer more than 0.5 mg/L than the other two studied groups. These findings coincide with the finding of [16] Also the results of our study showed significantly higher serum ferritin and ferritin /PCT ratio in COVID-19 pneumonia cohort than other viral pneumonia cohort and bacterial pneumonia cohort. Our results can be explained on the fact that PCT which is a marker of inflammation is inhibited by interferon gamma which is released with the viral infection [17]. Also high serum ferritin can be explained by the fact that, it results from intra-cellular cytolysis of the respiratory epithelium due to viral replication, but it is not so high in bacterial infection as the bacterial pathogens don't need the intracellular compartment for replication. Our result is coincident with the findings of Jimenez-García, R., et al [18].

Also our results showed that cases with COVID-19 pneumonia had significantly higher ground glass opacity in CT images (about 89.9% of cases) but no ground glass opacity was seen other viral pneumonia or bacterial pneumonia group. Other findings included perihilar thickening and our findings are coincident with Alireza et al,[19].Finally our result can provide characterization of COVID-19 pneumonia in children as that: It occurs in relatively older children, Fever and cough, vomiting , diarrhea , muscle ache and fatigue were the most common symptoms of children with COVID-19 pneumonia, it is mostly not so serious with mild course of the disease, with less transformation to very severe or critical illness than other causes of pneumonia in children.

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Also Fever temperatures were mainly low to moderate, and the proportion of cases with high fever was only 7.5% of COVID-19 pneumonia cases. Also its fever was of relatively short duration. It was associated with marked leucopenia, lymphopenia, and thrombocytopenia, with high neutrophil / lymphocyte ratio and low CRP/ MPV ratio, with low PCT , CRP, D-Dimer serum level, high serum ferritin and high ferritin/ PCT ratio and marked ground glass opacity of the lungs in CT images in addition to other findings as peri-hilar radio-opaque streaks , and less percentage of consolidation in radiological images. The limitation of our study was the relatively small sample size of patients with COVID-19, and no co-infection cases were included in the study. Also the investigations were done only at admission and there was no following up with the laboratory, radiological, and RT-PCR tests for all studied groups.

Conclusion

From the results of our study, we concluded that children are not protected during SARS-CoV-2 infection from developing COVID-19 pneumonia. The symptoms and severity of children with COVID-19 pneumonia were no more severe than that of other viral or bacterial pneumonia. During COVID-19 outbreak naso- pharyngeal swabs for multi-respiratory-pathogen tests, including SARS-COV-2, are necessary in children with pneumonia. Also characterization of COVID-19 pneumonia in children is important for proper management of this disease, and helps not to attribute pneumonia due to other causes to be due to COVID-19. However further large –sample studies are needed on large scale to have full blown picture on COVID -19 pneumonia in pediatric population.

Abbreviations

IFN: Interferon

NK: Natural killer cell

PBMC: Peripheral blood mononuclear cell

Pf: *Plasmodium falciparum*

PfRBC: *Plasmodium falciparum* infected red blood cell

uRBC: uninfected red blood cell

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References

1. Chen Y, Liu Q & Guo D. Emerging coronaviruses: genome structure replication, and pathogenesis. J. Med. Virol 2 (2020): 418–23.
2. Zhu N, Zhang D, Wang W, Li X, Yang B, et al. China novel coronavirus investigating and research team. A Novel Coronavirus from Patients with Pneumonia in China 2019. N. Engl J Med 382 (2020): 727–33.
3. World Health Organization Naming the Coronavirus Disease (COVID-19) and the Virus That Causes It. (2020).
4. Dong Y, Mo X, Hu Y, Qi X, Jiang F, et al. Epidemiology of COVID-19 among children in China. Pediatrics. 145 (2020): 1-10.
5. Qiu HY, Wu JH, Hong L, Luo YL et al. Clinical and epidemiological features of 36 children with coronavirus disease 2019 (COVID-19) in Zhejiang, China: an observational cohort study. Lancet Infect Dis 20 (2020): 689–96.
6. Lu XX, Zhang LQ, Du H, Zhang JJ, Li YY, et al. SARS-CoV-2 infection in children. N Engl J Med. 2020; 382(17):1663–5.
7. Braden DK, Jayson S, Glenys S, Nick D, Denise GT, et al. The impact of COVID-19 on community antibiotic use in Canada: an ecological study. Clinical Microbiology and Infection 10 (2021): 135
8. Zhu N, Aylin P, Rawson T, Gilchrist M, Majeed A, Holmes A. Investigating the impact of COVID-19 on primary care antibiotic prescribing in Northwest London across two epidemic waves. Clin. Microbiol. Infect (2021): 00082-00083
9. Huang C, Wang Y, Li X, Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China. Lancet 395 (2020): 497–506.
10. Wu ZY and Mcgoogan JM. Characteristics of and important lessons from the coronavirus disease 2019 (COVID-19) outbreak in China summary of a report of 314 cases from the Chinese center for disease control and prevention. JAMA 323 (2020): 1239–42.
11. Wang P, Anderson N, Pan Y, Poon L, Charlton C, et al. The SARS-CoV-2 outbreak: diagnosis, infection prevention, and public perception. Clin Chem 66 (2020): 644-651.
12. Jain S, Self WH, Wunderink RG, Fakhran S, Balk R et al. Communityacquired pneumonia requiring hospitalization among U.S. adults. N. Engl. J. Med 373 (2015): 415– 27.
13. Zimmermann P, Curtis N. Coronavirus infections in

Al-AsY HM, et al., Arch Microbiol Immunology 2024
DOI:10.26502/ami.936500149

children including COVID-19: an overview of the epidemiology, clinical features, diagnosis, treatment and prevention options in children. *Pediatr Infect Dis J* 39 (2020): 355–68.

14. Saheb Sharif-Askari N, Saheb Sharif-Askari F, Alabed M, Temsah MH, Al Heialy S et al. Airways expression of SARS-CoV-2 receptor, ACE2, and TMPRSS2 is lower in children than adults and increases with smoking and COPD. Mol Ther Methods Clin Dev 18 (2020): 1–6.
15. Ying L, Haizhou W, Fan W, Hui D, Xueru L, Peng C, Yanli W, et al. Comparison of hospitalized patients with pneumonia caused by COVID-19 and influenza A in children under 5 years. International Journal of Infectious Diseases 98 (2020): 80–83.
16. Sayed A, AllamA, Alraey M. The use of neutrophil-to-lymphocyte ratio (NLR) as a marker for COVID-19 infection in Saudi Arabia. Saudi Med J 42 (2021): 370-375.
17. Thomas J, Mercy V, Malinaskas M, Pociute A, Kevalas R, et al. Blood biomarkers differentiating viral versus bacterial pneumonia aetiology: a literature review. Ital J Pediatr 46 (2020): 4.
18. Jimenez-García R, Nogueira J, Retuerta-Oliva A, Sainz T, Cano-Fernández J, et al. Pneumonia in Hospitalized Children During SARS-CoV-2 Pandemic. Is it All COVID-19? Comparison Between COVID and Non-COVID Pneumonia. The Pediatric Infectious Disease Journal 40 (2021): e111-e113.
19. Alireza G, Moniba B, Seyed A, Amin S, Elnaz M & Sara G. Chest computed tomography findings of COVID-19 in children younger than 1 year a systematic review World Journal of Pediatrics 17 (2021): 234– 241.